Richmond Adaptation and Resilience Strategy 2025-2035

Contents

Glossary

Adaptation: "Adaptation is the process (or outcome of a process) that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change. Adaptation policies can lead to greater resilience of communities and ecosystems to climate change."[1]

Adaptive pathways: An adaptive approach imbeds monitoring and evaluation of how the climate is changing, including impacts associated with this, and adjusting approaches accordingly.

Attenuation ponds: A type of sustainable drainage system (SuDS) that manages excess rainwater, by intercepting and temporarily storing rainwater runoff.

Carbon Literacy Training: Training to support individuals, teams and organisations in being Carbon Literate, meaning they have "an awareness of the carbon costs and impacts of everyday activities, and the ability and motivation to reduce emissions, on an individual, community and organisational basis."[2]

Carbon sink: A natural environment that is able to absorb and store carbon dioxide from the atmosphere.

Carbon Disclosure Project (CDP): "CDP is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts."[3]

Climate Change Steering Group (CCSG): Richmond Council's internal body responsible for the monitoring and delivery of the Council's climate targets and actions.

Climate risk and vulnerability assessment: Technical analysis of the potential impacts of climate change in a given context.

Co-benefits: "Simultaneously meeting several interests or objectives resulting from a political intervention, private sector investment or a mix thereof. Co-beneficial approaches to climate change mitigation are those that also promote positive outcomes in other areas, such as air quality and health, economic prosperity and resource efficiency or more general in terms of Sustainable Development."[4]

Cost-benefit analysis: An evaluation of financial costs and savings associated with interventions in the short-, medium- and long-term.

Early-warning systems: "An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events."[5]

EU Mission – Adaptation to Climate Change: "The Mission on Adaptation to Climate Change focuses on supporting EU regions, cities and local authorities in their efforts to build resilience against the impacts of climate change."[6]

Intergovernmental Panel on Climate Change (IPCC): "The United Nations body for assessing the science related to climate change."[7]

Maladaptation: Actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence.[8]

Nature-based solutions: "Nature-based Solutions leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future."[9]

Net zero: Where total greenhouse gas emissions are equal to or less than the emissions removed from the environment through emissions reduction and/or removal.[10]

NO2: Nitrogen Dioxide.

Glossary

Paris Agreement: A "legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016."[11]

Parklets: Small-scale green infrastructure to reduce environmental risks in urban environments.

PM10: Particulate matter of 10 micrometers in size.

PM2.5: Particulate matter of 2.5 micrometers in size.

Representative Concentration Pathways (RCP): "Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases, as well as land use/land cover. The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasises that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. RCPs usually refer to the portion of the concentration pathway extending up to 2100, for which integrated assessment models produced corresponding emission scenarios."[12]

Resilience: "The ability of a system to recover from the effect of an extreme load that may have caused harm. Adaptation policies can lead to greater resilience of communities and ecosystems to climate change."[13]

Retrofit: "Retrofit refers to any improvement work on an existing building to improve its energy efficiency, making them easier to heat, able to retain that heat for longer, and replacing fossil fuels with renewable energy."[14]

Science-based target: These provide "a clearly defined pathway for companies and financial institutions to reduce greenhouse gas emissions in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement."[15]

Shrink swell subsidence: "Shrink–swell is the volume change that occurs as a result of changes in the moisture content of clay-rich soils. Swelling pressures can cause heave, or lifting of structures, whilst shrinkage can cause settlement or subsidence, which may be differential."[16]

Sponge cities: Urban areas with abundant natural spaces, including trees, lakes and parks, and/or other green infrastructure designed to absorb rain and prevent flooding.[17]

Standard Precipitation Index: An index to quantify meteorological drought.

Storm surge: "A change in sea level that is caused by a storm."[18]

Sustainable drainage systems (SuDS): "SuDS are designed to both manage the flood and pollution risks resulting from urban runoff and to contribute wherever possible to environmental enhancement and place making."[19]

Tipping points: "A critical threshold when global or regional climate changes from one stable state to another stable state".[20]

Vector borne diseases: "Human illnesses caused by parasites, viruses and bacteria that are transmitted by vectors."[21]

Foreword

In 2019, Richmond Council declared a climate emergency. In 2020, we adopted Richmond's Climate Emergency Strategy, which set out actions to reduce carbon emissions and tackle climate change. We've made good progress, playing a strong role locally as part of the global action that is needed. Even so, our climate is still changing. What is uncertain is the scale of change we will face.

Since the industrial revolution, global temperatures have risen by more than 1.5°C. This is being felt in the London Borough of Richmond upon Thames too, where average temperatures have risen, rainfall patterns are changing, and more extreme weather is experienced more frequently. Alongside that, we're seeing changes in invasive species in our parks, gardens, and rivers. Climate change has implications for our health, for the safety and comfort of our homes and workplaces, and for the beautiful green spaces, riversides, and heritage that we enjoy in so many places across the borough.

It's vital that we continue to act to protect the people, places, and wildlife of Richmond upon Thames. We need to step up preparations to enable us to cope with and recover well from the challenges that lie ahead. That means thinking of everybody's needs and circumstances, making sure that people who are more vulnerable are prioritised.

This Adaptation and Resilience Strategy has been written to help us do that. It describes how our climate has already changed, how it is expected to change further, and how vulnerable we are to these changes. It formalises the Council's response in adapting to climate change and sets out how our Council teams will be taking a robust and consistent approach.

Crucially, our Adaptation and Resilience Strategy will put the people of Richmond at its heart. We are uniquely fortunate in having many of the tools to tackle climate change. We have ample green space to implement nature-based solutions. We have knowledgeable residents keen to act to protect our wildlife, our parks and rivers, our culture and history, our homes, and each other. And it's worth bearing in mind that the efforts we put into this will bring many other benefits: healthy, thriving communities, and a greener, safer and fairer borough for everyone not just for today but also for the future.

Cllr Julia Neden-Watts
Joint Deputy Leader of the Council
Chair of the Environment, Sustainability, Culture & Sports Committee

Executive Summary

WHY THIS STRATEGY IS NEEDED

The year of 2024 is on track to be the warmest year on record and the first in which global temperatures exceed 1.5°C above pre-industrial levels.[22] A survey of nearly half of the scientists who contribute to the United Nation's Intergovernmental Panel on Climate Change (IPCC) found that 77% of climate scientists expected global temperatures to rise by at least 2.5°C by 2100.[23] The Paris Agreement commits nations to limit "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."[24]

As a result of globally rising temperatures, extreme weather events have been increasing in frequency and intensity, including heatwaves, floods, droughts, wildfires, and storms. These extreme events have significant impacts on local communities, including the loss of human life, homes, and livelihoods. An analysis of 185 extreme events globally over the last 20 years estimated that the costs of extreme events attributable to climate change equates to US$143 billion annually. Sixty three percent of this cost is associated with the loss of human life, with a net of 60,951 deaths globally attributable to climate change during this 20-year period.[25]

Extreme weather is already affecting Richmond, with severe surface water flooding in 2021 and extreme heat in the summer of 2022. During the 2022 heatwave, temperatures exceeded 40°C for the first time in London and there were an estimated 387 excess deaths across the city.[26] With global temperatures projected to continue rising, this poses further threats to Richmond borough, including more intense and frequent occurrences of existing climate-related risks and the emergence of new risks associated with climate change.

Richmond Council has a statutory duty to deliver its public services, many of which are vulnerable to climate change. This Adaptation and Resilience Strategy has therefore been developed to ensure Richmond Council is:

- Helping the borough adapt and increase its resilience to the impacts of climate change.
- Able to continue delivering its services, despite the impacts of climate change.
- Using a robust and consistent approach to climate adaptation and resilience across all Council teams to reduce the impacts of climate change.

In doing so, this Adaptation and Resilience Strategy will support Richmond Council's commitment to making the borough greener, safer and fairer.

WHAT THIS STRATEGY AIMS TO DO

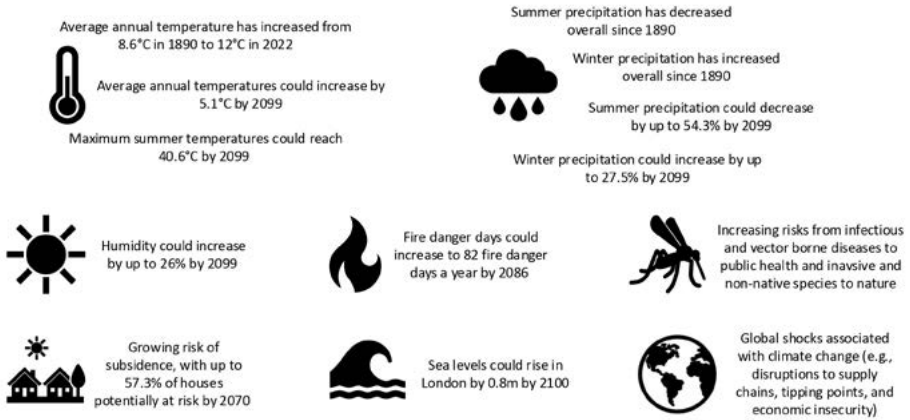
The Adaptation and Resilience Strategy has four primary aims:

1. Present the climate risk and vulnerability assessment conducted for Richmond.
2. Provide an Adaptation and Resilience Framework, to be used by all Council teams to ensure a robust and consistent approach.
3. Set long-term priorities to guide and inform Richmond Council's work on adaptation and resilience.
4. Inform local stakeholders and partnerships of climate risk in Richmond and the role of the Council in addressing these risks to help identify opportunities for collaboration.

CLIMATE RISK AND VULNERABILITY ASSESSMENT

A climate risk and vulnerability assessment was conducted for Richmond. Climate risk baselining was undertaken, including an analysis of observed climate trends and projections of future climate trends under different emissions scenarios.

The key findings of the climate risk assessment are summarised below.



The results of the vulnerability assessment highlight that extreme heat and flooding pose the greatest overall threat to the sectors included in the analysis, with every sector having a high vulnerability to extreme heat and flooding. Furthermore, a number of gaps and challenges were identified, including challenges around funding, knowledge, understanding and expertise, collaboration, short-term costs versus long-term savings, infrastructure, and engagement. These gaps and barriers at best reduce the effectiveness of the work the Council is doing on adaptation and resilience (for example, lack of collaborative working), and at worst prevent the Council from being able to do work on adaptation and resilience (for example, lack of funding).

ADAPTATION AND RESILIENCE FRAMEWORK

To ensure a robust and consistent approach to its work on adaptation and resilience, Richmond Council has developed an Adaptation and Resilience Framework. Importantly, this framework builds on the work that has been done regionally, aligning the work Richmond Council is doing with that being done across London and beyond.

Richmond Council's Adaptation and Resilience Framework embeds the five principles identified in the London Climate Resilience Review. These will guide the Council's work on climate adaptation and resilience:

1. Adaptation must take a **people-centred approach**, be locally led, strive to reduce vulnerability, and address socio-economic and racial inequality.
2. Adaptation must be **embedded across decision-making and organisations**, ensuring measures are owned at the strategic level and responsibility assigned.
3. Adaptation must be integrated with work to meet **net zero** to ensure coherent climate action.
4. **Adaptive pathways** approaches should be used to account for uncertainties and be flexible.
5. **Nature-based solutions** must be considered and prioritised.[27]

While embedding the five principles outlined above, Richmond Council's Adaptation and Resilience Framework has three key components:

1. **Climate risk and vulnerability assessment**: All projects will need to do a high-level climate risk and vulnerability assessment at the planning phase, with a tool being made available to all Council teams.
2. **Monitoring and evaluation**: As part of its adaptive pathways approach, all adaptation and resilience projects will be reviewed every five years to imbed flexibility and allow for adjustments to programmes of work as the impacts of climate change become clearer.
3. **A Council-wide approach**: An Adaptation and Resilience Board will be established under Richmond Council's Climate Change Steering Group to ensure the Adaptation and Resilience Framework is being used by all Council teams working directly and/or indirectly on adaptation and resilience and to monitor progress being made in this space.

PRIORITIES

Richmond Council has identified 5 overarching priorities on adaptation and resilience. These are long-term strategic priorities, which will guide the work undertaken on adaptation and resilience. The priorities are designed to be complemented by Richmond Council's annual Climate Action Plans, which commit to short- and medium-term actions.

The priorities represent a complementary and phased approach to adaptation and resilience, with each priority being necessary in order for them all to be successful:

1. Embed adaptation and resilience across the organisation.
2. Ensure a **joined-up approach** to adaptation and resilience to maximise the impact of the work done and increase the capacity of the Council to build a more resilient borough.
3. Compile and analyse the **data** required to effectively adapt to climate change and increase the resilience of the borough.
4. **Implement** effective adaptation and resilience measures across the borough.
5. Ensure formal **monitoring and evaluation** of adaptation and resilience.

1. Introduction

"Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming".[28] As a result, global temperatures have now risen by more than at any point since the industrial revolution. Indeed, 2024 is on track to be the hottest on record, with warming exceeding 1.5°C compared with pre-industrial temperatures (figure 1).[29]

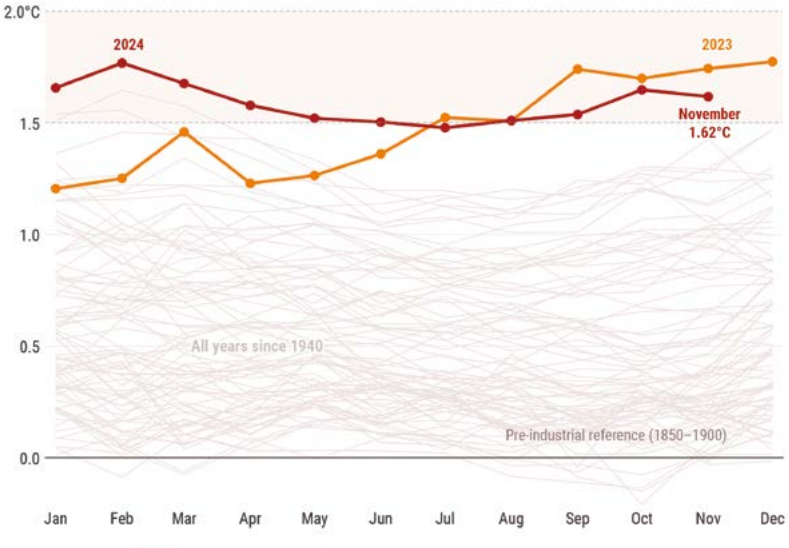


Figure 1. Monthly global surface air temperature anomalies (°C) relative to 1850–1900 from January 1940 to November 2024, plotted as time series for each year. 2024 is shown with a thick red line, 2023 with a thick orange line, and all other years with thin grey lines. Source: Copernicus: Second-warmest November globally confirms expectation for 2024 as warmest year | Copernicus

Whilst this is data for a single year, this new record is extremely concerning. Under the 2015 Paris Agreement, countries around the world agreed to limit "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels."[30] The limit of 1.5°C was set, as risks and impacts associated with climate change increase substantially above 1.5°C, and even more so above 2°C.[31]

Already, the impacts of climate change are being felt around the world, with extreme weather events becoming more frequent and severe. Such events are also affecting Richmond, including the breaching of 40°C for the first time during the 2022 heatwave (box 1), flash flooding in 2021 (box 2) and a destructive storm in 2022 (box 3). These threats require adaptation and resilience measures to be implemented, to ensure people are protected from the impacts of climate change.

Richmond Council declared a climate emergency in 2019, is committed to being a sustainable borough, and has made significant progress in reaching its ambitions. The Richmond Climate Emergency Strategy (RCES) was published in 2020 and sets the vision and strategy for the Council's role in mitigating and adapting to climate change.[32] The RCES is complemented by annual Climate Action Plans, which ensure the Council is advancing on tackling climate change, by regularly reporting on progress and raising the level of ambition of the Council's work on climate change. Richmond Council is publishing its new Climate and Nature Emergency Strategy in 2025.

Richmond Council has already delivered a range of projects contributing to the adaptation of the borough to climate change, including the following examples:

- Programmes of work to install sustainable drainage systems (SuDS) and parklets

to address environmental risks.

- Community Bluescapes programme to deliver natural flood management solutions to reduce flooding in the Beverley Brook catchment (box 9).
- Publication of Richmond Climate Risk Map, Local Flood Risk Management Strategy, Surface Water Management Plan, and drafting of Public Health Action Plan on Climate Change, and multiple event specific plans.
- Multi-agency Flood Response Plan and launch of public flood reporting tool.
- Severe weather advice and Heat Health Needs Assessment.
- Gully sensors to alert high water levels in problem areas for highway flooding.
- Establishment of warm/cool community spaces for vulnerable residents.
- Free water refill stations.
- Tree planting.

As such, this Adaptation and Resilience Strategy is not a starting point, but rather another step in ensuring progress in Richmond Council's work on climate change. Richmond Council's Adaptation and Resilience Strategy is a commitment to ensuring that a more effective, robust and consistent approach to adaptation and resilience is deployed across all Council teams. In doing so, the Council will maximise the effectiveness of its role in adapting to climate change and increasing the resilience of the borough.

A climate risk and vulnerability assessment was undertaken as part of the development of the Adaptation and Resilience Strategy. Furthermore, internal and external engagement and consultation were undertaken, as well as a detailed literature review, which together have informed the outcomes and proposed actions of this Strategy. The Adaptation and Resilience Strategy is designed to be complemented by the RCES and annual Climate Action Plans.

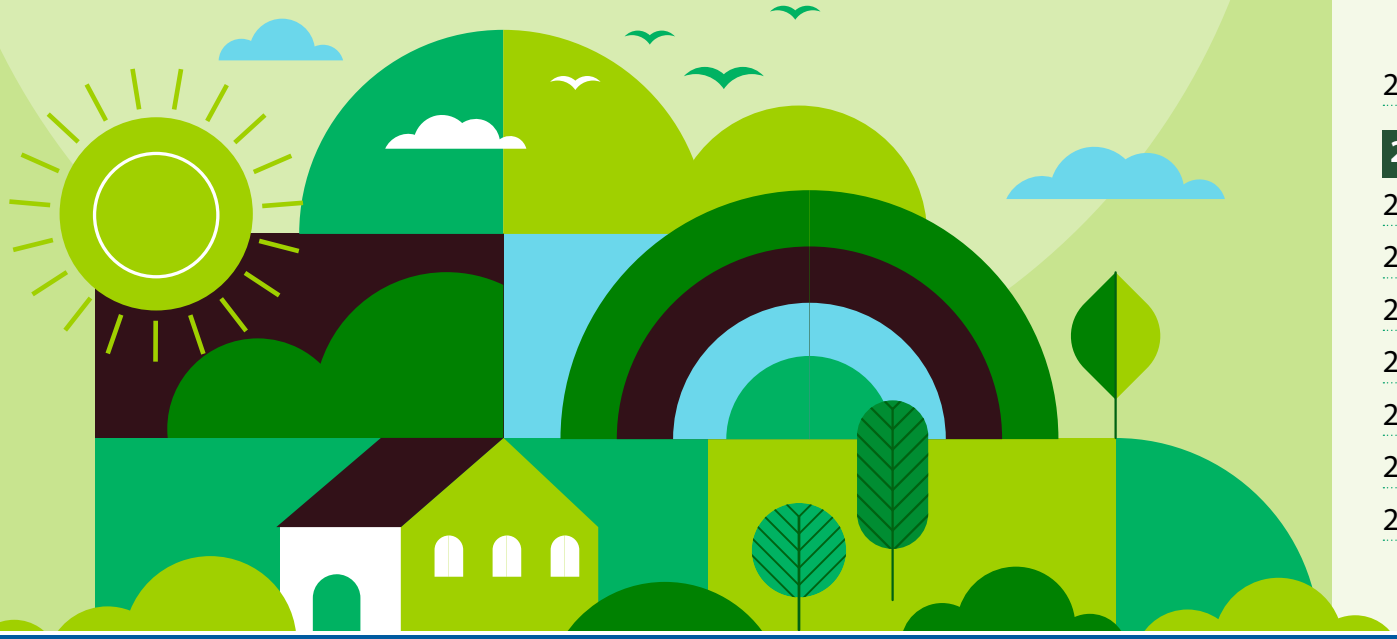
Furthermore, the Council has undertaken public consultation through Community Reporters and a Commonplace Platform. This engagement showed clear priorities from the public around adaptation and resilience, most notably:

- Investing in nature, parks, green spaces and nature-based solutions.
- Protecting the borough and residents from the direct impacts of climate change.
- Some of the key challenges highlighted included landscape changes; increased flooding and drainage issues; heatwaves; and water.
- Some of the key opportunities highlighted included investment in green spaces, local infrastructure and tree planting; adapting to heatwaves; and increasing awareness and accessibility of initiatives.

These findings have been incorporated into the framework (section 4) and priorities (5) of this Adaptation and Resilience Strategy.

2. Climate Risk Assessment

This section presents data to show the impact of climate change in Richmond. Observational data is used to show historic changes in Richmond's climate up to the present (section 2.1). Climate projections are used to show the expected changes in Richmond's climate up to 2100 (section 2.2).



2.1. Current Climate Risk

This section presents observational data on the climate in Richmond from the late 19th century to the present day. It is necessary to understand the current state of the climate, what climate-related impacts have already happened, and if there are any trends associated with the changing climate in Richmond. Understanding the baseline climate in Richmond is essential in order to assess the projected changes in the climate, the impacts associated with these changes, and what measures will need to be taken to reduce these impacts.

Using climate hazard and social vulnerability data, climate risk across Richmond borough have been mapped. Social vulnerabilities significantly affect the impacts associated with climate hazards, due to vulnerabilities either limiting the adaptive capacity of affected groups and/or vulnerabilities exacerbating climate impacts. Table 1 shows the full list of risks, exposures and vulnerabilities included in the Climate Risk Map. Full details can be found on the Climate Risk Map page.[33] The vulnerabilities included in Climate Risk Map were selected for their proven link in exacerbating exposures to the environmental hazards included in the Climate Risk Map. For example, the young and elderly are particularly vulnerable to extreme heat, as their bodies are less efficient at regulating core temperatures. Another example is those with asthma being more affected by high levels of air pollution, with potentially catastrophic consequences for their health and wellbeing. The vulnerabilities included are not necessarily comprehensive, and Richmond Council is undertaking a review of the Climate Risk Map to assess if other datasets should be included. Figure 2 shows the current overall climate risk across the borough, accounting for exposures and vulnerabilities.

Table 1. Risks, exposures, and vulnerabilities included in the Richmond Climate Risk Map.

Risks	Exposures	Vulnerabilities
Overall	Land Surface Temperature	Age 0-4 years
Overheating	Blue Space Accessibility	Age 75+ years
Flooding	Green Space Accessibility	English Language Proficiency
Air Pollution	Tree Canopy Cover	Social Renting
	Surface Water Flood Risk	Income Deprived
	River and Sea Flood Risk	Asthma Prevalence
	NO2	COPD Prevalence
	PM2.5	
	PM10	

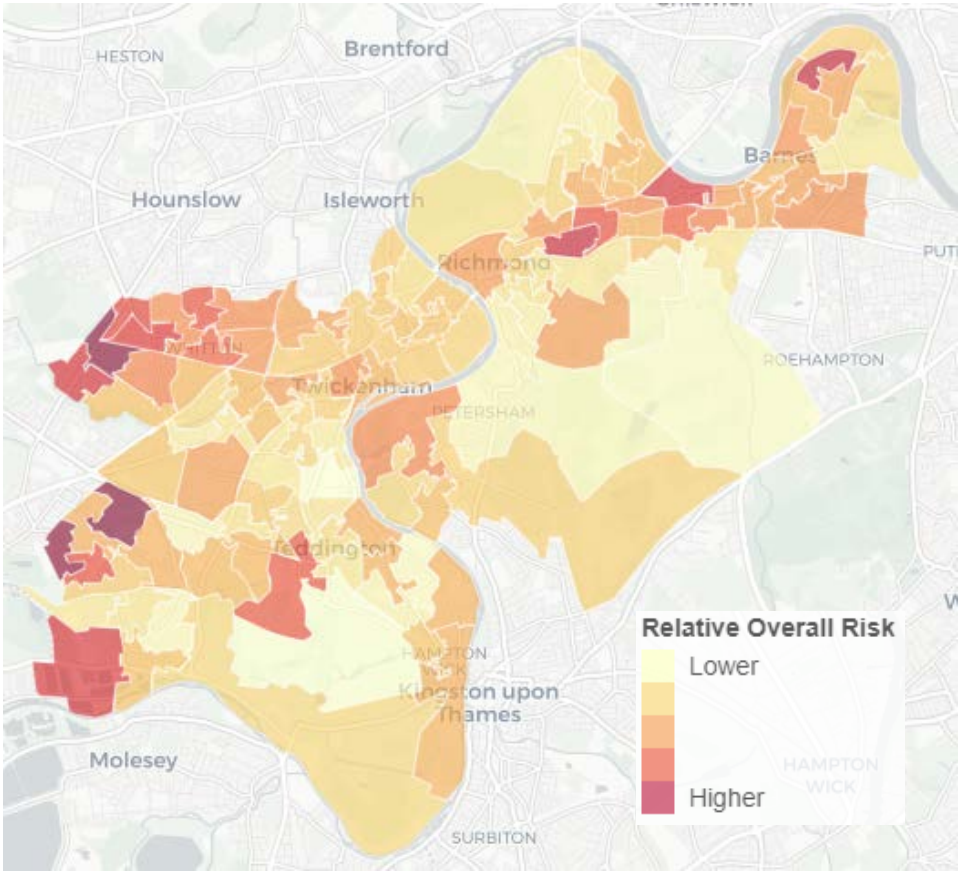


Figure 2. Overall climate risk across the London Borough of Richmond. Source: Richmond Climate Risk Map

2.1.1. Temperature

Annual mean air temperature has increased in Richmond since 1890 (figure 3). In 1890, the average annual temperature in Richmond was 8.6°C, whilst in 2022 it was 12°C. This trend is particularly strong over the summer months, with summer temperatures increasing by 4°C (figure 4) between 1890 and 2022 and winter temperatures by 2.6°C over the same period (figure 5).

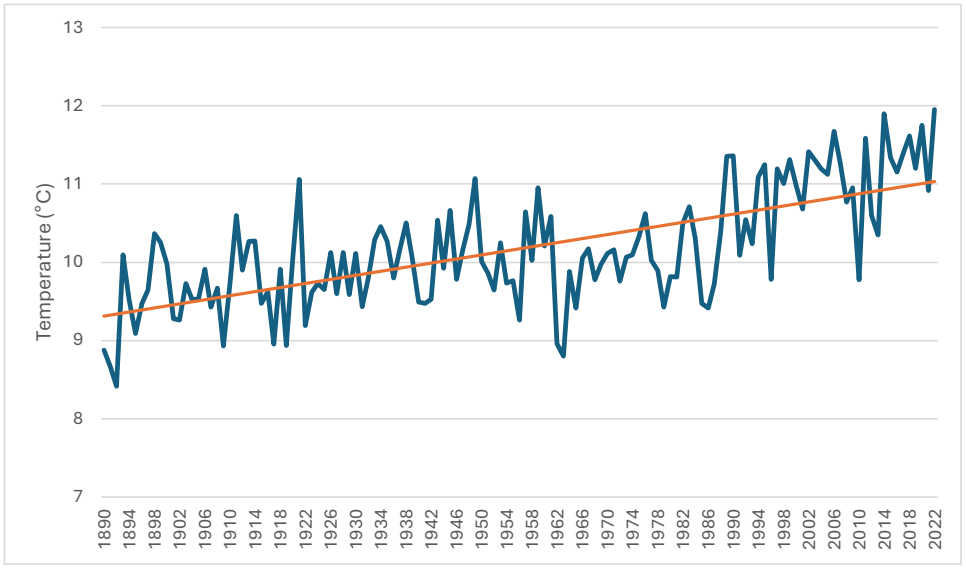


Figure 3. Observed mean annual air temperature at 1.5m in 25km grid square including Richmond (1890-2022). Source: UKCP.

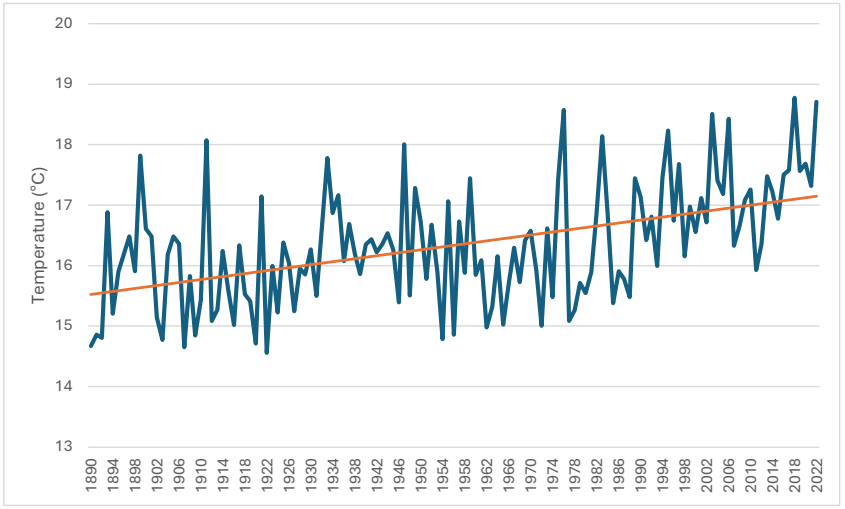


Figure 4. Observed mean summer air temperature at 1.5m in 25km grid square including Richmond (1890-2022). Source: UKCP.

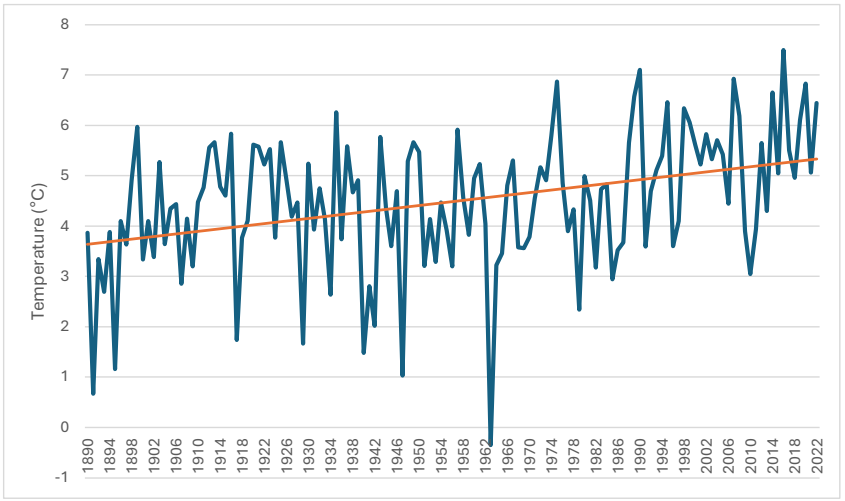
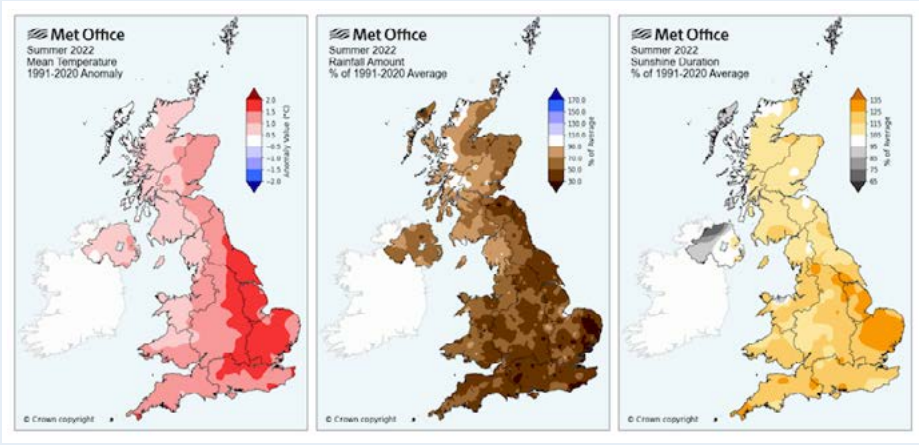


Figure 5. Observed mean winter air temperature at 1.5m in 25km grid square including Richmond (1890-2022). Source: UKCP.

Box 1. 2022 Heatwave

During the summer of 2022, London experienced a severe heatwave. Daily maximum temperatures exceeded the London threshold of 28°C for extended periods.[34] Five extreme heat episodes were recorded between June and August 2022, the highest number in any given year. The July 2022 heatwave was extremely rare, equating to a 1-in-1000-year event and was made ten times more likely due to human-induced climate change.[35] During this heatwave, there was a record number of Heat-Health Alerts (HHAs) issued since their introduction in 2004 and 387 excess deaths in London.[3637] Furthermore, there was a 50% increase in water consumption and UK reservoirs were at their lowest levels for 30 years.[38] The heatwave also had economic impacts for the city. For example, the number of visitors and workers in central London in July 2022 dropped to 74% below the previous month's levels, and TfL lost £8.4 million in revenue across their operations during the week of the July heatwave.[3940]



UK summer 2022 climate anomalies, relative to 1991-2020, for average temperature (°C), rainfall (%), and sunshine (%). Darker shading indicates larger anomalies. Credit: Met Office

Record-breaking temperatures were recorded in London at 40.2°C on 19 July 2022. These extreme temperatures on 19 July resulted in the first ever Level 4 Heat Health Alert and Red National Severe Weather Warning Service. On 19 July 2022, this extreme heat resulted in 683 excess deaths across England and more than 40 houses and shops across London were destroyed by fires.[41] Furthermore, the London Fire Brigade declared a Major Incident, as several fires broke out in and around the Capital; they experienced their busiest day since the Second World War.[42] The IT systems of London's largest NHS hospital trust failed, with impacts on healthcare in three hospitals and operations having to be cancelled due to the extreme heat. The trust incurred £1.4m out-of-plan spending on technology services to respond to the incident.[43]

Using heat-related data and social vulnerability data, figure 6 shows the current overall risk of overheating across the borough. In terms of the health impacts of heat waves, groups that are particularly vulnerable are the elderly, children, and those with preexisting health conditions. Extreme heat events are becoming more frequent, long-lasting and intense due to climate change that can be attributed significantly to human influence.[44]

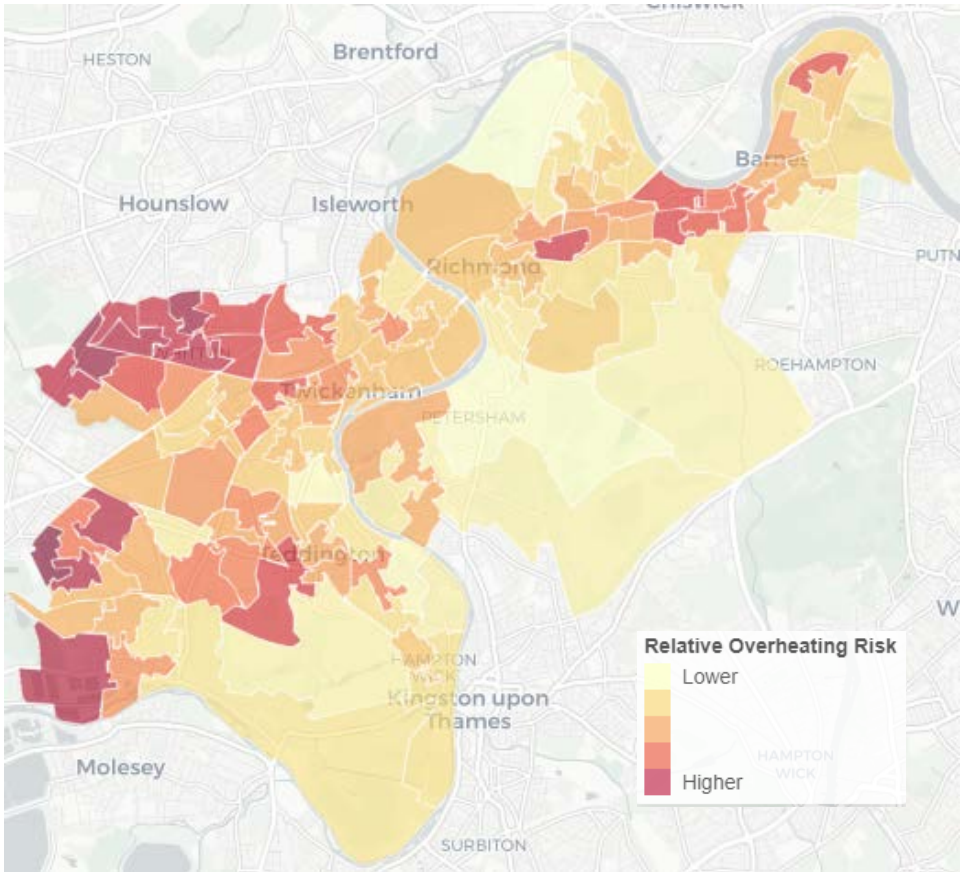


Figure 6. Overall overheating risk across the London Borough of Richmond Upon Thames. Source: Richmond Climate Risk Map

2.1.2. Precipitation

The overall trend in annual rainfall in Richmond has remained fairly consistent since 1890, although there has been significant year-on-year variability (figure 7). However, while the annual average has not changed significantly, there is an observed decrease in summer rainfall (figure 8) and an increase in winter rainfall (figure 14) between 1890 and 2022.

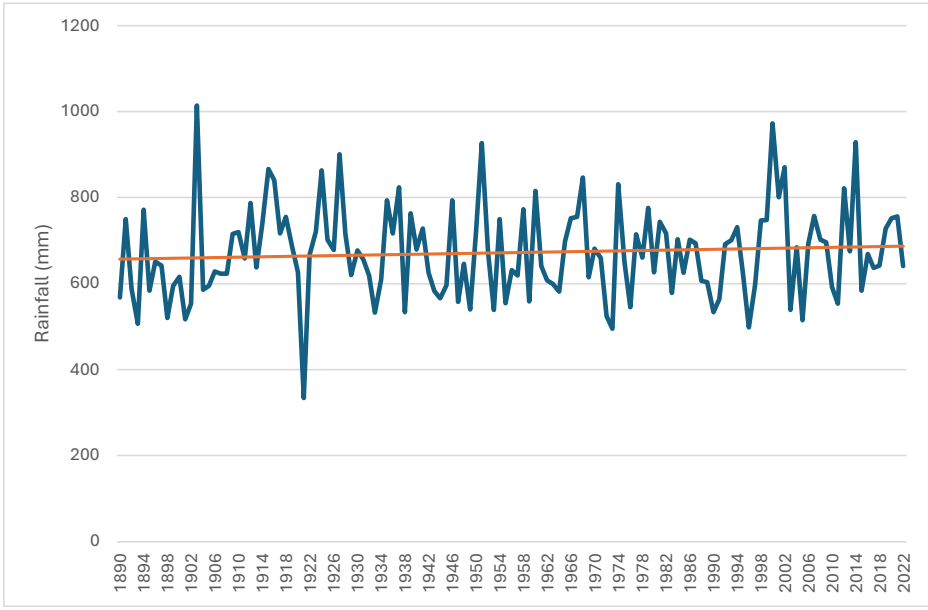


Figure 7. Observed total annual rainfall in 25km grid square including Richmond (1890-2022). Source: UKCP.

2.1.2.1. Drought

Drought most commonly occurs during the summer months, when rainfall is typically lower and temperatures higher. Summer rainfall has decreased overall in Richmond since 1890 (figure 8), whilst summer temperatures have increased (figure 4).

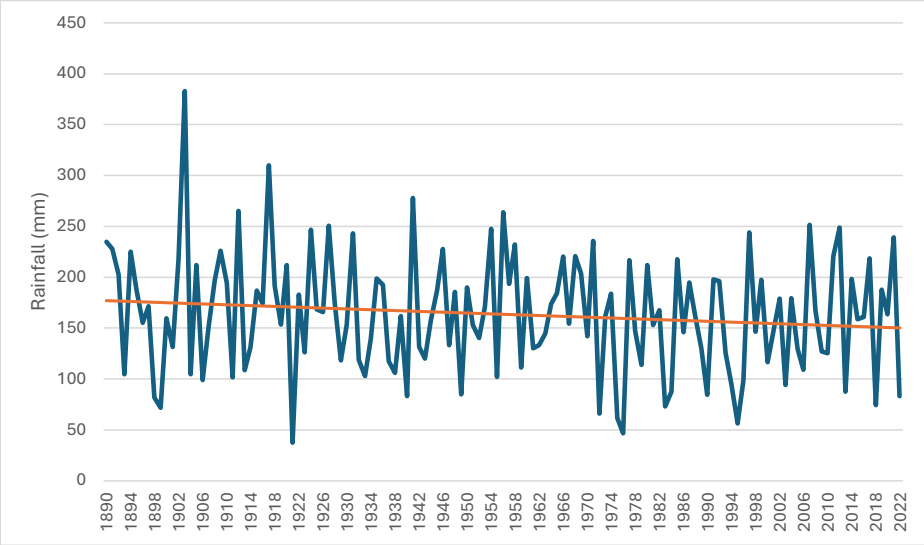
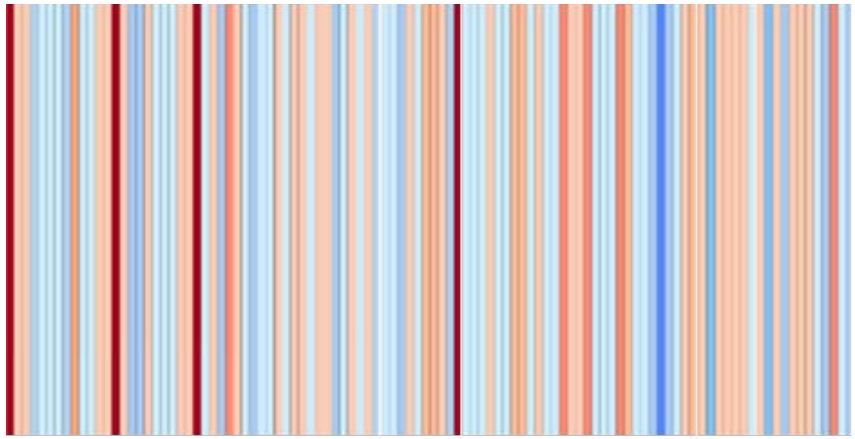


Figure 8. Observed total summer rainfall in 25km grid square including Richmond (1890-2022). Source: UKCP.

Figure 9 shows the Standard Precipitation Index (a strong indicator of drought occurrence and risk) recorded each July in Richmond since 1921, with each stripe representing one year. The observations highlight the strong annual variability in Standard Precipitation Index and a generally drying trend during the early 21st century. This highlights the already growing risk of drought in July in Richmond.



Key:
Each bar represents one year

The bar colour represents the precipitation level:

Extremely wet (above 2.0)
Severely wet (1.5 to 2.0)
Moderately wet (1.0 to 1.5)
Mildly wet (0.0 to 1.0)
Mildly dry (-1.0 to 0.0)
Moderately dry (-1.5 to -1.0)
Severely dry (-2.0 to -1.5)
Extremely dry (below -2.0)

The indices are dimensionless, meaning they lack any specific units. Negative values suggest that rainfall, flows, or levels are below the average, whereas positive values indicate that conditions exceed the average. Values above 2 represent extremely wet conditions, while those below -2 indicate extremely dry conditions. The greater the deviation from zero, the more severe the conditions, though such extreme values are

Figure 9. Standard Precipitation Index in Richmond 1921-2024. Source: UK Water Resources Portal (ceh.ac.uk)

2.1.2.2. Flooding

Richmond benefits from the broader flood defences within the Thames Estuary (including the Thames Tidal Defence System) and along the River Thames (including flood walls). Richmond is the only London borough to be bisected by the River Thames. The borough is completely dependent upon the defences of the Thames Estuary and local flood defences to ensure against river and tidal flooding. River flooding is "flooding from main rivers and is experienced when the amount of water within a channel is greater than the capacity of that channel".[45] Five tributaries of the River Thames run through Richmond borough, namely the Beverley Brook, River Crane, Duke of Northumberland's River, Whitton Brook and Longford River. These also present a flood risk (figure 10) and have some flood mitigation measures in place to reduce this risk. For example, natural flood management techniques are being implemented in the Beverley Brook catchment (box 9).

Figure 10. River and sea flood risk in the London Borough of Richmond Upon Thames. The green colouring shows where there is a risk of river and sea flooding. Source: Richmond Climate Risk Map

Tidal flooding "can occur during extreme high tides and/or during storm surges" in the tidal part of the River Thames downstream of Teddington Lock.[46] Although the River Thames is tidal downstream of Teddington Lock and Weir, Teddington Weir is sometimes overtopped when high tides coincide with high river levels. This can cause negative impacts for aquatic wildlife due to sudden changes in flow, temperature and salinity, and is a growing risk as sea levels rise and more extreme rainfall events affect the borough.

Whilst Richmond benefits from numerous, large green spaces, as an urbanised, outer London borough, Richmond is also vulnerable and susceptible to surface water flooding. This occurs when "rainwater cannot drain away quickly enough into the ground through infiltration or via existing drainage systems".[47] Surface water flooding is exacerbated in some parts of the borough by the underlaying London clay (which has a low infiltration rate); increasing impermeable surfaces (such as paving over gardens and driveways); and blocked or overwhelmed drainage systems. Consequently, significant areas of land across the borough are at risk of surface water flooding (figure 11).

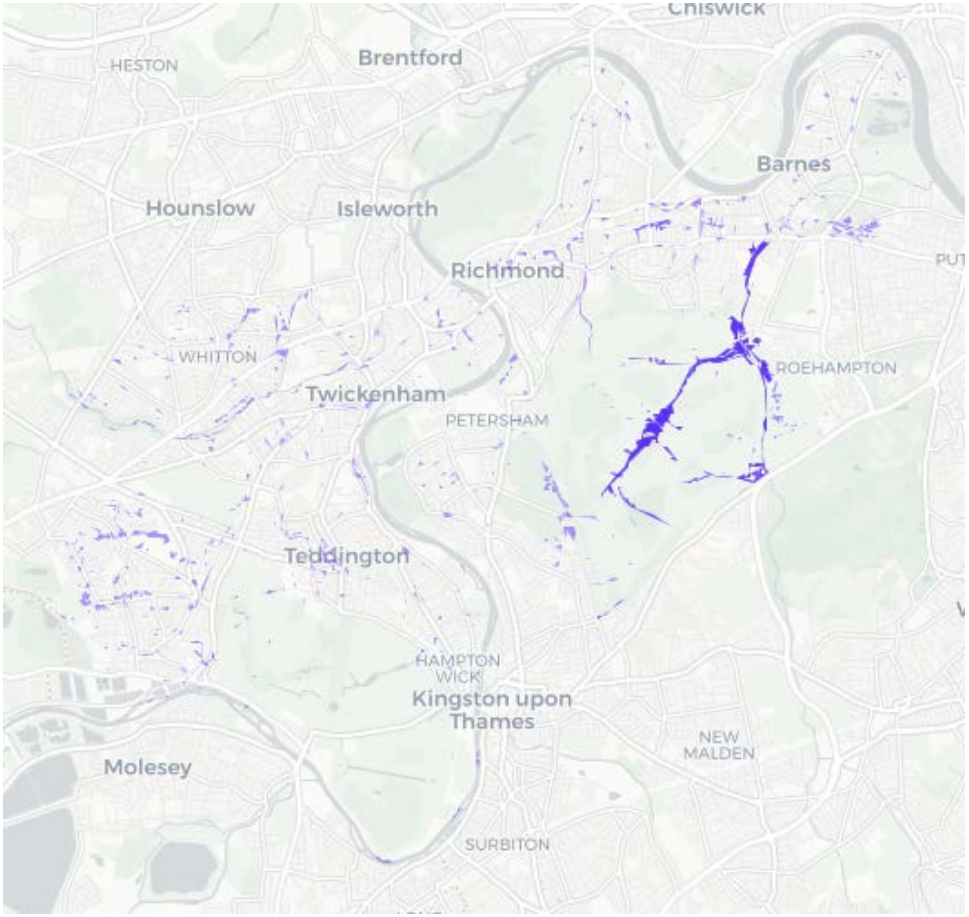


Figure 11. Surface water flood risk across the London Borough of Richmond Upon Thames. The blue colouring shows where this is a risk of surface water flooding. Source: Richmond Climate Risk Map

Groundwater flooding also affects the borough, occurring when "water which rises from underlying aquifers or sub-surface permeable strata", which normally happens during heavy or prolonged rainfall events.[48] Groundwater flooding

can also increase the risk of river and surface water flooding by reducing the infiltration capacity of the land.

Social vulnerabilities significantly compound the impact of flooding among the public. Figure 12 maps overall flood risk across the borough when these key social vulnerabilities are accounted for.

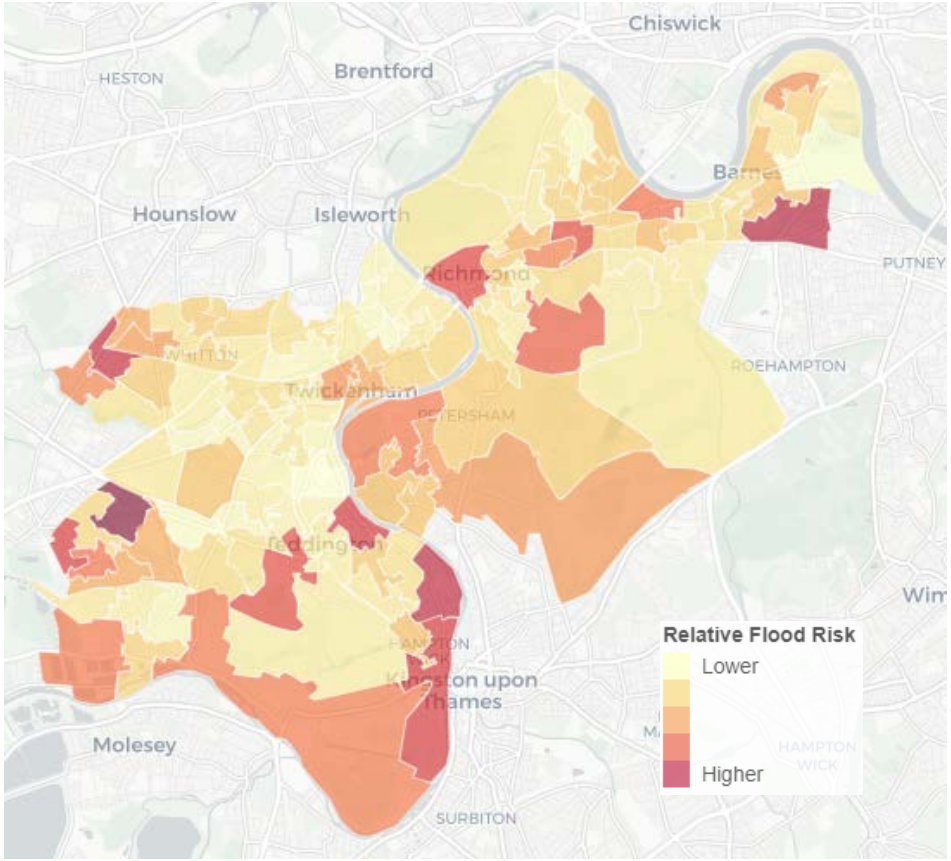


Figure 12. Overall flood risk across the London Borough of Richmond Upon Thames. Source: Richmond Climate Risk Map

Figure 13 shows recorded flood events in the borough, with Thames Water data shown since 2014 and publicly reported flood events recorded since 2020. The years with the highest number of flood events recorded by Thames Water were 2014 (134 floods), 2015 (132 floods), and 2021 (126 floods). Publicly reported flood events were highest in 2023, with 54 flood events reported.

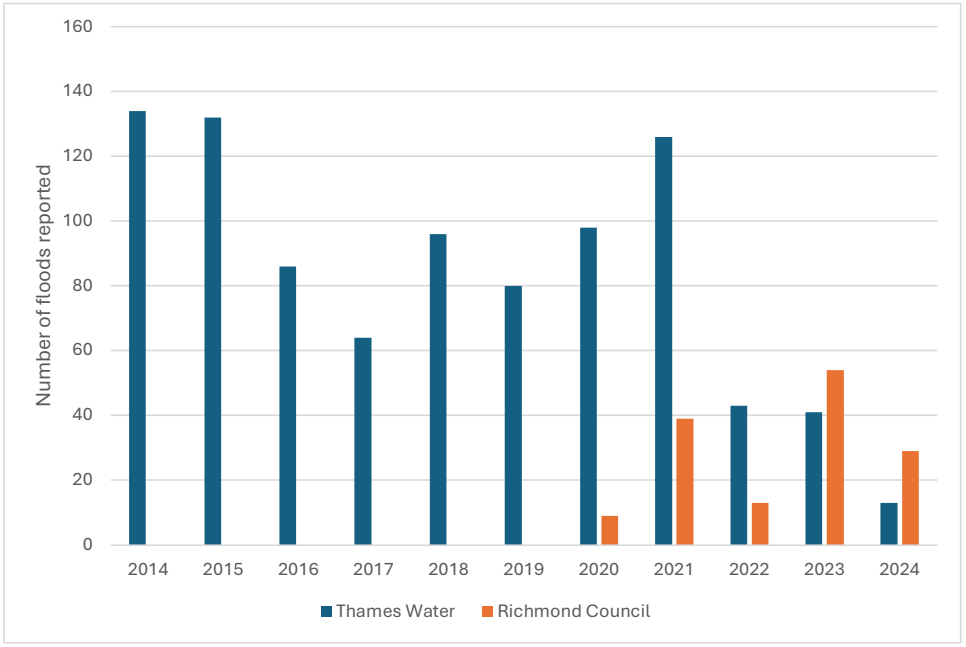


Figure 13. Recorded flood events in Richmond borough between 2014 and 2024. Blue bars represent flood events recorded by Thames Water (2014-2024). Orange bars represent flood events reported by the public to Richmond Council (2020-2024).

Figure 14 shows historic flood alerts and warnings within Richmond borough. These are dominated by risks from the "Tidal Thames riverside from Putney Bridge to Teddington Weir". Currently, the Thames Barrier protects Richmond borough from severe flooding associated with the tidal range of the Thames up

to Teddington Lock. However, with rising sea levels, high tides will become higher and storm tides will become bigger and more frequent, increasing the risk of water overtopping the Thames Barrier. The Thames Barrier therefore will need to be upgraded, as it will not be fit for purpose by the end of the century.[49] Whilst the Thames Estuary 2100 has identified options for upgrading the Thames Barrier to overcome these risks, this highlights the vulnerability of Richmond to sea level rise and its dependency on the effective functioning of the Thames Barrier.

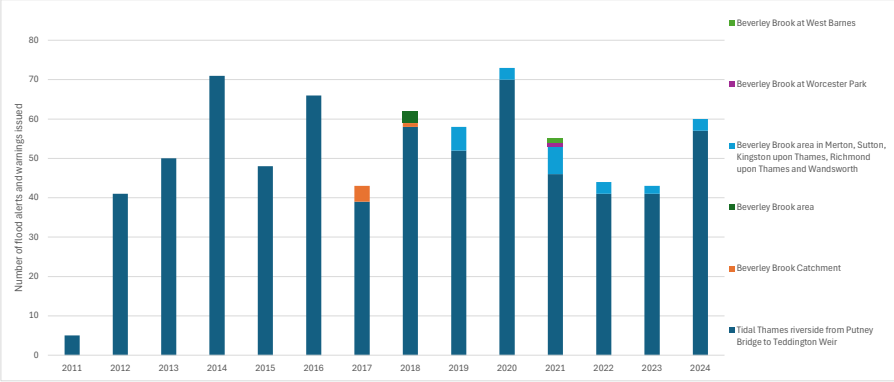


Figure 14. Historic flood alerts and flood warnings in Richmond borough from 2011 to 2024. Of note, in 2017, the categorisation of flood risk areas was updated, with the inclusion of new flood risk areas added at this time. These were the Beverley Brook Catchment; Beverley Brook area; Beverley Brook area in Merton, Sutton, Kingston upon Thames, Richmond upon Thames and Wandsworth; Beverley Brook at Worcester Park; and Beverley Brook at West Barnes. A 'flood alert' means flooding is possible and be prepared. A 'flood warning' means flooding is expected and immediate action required. Only two flood warnings occurred in figure 29: one in Beverley Brook at Worcester Park in 2021 and one in Beverley Brook at West Barnes in 2021. Source: Historic Flood Warnings - data.gov.uk

Whilst precipitation is not the only contributing factor to flood risk, it is one of the key ones. Annual observed rainfall has not changed significantly since the late 19th century (figure 7), but winter rainfall has increased overall since 1890 (figure 15). Precipitation tends to be higher overall in winter and this season can be particularly susceptible to flooding. However, although the general trends for precipitation have been decreasing summer and increasing winter rainfall, the implications for flooding are more complex than dry summers and wet winters. Flooding can occur at any point throughout the year. Indeed, heavy rainfall events which follow dry periods, as is often seen in the summer, can be particularly severe.

Heavy precipitation increases the risk of the different types of flooding (i.e., river flooding, surface water flooding and groundwater flooding) occurring at the same time and combining to result in a particularly severe flood event from multiple sources. Furthermore, such events can be worsened further still by high tides and storm surges causing tidal flooding, which London is susceptible to.

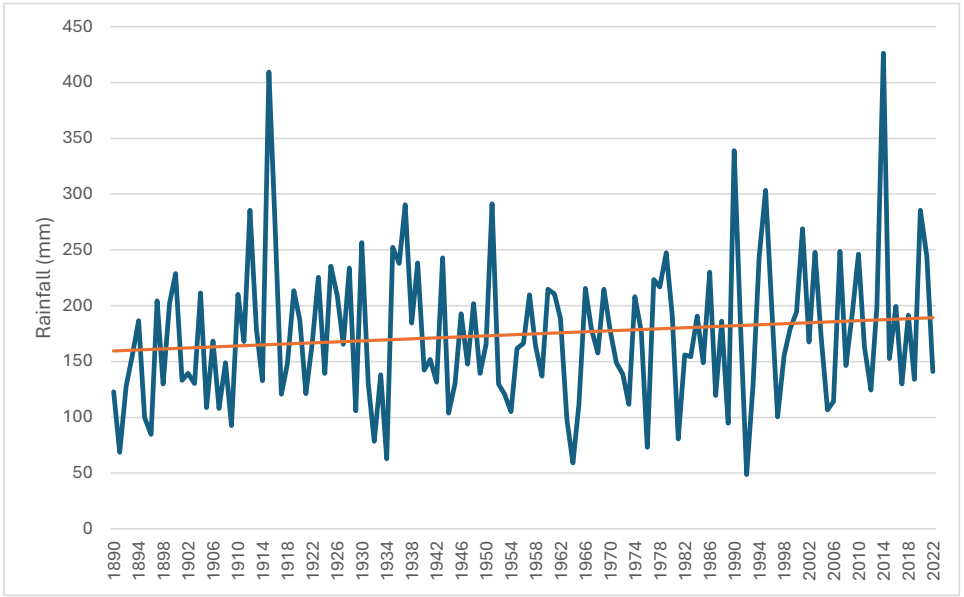


Figure 15. Observed total winter rainfall in 25km grid square including Richmond (1890-2022). Source: UKCP.

Box 2. July 2021 Flash Flooding

In July 2021, heavy rainfall across London caused significant flooding, including across Richmond borough. During this period, there were six reports of internal flooding and four reports of flooding on highways and outdoor areas. Furthermore, sewer flooding occurred, which can pollute nearby watercourses (with associated risks to aquatic life and contaminated land) and risks exposing people to diseases from contaminated water.[50] Across London, the flooding is estimated to have resulted in insurance losses equating to £281 million.[51] The average cost of repairing a home damaged by flooding is around £33,600.[52]

2.1.3. Storms

There are two key components to account for when observing storm activity: wind and rainfall. Trends in rainfall are shown in figures 7, 8 and 15, with winter rainfall (when storms are more likely to occur in the UK) having increased overall since 1890. Observational data of wind speeds have declined overall in Richmond since 1970 (figure 16), which is corroborated by the State of the UK Climate 2023 Report and supports global observations of a general slowdown in near-surface wind, known as "global stilling". There are some indications this trend may be slowing in the UK and reversing globally.[53] The Third UK Climate Change Risk Assessment concluded that there is currently no evidence for increased storminess in the UK, although changes in monitoring storm activity complicates this.[54] Figure 17 shows the number of named storms that have occurred in each storm season since 2015/16 in the UK and/or Ireland; there is no significant trend in storm occurrence during this period. Although there is currently no evidence for increased storminess in Richmond, severe storms have occurred in recent years, with significant impact across the borough (box 3).

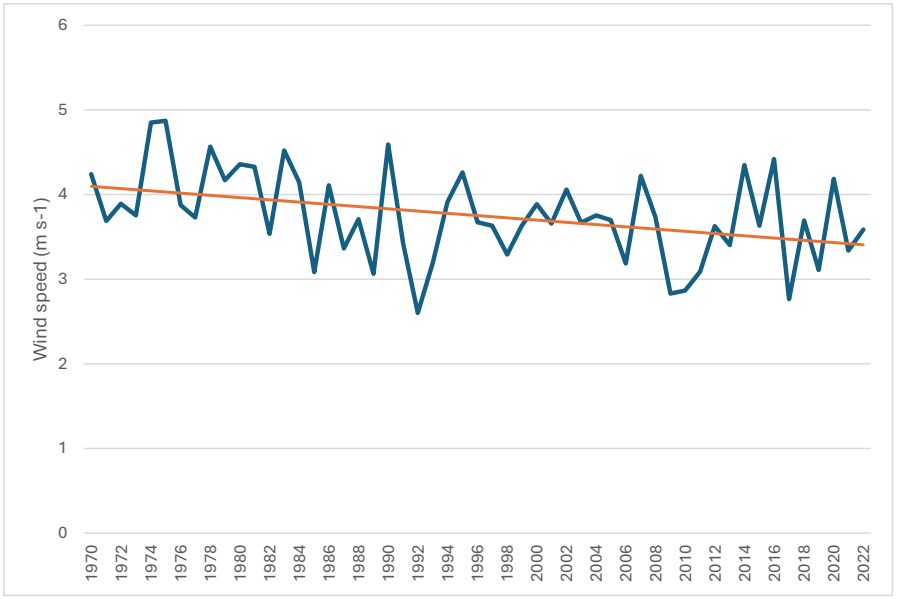


Figure 16. Observed average winter windspeed in 25km grid square including Richmond 1970-2022. Source: UKCP.

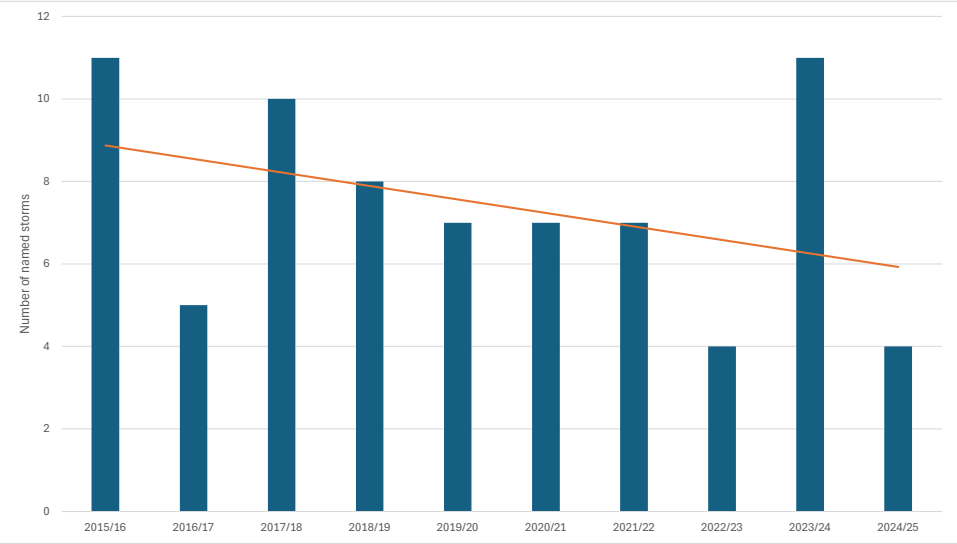


Figure 17. Total number of named storms in the UK and/or Ireland in each annual storms season (2015/16-2024/25). Source: UK Storm Centre - Met Office.

Box 3. Storm Eunice

Storm Eunice hit Richmond on 19 February 2022 and was the second of three named storms in one week in February 2022. As a result of the storms, shops, businesses and parks closed, including Kew Gardens and Richmond Park and Bushy Park.[55] Richmond Council issued a "Stay Indoors" warning to residents, as there was a risk to life due to high winds. Indeed, the Met Office issued Red Warning for strong winds, with wind speeds reaching up to 70mph recorded. In Richmond Park, a total of 60 trees fell, three of which were veteran oaks and two other veteran trees were damaged. In Bushy Park, more than 40 trees were lost.[56] Storm Eunice is estimated to have incurred insurance losses between £200 million to £350 million across the UK.[57] There were major delays to travel in the borough, with most train networks across London suffering from cancelled or delayed trains, including from Richmond Station.[58]

2.1.4. Air Pollution

Air pollution is one of the biggest environmental threats facing the UK, with 29,000 to 43,000 deaths associated with air pollution every year.[59] Of these, 3,600 to 4,100 deaths are in London, with 86-98 attributed to Richmond borough in 2019.[60] Deaths are especially high among the elderly and those with preexisting health conditions (such as asthma and chronic obstructive pulmonary disease (COPD)). Children are also extremely vulnerable to air pollution, with children consistently exposed to high levels of air pollution having had their lung capacity reduced by 5%.[61] Figure 18 shows current air pollution risk across Richmond.

Air pollution and climate change are intrinsically linked. The sources of air pollution and greenhouse gas emissions are largely the same (predominantly petrol and diesel vehicles in the UK) – this in turn means measures to address these challenges can tackle both air pollution and climate change. However, climate change is also expected to impact air pollution, due to changing weather patterns affecting the dispersal and concentrations of key pollutants. Whilst emissions of air pollutants will be the dominant factor in levels of air pollution in future, it is important to recognise that changes to the climate will also affect the public's exposure to air pollution.[62]

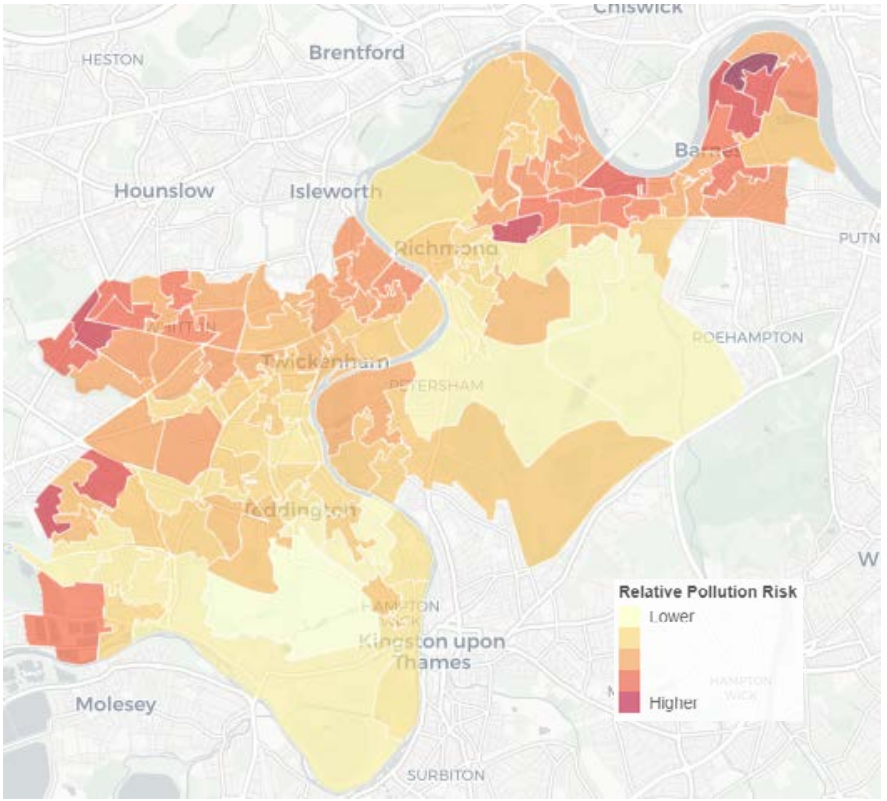


Figure 18. Overall air pollution risk from NO2, PM10 and PM2.5 across the London Borough of Richmond Upon Thames. Source: Richmond Climate Risk Map

Air pollution has decreased overall across the borough (figure 19). In 2023, only one site (Upper Richmond Road) had levels of NO2 which failed the Air Quality Objective guidance for NO2 (40 µg m-3). While this is significant progress since 2017, all sites failed to meet the World Health Organization (WHO) guideline of 10 µg m-3 for NO2 (figures 19.1 – 19.3). For PM10, all sites met the Air Quality Objective levels (40 µg m-3) in 2023, and two out of three sites met the WHO guidelines for PM10 (15 µg m-3) (figure 19.4).

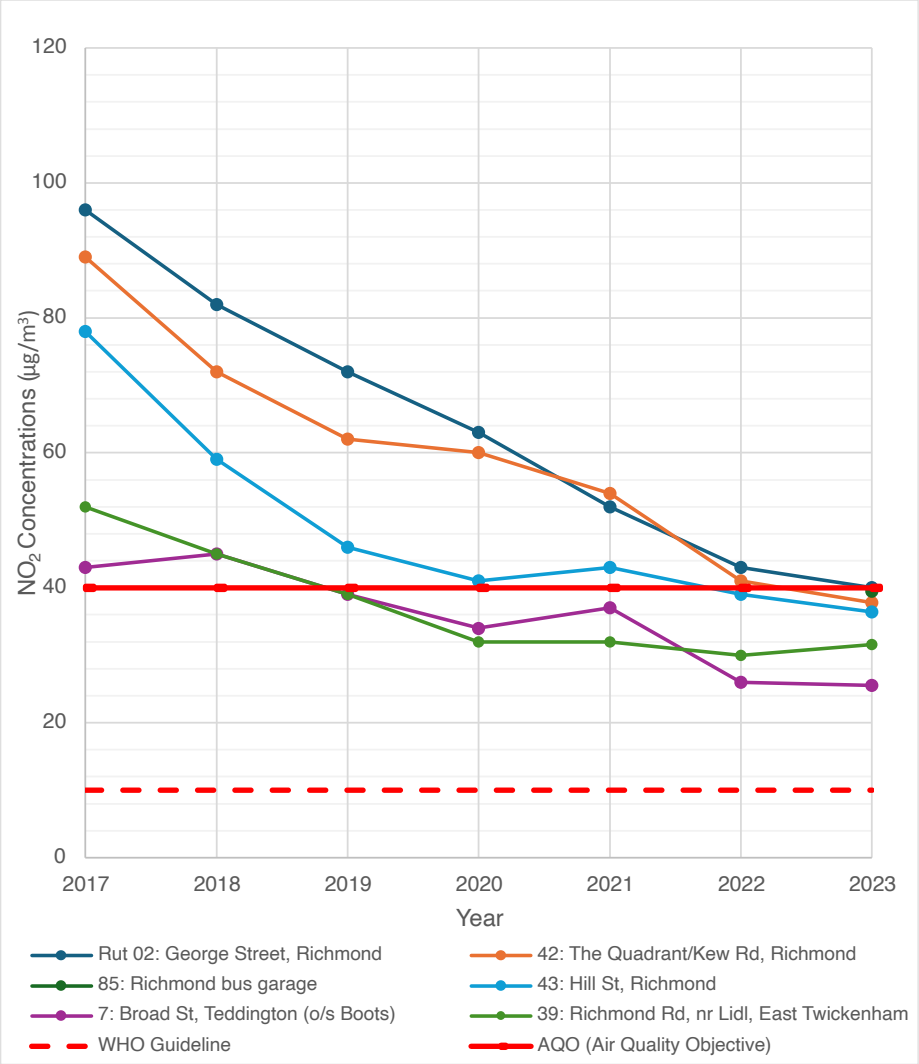


Figure 19.1. Annual Mean NO2 Measured in Richmond Circus and Bridge AQFA (µg m-3).

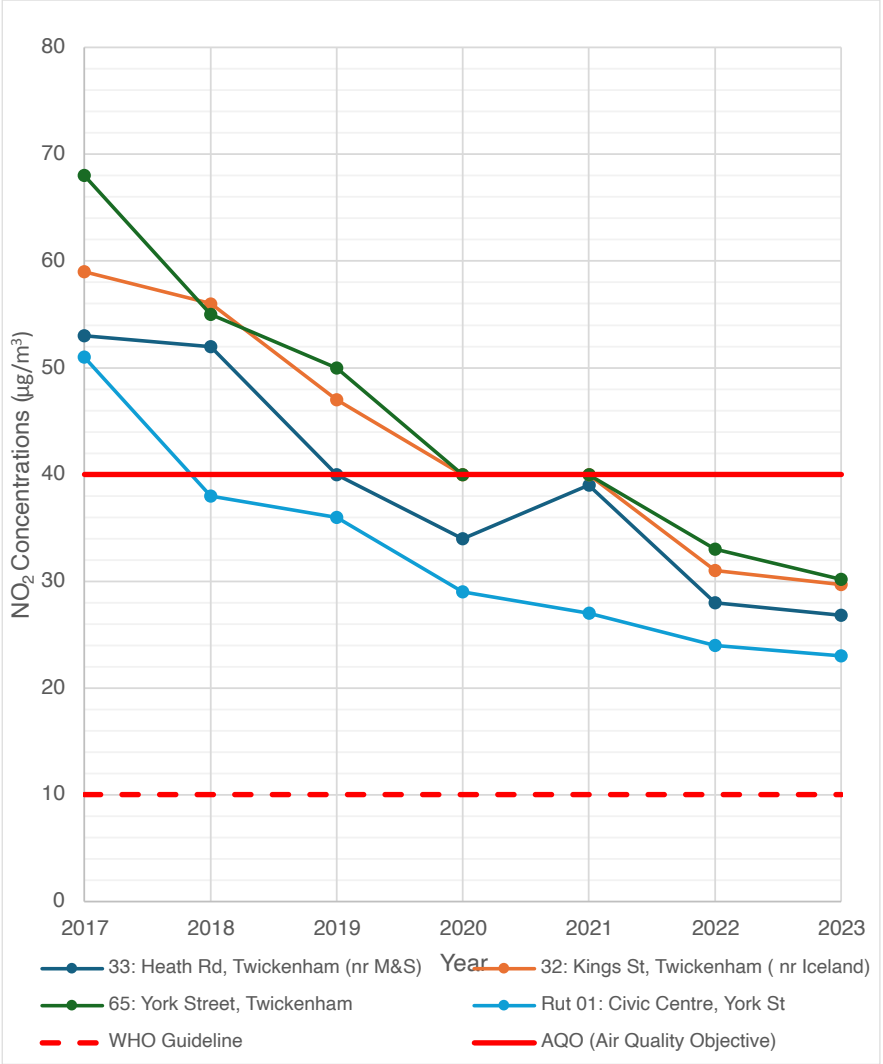


Figure 19.2. Annual Mean NO2 Measured in Twickenham King Street AQFA (µg m-3).

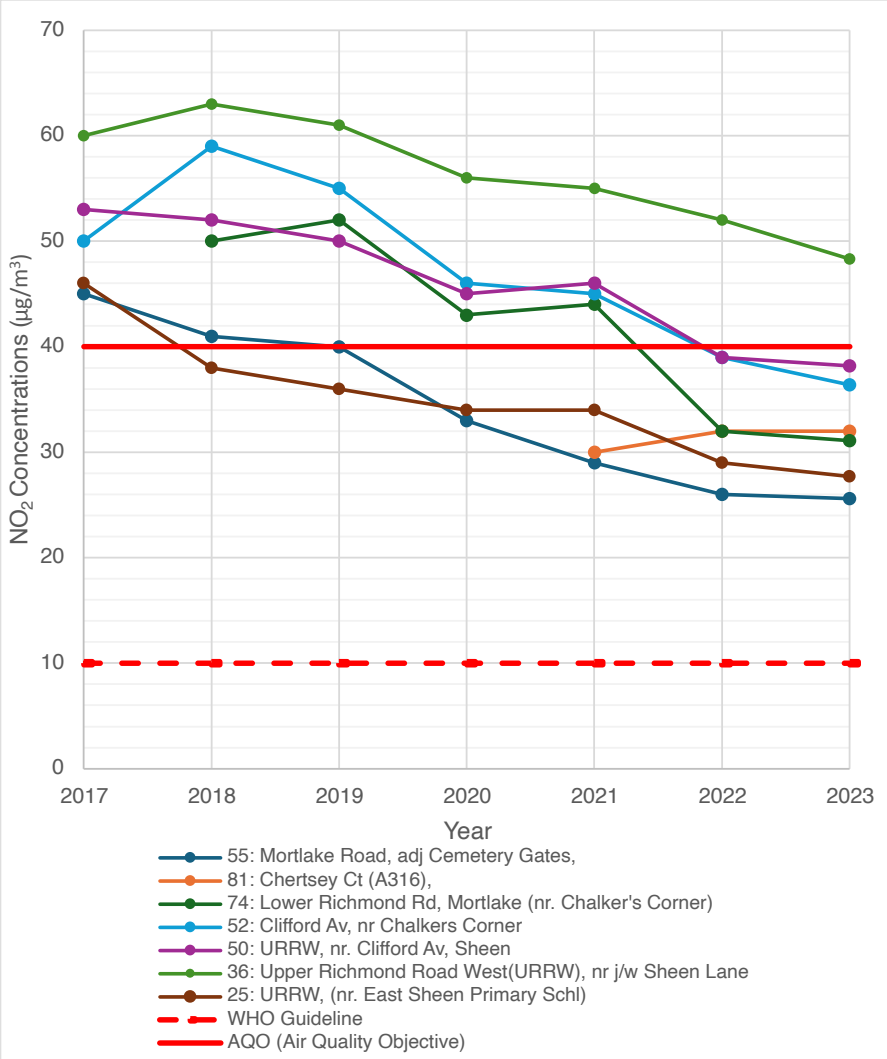


Figure 19.3. Annual Mean NO2 Measured in Clifford Avenue/A205/Upper Richmond Road AQFA (µg m-3).

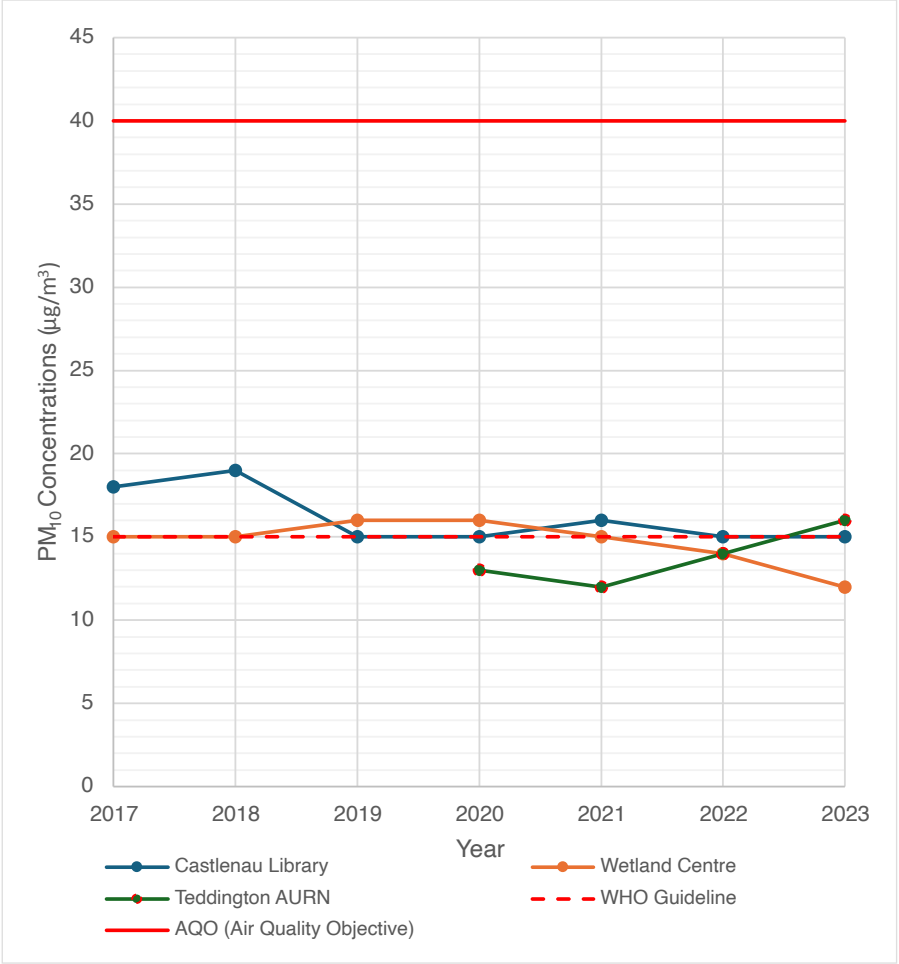


Figure 19.4. Annual Mean PM10 at Automatic Monitoring Sites (µg m-3).

Figure 19. Monitoring data from sites across Richmond showing trends in nitrogen dioxide (NO2) at Air Quality Focus Areas (AQFA) (figure 18.1, 18.2 and 18.3) and PM10 (figure 18.2) from 2017 to 2023 (where monitoring data permits).

2.2. Climate Projections

Climate projections are a powerful tool in helping to understand how the climate is expected to change. However, climate projections are not a prediction of the future, but rather a suite of possible futures that could manifest. The main uncertainties associated with climate projections are:

1. The emissions pathway the world follows (i.e., what concentration of greenhouse gases will be in the atmosphere).
2. The occurrence and impact of tipping points.
3. The uncertainties associated with the response of the climate system to different concentrations of greenhouse gases.

Despite these uncertainties, climate modelling can give a strong indication and reliable range of how the climate can be expected to change. These projections can therefore help to inform actions that can be taken to reduce the impacts of these changes. To help account for uncertainty in the fact it is unknown what emissions pathway the world will take, climate modelling uses four scenarios known as Representative Concentration Pathways (RCPs).

Representative Concentration Pathways

Four RCPs are used in climate modelling: RCP2.6, RCP4.5, RCP6.0, and RCP8.5. Each RCP represents specific concentrations of greenhouse gases in our atmosphere, associated with anthropogenic emissions of greenhouse gases. RCPs therefore give different pathways for the future in terms of how successful global mitigation efforts are (i.e., how much greenhouse gas emissions are reduced by).

RCP2.6 represents a scenario where greenhouse gas emissions are strongly reduced. RCP2.6 is broadly aligned with the Paris Agreement, a legally binding international treaty adopted by 196 countries, which commits to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels".[63]

RCP8.5 represents a business-as-usual scenario where no additional efforts are made to mitigate greenhouse gas emissions. Table 1 below shows the global temperature rise, compared with pre-industrial levels, associated with each RCP.

Table 2. Global mean temperature rise (°C) by 2081-2100 associated with each RCP.

RCP	Global mean temperature rise
RCP2.6	1.6°C
RCP4.5	2.4°C
RCP6.0	2.8°C
RCP8.5	4.3°C

For all scenarios, the 50th percentile is shown in the figures presented in section 2.2. The 50th percentile represents the mid-range of each scenario. As such, real climatic conditions in the future could be quite different to the mid-range scenarios presented here. For example, one year temperatures might be lower than the projections shown, whilst the following year temperatures might be higher. RCPs represent climatic trends – not weather. Climate relates to the long-term climatic conditions, whilst weather is the day-to-day conditions we experience. Nonetheless, the projections shown using RCPs are useful and informative in giving an indication of how we can broadly expect the climate to change, to enable measures to be implemented in time to reduce negative impacts.

2.2.1. Temperature

In all scenarios, mean annual temperature is projected to increase by the end of the century (figure 20). Under a high emissions scenario (RCP8.5), mean annual temperature could increase by 5.1°C by 2099. However, if significant mitigation occurs (RCP2.5), annual mean temperatures in Richmond could still be 1.5°C higher by 2099. Richmond Council has a target to be net zero as a borough by 2043. Mean annual temperature in 2043 is expected to be 1.3°C to 1.6°C higher (RCP2.5 and RCP8.5, respectively).

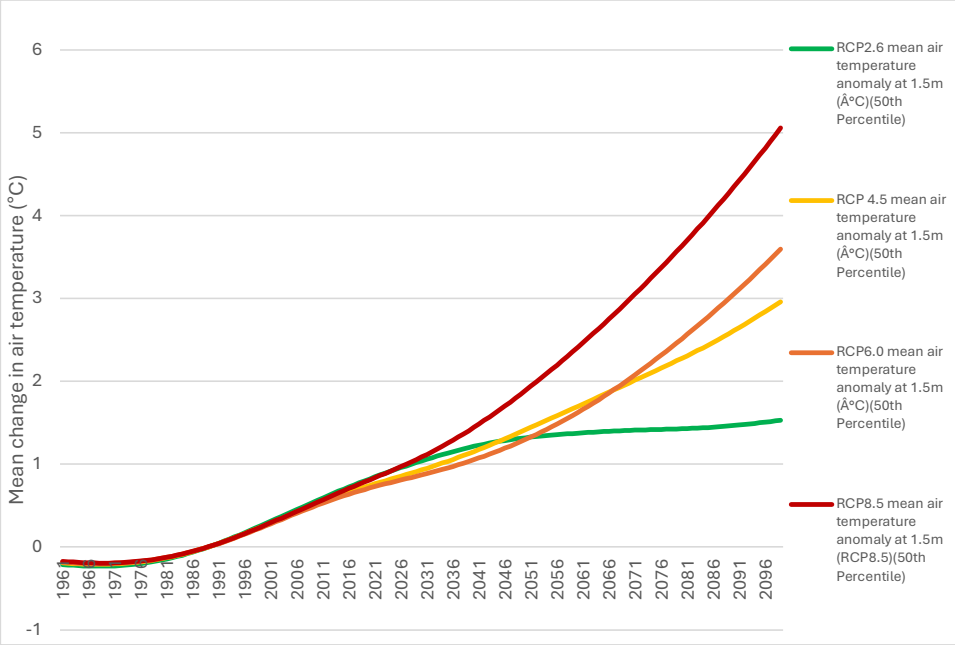


Figure 20. Mean annual air temperature anomaly at 1.5m (°C) for 1961-2099 in 25km grid square including Richmond (baseline 1981-2000). For each RCP, the 50th percentile is shown. Source: UKCP.

2.2.2. Extreme Heat

As the planet warms, heat waves are expected to be more frequent and severe in Richmond and UK as a whole. By the end of the century, maximum summer temperatures in Richmond are projected to be 36.2°C (RCP2.5) to 40.6°C (RCP8.5) (figure 21). In 2043, maximum summer temperatures are expected to be 35.7°C to 36.5°C (RCP2.5 and RCP8.5, respectively). Of note, these are the mid-range (50th percentile) projections for the scenarios. Temperatures could therefore also be higher or lower than these projections, as seen in 2022 when temperatures exceeded 40°C in the UK for the first time in recorded history.

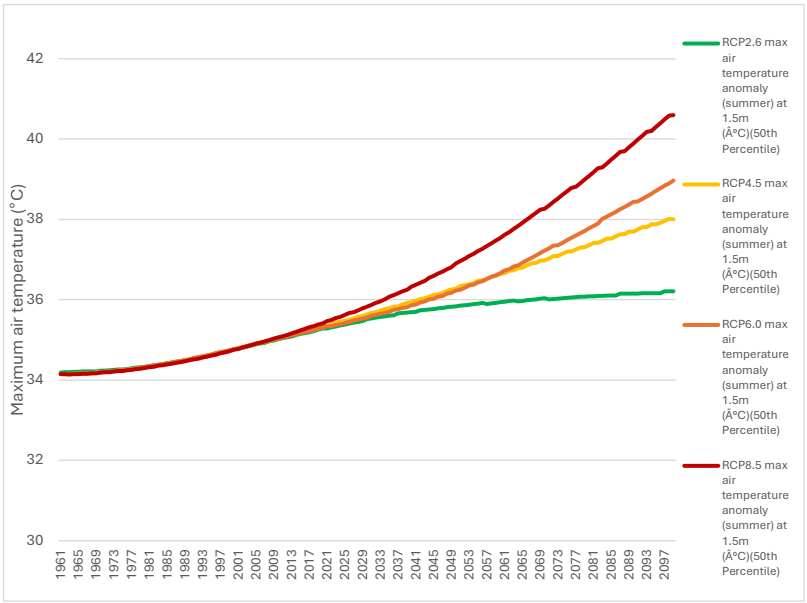


Figure 21. Maximum summer air temperature at 1.5m (°C) in June, July and August for 1961-2099 in 25km grid square including Richmond (baseline 1981-2000). For each RCP, the 50th percentile is shown. Source: UKCP.

2.2.3. Extreme Cold

Although extreme cold events are expected to become less frequent and severe with climate change, they will likely still occur sometimes. Nonetheless, the projected trend is that minimum winter temperatures will rise by 1.3°C to 4.3°C (RCP2.5 and RCP8.5, respectively) by the end of the century (figure 22).

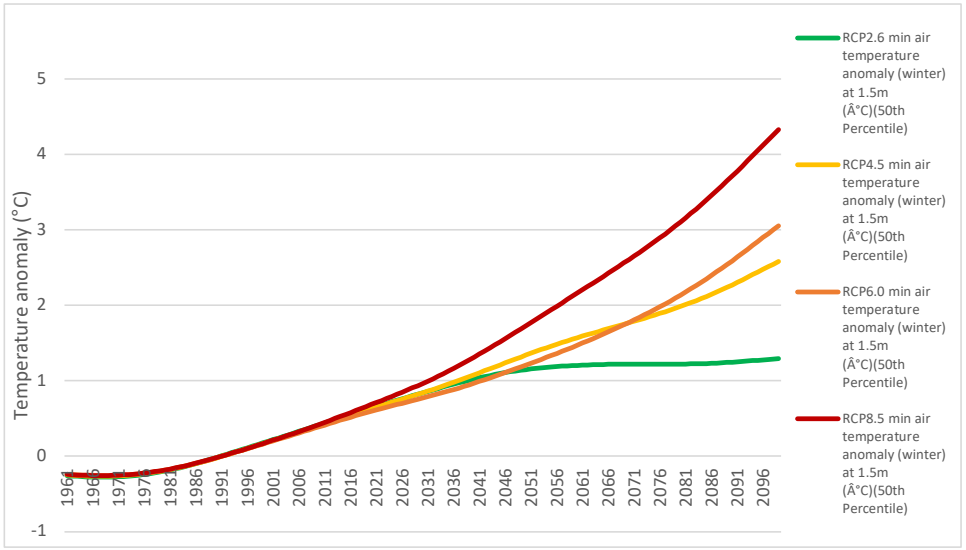


Figure 22. Minimum winter air temperature anomaly at 1.5m (°C) for 1961-2099 in 25km grid square including Richmond (baseline 1981-2000). For each RCP, the 50th percentile is shown. Source: UKCP.

2.2.4. Precipitation

While annual precipitation rates are projected to remain fairly consistent, there are significant seasonal variations. In general, summer precipitation is projected to decrease, while winter precipitation is projected to increase. This presents a dual challenge, with potentially not enough water in summer (increased risk of drought) and too much water in winter (increased risk of flooding) in Richmond.

However, the picture is more complex than that. Indeed, prolonged dry periods during summer are likely to result in extremely hard and dry ground, which is less able to absorb water. Should heavy rainfall follow a dry period, there is therefore an increased risk of flash flooding. As such, whilst the overall trend is expected to be drier summers and wetter winters in Richmond, the summer drying trend presents an increased risk of both drought and flooding.

2.2.4.1. Drought

Summer precipitation is projected to decrease by 28.6% to 54.3% (RCP2.5 and RCP8.5, respectively) by the end of the century (figure 23). This increases the risk of drought, most especially when combined with higher temperatures increasing evapotranspiration rates.

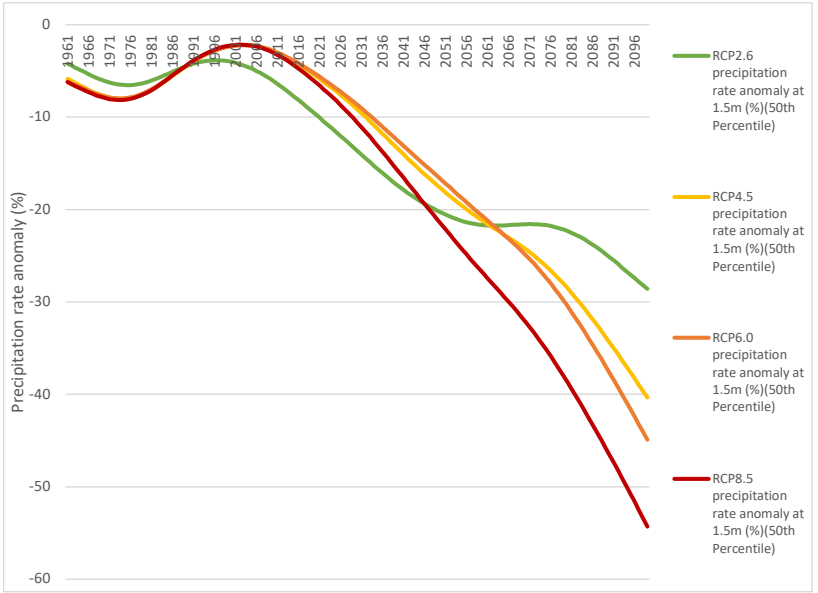


Figure 23. Seasonal average precipitation rate anomaly (%) in June, July and August for 1961-2099 in 25km grid square including Richmond (baseline 1981-2000). For each RCP, the 50th percentile is shown. Source: UKCP.

2.2.4.1. Flooding

Winter precipitation is projected to increase by 9.9% to 27.5% (RCP2.5 and RCP8.5, respectively) by the end of the century (figure 24). High levels of rainfall, particularly more intense downpours, could increase river, surface water and groundwater flood risk in Richmond.

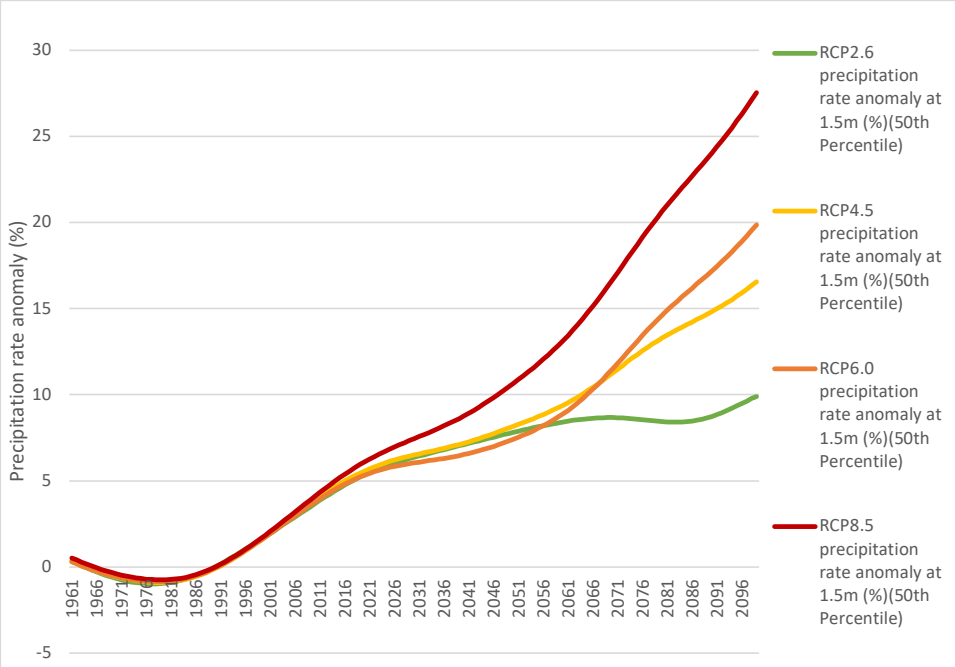


Figure 24. Seasonal average precipitation rate anomaly (%) in December, January and February for 1961-2099 in 25km grid square including Richmond (baseline 1981-2000). For each RCP, the 50th percentile is shown. Source: UKCP.

2.2.5. Storms

Projections of future storminess in the UK do not show an overall change in storminess.[64] However, winter wind speeds and precipitation are projected to increase from 2050, with an associated increase in the frequency of storms in the winter months.[65] Although this could increase the risk of storm surges, which could in turn cause flooding in London, the dominant driver for storm surges is projected to be sea level rise.[66]

2.3. Emerging Risks

2.3.1. Humidity

As well as higher maximum summer temperatures, humidity is projected to rise overall in summers in Richmond, increasing by as much as 8.3% to 26% (RCP2.5 and RCP8.5, respectively) by the end of the century (figure 25).

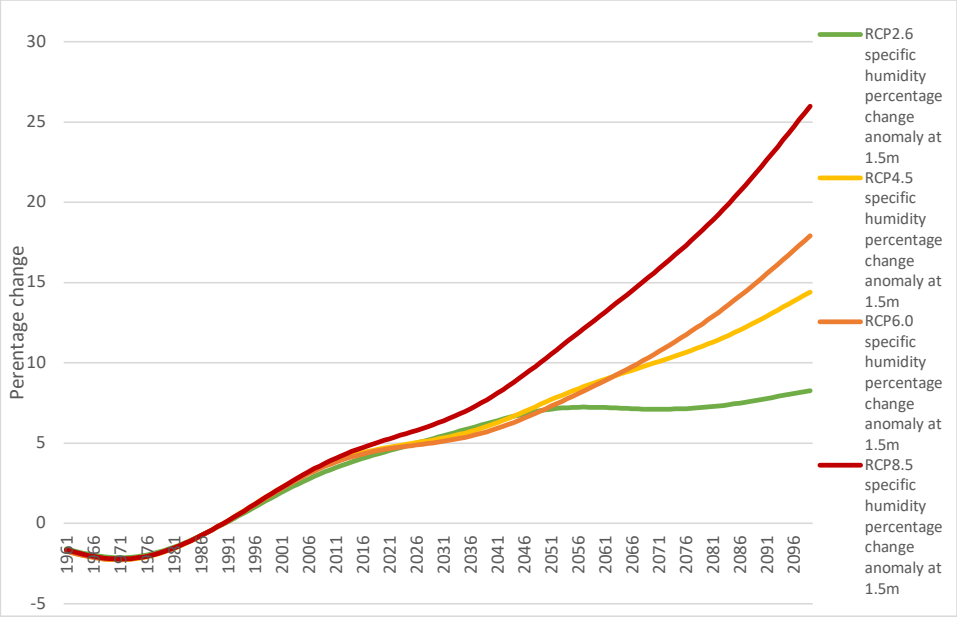


Figure 25. Seasonal average specific humidity percentage change anomaly (%) at 1.5m in June, July and August for 1961-2099 in 25km grid square including Richmond (baseline 1981-2000). For each RCP, the 50th percentile is shown. Source: UKCP.

2.3.2. Wildfires

The UK's weather is projected to become more conducive to wildfires, with hotter and drier summers. This poses significant risks to climate and biodiversity targets, as well as risks to people and infrastructure. Currently in the UK, most wildfires are started by humans.[67]

In London, the number of Met Officer Fire Danger days is projected to increase under all RCPs over the century, with potentially 45 to 82 days (RCP2.6 and RCP8.5, respectively) being fire danger days by 2086 (figure 26).

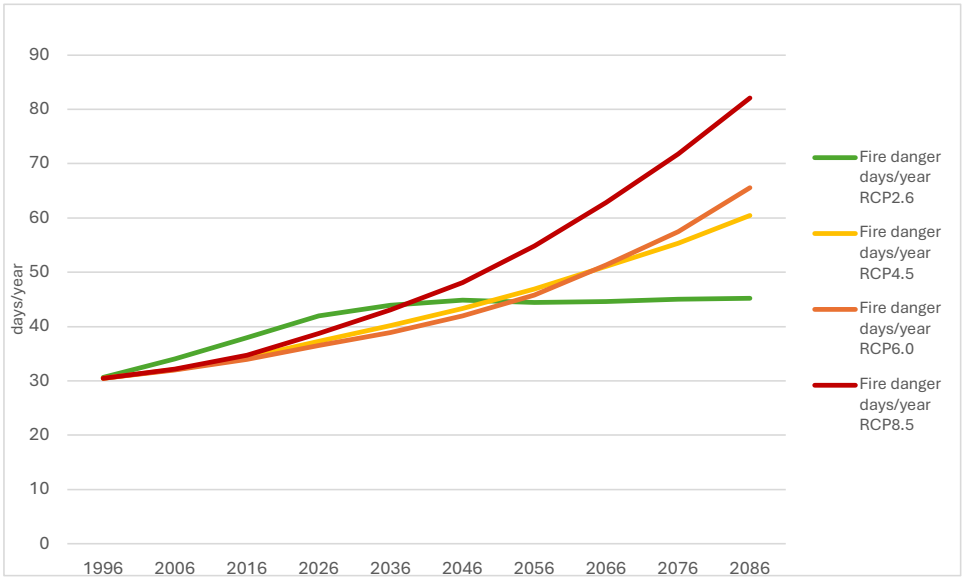


Figure 26. Met Officer Fire Danger Days per year in London (1996-2086). For each RCP, the 50th percentile is shown. Source: UK-CRI.

2.3.3. Infectious and Vector Borne Diseases

Infectious and vector borne diseases can be climate-sensitive. As the UK's climate warms, there is potentially an increased risk of infectious and vector borne diseases.

The impact of climate change on infectious diseases is complicated, as there are many contributing factors, including sociodemographic factors that are hard to project. However, warmer climates influence the geographical distribution and extend transmission periods of some infectious diseases. For many pathogens, there is not enough evidence to reliably anticipate how climate change may affect them, but for Salmonella, Campylobacter, and Vibrio spp. (food and waterborne bacteria causing gastrointestinal illness) there is evidence to suggest the risk of these diseases could increase in future in the UK.[68]

Vector borne diseases are closely linked with climate, as weather and climate impact vectors and in turn the diseases they carry. In general, warmer temperatures and sufficient precipitation favour vectors. As such, warmer and wetter conditions in the UK could increase the presence and survival of vectors, and in turn increase the risk of vector borne diseases. Additionally, extreme weather events can cause infectious disease outbreaks. For example, flood events can result in the spread of infectious disease, including skin and gut infections from contaminated flood water.[69]

2.3.4. Invasive and Non-Native Species

Climate change also poses a significant threat to nature. The UK is one of the most nature-depleted counties in the world, with mass decreases in abundance and rage across different species recorded over the last 50 years. Climate change is one of the primary causes of this.[70] Yet climate change poses further threats to nature, due to potential outbreaks of new pests and diseases and changes in the frequency and severity of existing outbreaks. This is because a warmer climate can result in some pests and pathogens extending their range further north into the UK where they were not previously found. Furthermore, milder temperatures increase the ability of some pests and pathogens to survive through the winter and increase their growth.[71]

For example, rising soil temperatures in the UK are thought to have resulted in an increase in activity of the pathogen *Phytophtora cinnamomic*, which causes acute oak decline. Additionally, the horse chestnut leaf miner moth, which is present in most if not all horse chestnuts in the borough, is an invasive non-native species benefitting from climate change. These moths feed on the inside of the horse chestnut leaf and, rather than killing the tree, weaken it. The weakened tree is then more vulnerable to attacks from further pathogens and fungi, such as the non-native bleeding canker rust that is also prolific in horse chestnuts. Both these species thrive with the rising temperatures in the UK being fuelled by climate change. Invasive and non-native species are not kept in a state of equilibrium by the environment as they would be in their native range by natural and biological processes, such as predation, seasonal climatic conditions and competition. As such, if unmanaged, they can cause widespread outbreaks and loss of native species.

2.3.5. Subsidence

With potentially hotter and drier weather affecting the UK, the risk of shrink-swell subsidence is expected to increase. The number of properties at risk of subsidence in London could be as high as 57.3% in 2070 (RCP8.5) (figure 27).[72] Figure 28 shows how the risk of subsidence is expected to increase across much of Great Britain, with London being particularly badly affected.[73]

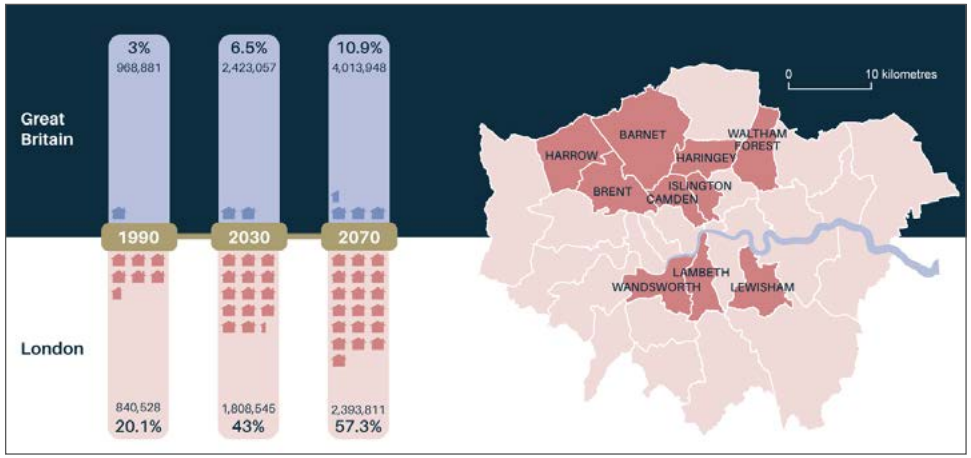


Figure 27. The proportion of properties that are highly likely or extremely likely to be affected by clay shrink-swell due to climate change, under RCP8.5. Source: BGS.

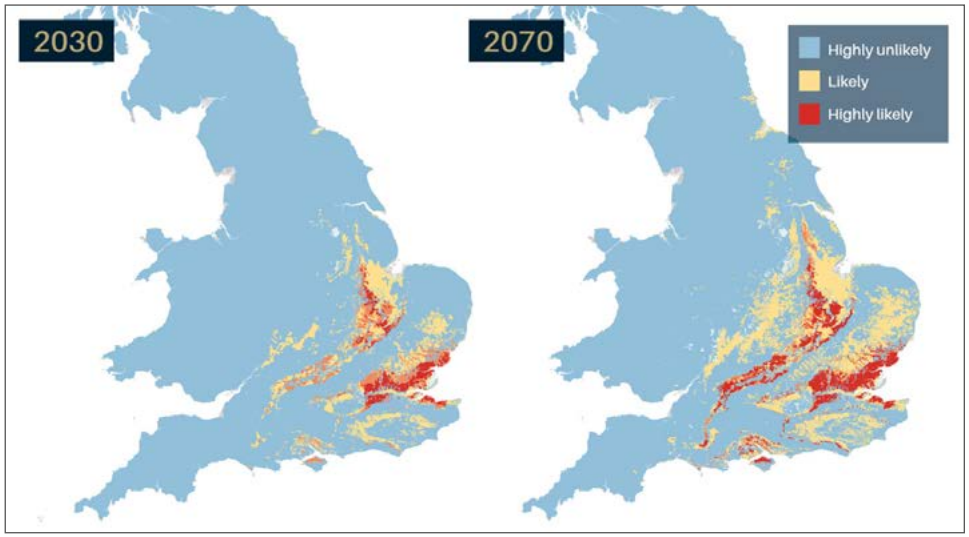


Figure 28. GeoClimate UKCP18 2030 and 2070 projections showing potential change in shrink-swell subsidence susceptibility due to climate change, under RCP8.5. Source: BGS.

In attempting to reduce the impacts of subsidence, there is a risk that trees may be removed, as trees can be blamed for subsidence despite the main climate-related risks associated with subsidence being due to shrink-swell subsidence. When a property is at risk of subsidence and trees are close, trees could be lost and in turn the wealth of benefits these natural assets provide. This highlights the need for joined-up thinking when adapting to climate change.

Most of Richmond Upon Thames is underlain by riverside gravel. As such, the risk of subsidence is relatively low across the borough and is not a consideration when, for instance, pollarding trees. However, there are pockets of London clay, most notably in Richmond Hill and East Sheen, which can present a risk of subsidence through shrink-swell subsidence. Whilst this rarely results in building subsidence, this will need to be monitored as the climate changes and potentially increases the risk of shrink-swell subsidence here.

2.3.6. Sea Level Rise

The stretch of the River Thames running through Richmond borough is tidal up to Teddington Lock and as such affected by sea level rise. Projections of sea level rise in London in 2100 show the sea level will rise under all RCPs, with the average rise projected ranging from 0.5m to 0.8m (RCP2.6 and RCP8.5, respectively).[74] Figure 29 shows the average projected range of sea level rise in London under different emissions scenarios. Such rises in sea level have significant implications for flood risk in Richmond, particularly during high tides and storm surges, with flood defences both within the borough (for example, Teddington Weir) and within the Thames Estuary (for example, the Thames Barrier) being put under increasing pressure.

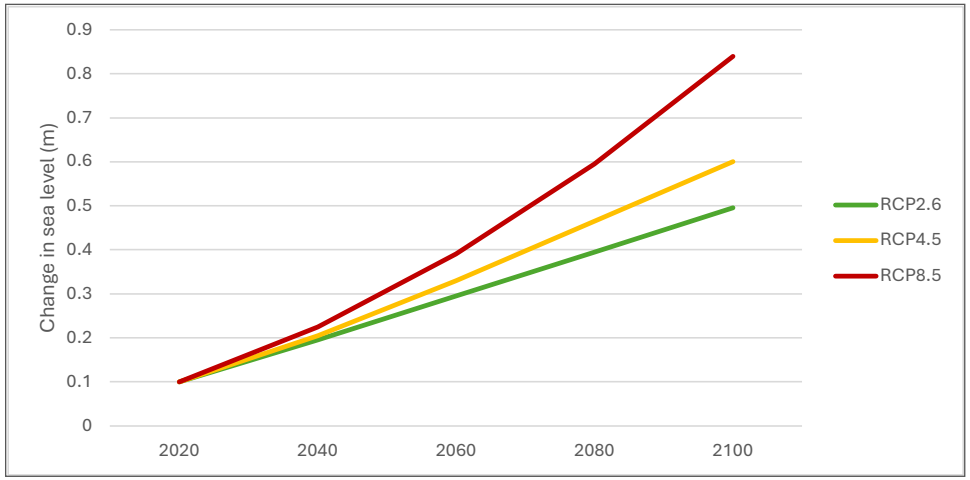


Figure 29. Change in sea level (m) in London relative to the 1981-2000 average. For each RCP, the 50th percentile is shown. Source: Met Office

2.3.7. Global Shocks

Global shocks can have significant impacts locally. The COVID-19 pandemic is a prime example of this. The rapid spread of COVID-19 around the world had huge repercussions locally, including illness and deaths from those infected with COVID-19, enforced lockdowns, job losses, and economic shocks.

Global shocks from climate change are expected to trickle down and cause significant local impacts. These global shocks can therefore have significant implications for everyone around the world. As such, whilst the most severe impacts of climate change may occur in another part of the world, Richmond is not immune to these global impacts. Table 3 shows some examples of potential global shocks and the implications locally.

Table 3. Examples of global shocks associated with climate change and how these could affect Richmond.

Global Shocks associated with climate change
Tipping Points
As global temperatures rise, this could trigger tipping points in the global climate system. A tipping point is the triggering of a threshold, which causes an abrupt and fundamental change in the Earth's climate system. An example of a tipping point is mass thawing of permafrost. Permafrost stores around double the amount of carbon as is currently in the atmosphere. As the planet warms, there is a growing risk that mass permafrost melting will occur on a greater scale than that recorded to date and release the carbon dioxide and methane stored in it, causing potentially catastrophic warming.[75] The mass release of methane is particularly concerning, as methane has 28 times the global warming potential as carbon dioxide. This scale of planetary warming would have severe implications around the world, including in Richmond.

Global Shocks associated with climate change
Food Security
While the UK's food security is broadly stable, climate change poses a significant risk to this stability. Approximately 60% of food is produced in the UK and 40% imported (2023).[76] Extreme weather both in the UK and globally therefore poses a significant threat to food security. The UK's high reliance on food imports means extreme weather events around the world potentially put food security in the UK at risk if crops fail. To mitigate this, efforts have already increased to grow more imported food domestically. However, extreme weather in the UK is affecting domestic production, as seen with the exceptionally wet winter of 2023-24.[77][78]
Economic Security
Catastrophic disruption to the global economic system is considered the greatest risk under current climate policies. Indeed, this could cost 4.1% of the UK's GDP by 2100. Disruption to foreign trade is the single largest impact, as climate impacts around the world cause losses for countries, resulting in a 1.1% decrease in the UK's GDP. Furthermore, damages from climate change are expected to increase from the present 1.1% of GDP to 3.3% by 2050 and 7.4% by 2100.[79]
Wealth Inequality
Climate shocks increase wealth inequality, with poorer populations bearing climate impacts more than richer populations. There is growing evidence that rich countries are not as immune to climate change as previously thought, due to the disproportional impact on poorer populations within those countries. In the UK, which is one of the countries in Europe with the highest level of income inequality, climate change is having a disproportionately increased burden on households in poverty, most especially when these households are in areas at high risk to climate impacts.[80] Despite being perceived as an affluent borough, Richmond has areas of deprivation, where the impacts of climate change will be particularly severe. Global shocks from climate change could increase wealth inequalities in Richmond, with poorer areas being more exposed and vulnerable to climate-related risks and bearing greater health, social and economic burdens as a result.

Global Shocks associated with climate change
International Trade
Climate change is expected to impact international trade, with extreme weather events affecting supply chains, transportation infrastructure, and manufacturing. For example, in 2023 there was a severe drought in Panama, resulting in the drying of the Panama Canal and disruptions to global shipping distribution. Such disruptions could have severe consequences in the UK. For example, the UK imports medicines from around the world, which are essential to healthcare. Additionally, manufacturing could suffer from productivity losses during extreme heat events and extreme weather events affecting manufacturing facilities.[81] Furthermore, international trade is a common gateway for invasive and non-native species to arrive in the UK, which can bring diseases affecting people and nature.
Antimicrobial Resistance
There is growing evidence that warmer temperatures resulting from climate change could increase antimicrobial resistance. Warmer temperatures can increase bacterial growth, bacterial infection rates, frequency of infections, and geographical distributions. All of this combines to make horizontal gene transfer and therefore the emergence of drug-resistant infections more likely. Furthermore, more extreme precipitation events are likely to increase pollutants in water, resulting in bacterial blooms and potential antibiotic resistant gene transfer.[82]
Climate Migrants
As extreme weather events become more frequent and severe, and some parts of the world become inhospitable, the people living in these places will need somewhere safe to take refuge. Estimates for the number of environmental migrants globally by 2050 range from 25 million to 1 billion people.[83] Richmond is a Borough of Sanctuary, formalising its role in welcoming, supporting and celebrating refugees. Systems need to be in place to ensure potential climate migrants are supported.

3. Vulnerability to Climate Change

Climate change poses sector-specific threats, which need to be understood to reduce associated impacts. The following sectors have been identified as part of this vulnerability analysis.

3. Vulnerability to Climate Change

Vultnerability Analysis
Public Health
Climate change risks a range of direct and indirect health impacts, which could significantly affect public health in Richmond. This includes a rise in demand for healthcare due to the impacts of climate change on health; challenges to the functioning of healthcare (for example, staffing shortages or other infrastructure issues that prevent operation due to extreme weather); and these impacts collectively or individually diverting resources from other healthcare needs that mean indirect morbidity/mortality (for example, delays to a surgical procedure due to system impacts). Furthermore, those with disabilities could be disproportionately impacted by climate change, in potentially having a lower adaptive capacity and additional vulnerabilities that exacerbate the impacts of climate-related risks.
Housing and Residents
Housing in Richmond is vulnerable to a changing climate, particularly the increasing severity and frequency of extreme weather events (such as flooding), which can have very sudden and dramatic consequences. Slower onset risks also pose a threat to housing, including subsidence and sea level rise. Impacts on housing in turn affect residents, who may be exposed to extreme weather events in homes that are not designed to cope with such events (such as extreme heat). Residents are also vulnerable to the broader impacts of climate change, which directly and indirectly threaten their health and wellbeing.
Nature and Biodiversity
Nature and biodiversity in Richmond and the UK at large has evolved under a generally stable climate. As the climate warms, this poses a threat to nature and biodiversity, with some species at risk of extinction, as their habitats rapidly become unsuitable for them. As well as these longer-term changes, extreme weather events also pose a risk to nature and biodiversity; for example, drought may cause the drying of vital habitats that species depend upon. Furthermore, as the climate changes, invasive non-native species, biological pests and diseases present an increasing risk of significant loss of nature and biodiversity in the borough.

Infrastructure Services
Infrastructure services have largely been designed based on assumptions of our current climate. Changes to these assumptions therefore pose a risk to the functioning of infrastructure services. For example, water provision needs to adapt to be able to cope with sudden intense downpours, but also drought. Additionally, the location of infrastructure services can make them vulnerable; for example, electricity substations may become increasingly vulnerable to groundwater flooding, whereas this may not have previously been a risk. Furthermore, our roads and rails often suffer in extreme heat, with melting and buckling. Lessons need to be learned from hot countries to understand how to work with our partners to adapt our transportation systems to extreme heat.
Public Services
Public services cover a huge array of services, many of which the Council is responsible for delivering. Extreme weather events pose a particular threat to the reliability of these services, including staff being unable to carry out duties during extreme weather. This could include, for example, outdoor workers being unable to carry out essential works during extreme heat or staff being unable to reach people in need during flooding. Furthermore, climate change could affect the nature of the work that needs to be delivered by public services, and therefore such services need time to adapt to their changing roles.
Business and Industry
Business and industry face a range of challenges from climate change. This includes localised impacts, such as flooding to properties and staff being unable to work during extreme heat. Global threats also pose potential challenges to business and industry, including disruptions to global supply chains from extreme weather events affecting shipping routes and reductions in manufacturing productivity during extreme weather.

3. Vulnerability to Climate Change

A survey was completed by 21 key internal Council officers on the impact of different climate hazards on key sectors and the likelihood of these climate hazards occurring. The following climate hazards were included in the analysis, as these present the greatest growing and emerging risks in Richmond: extreme heat, drought, flooding, storms, wildfires, infectious and vector borne diseases, and subsidence. Table 4 is a matrix showing the outcome of this survey, whereby average impact and likelihood are multiplied to give overall vulnerability of key sectors to these climate hazards.

The results of the vulnerability assessment highlight that extreme heat and flooding pose the greatest overall threat to the key sectors included in the analysis, with every sector having a high vulnerability to extreme heat and flooding. Three sectors had a high vulnerability to another climate impact: nature and biodiversity and business and industry were identified as having high vulnerability to drought and infrastructure services were identified as having a high vulnerability to storms.

This does not mean that sectors are not vulnerable to other climate hazards. The matrix in table 4 is intended to give an indication of relative vulnerability and to help with prioritising actions.

Sectors were identified as having the lowest vulnerability to impacts associated with emerging climate risks, in particular subsidence. However, it is important to note that the response "I don't know" was selected for "subsidence" more than any other climate hazard. Where the response "I don't know" was chosen, this was omitted from the numerical analysis on average impact and likelihood. A lack of knowledge and understanding of subsidence and its relationship with climate change may therefore have been a contributing factor to the lower overall vulnerability rating.

Of note, this vulnerability assessment is not static. Richmond Council will continue to liaise with stakeholders and revisit this matrix, to ensure it is continually evolving and accurate. Furthermore, the results of this survey will be used to support in increasing awareness, knowledge and understanding of stakeholders around the impacts of climate change and associated adaptation and resilience measures required.

3. Vulnerability to Climate Change

Table 4. Matrix showing the vulnerability of key services to climate impacts.

Vulnerability has been estimated by multiplying average ratings for impact and likelihood. A survey was shared with internal officers working directly and indirectly on adaptation and resilience. Twenty-one officers responded to the survey, with representation from engineering, public health, parks and ecology, housing, flooding, planning, emergency planning, and climate change and sustainability. Officers were asked to rate the impact of each climate hazard on each key sector and the likelihood of each climate hazard occurring from 1 (low) to 5 (high) (there was also an option to respond with "I don't know"). The average ratings for impact and likelihood across all hazards and sectors is showed in the matrix. These average ratings were multiplied to calculate relative vulnerability of key sectors to these environmental hazards. The key shows the corresponding low, medium or high vulnerability of the ratings calculated.

		Extreme Heat	Drought	Flooding	Storms	Wildfires	Infectious and Vector Borne Diseases	Subsidence
Public Health	Impact	4.75	3.68	3.9	3.5	3.11	4.23	2.29
	Likelihood	4.6	4.4	4.6	4.3	3.25	3.41	3.14
	Vulnerability	**21.85**	**16.192**	**17.94**	**15.05**	**10.1075**	**14.4243**	**7.1906**
Housing and residents	Impact	4.6	3.75	4.4	3.84	3	3.53	3.44
	Likelihood	4.6	4.4	4.6	4.3	3.25	3.41	3.14
	Vulnerability	**21.16**	**16.5**	**20.24**	**16.512**	**9.75**	**12.0373**	**10.8016**
Infrastructure Services	Impact	4.45	3.65	4.7	4.3	3.33	2.56	3
	Likelihood	4.6	4.4	4.6	4.3	3.25	3.41	3.14
	Vulnerability	**20.47**	**16.06**	**21.62**	**18.49**	**10.8225**	**8.7296**	**9.42**
Public Services	Impact	4.58	3.75	4.3	3.85	3.11	3.72	2.54
	Likelihood	4.6	4.4	4.6	4.3	3.25	3.41	3.14
	Vulnerability	**21.07**	**16.5**	**19.78**	**16.555**	**10.1075**	**12.6852**	**7.9756**
Nature and Biodiversity	Impact	4.6	4.75	4.25	3.68	4.16	3.12	2
	Likelihood	4.6	4.4	4.6	4.3	3.25	3.41	3.14
	Vulnerability	**21.16**	**20.9**	**19.55**	**15.824**	**13.52**	**10.6392**	**6.28**
Business and Industry	Impact	4.44	3.83	4.26	3.74	3.06	3.5	2.46
	Likelihood	4.6	4.4	4.6	4.3	3.25	3.41	3.14
	Vulnerability	**20.42**	**16.852**	**19.596**	**16.082**	**9.945**	**11.935**	**7.7244**

	Low vulnerability	Vulnerability score = 0 to 8.3	Medium vulnerability	Vulnerability score = 8.3 to 16.6	High vulnerability	Vulnerability score = 16.6 to 25

3. Vulnerability to Climate Change

Two workshops with internal officers were also held in April 2024. The aim of these workshops were to understand and map:

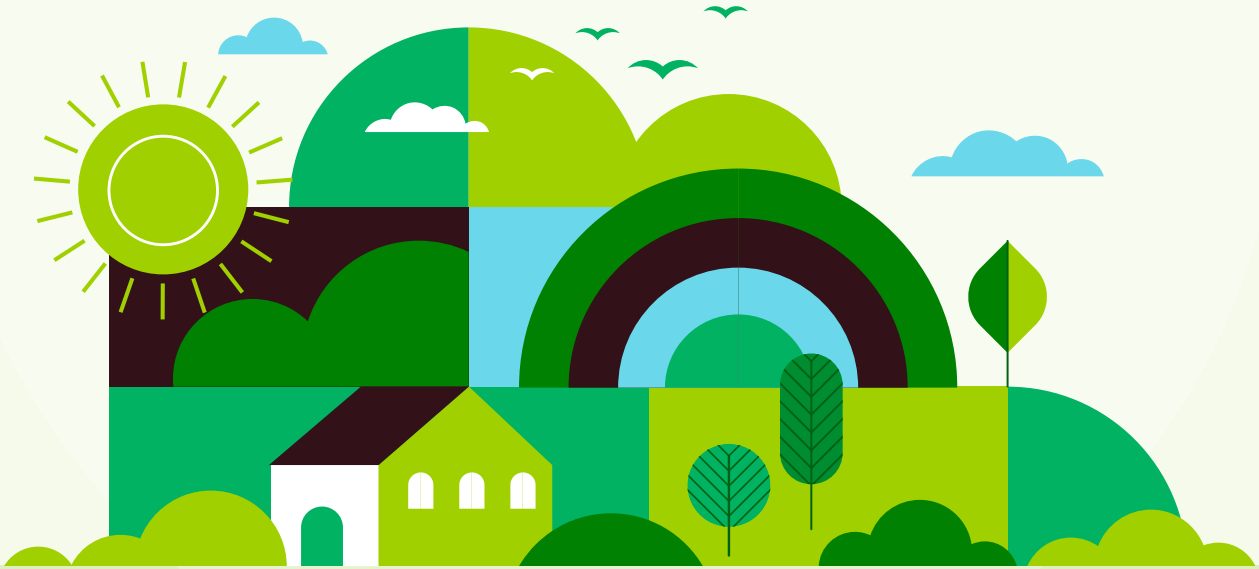
1. Climate-related problems that need addressing.
2. Existing adaptation and resilience projects across the Council.
3. Gaps to implementing adaptation and resilience projects.
4. Internal and external stakeholders across different climate risks and vulnerabilities.
5. Key enabling conditions.
6. Existing and planned resources for adaptation and resilience work.

The outcomes of this workshop have been used to inform the development of this strategy and will continue to inform Richmond Council's work on adaptation and resilience going forward.

The workshops identified a number of gaps and challenges, which affect the Council's ability to do work on adaptation and resilience and reduce the effectiveness of work being done on adaptation and resilience. As such, these barriers increase the vulnerability of the borough to climate change. The main barriers and challenges identified were:

- **Funding**: there is not enough funding for adaptation and resilience work, which significantly hinders the ability to carry out the projects that are needed to adapt to climate change and make Richmond a climate resilient borough.
- **Knowledge and expertise**: there a lack of knowledge and understanding in some specific areas of expertise, including project management of adaptation and resilience work, technical knowledge in some aspects of adaptation and resilience, and the loss of local knowledge due to staff turnover.
- **Collaboration**: it was highlighted that there is not currently a joined-up approach to adaptation and resilience work internally and externally and there needs to be greater collaboration with a range of internal and external stakeholders. Many of the issues related to this area are outside of Council control and as such better collaborative and partnership working is needed.
- **Knowledge and understanding of nature-based solutions (NBS)**: there is a need to improve knowledge and understanding of NBS, including the benefits of NBS over traditional engineering and urban design and the ongoing maintenance required of NBS.
- **Long-term gains**: there is currently not a good understanding and appreciation of the fact that adaptation and resilience work have upfront costs and long-term gains. There can be resistance to adaptation and resilience projects, because the gains are sometimes not necessarily felt immediately. This can be exacerbated by conflicting priorities and urgent priorities taking precedence.
- **Infrastructure**: much of the current infrastructure in Richmond is outdated, but there is a lack of prioritisation and strategy for ensuring such infrastructure is modified and climate resilient.
- **Engagement**: there needs to be better communications and engagement on the impacts of climate change, including targeted support for vulnerable groups.

4. Adaptation and Resilience Framework



4.1. Adaptation Principles

The London Climate Resilience Review is an independent report, which was published in July 2024 and commissioned by the Mayor of London, "to take stock of London's preparations for climate impacts and make recommendations".[84]

Richmond Council submitted evidence to the London Climate Resilience Review, which published its full findings in July 2024.[85] The recommendations of this Review highlight the need for collaborative working across London, as climate impacts do not respect borough boundaries. The six areas that the London Climate Resilience Review identified as needing urgent attention and action were:

1. A strategic, London-wide action plan on heat risk.
2. Better preparation across London to surface water flood risk.
3. Understanding cascading risks and system interdependencies within and beyond London's boundaries.
4. Enabling investment in climate resilience by national, regional and local governments.
5. Engaging Londoners on climate impacts, including associated risks and adaptation options.
6. Strategic coordination and a shared regional vision and framework for adaptation.

The London Climate Resilience Review also identified five principles that are recommended should guide climate adaptation and resilience:

1. Adaptation must take a people-centred approach, be locally led, strive to reduce vulnerability, and address socio-economic and racial inequality.
2. Adaptation must be embedded across decision-making and organisations, ensuring measures are owned at the strategic level and responsibility assigned.
3. Adaptation must be integrated with work to meet net zero to ensure coherent climate action.
4. Adaptive pathways approaches should be used to account for uncertainties and be flexible.
5. Nature-based solutions must be considered and prioritised.[86]

To ensure consistency with work being done across London, Richmond Council is adopting these five principles in its Adaptation and Resilience Framework. The impacts of climate change are not limited to borough boundaries and as such it is important that Richmond Council's approach to adaptation and resilience is complementary to and consistent with the approach being adopted across London. Furthermore, Richmond Council is actively involved in a number of pan-London projects working on adaptation and resilience (such as London Councils' Resilient and Green Working Group; the GLA's and London Councils' Pathways2Resilience Programme (box 4); the Joint Thames Strategy (box 5); and the River Thames Scheme (box 6)) and so adopting the principles of the London Climate Resilience Review will best ensure consistency with the work Richmond Council is involved with regionally.

Box 4. EU Pathways2Resilience

The EU Pathways2Resilience (P2R) funding supports "regions in developing transformative solutions to foster their climate adaptation".[87] The GLA and London Councils submitted a successful bid to P2R, to create and deliver a "shared regional vision for climate adaptation in London". The funding will support the delivery of the recommended actions in the London Climate Resilience Review and accelerate progress made. Richmond Council is partnering with the GLA and London Councils to support in the delivery of this work.

Box 5. Joint Thames Strategy

The Joint Thames Strategy is a comprehensive guide for riverside strategy development, leading to the climate resilience and offer wider benefits. The Joint Thames Strategy brings together the five individual strategic areas along the River Thames and in doing so ensures a consistent approach to flood risk management across London. The five strategic areas run from Surrey to Kent and Essex:

1. Thames Landscape Strategy Weybridge Hampton Kew.
2. Thames Strategy Kew to Chelsea.
3. Thames Strategy London Central.
4. Thames Strategy east.
5. Thames Strategy Kent and Essex.

The Joint Thames strategy aims to:

1. Improve flood risk management along the Thames.
2. Deliver wider benefits.
3. Promote a collaborative approach.[83]

The Joint Thames Strategy is also working in collaboration with other key programmes of work, notably the Thames Estuary 2100.[84]

Box 6. River Thames Scheme

The River Thames Scheme is taking a landscape-based approach to reduce flooding along the River Thames between Egham and Teddington. The Scheme will see the creation of a new flood channel, with two sections running through Runnymede and Spelthorne. The focus of the Scheme is to reduce flood risk, but also to unlock the economy, health and environmental benefits of this stretch of the River Thames. The increase in the capacity of the River Thames will help the area adapt to climate change, while the expansion of green spaces and creation of a network of high-quality habitats will support nature and biodiversity.[88]

4.1.1. People-Centred

The impacts of climate change are not uniform. One of the greatest determining factors in the severity of the impacts of climate change is social vulnerability. Such vulnerabilities include, but are not limited to, factors such as age (elderly and young), preexisting health conditions, and income. These vulnerabilities can exacerbate climate-related impacts on an individual or group (e.g., elderly people are more susceptible to illness and death during heatwaves) and limit an individual or groups adaptive capacity and resilience to climate change (e.g., people on lower incomes are less able to adapt their housing to reduce exposure to climate hazards). People therefore have to be at the centre of all adaptation and resilience measures. By adopting a people-centred approach, so too can a 'just transition' be assured and existing vulnerabilities reduced (box 7).

Box 7. Just Transition.

North American trade unions developed the concept of a 'just transition' to provide a framework for discussions surrounding what necessary social and economic interventions should be put in place to secure workers' livelihoods through the shift from a high-carbon economy to a low-carbon and climate-resilient economy.[89] Embedding the just transition principles into Richmond Council's climate change policies is integral to achieving Net Zero by 2043, whilst simultaneously improving equity and increasing the climate resilience of Richmond. A just transition is about building a fairer, cleaner, and resilient borough that leaves no one behind and improves wellbeing for all.

Richmond Council has published its own Climate Risk Map, which shows individual layers for climate hazards and social vulnerabilities. The Climate Risk Map also shows overall risk to climate change (i.e., all exposures), overheating, flooding and air pollution, by combining the exposure and vulnerability factors. Table 1 provides a complete list of risks, exposures, and vulnerabilities included in the Climate Risk Map.

By including vulnerability in the Climate Risk Map, this enables more thorough analysis of the impacts and risks associated with different climate exposures and therefore better prioritisation of actions. For example, the young and elderly are particularly vulnerable to extreme heat, as their bodies are less efficient and able to regulate their core temperatures. Areas where exposure to extreme heat is high and there is a large proportion of young/elderly should be prioritised for action, as the impacts are more likely to be very severe here, with acute risks to public health among vulnerable groups.

Taking a people-centred approach to adaptation and resilience also empowers individuals to take action. The impacts of climate change and complex and not uniform. As such, individuals can sometimes feel helpless or uncertain as to how to best prepare for climate change. By providing people with information as to how climate change might affect them (for example, in consideration of a specific vulnerability) and their area (i.e., climate-related risks where they live), people will be more empowered to adapt and increase their resilience to climate change.

Furthermore, a people-centred approach helps ensure that local concerns and priorities are captured. For example, the River Thames serves an important recreational role in the borough, but is increasingly unusable with river volume and flow rate being too high. This has physical and mental health impacts for those who use the river for recreation; can result in decreased membership of associated water sports organisations that can in turn negatively affect the local economy; and reduces the broader benefits these services offer, such as for children taking part in river-based activities.

4.1.2. Embedding Adaptation

Climate change has the potential to affect every sector and aspect of society. As such, measures to adapt must be embedded across all teams at Richmond Council. The Climate Change and Sustainability Team already works in close collaboration with teams from across the Council, but more needs to be done to effectively embed climate change, and adaptation and resilience specifically, into all Council teams. One of the primary aims of this Adaptation and Resilience Strategy is to provide a framework for all Council teams to use, to ensure a consistent and robust approach to climate adaptation. To inform the develop of this Strategy, two workshops were held with officers in April 2024 whose work relates to adaptation and resilience (directly and/or indirectly). These workshops looked at:

1. Climate-related problems that need addressing.
2. Existing adaptation and resilience projects across the Council.
3. Gaps to implementing adaptation and resilience projects.
4. Internal and external stakeholders across different climate risks and vulnerabilities.
5. Key enabling conditions.
6. Existing and planned resources for adaptation and resilience work.

4.1.3. Integrating with Net Zero

Richmond Council has set a target to be net zero as a borough by 2043. This is a science-based target, set by calculating the borough's fair contribution to the 2015 Paris Agreement. The Council has undertaken an emissions pathways analysis, to understand the actions needed across sectors to reach net zero by 2043. This analysis included co-benefits, such as nature-based solutions, which can be highly effective in both mitigating and adapting to climate change and sequestering carbon. Opportunities for crossovers and co-benefits will be identified in all climate activities, to ensure that, where possible, mitigation and adaptation are undertaken collaboratively to maximise the effectiveness and efficiency of measures and a consistent approach to tackling climate change.

4.1.4. Adaptive Pathways

As discussed in section 2.2, there is uncertainty as to how the climate will change and what the impacts associated with this are. By providing a range of expected impacts under different scenarios, climate projections support planning and the implementation of measures to adapt and increase resilience to climate change. However, as there is still inherent uncertainty around future impacts, so too there is uncertainty as to the precise measures needed to ensure robust adaptation. By implementing rigid measures based on a specific scenario, there is a danger of locking into measures that are not fit for purpose under different scenarios. This is known as maladaptation.

An adaptive pathways approach to adaptation and resilience promotes a more flexible approach to adaptation and resilience, which not only accounts for climate uncertainty, but embeds it. An adaptive pathways approach supports and enables decision-making, despite uncertainty, by supporting the identification of actions that can be taken now and in future. This approach incorporates review points that ensure adaptation and review measures are regularly scrutinised and assessed to enable action to be taken as needed and ensure the approaches are still working.

Richmond Council will adopt an adaptive pathways approach to its adaptation and resilience work, to ensure that all measures implemented are robust, sustainable and effective. This supports the recommendations of the London Climate Resilience Review and the compliments the Thames Estuary 2100 (TE2100) Plan.[90] [91] More details on how Richmond Council will do this are outlined in section 4.2.

4.1.5. Nature-Based Solutions

Nature-based solutions (NBS) are measures that use the benefits of nature to meet particular objectives. NBS is particularly effective in adaptation and resilience, by working with nature to reduce the impacts associated with climate change. NBS can be used to reduce flood risk in urban areas, by putting in measures such as wetlands, attenuation ponds, and vegetation to slow the flow and make more space for water by allowing flooding in certain areas (box 8). Green spaces and trees also play a significant role in cooling urban areas.[92][93] Smaller-scale intervention can also be highly effective at reducing environmental risks, including greening and SuDS (box 9). At scale, these smaller-scale interventions can create "sponge cities", whereby urban areas are strategically designed to hold water and reduce flooding in undesirable locations. Furthermore, NBS also offer numerous co-benefits, in creating green space for nature and biodiversity; human health benefits (including better mental and physical health from access to new and improved green space); better air, soil and water quality; and acting as carbon sinks and so helping mitigate climate change.

Nature itself is also vulnerable to climate change. The vulnerability of the River Thames is recognised by Richmond Council, which is exploring formalising the Charter for Rivers.[94] The Councils believes that pollution in the River Thames and its tributaries threatens local water quality and wildlife; investment in water security must be prioritised by the water industry whilst abstraction from rivers must be significantly reduced; and harmful chemical, domestic, industrial and plastic waste must be prevented from entering rivers, through legislation and education.

To address these challenges and help protect the River Thames, Richmond Council will continue its partnership work with the Thames Strategies and with local environmental organisations and communities to conserve riparian environments; restates its opposition to the proposed Teddington Direct River Abstraction Scheme; and will explore the merits of formally endorsing the Charter for Rivers. NBS can help to reduce the negative impacts of climate change on our natural environment by enhancing its natural resilience and ensuring climate-appropriate measures are used when implementing NBS (for example, drought-resilient trees). NBS should therefore be prioritised where possible, to maximise the co-benefits available, so long as the measures would not be detrimental to biodiversity priorities.

Box 8. Community Bluescapes

Community Bluescapes is a Defra-funded programme to implement NBS in the Beverley Brook catchment to reduce flood risk. It is a £6m project running from 1 April 2021 to 31 March 2027.[95] By the end of the programme, Community Bluescapes will have improved and promoted the resilience of communities to flooding in the Beverley Brook catchment both now and in the future, with people at the core of the project in co-producing the solutions implemented. Richmond Council is working in partnership with Barnes Common Limited and WWT. A range of measures are being implemented, including:

- SuDS (drainage ditches) to prevent highway flooding on Rocks Lane/ Station Road.
- Permeable paving and hydrorock flood storage installed on Kitson Road, making it fully permeable.
- Reedbeds on Barnes Common, with attenuation at high flows & biodiversity benefits.
- Vine Road Pond, which takes water from the highway into a drainage pond.
- Community BlueScapes Fund to support projects that improve flood resilience, nature and community connection.
- Castelnau Future-proof Neighbourhoods is co-production process that has led to SuDS retrofit projects in Lwother Primarty School and Castelnau Community Centre, and a new supporters group for Castelnau recreation ground.
- Primary learning programme about flooding, water and climate change.
- Water Quality monitoring citizen science project.
- Gully guardians established whereby voluntary residents monitor and report any issues with local drainage.

Box 9. Parklets.

One way in which Richmond Council intends to increase the resilience of the borough is through the implementation of parklets. These are small, targeted green spaces which address specific environmental risks, including flooding, overheating and air pollution. The Council is mapping environmental hazards against social vulnerabilities and practical locations to convert into parklets to determine which locations will most significantly reduce environmental risks and maximise co-benefits. Greening measures include rain gardens, SuDS, and planting to support particular objectives. Parklets offer many co-benefits, including connecting the community to each other and nature.

4.2. Adaptation and Resilience Framework

While embedding and enabling the five principles outlined above, Richmond Council's Adaptation and Resilience Framework has three key components:

1. Climate risk and vulnerability assessment.
2. Monitoring and evaluation.
3. A Council-wide approach.

4.2.1. Climate Risk and Vulnerability Assessment

All projects will need to do a high-level climate risk and vulnerability assessment at the planning phase. A high-level tool will be made available to all Council teams to support them in undertaking such assessments. This tool will serve a dual purpose. Firstly, it will help ensure that climate change impacts are being formally accounted for in the planning stages of projects, which will enable adaptation and resilience measures to be incorporated early. In doing so, this will reduce longer-term costs by reducing the impacts of climate change and the need for retrofitting infrastructure projects. Secondly, it will provide teams with the invaluable information and evidence they seek to justify and prioritise programmes of works.

4.2.2. Monitoring and Evaluation

The Thames Estuary 2100 (TE2100) was the first strategy of its kind to adopt an adaptive flood management approach.[96] The adaptation pathways approach of TE2100 has since been applied internationally. Richmond Council will also adopt this approach, helping ensure consistency with adaptation work happening across London and further afield.

Key to an adaptation pathways approach is the monitoring of how the climate is changing, associated impacts, and the effectiveness of adaptation and resilience interventions.

Under Richmond Council's Adaptation and Resilience Framework, all adaptation and resilience interventions will be monitored every five years. Indicators have been identified, and are being further refined, across all climate hazards to support with monitoring and evaluation. This regular monitoring will embed flexibility into Richmond Council's approach to adaptation and resilience, ensuring actions are not "locked in" and can be updated as the impacts of climate change are better understood.

Furthermore, Richmond Council's Adaptation and Resilience Strategy will be updated every ten years, to ensure the climate risk and vulnerability assessment is up to date and the latest scientific evidence is accounted for in the Council's adaptation and resilience work.

4.2.3. A Council-Wide Approach

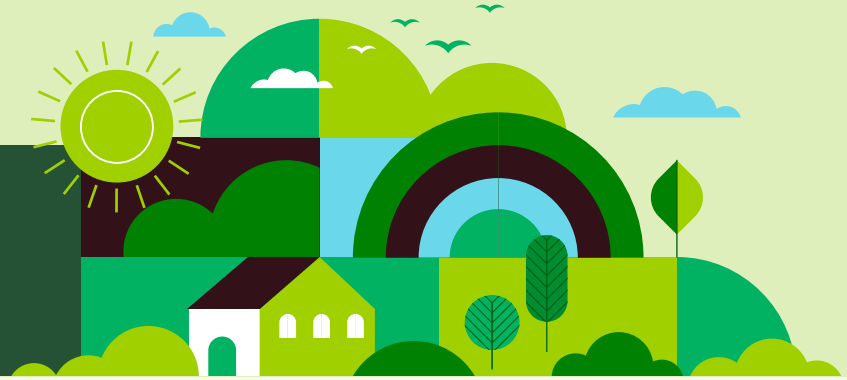
This Adaptation and Resilience Framework will be shared with all teams from across the Council, to ensure any projects that have direct and indirect links to climate adaptation and resilience are using the framework. This will ensure a consistent and robust approach to adaptation and resilience is being used across Richmond Council.

Three main mechanisms will be used to ensure the Adaptation and Resilience Framework is being used by teams across the Council and that adaptation and resilience is being imbedded into all teams across the Council working directly and indirectly in this space:

1. The Climate Change and Sustainability Team already work closely with teams across the Council and so these existing relationships will help support the rollout of the Adaptation and Resilience Framework and imbed this across the organisation. This will include providing information, training and guidance on adaptation and resilience, including support on the monitoring and evaluation of interventions to enable the adaptive pathways approach being adopted by Richmond Council.
2. Richmond Council will establish an Adaptation and Resilience Board within its Climate Change Steering Group (CCSG), which will be responsible for monitoring progress on adaptation and resilience and ensuring that all teams working directly and indirectly on adaptation and resilience are using the Council's Adaptation and Resilience Framework. Every six months, CCSG's meeting will focus on adaptation and resilience (i.e., taking the function of the Adaptation and Resilience Board).

The Council's Infrastructure Board will be a key mechanism for imbedding the Adaptation and Resilience Framework in all infrastructure projects. There is already a process for including high-level climate mitigation and adaptation considerations in infrastructure projects, which can be used as a platform to expand this work to include the Adaptation and Resilience Framework. The existing process by which climate change is considered through Infrastructure Board is a good starting point, but a more detailed and robust mechanism is needed to enable Richmond Council to adopt an adaptive pathways approach and more successfully adapt and increase resilience to climate change.

5. Priorities



This Adaptation and Resilience Strategy is designed to be complemented by the annual Climate Action Plans published by Richmond Council. To this end, long-term, aspirational priorities have been identified, informed by the climate vulnerability and risk assessment and engagement undertaken as part of this strategy. These long-term priorities will be supported by short- and medium-term actions, set out in the annual Climate Action Plans.

There are five broad priorities, which represent a complementary and phased approach to adaptation and resilience. Each priority is necessary in order for them all to be successful:

1. **Embed** adaptation and resilience across the organisation.
2. Ensure a **joined-up approach** to adaptation and resilience to maximise the impact of the work done and increase the capacity of the Council to build a more resilient borough.
3. Compile and analyse the **data** required to effectively adapt to climate change and increase the resilience of the borough.
4. **Implement** effective adaptation and resilience measures across the borough.
5. Ensure formal **monitoring and evaluation** of adaptation and resilience.

Within these overarching priorities, more specific objectives are detailed in table 5.

5. Priorities

Table 5. Richmond Council's Adaptation and Resilience Priorities

Priority 1. Embed adaptation and resilience across the organisation.	
Objectives	
Ensure decision-making on adaptation and resilience is owned at strategic level and responsibility assigned.	To ensure decision-making is owned at the strategic level, this Adaptation and Resilience Strategy will be taken to Committee for formal approval. Three initial steps will be to: support teams across the Council in using the Adaptation and Resilience Framework; set up the Adaptation and Resilience Board under CCSG; and ensure all projects going through Infrastructure Board are using the Adaptation and Resilience Framework. The Adaptation and Resilience Board will have ultimate ownership and responsibility for work in this space.
Continue and expand training for internal officers on climate change impacts, adaptation and resilience.	Richmond Council will continue to roll out its Carbon Literacy Training for internal officers. The Council will also scope how best to engage and support Councillors, as well as officers working directly and indirectly on climate adaptation and resilience, including improving their knowledge and understanding of the risks and impacts of climate change and, in turn, what measures can be delivered through the work of teams across the Council to adapt and increase resilience to these. This will involve targeted and tailored support to ensure the priorities and needs of different teams are met.

Prioritity 2. Ensure a joined-up approach to adaptation and resilience to maximise the impact of the work done and increase the capacity of the Council to build a more resilient borough.	
Objectives	
Identify and leverage opportunities to increase funding and maximise efficiencies around adaptation and resilience work.	The lack of funding for adaptation and resilience work is a significant barrier for local authorities. Three key routes will be taken by Richmond Council to try and overcome this barrier. Firstly, Richmond Council's Policy and Review Team have created new roles responsible for leveraging external funding. The Climate Change and Sustainability Team will work closely with the Policy and Review Team to identify and bid for funding opportunities for adaptation and resilience work. Secondly, by embedding adaptation and resilience across the Council, this will significantly increase efficiencies in this area of work, thus helping to maximise the impact of the resources available. Thirdly, Richmond Council will continue its existing partnership working and expand its partnership working with external stakeholders locally, regionally and nationally to identify potential opportunities for collaborative working, which could help leverage funding and/or implement adaptation and resilience work locally.
Work with internal and external local, regional and national partners to reduce climate impacts, ensure a consistent approach to adaptation across all boroughs, and promote more joined-up working.	There is a need for more joined-up thinking within and between Council teams to ensure projects maximise impacts, efficiencies, and co-benefits. Richmond Council will continue to work with key internal and external stakeholders (locally, regionally and nationally), including with London Councils, the Greater London Authority (GLA)) and the NHS, and identify new opportunities to contribute to and benefit from adaptation and resilience work happening across London and beyond. The Council will also identify gaps and lobbying needs. Furthermore, the Council will work with groups such as the Thames Regional Flood and Coastal Committee and London Strategic Surface Water Group. Greater collaboration with a range of internal and external stakeholders will help promote a more joined-up approach and enable a place-based approach to adaptation and resilience.

Prioritity 3. Compile and analyse the data required to effectively adapt to climate change and increase the resilience of the borough.	
Objectives	
Understand the proportion of residential, commercial, and service buildings at risk from climate extremes and implement retrofit measures to reduce these risks.	Residential, commercial and service buildings will require retrofitting in order to meet Richmond Council's target to be a net zero borough by 2043, but also to ensure that these buildings are resilient to extreme weather events. Richmond Council has published its' Retrofit Strategy, with close collaboration being undertaken between that and this Adaptation and Resilience Strategy to ensure the approaches are aligned and that efficiencies and co-benefits are maximised.
Map and establish public refuges accessible during extreme weather events.	Publicly accessible refuges during extreme heat, extreme cold and flooding are an essential part in adapting to climate change, by providing reliably cool, warm and dry spaces for the public to use during extreme weather events. The current number and location of such spaces needs to be mapped. Subsequently, public refuges need to be established in collaboration with partners where there are gaps in provision, most especially in areas where social vulnerability is high.
Understand and monitor the impact of climate change on critical infrastructure.	Understanding the potential impact of climate change on critical infrastructure is an essential first step in informing adaptation measures, as infrastructure is vulnerable to extreme heat, extreme cold, drought, flooding, storms and subsidence. Critical infrastructure includes Council managed infrastructure, such as highways, and non-Council managed infrastructure, such as energy and water provision. Richmond Council will explore how best to map these risks and work with relevant stakeholders to identify and rollout adaptation measures to reduce risks to critical infrastructure associated with climate change.
Use data and mapping to enable joined-up thinking and information sharing across the organisation.	Richmond Council has a number of different mapping tools hosting data related to climate change, adaptation and resilience. The Council will explore how best to ensure all teams have access to this information and options for incorporating and expanding the data to inform adaptation and resilience measures. This could include, for example, mapping past climate and projection data; the impacts of different emissions scenarios, including on extreme events and green infrastructure; the capacity of green spaces to act as nature-based solutions; properties vulnerable to extreme heat; and potential cool routes using trees.

Prioritity 4. Implement effective adaptation and resilience measures across the borough.	
Objectives	
Prioritise nature-based solutions and maximise co-benefits.	Nature-based solutions (NBS) can significantly reduce the impacts of extreme events, including extreme heat, drought, flooding and wildfires. Richmond Council will prioritise NBS in its approach to adapting to climate change, including measures to promote urban cooling, effectively store and manage water, natural flood management strategies, and habitat management. NBS also offer a wealth of co-benefits, which will be identified and maximised as much as possible.
Undertake public information campaigns on the impacts of climate change and associated risks.	Improving public awareness of the range of risks associated with climate change is essential. In particular, exposed and vulnerable populations need to be engaged with and supported in implementing measures that reduce their vulnerability to climate impacts, including extreme heat, extreme cold, drought, flooding, storms, wildfires, infectious and vector borne diseases, and subsidence.
Ensure robust and effective early-warning systems are in place.	Early warning systems are a central tenet of effective adaptation, in making people aware of upcoming risks and providing time to prepare and reduce associated impacts. Richmond Council will assess the current systems around extreme events and ensure that robust and effective early warning systems are in place. Early warning systems need to be in place for extreme heat, extreme cold, drought, flooding, storms, wildfires, and infectious and vector borne diseases.

5. Priorities

Prioritity 5. Ensure formal monitoring and evaluation of adaptation and resilience.	
Objectives	
Review and assess the costs and benefits associated with climate impacts and adaptation in Richmond.	Richmond Council will regularly review and assess the costs and benefits associated with the impacts of climate change and adaptation and resilience, to continually improve understanding of action required. Richmond Council has already completed an analysis of the costs associated with reaching its target to be a net zero borough by 2043. Cost-benefit analyses (CBA) to inform adaptation and resilience therefore needs to focus on the costs associated with the impacts of climate change in Richmond, the investment required in adaptation and resilience measures to mitigate these risks, and the savings associated with this risk reduction. The health impacts of climate change, the impact of the cost-of-living crisis on adaptation and resilience, and the savings associated with the co-benefits of adaptation and resilience activities will need quantifying and reviewing regularly.
Continue to use external frameworks to validate, report and support our work on adaptation and resilience.	Richmond Council will continue to use and identify opportunities for validating, reporting and supporting its work on adaptation and resilience. For example, the Council already reports to the Carbon Disclosure Project (CDP) each year, which provides an independent assessment and rating of the work Richmond Council does on climate change, including adaptation and resilience. This provides an important opportunity to have the Council's approach independently reviewed and holds the Council publicly accountable for the work being done on adaptation and resilience. Richmond Council will continue its work with the GLA and London Councils to align with the EU Mission: Adaptation to Climate Change, which supports regions, cities and local authorities in adapting and building resilience to climate change by helping them understand current and future climate risks; develop pathways to improve preparedness; and test and rollout innovative solutions needed to increase resilience to climate change.
Monitor, assess and prepare for potential global shocks associated with climate change.	Whilst many of the impacts of climate change will be felt directly in Richmond, impacts around the world could result in global shocks that could trickle down to indirectly impact Richmond as well. Richmond Council will monitor, assess and prepare for these potential global shocks, to ensure the systems are in place to mitigate these impacts should they occur.

6. Conclusion

6. Conclusion

Global temperature rise has now exceeded 1.5°C since pre-industrial times, breaching the targets committed to by nations under the 2015 Paris Agreement. The impacts of this rise in temperatures globally are already being felt in Richmond. Average annual temperatures have increased in Richmond from 8.6°C in 1890 to 12°C in 2022 and are projected to increase further over the course of the century, with maximum summer temperatures potentially reaching 40.6°C by 2099. Precipitation patterns have also changed in Richmond, with a trend of drier summers and wetter winters observed since 1890. This trend is projected to continue, with summer precipitation potentially decreasing by as much as 54.3% by 2099 and winter precipitation increasing by as much as 27.5% by 2099. There are also new and emerging risks that could affect the borough, including wildfires, infectious and vector borne diseases, invasive and non-native species, sea level rise, and subsidence. Furthermore, global shocks have the potential to trickle down to have localised impacts in Richmond.

A vulnerability assessment highlighted that all sectors were identified as having a high vulnerability to extreme heat and flooding. These were the only climate hazards for which this was the case. Furthermore, a number of gaps and challenges were identified. At best, these gaps and barriers reduced the effectiveness of the work the Council is doing on adaptation and resilience. At worst, these gaps and challenges prevented the Council from being able to do work on adaptation.

Richmond's Adaptation and Resilience Strategy has been published to formalise the Council's approach to adaptation and resilience, in recognition of the existing and growing threat climate change poses. This builds upon the progress Richmond Council has made in meeting its targets to be carbon neutral as an organisation by 2030 and a net zero borough by 2043. An Adaptation and Resilience Framework is presented in section 4, which details how Richmond Council will approach adaptation and resilience work.

The Adaptation and Resilience Framework is centred on the five principles recommended in the London Climate Resilience Review, to ensure Richmond Council is adopting a consistent approach alongside London as a whole:

1. Adaptation must take a people-centred approach, be locally led, strive to reduce vulnerability, and address socio-economic and racial inequality.
2. Adaptation must be embedded across decision-making and organisations, ensuring measures are owned at the strategic level and responsibility assigned.
3. Adaptation must be integrated with work to meet net zero to ensure coherent climate action.
4. Adaptive pathways approaches should be used to account for uncertainties and be flexible.
5. Nature-based solutions must be considered and prioritised.[97]

Building off these principles, Richmond Council's Adaptation and Resilience Framework has three key components to ensure an effective, robust and consistent approach to adaptation and resilience: climate risk and vulnerability assessments; monitoring and evaluation; and a Council-wide approach.

To support the implementation of the Adaptation and Resilience Framework and address climate risks in Richmond, the Council has identified 5 overarching priorities on adaptation and resilience. These are long-term strategic priorities, which will guide the work undertaken on adaptation and resilience. The priorities are designed to be complemented by Richmond Council's annual Climate Action Plans, which commit to short- and medium-term actions.

The priorities represent a complementary and phased approach to adaptation and resilience, with each priority being necessary in order for them all to be successful:

1. **Embed** adaptation and resilience across the organisation.
2. Ensure a **joined-up approach** to adaptation and resilience to maximise the impact of the work done and increase the capacity of the Council to build a more resilient borough.

6. Conclusion

3. Compile and analyse the **data** required to effectively adapt to climate change and increase the resilience of the borough.
4. **Implement** effective adaptation and resilience measures across the borough.
5. Ensure formal **monitoring and evaluation** of adaptation and resilience.

Climate change is not a future problem. It is here now, and the impacts are already being felt. These impacts will worsen in future if action is not taken now to adapt and increase resilience to climate change. Many of the public services Richmond Council is responsible for delivering are vulnerable to climate change.

This Adaptation and Resilience Strategy has therefore been published to ensure Richmond Council is:

- Helping the borough adapt and increase its resilience to the impacts of climate change.
- Able to continue delivering its services, despite the impacts of climate change.
- Using a robust and consistent approach to climate adaptation and resilience across all Council teams to reduce the impacts of climate change.

In doing so, this Adaptation and Resilience Strategy will support Richmond Council's pledge of creating a greener, safer and fairer borough.

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