Climate Change Adaptation Plan

Warwickshire County Council

22 December 2022

Delivering a better world

Quality information

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Introduction

A climate emergency

In July 2019, we as a Council declared a climate emergency. In our recently adopted Council Plan (2022-2027), we set out our three strategic priorities:

- We want Warwickshire to have a thriving economy and places that have the right jobs, skills, education, and infrastructure.
- We want to be a county where all people can live their best lives; where communities and individuals are supported to live safely, healthily, happily, and independently.
- **We want to be a county with a sustainable future which means adapting to and mitigating climate change and meeting net zero commitments.**

The core ambition is *to make Warwickshire the best it can be, sustainable now and for future generations*. The plan acknowledges that the impacts of climate change will disproportionately be borne by the most vulnerable and poorest in the county, therefore efforts to prepare for and adapt to climate change must identify and prioritise means to mitigate risks to people's quality of life. We also committed to addressing climate change through a concerted effort to become carbon net zero as an organisation by 2030, and to support the county of Warwickshire to be carbon net zero by 2050.

This Climate Adaptation Plan has been prepared alongside a *Sustainable Futures Strategy*, which lays out our approach to reducing both Council and county-wide greenhouse gas emissions. The following plan therefore also considers low-carbon approaches to climate adaptation and landscape scale adaptation, which will help to offset residual emissions within the county.

National context

To date, strategic climate adaptation planning in the UK has mostly taken place at a national level. Under the 2008 Climate Change Act,[1] the Climate Change Committee (CCC) was established as an independent statutory body with a responsibility to advise the UK government on preparing for climate change and to update Parliament on implementation of climate programmes, including the Government's National Adaptation Programme (NAP).

In June 2021, the CCC published the third UK Climate Change Risk Assessment (CCRA) Technical Report which sets out the priority climate change risks and opportunities for the UK.[2] The UK Government and devolved administrations must then set out their response to the risks and opportunities in their national adaptation programmes. The National Adaptation Programme will now be updated on the back of the 2021 CCRA (the first National Adaptation Programme was published in July 2013 and the second in 2018).

In contrast to national efforts, adaptation planning among local authorities in the UK has been limited. Local planning is now recognised as essential for adequately preparing for climate impacts.[3] At the local level, there is a need to (i) share knowledge of climate risks with a variety of stakeholders, including those working with the most vulnerable people and in the most vulnerable sectors; (ii) coordinate, develop and support local adaptation initiatives; and (iii) support the development of local planning and policy that considers climate risks, to ensure that future development is resilient to the impacts of climate change.

Purpose of this plan

The purpose of this plan is to identify how the climate is changing in Warwickshire, establish what the likely risks and impacts of climate change are, and identify the role that we can play in mitigating these risks through a range of adaptation and resilience-building initiatives.

UK Climate Impacts Programme (UKCIP) is currently supporting us develop internally focused climate adaptation plans for services in public health, flood, as well as fire and rescue. This internal climate adaptation planning is soon expected to be expanded to transport services as our capacity to develop climate adaptation plans increases.

This Plan is, therefore, more externally focused. It considers how we can work with and influence a range of stakeholders across the county to reduce

[1] The Climate Change Act was updated in 2019.
[2] Betts, R.A. and Brown, K. 2021. Introduction. In: The Third UK Climate Change Risk Assessment Technical Report. Prepared for the Climate Change Committee, London.
[3] Local Partnerships, established by the Local Government Association, provides advise and tools to UK local authorities on climate change adaptation, resilience, and climate leadership.

the risk to communities, assets, infrastructure, business, and the environment to deliver a more resilient future.

This Plan is our first externally facing climate adaptation plan and represents a starting point from which to build resilience by implementing (or supporting implementation of) the adaptation initiatives found in this plan. Through the implementation of the initiatives, new partnerships will be established across the county and existing 'resilience' partnerships will be strengthened. This Plan sets our crucial role in leading, convening and supporting these partnerships, sharing knowledge and data, as well as influencing partners and stakeholders towards a more resilient county.

The intention is that we review and update this plan regularly as lessons are learned, our capacity to adapt develops, and opportunities for more integrated climate change adaptation arise.

Approach to adaptation planning

The adaptation plan was developed through the following three work phases, through a consultative process from May to December 2022.

Hazard and climate change analysis

We started by evaluating key climate-related hazards that pose risks to Warwickshire. The analysis includes analysis of both historic events, as well as recent and projected trends of key climate variables relating to those hazards. This analysis provides the basis for the climate risk assessment for Warwickshire (the next phase).

For the purposes of this plan, the climate projections are based on a Representative Concentration Pathway (RCP) of 6.0. The RCP 6.0 scenario is a medium emissions scenario where emissions peak around 2080, then start to decline.[4] Under RCP 6.0 global mean surface temperature is expected to increase by 2.8ºC by 2100 (compared to pre-industrial levels).[5]

We selected RCP 6.0 rather than lower emissions scenarios to ensure the climate change risk assessment is conservative and therefore the adaptation plan is illustrative of more severe risks of climate change, that would result if global climate action is not sufficient to reduce emissions against the baseline.

Climate change risk assessment

The Climate Change Risk Assessment for this plan was developed between March and September 2022 using the same risks identified in the UK Climate Change Risk Assessment (UK CCRA), excluding risks which were not relevant to Warwickshire, such as those related to coastal areas and international risks. The risk assessment is based on (i) information in the national risk assessment, (ii) the Warwickshire-specific hazard and climate change assessment undertaken in the previous phase, (iii) key strategic documents including e.g. Severn Trent Water's *Drought Management Plan 2019-2024*, Severn Trent Water's *Water Resources Management Plan 2019*, the *Strategic Flood Risk Assessment*, and (iv) information provided by the Local Resilience Forum, Warwick District Council, and our operational departments, including Warwickshire Fire and Rescue Services.

Some of the spatial data that was used to inform the risk assessment has been compiled into a set of Hazard, Vulnerability, and Opportunity maps for Warwickshire[6]. These complement the risk assessment and establish a high-level spatial distribution of risks in the county, displaying where they intersect with vulnerable communities and environments, and other assets.

Development of county-wide adaptation initiatives

Finally, we prepared a comprehensive list of county-wide initiatives under an integrated climate adaptation framework.

The initiatives were developed through internal and external consultation to identify existing and potential partnerships and opportunities for adaptation. The initiatives include actions for us to implement directly, actions for us to provide leadership and/or coordination, as well as actions where we can influence or provide a supporting role in our function as a County Council.

[4] van Vuuren, D.P., et al. 2011.The representative concentration pathways: an overview. Available: https://link.springer.com/article/10.1007/s10584-011-0148-z

[5] Met Office. 2018. UKCP18 Guidance RCPs.

[6] These have been provided to WCC separately due to the file size.

Hazard and climate change analysis

The climate risk posed by an event is a function of the hazard (e.g., flooding), the exposure to this hazard (e.g. the neighbourhood where the flooding is occurring), and the vulnerability to that event (e.g. households' and businesses' coping capacity to respond to the flooding in the particular neighbourhood). For this assessment, *risk* has been evaluated through historic events or trends and an assessment of vulnerability. Climate change projections for relevant indicators are included to understand how risks are likely to change over time. As noted previously, these have been based off the RCP 6.0 scenario, using UK Met Office UKCP18 data.[7] This chapter describes hazard and vulnerability to inform the Climate change risk assessment in the next chapter.

This hazard and climate change analysis focuses on:

- Flood risk and rainfall intensity projections,
- Drought risk and rainfall total projections,
- Extreme heat risk and maximum temperature projections,
- Extreme cold and minimum temperature projections; and,
- High winds and projected changes in windiness.

Flooding

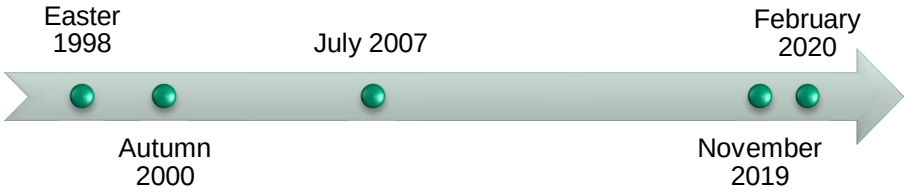
There are 26,499 people at risk of flooding in Warwickshire,[8] this equates to 4% of the population of Warwickshire. To provide some context, in some other LLFA (Lead Local Flood Authority) areas in Lincolnshire, and London boroughs, over 30% of the population are exposed to flood risk. The River Severn Partnership[9] have estimated that residential property at risk of flooding in Warwickshire is worth over £2.9bn, and commercial property at risk is worth over £1.3bn. They have also identified the following key knock-on effects resulting from flooding in Warwickshire:

- Detrimental impact on health and well-being and risk to life,
- Damage to properties and infrastructure,
- Reduced accessibility,
- Disruption to businesses, impacting turnover and jobs,
- Decreased land value and business rate recovery,
- Increased risk of pollution due to flood,
- Remediation and clean-up costs,
- Damage to aesthetic, cultural and heritage value and assets,
- Negative impacts on the destination and visitor economy; and,
- Negative impacts on the destination and visitor economy.

Historic flooding

The Rivers Stour, Arrow and Avon are the largest watercourses in the county and subject to repeated fluvial flooding which has impacted places such as Stratford-upon-Avon, Leamington Spa, Shipston on Stour, Alcester, and Bidford-on-Avon. Recent events have largely occurred within Stratford District and around Leamington Spa. A map showing historic flooding can be viewed online.[10]

Timeline of key historic flood events



[7] Data has been adapted from the Met Office. UK Climate Projections under the RCP6.0 Scenario were used. Available: https://ukclimateprojections-ui.metoffice.gov.uk/ui/home
[8] Environment Agency. 2022. Risk of Flooding from Rivers and Sea.
[9] River Severn Partnership: Pre-Workshop Meeting (.pdf, provided by WCC)
[10] Warwickshire County Council. Historical Flooding. Available: https://maps.warwickshire.gov.uk/historical-flooding/

Easter 1998: Frequent flood events have occurred over the past two decades including the Easter of 1998. The primary impacted area was in the River Avon catchment which led to widespread flooding in Leamington, Stratford and Shipston on Stour. The event was attributed to a slow-moving weather front crossing the county with daily rainfall reaching 74mm. Flood defences were overtopped in Alcester, Long Itchington and Wellesbourne.[11]

Autumn 2000: In October and November 2000, England and Wales experienced the wettest autumn for 270 years. Major flooding occurred impacting key infrastructure in the county, such as the A426, B4112 and B5414 and several properties including 30 in Wellesbourne and 4 in Shipston/Clifford.[12]

July 2007: Widespread flooding in the summer of 2007 resulted from four times the July average rainfall in the South midlands, following a slow-moving depression.[13] The lower Severn flooded, together with several other rivers. The return period of the rainfall event was estimated to be more than 200 years.[13] The consequences of this event included damages in the county to 60 roads and 20 bridges, 2,000 properties flooded and flooding of 5 market towns including Shipston, Wellesbourne, Henley-in-Arden, Alcester, Bidford and Leamington.

November 2019: The floods of November 2019 led to 24 internal reports of flooding, 28 emergency school closures and 150 reports of highway flooding.[9] Approximately 5,000 pupils affected by school closures and an economic impact of >£320k was estimated in the education sector alone.[9]

Spring/Summer 2020: Flooding affected 24 properties with internal property damage throughout the county.

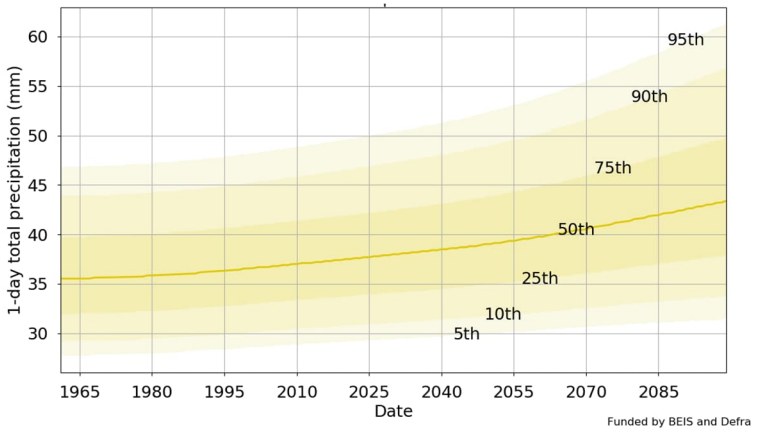
Projected increase in rainfall intensity

Flood risk is driven by rainfall intensity. To evaluate how climate change will impact flood risk we have presented 100-year return period (1% Annual Exceedance Probability (AEP)) maximum 1-day and maximum 5-day winter rainfall. The short duration 1-day rainfall event would impact smaller catchments and provides an indicator of how climate change projections may impact flood risk in urban settings and other small catchments. The longer 5-day duration event would be more representative of larger catchments such as, for example the River Avon, due to the longer hydrological response time of a larger catchment.

Figure 1 and Figure 2 below, present the historic and projected precipitation (in mm) for a 100-year event (1% annual exceedance probability) for the winter season can be seen for 1-day and 5-day event respectively. The charts use UKCP18 data. The figures illustrate that rainfall intensity in Warwickshire has been steadily increasing since 1965, and this trend is projected to steepen in the future. Currently, the 100-year return period 1-day maximum rainfall is estimated around 35mm and the equivalent 5-day event is around 71mm. These are projected to increase to 43mm (23%) and 81mm (14%), respectively, by 2100.

Projections for summer 1-day and 5-day rainfall are not anticipated to increase, so this increase in flood risk is predominantly seasonal – i.e. according to the projections, flood risk in winter will increase and flood risk in summer will remain the same.

Figure 1 1-Day Max Winter Precipitation 1% AEP



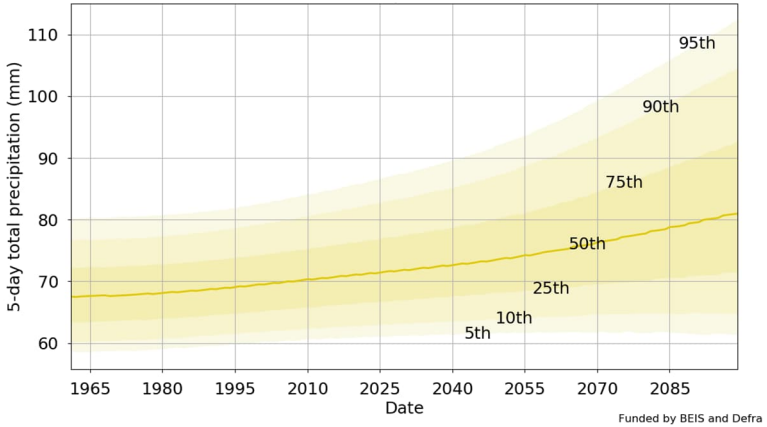
Source: Met Office. 2022.

[11]Met office. Historic flooding in Warwickshire: Appendix 08.00. Available : www.geography.com

[12] Environment Agency. 2001. Autumn 2000 floods review regional report: Midlands region. Solihull.

[13] Met Office. 2007. Heavy rainfall/flooding - July 2007. Available: https://www.metoffice.gov.uk/weather/learn-about/past-uk-weather-events#y2007

Figure 2 5-Day Max Winter Precipitation 1% AEP



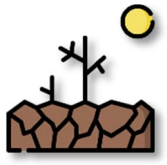
Source: Met Office. 2022.

Flood risk management

Under the Flood and Water Management Act (2010), we became a lead local flood authority (LLFA), responsible for managing local flood risk. Within Warwickshire this is related to surface water, groundwater and ordinary watercourses. The Environment Agency has responsibility for strategic reduction of flood risk from main rivers.

As the LLFA, we are the statutory planning Consultee for flood risk in Warwickshire – we advise on flood risk for planning applications – and our Strategic Flood Risk Assessment (SFRA) enables the Local Planning Authorities to undertake sequential testing in line with the Government's principles of flood risk and planning set out in the National Planning Policy Framework.

To manage local flood risk, we have developed a local flood risk management strategy (LFRMS) and action plan, which includes local projects, and policy initiatives to reduce flood risk, prioritised through a spatial flood risk assessment outlined in our Surface Water Management Plan (SWMP).



Drought

Drought risk is determined by the combination of a prolonged period with lower-than-average rainfall and a water-dependent activity, such as public water supply or other water uses. Warwickshire's water is supplied by Severn Trent Water on their Strategic Grid supply zone, which is fed by both surface and groundwater sources. Approximately 30% is supplied from the River Severn, 10-15% from local groundwater sources, and the majority is from surface water reservoirs within the county and across the wider grid.

The impact of a drought can vary between counties depending on the severity, extent, and duration of the drought, as well as dependent on the water sources which are affected (rivers, groundwater or reservoirs) and the demand imposed on them. In the UK, droughts are particularly linked to poor winter rainfall as it is during these months, when evapotranspiration is low, that the majority of groundwater recharge occurs, which provides groundwater resources for consumption and supports baseflows of many rivers. Droughts are also linked to summer temperatures: high temperatures increase evapotranspiration rates, leading to greater water demand for irrigation, cooling, landscaping (e.g. golf courses), public water supply, and other uses.

According to the River Severn Partnership, the potential economic impacts of drought on agriculture, plant retail nurseries, and landscaping services in Warwickshire are £9.9M, £6.9M, and £6.4M respectively,[14] and impacts would also be felt on the food and drink and manufacturing sectors, which are significant in Warwickshire.

Historic droughts

The UK Centre of Ecology and Hydrology Drought Map shows a history of oscillating precipitation conditions, leading to some 'extremely dry' periods including the summers of 1995, 1996, 2011 and 2022. These years of dry conditions have coincided with high temperatures associated with El Niño. There has been no historic trend of increasing dry conditions in Warwickshire.

For Severn Trent Water, the most severe drought of the 20th century occurred in 1975-76 according to hydrological and hydrogeological records.[15] This drought led

[14] Based on: DEFRA. 2013. The impacts of Drought in England.

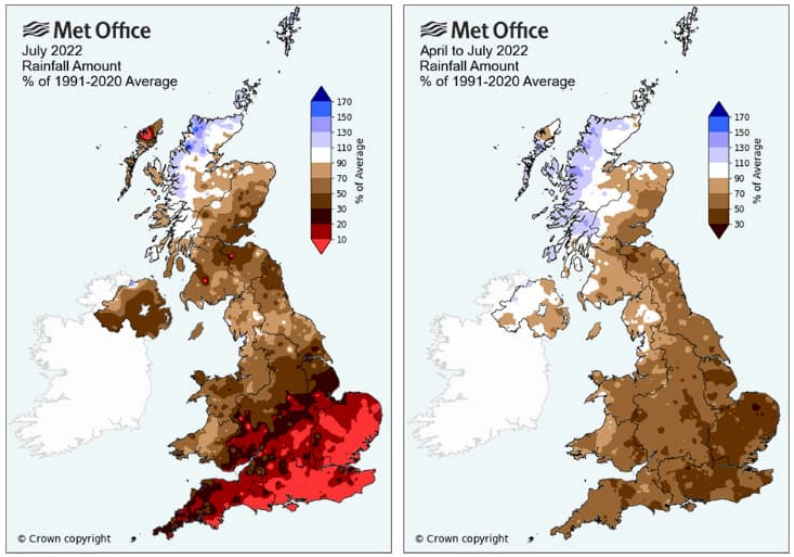
[15] Severn Trent Water. 2018. Draft Drought Plan 2019-2024.

to interruptions in mains supply in Warwickshire and ultimately triggered the passing of the Drought Act of 1976.

More recently, Warwickshire has been subjected to periods of drought including between 2010 and 2012 with a prolonged period of below average rainfall in England and Wales. Considerably low autumn and winter rainfall in 2011 limited recharge of groundwater and reservoirs, which resulted in significant drought impacts until the summer of 2012.[16]

The summer 2022 drought has been the worst felt since 1975, and 'drought status' was declared by the Environment Agency across most of England, including Warwickshire. It was caused by lower-than-average winter rainfall and particularly dry conditions from April to July 2022 (Figure 3). While many water companies issued hosepipe bans, this was never declared by Severn Trent, partly due to efforts that already reduced per capita consumption in previous years.

Figure 3 April to July 2022 rainfall as a percent of long-term average

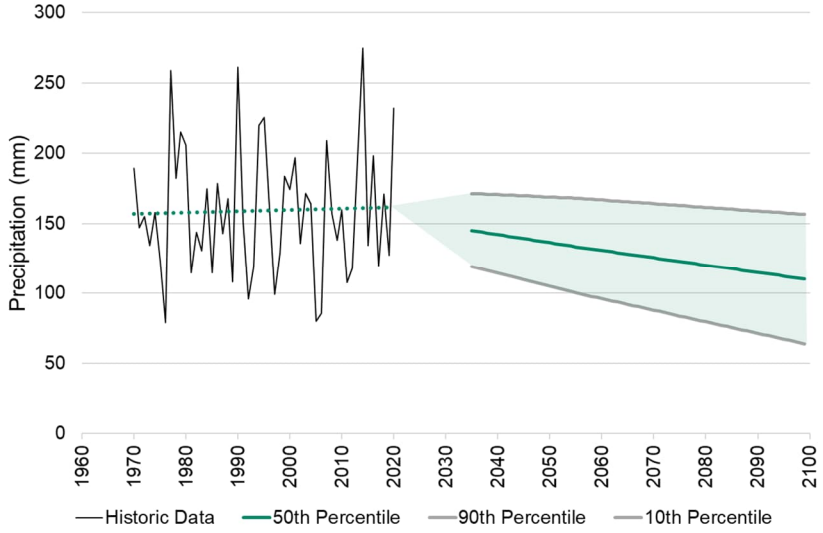


Source: Met Office. 2022.

Projected rainfall totals

To determine future drought risk, we evaluated UKCP18 projections in future rainfall. While average annual rainfall is not projected to change significantly, when we consider seasonal expected rainfall patterns, we can see that average winter rainfall (Dec-Jan-Feb) is expected to decline from around 150mm to approximately 110mm by 2100 (Figure 4). *[note the projections are for the average and show uncertainty bounds – the 90th and 10th percentile and do not account for the inter-annual variability that can be seen in the historic data plotted in Figure 4]*.This is contrary to summer rainfall (Jun-Jul-Aug), which is expected to increase from around 150mm to 210mm by 2100 (Figure 6). As previously noted, lower than average winter rainfall has a greater impact on drought in the UK due to the lower temperatures and lower evapotranspiration during winter months – it is the period when all aquifers (natural groundwater storage) in the UK are replenished for the year. The climate change projections for rainfall therefore indicate a trend of increasing drought risk in Warwickshire.

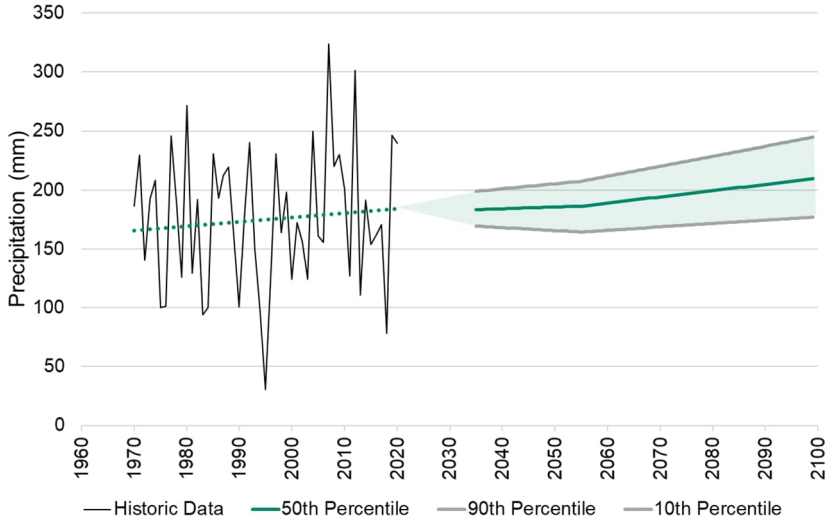
Figure 4 Historic and Projected Average Winter Precipitation (mm)



Source: AECOM. 2022. [Data downloaded from the Met Office UKCP18]

[16] Met Office. 2013. England and Wales drought 2010 to 2012.

Figure 6 Historic and Projected Average Summer Precipitation (mm)



Source: AECOM. 2022. [Data downloaded from the Met Office UKCP18]

Warwickshire's location within Severn Trent Water's Strategic Grid Water Resource Zone (WRZ), which is the largest of Severn Trent Water's resource zones, provides greater resilience to drought as water can be moved from multiple sources to meet current and future demand.

However, Figure 5 shows the 2019 supply and demand forecasting for the Strategic Grid resource zone. These projections demonstrate that total future water available for use is less than the target for water availability (demand plus headroom), and this gap is expanding.

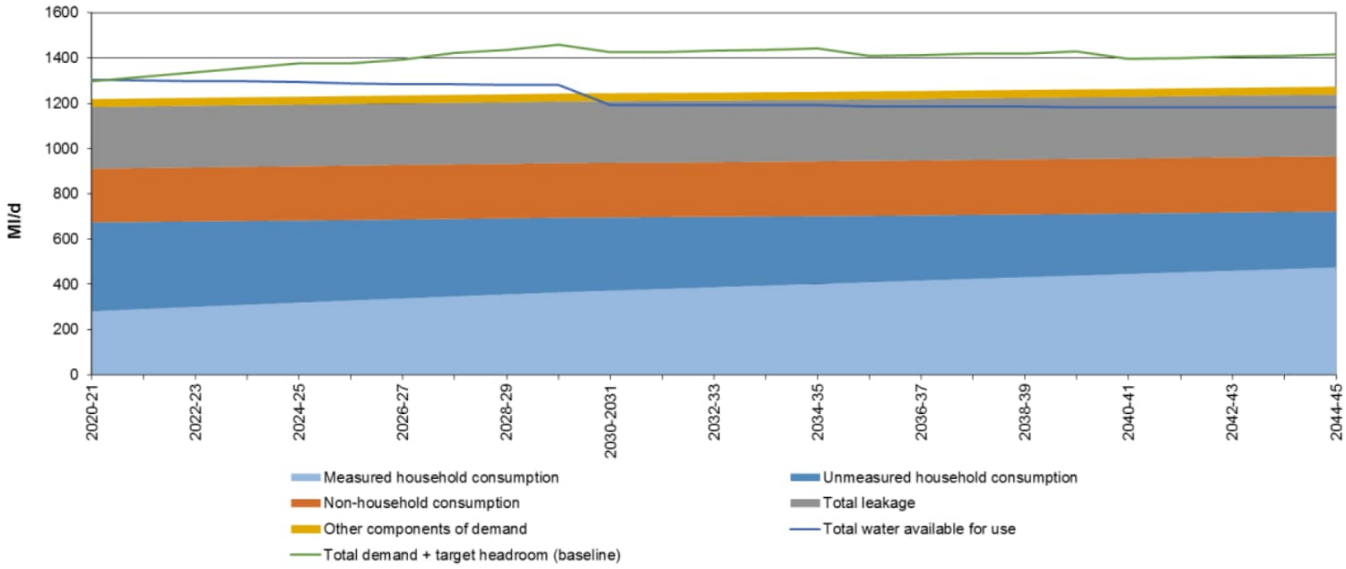
The primary purpose of Severn Trent Water's Water Resources Management Plan is to demonstrate that we will be able to sustainably meet the demand for water over the next 25 years, even when under drought conditions, which includes stress testing the supply system against a 1 in 200-year return period drought, using statistical techniques to simulate theoretical drought events that go beyond historic experiences.

The Water Resource Management Plan concludes that Severn Trent's raw water supplies are already resilient to a 1 in 200-year drought event, but still need to consider how to respond to long-term water supply and demand pressures.

Severn Trent Water's Climate Adaptation Plan identifies, among other things, the need to reduce per capita consumption by 3.5% by 2025, deliver 35,000 home water efficiency visits, and educate 500,000 children on the value of water and provide services for a growing population. These demand management activities are where we can support deliver a drought-resilient water supply system for Warwickshire that will reduce the economic and social impact of future drought, which is becoming more likely to occur with climate change.

Figure 5 Strategic Grid Water Resource Zone baseline supply and demand balance

Source: Severn Trent. 2019. Water Resources Management Plan 2019.



Heatwave

Risks from extreme heat arise from a combination of extended warm weather (days over 20°C) combined with low precipitation. The average summer maximum temperature between 1970 and 2020 has trended higher, rising from 20.6°C to 21.4°C, with years experiencing much higher temperatures in between (Figure 10). The worst recorded heatwaves tend to occur in El Niño years.

The impacts of heatwaves include health and mortality, damage to the natural environment and loss of ecosystem services, damage to crops and agricultural assets, higher than average water and electricity demand (for example for food storage), increase in food and drink sales, disruptions to rail transport (speed reductions), deterioration of road surfaces, and subsidence.[17] Increased fire risk is a combination of both dry conditions and high temperatures – we have to deal with many more fires than average during hot and dry periods.

Heat warnings in Warwickshire, alongside the rest of the UK, have become more frequent and have a longer duration. The Met Office issued the first red weather warning in July 2022 for extreme heat, and for the first time issued a level 4 health alert (Box 1).[18] A level 4 health alert indicates that adverse health impacts and fatalities could occur to people outside of the most vulnerable groups.

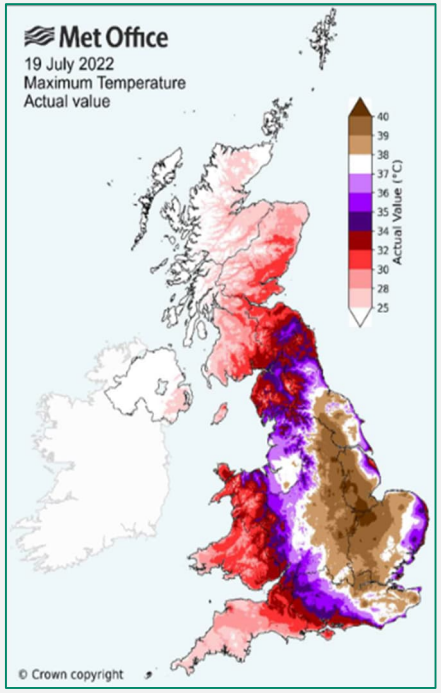
Heat vulnerability

Heat socio-spatial vulnerability maps show how social vulnerability combined with potential exposure to heat-related events, can disproportionally impact vulnerable people (marginalised or at-risk communities, such as low-income communities or elderly). Warwickshire county is mostly comprised of rural land; therefore, the risk across the county is generally average or low. However, the urban areas, including Rugby and Nuneaton, contain relatively or extremely high-risk areas where deprivation intersects with greater exposure to extreme temperatures as a result of the urban heat island[19] effect (Figure 7 and Figure 8).

Box 1 Met Office Issues First Red Weather Warning for Extreme Heat

July 2022 Extreme Heat

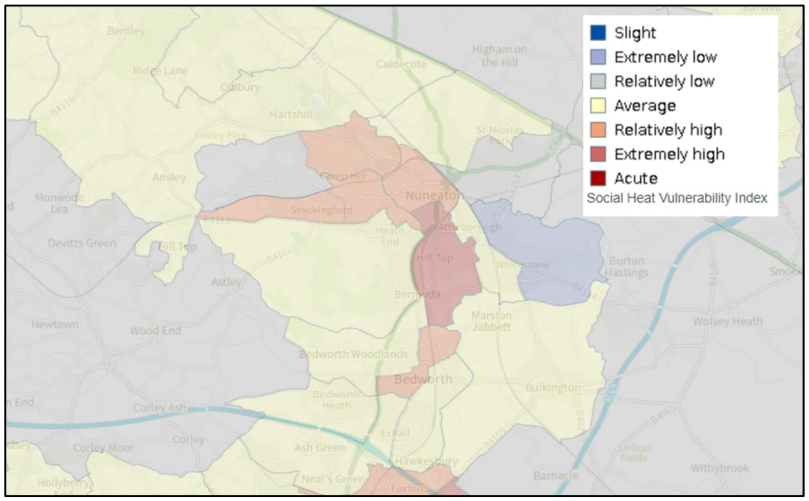
The UK experienced an unprecedented heatwave between 16 and 19 July 2022, resulting in a record extreme high temperature of 40.3°C. Alongside an unprecedented daily maximum temperature, the record daily minimum temperatures were also broken. Wellesbourne, Warwickshire was one of 60 stations recording a “tropical night”, defined as a 24-hour period with temperatures remaining above 20°C.The heatwave triggered the Met Office to issue the first red warning for extreme heat since the Extreme Heat National Weather Warning Service was introduced in June 2021 and to issue a level 4 alert, prompting the government to declare a national emergency. This alert indicated adverse health impacts and fatalities could occur to people outside of the most vulnerable groups. Among counties across the UK, Warwickshire recorded high temperatures of 39.0°C, exceeding the previous record by 0.3°C.



Source: Met Office. 2022.

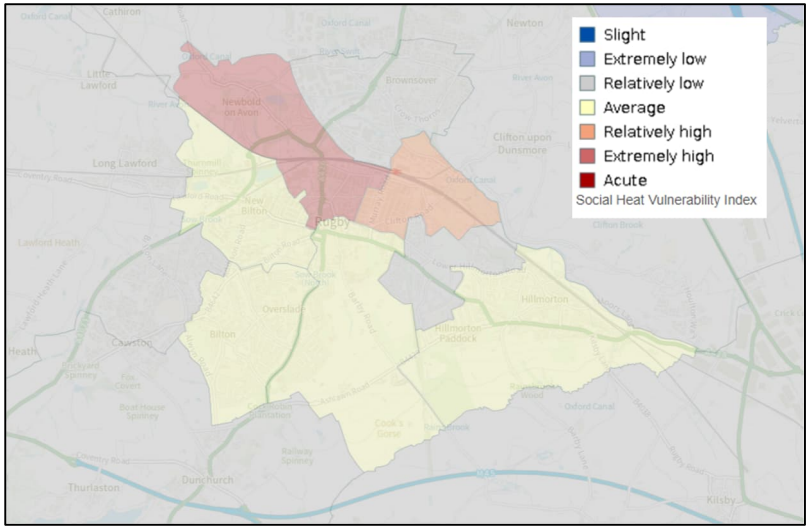
[17] Environment Agency. 2007. The Social Impacts of Heatwaves.
[18] Met Office. 2022. Unprecedented extreme heatwave, July 2022.
[19] Elevated temperatures in urban areas resulting from greater absorption of solar radiation by urban surfaces.

Figure 7 Heat Socio-spatial Vulnerability for Nuneaton



Source: Climate Just. Accessed 2022.

Figure 8 Heat Socio-spatial Vulnerability for Rugby

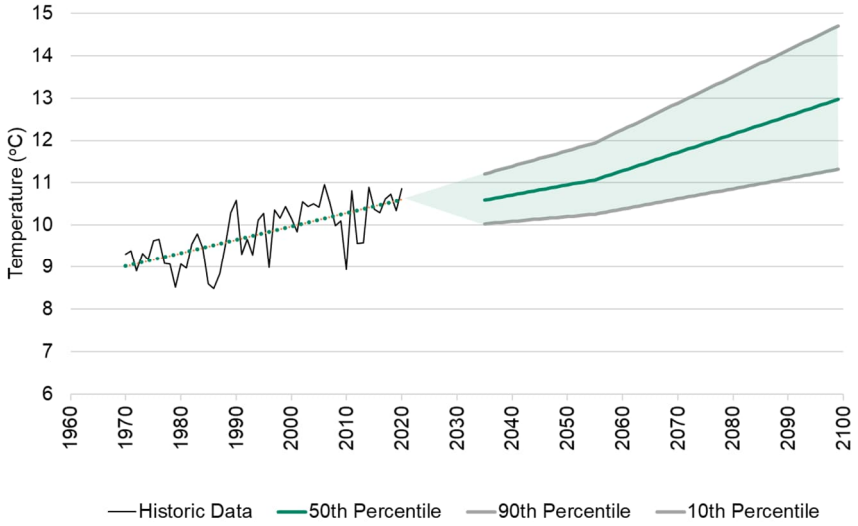


Source: Climate Just. Accessed 2022.

Projected extreme heat

Mean annual temperature (Figure 9) along with summer maximum temperature (Figure 10) has been projected. Higher mean annual temperature has implications for businesses, communities, and particular implications for agriculture, including impacts on growing seasons, water availability, soil quality and yields. Some impacts might be positive including increases in harvest for certain crops.

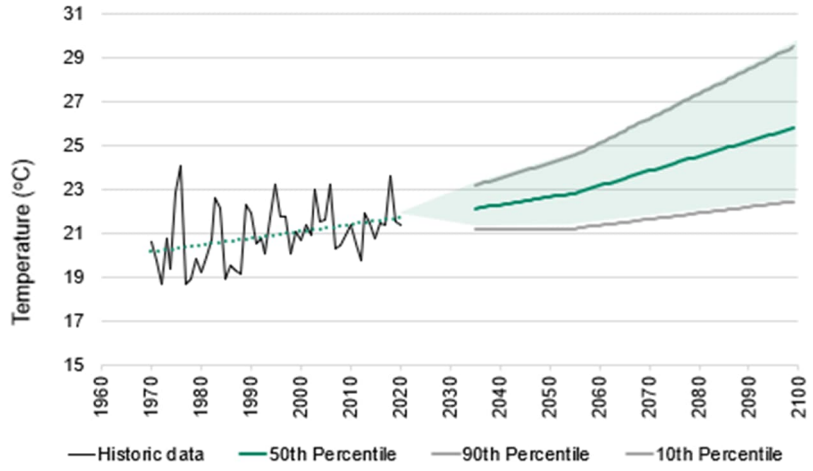
Figure 9 Historic and Projected Mean Annual Temperature (ºC)



Source: AECOM. 2022. [Data downloaded from the Met Office UKCP18]

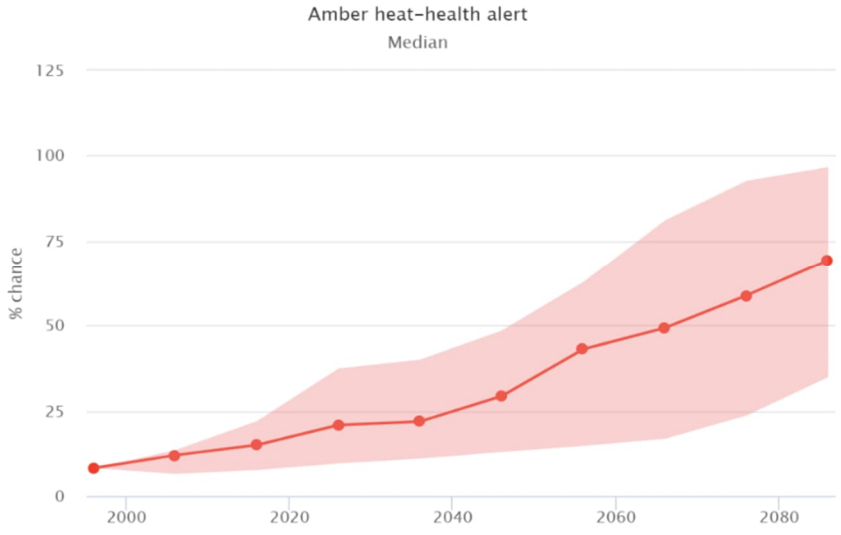
The summer maximum temperature is projected to be consistently above 25°C by 2088 in the 50th percentile projections and 2061 in the 90th percentile projections. This means an increase in the number of very hot days resulting in increased frequency of heatwaves and extreme heat conditions in Warwickshire will become the norm. Our Public Health Service responds to heatwaves based on the Amber Heat Health alerts issued by the Met Office, the threshold for which is 30°C. Figure 11 shows how these warnings are projected to increase in number throughout the decades, demonstrating the rise in frequency and severity of heatwaves. Currently we issue national heatwave plan and associated material but do not currently have a heatwave plan for Warwickshire.

Figure 10 Historic and Projected Summer Maximum Temperature (ºC)



Source: AECOM. 2022. [Data downloaded from the Met Office UKCP18]

Figure 11 Annual Probability of an Amber Heat-health Alert Projection



Source: UK Climate Risk Indicators. Accessed 2022.[20]

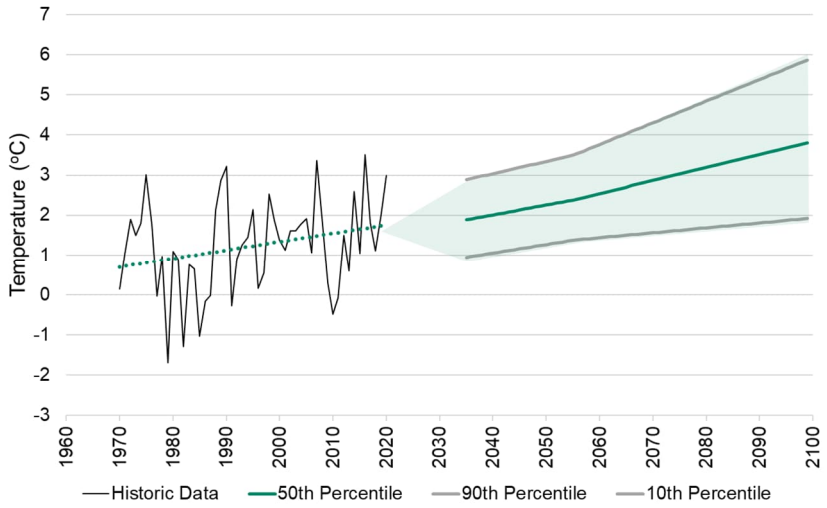
[20] UK Climate Risk Indicators. Available: https://uk-cri.org/

Extreme cold

Extreme cold occurs during a period of icing days, when daily temperatures remain below 0°C. Associated hazards with extreme cold include frost, ice and snow, with impacts on transport, infrastructure, and public health, including mortality. The number of extreme cold events has decreased over time in Warwickshire, particularly beyond 1990, where there is only one recorded recent winter (2010) with extreme cold conditions (Figure 12). Winter minimum temperature has increased by around 1°C in the last 50 years.

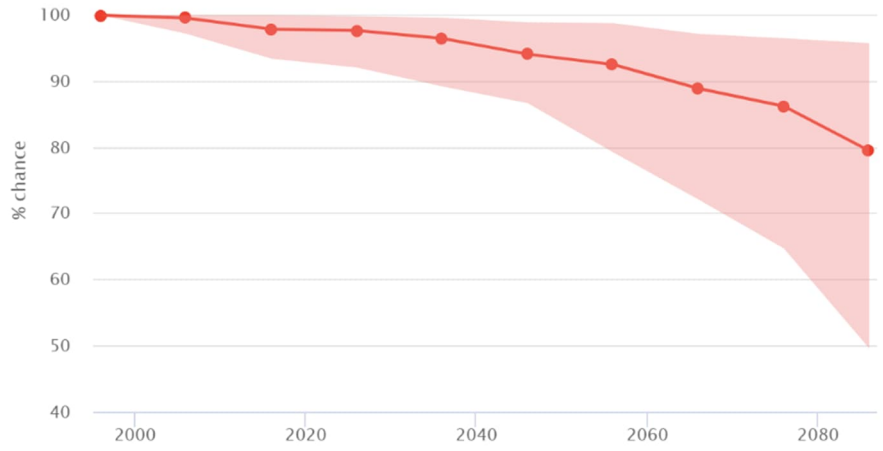
It is expected that the number of extreme cold events will reduce further to a negligible risk as a result of rising temperatures. UKCP18 projections illustrate an expected increase in Winter minimum temperature (Figure 12) and the likelihood of extreme cold will rapidly reduce by 2080, to become a less likely risk. Combined with this, the percentage chance of cold weather alerts being issued is expected to decline towards the end of the century indicating that extreme cold temperatures will be less frequent and have a shorter duration (See Figure 13).

Figure 12 Historic and Projected Winter Minimum Temperature (ºC)



Source: AECOM. 2022. [Data downloaded from the Met Office UKCP18]

Figure 13 Projections of % Chance of Cold Weather Alert



Source: UK Climate Risk Indicators. Accessed 2022.[21]

High winds

High winds present a hazard to transport, infrastructure, buildings, agriculture, and people. Nationally, there has been no trend in maximum gust speeds recorded. Since 2019, there have been an average of 27 thunderstorm warnings issued in Warwickshire each year. There have been no lightning warnings.

A recent study from Krueger et al. (2019),[22] confirmed that trends in storm activity are entirely dependent on the period of time of the analysis. When viewed over a longer period of time, storms often emerge as part of a longer term natural climate variability such as the North Atlantic Oscillation which is the primary determinant of storms in the UK.[23] The North Atlantic Oscillation varies greatly between years and decades.

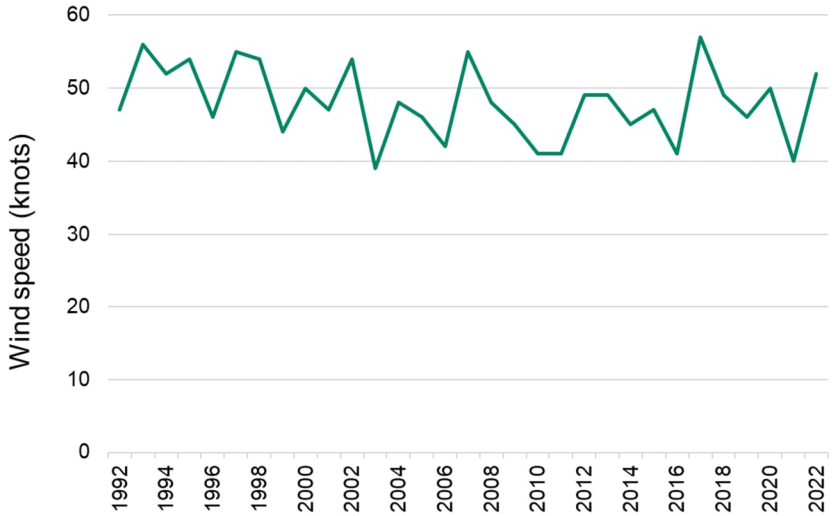
Notable storm events for Warwickshire include:

2013: The stormiest winter in the last 143 years occurred in the winter of 2013/14 in the UK, based on cyclone frequency and intensity. It resulted in widespread fluvial flooding, although less severe than other flood events.[24]

2022: In February 2022, Warwickshire was affected by two storms: Storm Eunice and Storm Franklin. The former was the strongest storm in the UK since 1987. Warwickshire was under an amber warning due to the strong winds and heavy rainfall that was expected, and realised, under both storms. Similar events, to lesser extents, have occurred during winter months in most years in Warwickshire.

We obtained maximum annual gust data for Church Lawford weather station in Warwickshire from the Met Office (Figure 14) as historic wind speed data are not available for gridded download from UKCP18.

Figure 14: Annual maximum gust speed at Church Lawford, Warwickshire



[21] UK Climate Risk Indicators. Available: https://uk-cri.org/
[22] Krueger, O., Feser, F. and Weisse, R. 2019. Northeast Atlantic Storm Activity and Its Uncertainty from the Late Nineteenth to the Twenty-First Century. J. Climate, 32, 1919-1931.
[23] Betts, R.A. and Brown, K.. 2021. Introduction. In: The Third UK Climate Change Risk Assessment Technical Report [Betts, R.A., Haward, A.B. and Pearson, K.V. (eds.)]. Prepared for the Climate Change Committee, London.
[24] Muchan, et al. 2015. The winter storms of 2013/2014 in the UK: hydrological responses and impacts.

These data illustrate no significant trend in 'windiness' from 1992 to 2022, which corresponds with the findings of the UK National Climate Change risk assessment, which concludes that there is no clear evidence for increased storminess in the UK based on analysis of long-term data sets.[25]

Projected winds

Wind speeds are challenging to predict, with no compelling trend in national wind speed since 1970. The third UK Climate Change Risk Assessment analysis of observed and projected climate[25] recognises that future winter weather may be dominated by more storms particularly affecting western parts of the UK which may bring higher incidence of strong winds. Trends in storminess are often debated, and future trends challenging to predict. Many conclude that there is no obvious evidence for increased storminess[22] but it is safer to assume some increase in high winds above the existing long-term average.

One of the most exposed asset types in Warwickshire to high winds is overhead power distribution cables. National Grid (formerly Western Power Distribution) are responsible for operation and maintenance of grid assets across Warwickshire. They have concluded in their climate change studies, that (i) winds and lightening are their primary weather-related risk,[26] (ii) that there is no clear evidence of increasing frequency and magnitude of occurrence of these events,[27] and (iii) that recent responses to winter storms illustrate that they are prepared for any predicted changes to wind and gales.[26]

[25] Slingo, J. 2021. Latest scientific evidence for observed and projected climate change. In: The third UK Climate Change Risk Assessment Technical Report [Betts, R.A., Haward, A.B. and Pearson, K.V. (eds.)] Prepared for the Climate Change Committee, London.

[26] Western Power Distribution. 2015. Adaptation to Climate Change Second Round Report.
[27] Western Power Distribution. 2011. Adaptation to Climate Change Report.

Climate change risk assessment

To align the Climate Change Risk Assessment with our existing approach to risk assessment, it follows our Risk Assessment and Evaluation Matrix, which is Appendix 2 of our Strategic Risk Management Framework. The Climate Change Risk Assessment applies our Likelihood Assessment Criteria and Impact Assessment Criteria using a 5-point scale of Likelihood and Impact of risk, from low (1) to high (5).

The risks evaluated are taken directly from the UK Climate Change Risk Assessment 2022 (UK CCRA), and the risk ID from that assessment is provided in the Climate Change Risk Assessment below (Table 2), for reference. All the UK CCRA risks have been evaluated, apart from those with an international and coastal focus, as this is a local climate change risk assessment for a landlocked county.

The Climate Change Risk Assessment for Warwickshire is underpinned by information provided in the national risk assessment but uses locational and climate change information to downscale the national risk assessment for Warwickshire. The effects of climate change have been incorporated into the assessment of likelihood of risk based on the analysis of hazard exposure and vulnerability (in the previous chapter).

Table 1 Risk Score Key

Risk Rating	Score
Positive/ Neutral	N/A
Low	0-8
Moderate	9-14
High	15+

Table 2 Assessment of possible climate change risks and opportunities to Warwickshire based on UK National Climate Change Risk Assessment and local sources

ID	Risk / Opportunity	Likelihood of Risk		Impact From Risk		Risk rating
		Score	Explanation and references	Score	Explanation and References	
Natural Environment						
Ne1	Risks to species and habitats due to	Moderate [3]	Climate projections indicate temperature and precipitation changes which are likely to	High [5]	Warwickshire has a number of critical habitats which provide vital ecosystem services, critically flood	15

	inability to respond to changing climatic conditions		impact species and habitats in Warwickshire, given their fragmentation.		risk reduction for downstream areas. Their loss could have significant impacts on agriculture, human wellbeing, and significant reputational damage.	
Ne2	Opportunities from new species colonisations	Moderate [3]	Climate projections indicate changes in temperature and precipitation, which are likely to enable new species colonisations.	No net change/ positive	With the colonisation of new species, overall biodiversity would increase, improving ecosystem health and strengthening ecosystem services. Note that changing conditions could also have a negative impact on native species.	No net risk/ Positive
Ne3	Risks and opportunities from changes in agricultural and forestry productivity and land suitability	Moderate [3]	Climate projections indicate changes in temperature and precipitation which are likely gradually change suitability of land used for agriculture and forestry in some locations.	Moderate [3]	Changes in the suitability of land for agriculture and forestry will have a significant impact on the social, economic, and environmental landscape of the county. Significant changes will be localised (e.g. resulting from flooding), other changes will be gradual.	9
Ne4	Risks to soils from increased seasonal aridity and wetness	High [5]	More frequent and intense drought and flooding events, coupled with existing agricultural practice, is likely to impact soil conditions.	Moderate [3]	Gradual decline in the availability (due to erosion) quality and structure of soils will negatively affect agricultural productivity, with negative impacts on food security and the local economy. Soils in areas of high-quality habitat supported by diverse ecosystems will be safeguarded. This has secondary impacts on surface water quality.	15
Ne5	Risks to natural carbon stores and carbon sequestration	Moderate [3]	Climate projections indicate temperature and precipitation changes which are likely to impact species and habitats in Warwickshire, given their	High [5]	Warwickshire has a number of habitats which provide carbon services, critically flood risk reduction for downstream areas. Their loss has an impact on the global atmosphere (warming) but will have a high	15

			fragmentation. Changes will be gradual.		reputational impact in Warwickshire who has committed to Net Zero.	
Ne6	Risks to agriculture and wildlife from water scarcity and flooding	High [5]	Climate projections indicate more frequent and intense drought and flooding events which will likely impact agriculture and wildlife. A useful water resources metric (NResQ50Imp) predicts 24% water availability reduction on average by 2050.	High [5]	Agricultural systems are generally rainfall fed in Warwickshire, apart from in the Avon Valley. Drought and water scarcity could undermine the viability of agriculture in the county having a significant impact on the social, economic, and environmental landscape of the county.	25
Ne7	Risks to freshwater species from higher water temperatures	Moderate [3]	Climate projections suggest temperature changes are likely to impact freshwater species. There is limited riparian forest cover in Warwickshire which would reduce the likelihood of heating. Changes will be gradual.	Moderate [3]	Impacts on freshwater species from higher water temperatures will cause impacts to spawning and aquatic biodiversity, affecting angling and small-scale aquaculture in Warwickshire's rivers and water courses. There is potential for reputational damage. The majority of freshwater bodies in Warwickshire currently receive bad, poor, or moderate WFD ecological status.	9
Ne8	Risks of land management practices exacerbating flood risk	Moderate [3]	Changes in land management could exacerbate flood risk, increasing frequency and severity of both surface water and fluvial flooding. Development controls are in place to reduce likelihood, but historically, gradual land use changes and changes in agricultural practices have exacerbated flood risk.	High [5]	Land management practices could involve development on river flood plains, deforestation, reduction of infiltration and evapotranspiration rates through paving of green spaces, all of which will considerably increase flood risk within the county.	15
Ne9	Risks to agriculture, forestry, landscapes and wildlife	Moderate [3]	Climate projections indicate changes in temperature and precipitation which may increase	Moderate [3]	Increase in invasive species, pests and pathogens will likely decrease the productivity of agricultural systems, the health and productivity	9

	from pests, pathogens, and invasive species		the incidence of pests, pathogens, or invasive species.		of forestry systems and significantly outcompete and harm wildlife.	
Ne10	Risks to agriculture, forestry, wildlife, and heritage from changes in frequency and/or magnitude of extreme weather and wildfire events	Moderate [3]	Climate projections suggest that incidence of wildfires and other extreme weather events are likely to increase within Warwickshire. Recent trends in the number of annual wildfires illustrate this.	Moderate [3]	Wildfires pose a severe risk to agriculture, forestry, wildlife, and heritage affecting productivity, yields and ecosystem health. Extreme events are likely to cause severe damage to these systems but are localised. Warwickshire have a number of strategic and operational controls to reduce impact of wildfires, but they do not fully consider climate change. Availability for water sources and hydrant in rural areas is a key issue.	9
Ne14	Risks and opportunities from changes in landscape character	Moderate [3]	Climate projections indicate changes in temperature and precipitation which are likely to affect the landscape character of the local area.	Low [1]	Climate changes are likely to have minor negative or minor positive impacts on the landscape character.	3
Infrastructure						
In1	Risks of cascading infrastructure failures across interdependent networks	High [5]	Climate projections for Warwickshire indicate that extreme weather events including flooding, heatwaves and storms are likely to increase in severity and intensity, making interdependent infrastructure more vulnerable to failure.	High [5]	Failure of infrastructure networks and cascading failures will significantly impact communities and businesses, including emergency services, transport, energy, and water, which could lead to injuries and fatalities.	25
In2	Risks to infrastructure services from river, surface	High [5]	Climate projections indicate that increased flooding, mainly fluvial flooding and flash flooding, is likely to increase and therefore	Moderate [3]	Warwickshire has significant flood risk areas, with local infrastructure affected by fluvial and surface water flooding. Apart from transport, there	15

	water and groundwater flooding		impact local infrastructure. Capacity of existing drainage is insufficient for both current and future flood water.		is limited critical infrastructure located in fluvial flood zones. 67km of A roads, B roads and motorways are located in flood zones.	
In4	Risks of sewer flooding due to heavy rainfall	Moderate [3]	Climate projections indicate increased rainfall intensities, combined sewer lines are likely to be overwhelmed and flood/overflow more regularly.	High [5]	Sewer flooding and combined sewer overflows will have negative impacts for communities and public health as well as impacts on water quality and freshwater biodiversity. The reputational risk lies with Severn Trent Water, but impacts are felt across Warwickshire. .	15
In5	Risks to bridges and pipelines from high river flows and bank erosion	Moderate [3]	Increased rainfall projected from climate change will likely increase river flows and hydraulic scour potential, damaging near-by bridges and pipelines, causing sediment build up and likely reduce conveyance. There is a design guide and inspection/operation system which reduces likelihood.	High [5]	Damage to bridges and pipelines will cause disruptions to transport, water and energy distribution and impact travel times for commuters and emergency services.	15
In6	Risks to transport networks from slope and embankment failure	Low [1]	Increased rainfall is anticipated with climate change which can lead to landslides and slope failures, but as there are not widespread areas of steep/unstable slopes within Warwickshire it is likely to be localised and infrequent.	Moderate [3]	Landslides and embankment failures are localised. They can have severe impacts for transport networks, particularly rail due to the steep embankments due to outdated design.	3
In8	Risks to subterranean and surface infrastructure	Low [1]	Increased temperatures, prolonged periods of heat and drought are projected to be more frequent, there can be increased risk of subsidence, but land	Moderate [3]	With incidences of subsidence near transport, energy, water or ICT networks, there are likely negative impacts including damage and	3

	from subsidence		movements within Warwickshire is not likely to occur.		disruption, with expensive and long-term impacts.	
In9	Risks to public water supplies from drought and low river flows	High [5]	The likelihood of drought is increasing due to changing rainfall patterns and increasing temperature.	Moderate [3]	Water supply planning by Severn Trent Water considers projected climate changes and prepares for water availability changes, which should reduce the impact of severe drought to restrictions rather than large scale interruptions of water supply.	15
In10	Risks to electricity generation from drought and low river flows	Moderate [3]	Climate projections indicate changes in rainfall patterns and droughts which may affect hydro-power generation in the UK.	Low [1]	There is limited reliance on hydropower in the national energy supply system.	3
In11	Risks to energy, transport and digital infrastructure from high winds and lightning	Low [1]	There is limited evidence that wind speed or frequency of high winds is increasing in the UK.	Moderate [3]	Damage to energy, transport and digital infrastructure will have negative impacts to communities, businesses, and emergency services. Operators have controls in place to manage existing risks, which are not expected to be exacerbated by climate change.	3
In13	Risks to transport, digital and energy infrastructure from extreme heat	Moderate [3]	Climate projections suggest temperature changes and increased heatwave incidence which may expose infrastructure to heat stress	Moderate [3]	Damage to energy, transport and digital infrastructure will have negative impacts to communities, businesses, and emergency services by impeding communication systems and access. Additional energy may be required to keep data centres cool during hot weather.	9
In14	Potential benefits to water,	Moderate [3]	Climate projections suggest temperature changes which may reduce the exposure of	Positive	A reduction in exposure of infrastructure to cold events would increase the reliability and efficiency	Positive

	transport, digital and energy infrastructure from reduced extreme cold events		infrastructure to extreme cold events.		of community services, including transport, energy, and ICT from reduced damage to infrastructure (for example reduced cracking roads and pavements and damage to vehicles).	
People and the built environment						
PB1	Risks to health and wellbeing from high temperatures	High [5]	Climate projections suggest increased heatwave incidence which is highly likely to impact public health and wellbeing.	High [5]	High temperatures will cause heat related illnesses and mortalities including dehydration and heat stroke, with severe impacts for vulnerable communities in particular the elderly and children. Level 4 heatwaves will also cause illness and fatalities among healthy adults. Illness and fatalities will impact the workforce and productivity.	25
PB2	Risks to drivers and passengers from high temperatures on public transport	Moderate [3]	Climate projections suggest temperature changes and increased heatwave incidence which are likely to impact private and public transport conditions.	Moderate [3]	High temperatures on public transport will result in negative impacts to the health and wellbeing of passengers, in particular vulnerable groups such as the elderly.	9
PB3	Opportunities for increased outdoor activities from higher temperatures	Moderate [3]	Climate projections indicate Warwickshire will experience higher temperatures therefore there will be more opportunities for outdoor activities. However, these will be accompanied by temperature extremes.	Positive/ Neutral	More opportunities and availabilities of outdoor activities will have a positive impact on the health and wellbeing of the population, potentially reducing inequalities among the population and increasing tourism. Conversely, more water related outdoor activities in hot weather has led to increased rescue call outs for people swimming in	Positive/ Neutral

					rivers and lakes for our Fire and Rescue Service.	
PB4	Potential benefits to health and well-being from reduced cold	Moderate [3]	Climate projections indicate temperature changes which are likely to reduce the incidences of extreme cold to a negligible level, reducing the risk to public health and wellbeing.	Positive	A reduction in the occurrences and severity of extreme cold temperatures will improve public health and wellbeing, reducing the burden on emergency services in the winter period and reduce the associated costs, including winter energy requirements.	Positive
PB5	Risks to people, communities, and buildings from flooding	High [5]	Climate projections suggest that increased pluvial and fluvial flooding is likely to impact some areas of the local community. Surface water flood risk has been mapped and fluvial flood risk is relatively widespread in the county, impacting among other communities, Nuneaton, Stratford, Warwick, Royal Leamington Spa, Barford, Shipston.	High [5]	Flooding can cause severe impacts for people, communities, and buildings with severe social, economic, and environmental impacts such as property damage, school closures, disruption to services such as transport including emergency services and injury and fatality risks to people.	25
PB7	Risks to building fabric from moisture, wind and driving rain	Moderate [3]	Climate projections for Warwickshire indicate that extreme weather events including flooding, and storms are likely to increase in severity and intensity, although specific data on storms are limited. However more frequent, intense rainfall events may lead to greater moisture inside buildings.	Low [1]	Higher moisture inside buildings is anticipated to have minor impacts, such as damage to furniture and carpets although this is more likely to occur in vulnerable households.	3
PB8	Risks to culturally valued structures and	Moderate [3]	Climate projections indicate that temperature, precipitation, and extreme weather changes might increase in frequency and	Moderate [3]	Culturally valued structures and historic areas are generally sensitive to environmental hazards. Heatwaves, floods, and droughts are	9

	the wider historic environment		intensity, which are likely to impact cultural or historical environments.		likely to cause irreversible damage. Damage to cultural structures has a lower impact than housing on residents, however, it will have a negative impact on tourism, and therefore the local economy.	
PB9	Risks to health and social care delivery from extreme weather	High [5]	Projected increases in extreme weather, particularly heatwaves would likely to impact delivery of health and social care and increase negative health impacts such as heat stress.	High [5]	Inability to deliver health and social care due to extreme weather will have severe negative impacts for the community including higher fatality rates and considerably among the vulnerable population.	25
PB10	Risks to health from changes in air quality	Moderate [3]	Projected increases in the intensity and severity of heatwaves and wildfires, will impact air quality conditions, particularly in urban areas.	Moderate [3]	Poor air quality can have considerable impacts on the health and wellbeing of communities such as respiratory diseases. These impacts are likely to be in urban areas and primarily impact vulnerable people such as children, the elderly and low-income people.	9
PB11	Risks to health from vector-borne pathogens	Low [1]	Global changes in both temperature and precipitation may lead to a greater risk of vector borne diseases if changes create favourable conditions for survival of the vectors.	Moderate [3]	Increase in prevalence of vector borne diseases will have significant impact on public health, increasing illness and fatalities and increasing the burden on health care providers. It will likely also increase stress among the population of Warwickshire.	3
PB12	Risk of food borne disease cases and outbreak	Moderate [3]	Projected changes in temperature may lead to greater risk of food borne diseases, particularly in extreme heat.	Moderate [3]	Food-borne diseases have negative public health and wellbeing implications and cause increased burden to public health services.	9
PB13	Risks to health from poor water quality	Low [1]	Water supply planning by Severn Trent considers projected climate changes and prepares for water	Moderate [3]	Poor water quality has negative public health and wellbeing	3

			availability and quality changes therefore mitigation measures in place will prevent poor water quality.		implications and causes increased burden to public health services.	
PB14	Risk of household water supply interruptions	Low [1]	Water supply planning by Severn Trent considers projected climate changes and prepares for water availability and quality changes therefore there is low risk of interruption to household water supply. There is a risk of water restrictions.	High [5]	Interruptions to water supply likely to have negative public health and wellbeing implications and cause increased burden to public health services.	5
Business and industry						
Bu1	Risks to business sites from flooding	High [5]	Climate projections indicate there will be increased frequency and severity of fluvial and pluvial flooding.	High [5]	Currently commercial properties worth over £1.3bn are exposed to flooding in Warwickshire. Flooding would likely impact business located in flood-risk areas (and adjacent to as climate change exacerbates flooding) and the supply chains and operations of many businesses.	25
Bu3	Risks to business operations from water scarcity	Moderate [3]	Non-household abstractions in Warwickshire are relatively limited but include machinery and electronics, quarrying and extraction, and waste and recycling, golf courses, and agriculture. Water availability is expected to reduce with climate change.	High [5]	Drought and reduced water availability can severely impact water dependent industries including manufacturing and industrial processes which will disrupt and delay business operations.	15
Bu4	Risks to business from reduced access to capital	Low [1]	Increases in global and national extreme weather events may reduce business access to capital, however this is unlikely.	Moderate [3]	If climate change reduces access to capital, certain businesses might experience negative financial impacts.	3

Bu5	Risks to business from reduced employee productivity, due to infrastructure disruption and higher temperatures in working environments	Moderate [3]	Projections of temperature and precipitation indicate likely changes in the frequency and severity of flooding, heatwaves, and droughts, which are all likely to effect employee productivity. The workforce represents a less vulnerable sector of the demographic to such weather, although level 4 heatwaves will also impede healthy adults.	Moderate [3]	Heatwaves and extreme temperatures are likely to impact health and wellbeing of workers, decreasing productivity, preventing access to workplace and more absences. Similarly, there will be an increase in school closures in high temperatures.	9
Bu6	Risks to business from disruption to supply chains and distribution network	Moderate [3]	Global and national changes in temperature, precipitation and extreme weather are likely to disrupt supply chains and distribution networks.	Moderate [3]	Disruption to supply chains and distribution network is likely to have financial implications for businesses by delaying and disrupting business operations. There would wider economic implications including rising inflation and higher cost of living for residents.	9
Bu7	Risks and opportunities for business from changes in demand for goods and services	Moderate [3]	Changes in local, national, and global climate will likely change demand patterns towards certain goods and services, for example and increased demand for air conditioning and a reduced demand for heaters.	Low [1]	Changes in demand is likely to have minor positive or minor negative impacts on businesses in Warwickshire.	3

Climate change adaptation framework

We have developed an integrated framework (right) to deliver climate change adaptation across Warwickshire under four Themes. The framework allows space for both internal and external partnerships to deliver climate change adaptation across our service areas and the county as a whole. Under this framework, we can develop integrated climate adaptation initiatives which will have climate adaptation and wider benefits, raising awareness of climate risks and integrating the council's response to climate change across a range of service areas and partnerships.

We have prioritised the initiatives under Themes 2 to 4 by identifying which risks in the Climate Change Risk Assessment (Table 2) are addressed by each initiative, and then calculating the combined risk score. The 10 highest combined scores have been identified below as priority initiatives.

Guiding principles

The principles guiding this plan are as follows:

- The plan is integrated across sectors and service areas and into existing and planned projects and programmes to bring about multiple benefits including climate adaptation.
- The plan includes both mainstreaming resilience into our operations and supporting partners to adapt the wider county to climate change.
- We can test strategic initiatives, where there are opportunities for us to show leadership and innovation to encourage wider take-up.
- We have grounded this plan in our existing strengths and processes, linking ongoing initiatives, and addressing existing weaknesses. Realistic short- and medium-term initiatives have been developed which can be scaled up in future iterations of this plan.
- The planning and engagement process required to develop this plan has built understanding of climate risks across the council and involved stakeholders, improving capacity to deliver resilience.

Mainstreaming resilience into council operations

- Mainstreaming climate change resilience into policy development
- Mainstreaming climate change resilience into project planning and prioritisation processes
- Embedding climate change risks into our risk assessment processes across council operations
- Creating a climate change adaptation responsibility in the Council to:
  - Develop and communicate knowledge resources and data around climate change risks and resilience to both internal and external stakeholders
  - Take a strategic lead in climate change adaptation across Warwickshire
  - Review, monitor, update, coordinate and supporting delivery of this Plan.

Water, land and biodiversity

i. Strategically integrate adaptation into WCCs biodiversity program
ii. Develop a flood risk management program which supports adaptive water systems
iii. Support development of resilient agricultural systems which provide benefits across climate impacts
iv. Use WCCs land assets to pioneer systems based adaptive approaches through partnerships

Infrastructure, places and people

i. Adapt transport system to support a resilient economy and adaptive and inclusive service provision across waste, fire and rescue and health
ii. Support development of a resilient energy and water supply and distribution networks
iii. Lead on placemaking for urban climate adaptation
iv. Support development of adaptable work environments, buildings, and a public health system that can cope with extreme weather

Mainstreaming climate change into emergency planning and response

i. Knowledge of climate change integrated into emergency planning and risk assessment for extreme weather and other climate related risks
ii. Improved communication of weather warnings and forecasts
iii. Support community-based emergency planning and adaptation

Theme 1: Mainstreaming climate change resilience into council operations

We, as a Council, declared a climate emergency on the hottest day of summer 2019 and embedded climate change into our strategic priorities. We have identified a set of enabling actions which we need to follow across the council to mainstream climate change resilience into our operations.

1. **Mainstreaming climate change resilience into policy development**. We have adopted a Health in All Policy (HiAP) approach (see Box 2). Similar to this, we propose that when policy is being updated or newly developed, the impacts of climate change will be considered and the policy wording amended appropriately, where necessary.
2. **Mainstreaming climate change resilience into project planning and prioritisation processes**. We are currently adapting a climate change investment rating tool developed by Cambridge City Council for use in evaluating how investments will affect (positively or negatively) the ability of Warwickshire to withstand flooding, overheating, water stress/drought, and ecological resilience. These considerations will be embedded into project development and approval processes, which will provide opportunities for project design to consider climate change, and ultimately develop more climate resilient investments in Warwickshire.
3. **We will embed climate change risks into our risk assessment processes across council operations**. We will update our risk assessment process and risk registers of relevant service areas to incorporate how a changing climate may impact each risk.

Box 2 Health in All Policy Approach

Health in All Policys: Adopting a (Health in All Policies) HiAP approach aims to make health everyone's business and to support people to understand the connections between policies and programmes and health and wellbeing. The approach focusses on areas within the wider determinants of health including climate and sustainability, transport, education, and employment.

To support delivery of this climate change adaptation plan, and the initiatives described in the coming sections, we have identified a set of actions that will need to be coordinated across the Council by a newly established dedicated resource for climate change adaptation who would report to our climate change coordinator to:

- Work across the council to play a lead role in embedding climate change adaptation in all that we do through a joined-up approach, this includes supporting the delivery of the 'mainstreaming' actions identified to the left.
- Develop knowledge resources and approaches to communicating risk and resilience measures to relevant internal and external stakeholders (see below table), in assessing climate change risks and delivering climate change adaptation initiatives.
- Take a strategic lead in climate change adaptation across Warwickshire. This includes convening events to stimulate collaboration, sharing knowledge, and acting as a repository for data, information and tools related to climate change adaptation.
- Coordinating and supporting delivery (by providing technical inputs) of this plan and the initiatives developed within it. Evolve the plan as necessary to ensure that we meet our commitments to mitigate risks to Warwickshire from climate change.

Table 3 Key stakeholders identified during this planning process

Key stakeholder	
Districts and borough councils of Warwickshire	The West Midlands Combined Authority
Severn Trent Water	Western Power Distribution
River Severn Partnership	River Trent Partnership
Warwickshire Wildlife Trust	NFU West Midlands
The Warwickshire Local Resilience Forum	Coventry Solihull Warwickshire Resilience Team

Source: AECOM. 2022.

Theme 2: Water, Land and Biodiversity: Climate change adaptation initiatives

WL1 (priority initiative) – Integrate climate adaptation into the criteria for selection of Biodiversity Net Gain (BNG) sites.

Climate Change Risks Addressed:

- Ne1, 2, 5, 6, 9
- In2, 6, 9
- PB1, 5, 8, 11
- Bu1, 3

Action Owner:

Ecology, Historic Environment and Landscape

Actions:

1. Review Biodiversity Net Gain Strategy and assess criteria for selection of sites.
2. Maintain focus on habitat connectivity and quality but integrate criteria for adaptation potential. This will include: sites upstream of a high flood risk area; site located in Source Protection Zones (groundwater recharge area); steep slopes susceptible to soil erosion; river corridors; sites in or near an area susceptible to urban heating or wildfire risk.
3. Map these areas with the highest land-based adaptation potential.
4. Share information and map with districts to safeguard land-based adaptation assets through development of Local Plans.

Description and Purpose: Climate change adaptation and biodiversity are inextricably linked, changes in climate such as temperature, rainfall, humidity etc. directly impact ecosystems, including the survival of different species. This includes species behaviour (i.e., seasonal life cycle events such as migration, blooming, hibernation, or reproduction), distribution and abundance of species, and also habitat change or destruction.

Greater size, variety, quality, and connectivity of habitat provides greater ecosystem resilience to climate change. Furthermore, healthy ecosystems also provide ecosystem services, beyond biodiversity itself. Strategically located areas for ecological restoration can provide adaptation services to Warwickshire, by reducing surface runoff, improving water quality, promoting groundwater recharge.

WCC plays a role in achieving biodiversity net gain of development projects by supporting developers identifying and prioritising mitigation sites. Currently, the focus is on habitat connectivity and quality, but additional criteria will be included in the site selection process to strategically provide adaptation benefit through natural flood management approaches.

WL2 (priority initiative) – Provide leadership in developing and implementing Environmental Net Gain Policy.

Climate Change Risks Addressed:

- Ne 1, 2, 3, 5, 6, 8, 9
- In2, 5, 6, 9
- PB1, 5, 10, 11, 13
- Bu1

Action Owner:

Ecology, Historic Environment and Landscape

Actions:

1. Lead and collaborate with Local Authorities on development of ecosystem services markets
2. Develop a natural capital investment approach which has biodiversity climate change adaptation and mitigation at its core.
3. Support development of local policy through local plans, and supplementary planning documents.
4. Develop pilot projects for both nutrient neutrality and flood risk mitigation.

Description and Purpose: Building on WCC's leadership in development of local Biodiversity Net Gain Policy within the county's districts and boroughs and integrating climate adaptation principles into the approach to site selection (Initiative WL1), work is ongoing to establish other ecosystem services markets in Warwickshire.

WCC will lead dialogue, research, and development of policy to be enacted by local authorities for environmental net gain. WCC can lead this by developing an overarching natural capital investment approach based on a range of mandatory and voluntary ecosystem services markets which can contribute to climate adaptation, including BNG, nutrient neutrality, flood risk mitigation, air quality, as well as markets for carbon and social prescribing. This is currently in the early stages of planning.

WL3 (priority initiative) – Update tree planting strategy to benefit climate adaptation.

Climate Change Risks Addressed:

- Ne1, 2, 4, 5, 6, 9, 10
- In1, 2, 5, 9,10
- PB2, 5, 10
- Bu1, 3

Action Owner:

Ecology, Historic Environment and Landscape

Actions:

1. Review the strategic approach of Warwickshire and West Midland's Combined Authority's tree planting scheme and identify priority areas which would increase climate resilience in the county – in floodplains, upstream of high flood risk areas, in urban areas to provide shading and temperature control.
2. Evaluate and select a variety of species for their resilience to high temperature, drought, extreme rainfall, and pests. This includes their ability to grow, resist and perform their primary function of carbon sequestration under new climatic conditions.

Description and Purpose: Tree planting schemes have been initiated across the UK and globally to mitigate climate change and offset residual GHG emissions. In this sense, tree planting has focussed on maximising carbon sequestration which often requires intensive forest management. With this aim, the tree species are selected for factors such as high growth potential, and carbon capture potential but rarely consider possible climate adaptation benefits.

We are aiming to plant 556,000 trees (one for every resident) by 2030. Like initiative WL1, the location of tree planting sites will be strategically selected to provide additional benefits for climate adaptation.

Additionally, to promote climate resilience of the planting programme, native species shall be prioritised, and species diversity will be considered, rather than the monoculture nature of most tree planting schemes. Species will be selected for drought tolerance and resilience to pests which may become more prevalent as a result of climate change.

WL4 – Support reintroduction of keystone species for water-based climate adaptation.

Climate Change Risks Addressed:

- Ne1, 2, 6, 9
- In2, 5, 9
- PB5, 10, 11, 13
- Bu1

Action Owner:

Ecology, Historic Environment and Landscape
(supporting role only if plans emerge within Warwickshire)

Actions:

1. Support projects put forward by landowners or conservation groups for sustainable reintroduction of keystone species.
2. Consult with the Environment Agency, Natural England, Warwickshire Wildlife Trust, Severn Rivers Trust, Severn Trent Water, and other relevant stakeholders.
3. Support development of a collaborative plan for reintroduction, advising on ecology and flood risk.
4. The plan would require EIA to evaluate and mitigate any negative impacts (e.g. beavers increasing flood risk locally, meaning landowner and site selection are critical)

Description and Purpose: Keystone species, like beavers, play an essential role in natural ecosystems. Specifically, beavers have the ability to transform freshwater ecosystems and hydrological function. The natural behaviour of beavers supports creation of wetland, improved water resources during droughts, supports continuous water flows, attenuates flow peaks to reduce downstream flooding risk, and improves water quality – in relation to both sediment and nutrients.

Beavers have been successfully reintroduced to Derbyshire after 800 years through Derbyshire Wildlife Trust project supported by Severn Trent Water.

WL5 – Prepare public awareness materials on threats to wildlife such as invasive species and climate risks based on national guidelines.

Climate Change Risks Addressed:
Ne1, 2, 6, 7, 9

Action Owner:

Ecology, Historic Environment and Landscape

Actions:

1. Review national strategy for invasive species management including Management measures for widely spread Invasive Alien Species (IAS) in England and Wales, 2019, as well as guidance from the woodland trust.
2. Consult and collaborate with other stakeholders including Warwickshire Wildlife Trust, The Environment Agency and DEFRA to align strategies.
3. Disseminate published materials to local wildlife, conservation, and land management groups.
4. Implement invasive species management in council landholdings, including country parks, in line with strategic guidance.

Description and Purpose: There are several threats to biodiversity including habitat loss, human activity (i.e. collisions and pollution), and a changing climate. Invasive species and pests exacerbate these, as they outcompete native species and can have negative impacts on native ecosystems.

Involving citizens in tackling this issue can extend the council's resources for control of invasive species, protection of ecosystems and support climate resilience. If citizens are more aware of, and able to, identify invasive species, they can support the council to tackle the threat and might volunteer time and resources to the issue.

One such threat is the North American Grey Squirrel, introduced in the 19th century. The Grey Squirrel threatens and outcompetes the native Red Squirrel and lacks natural predators to control the population. Moreover, the Grey Squirrel hinders the UK's ambitions to restore woodlands for carbon sequestration, biodiversity gain and climate change adaptation by stripping trees of their bark and killing broadleaf and other species critical to achieving the goals of these environmental issues.28

WL6 – (priority initiative) Identify areas with biodiversity and climate adaptation potential for safeguarding from development.

Climate Change Risks Addressed:

- Ne1, 2, 4, 6, 8
- In2, 4, 9

Action Owner:

Ecology, Historic Environment and Landscape

Actions:

1. Develop a Green Infrastructure Strategy (ongoing) which identifies green infrastructure, habitats, including opportunity mapping for nature-based solutions (NbS).
2. Provide support to local authorities in undertaking biodiversity audits and maintain and continue to update WCC's existing geodatabase of habitats in Warwickshire.
3. Share with Local Authorities and provide ecological advice to safeguard areas with biodiversity and adaptation potential in the Local Planning process.

[28] Forestry Commission. 2019. Controlling grey squirrels in forests and woodlands in the UK. Controlling grey squirrels in forests and woodlands in the UK - Forest Research

• PB1, 5, 10, 11, 13 • Bu1		
Description and Purpose: WCC has online maps of current habitats across Warwickshire, some of which are critical to local biodiversity and provide other benefits, including resilience. To protect and augment these, we propose to develop a green infrastructure strategy which includes updated mapping that will enable Local Authorities to ensure critical habitats, and areas with high biodiversity potential (e.g., potential future wildlife corridors), are safeguarded from development through Local Plans.		

WL7 – Support Severn Trent Water to reduce wastewater pressure on water quality.		**Actions:**
Climate Change Risks Addressed: • Ne6, 8, 9 • In2, 4 • PB5, 13	**Action Owner:** Lead Local Flood Authority (LLFA)	1. Support Severn Trent Water in developing strategies for CSO reduction in Warwickshire, offering implementation support where WCC has responsibilities, opportunities, and influence – particularly related to existing and future flood risk reduction to property. 2. As statutory consultee, the LLFA will ensure all new development meets the highest standard for discharge of surface water to support infiltration. This will include avoiding discharge of water to foul networks.

Description and Purpose: Climate change will increase pressure on water resources and could impact water quality through a number of mechanisms: for example, increased soil erosion, and agricultural runoff, increased frequency of combined sewer overflows (CSOs). These climate change impacts will impact freshwater ecosystems. Under the Environment Act 2021, the government placed a legally binding duty on water companies to progressively reduce the occurrence of CSOs, including by 2050 no CSOs will occur outside unusually heavy rainfall periods[29]

As noted in Severn Trent Water's Climate Adaptation Plan[30] their Green Recovery project includes environmental improvements on 500km of rivers, 35 additional phosphate removal projects, monitoring at 150 CSO locations, and fast-tracking improvements at 100 CSOs. In the Drainage and Wastewater Management Plan, Severn Trent Water outline a strategic aim to reduce spills from CSOs to an average of 20 per year by 2025.

The LLFA will work closely with Severn Trent Water wherever possible at both strategic and operational levels to ensure flood risk and surface water drainage is managed appropriately and as sustainably as possible. This will support Severn Trent in their role in reducing water quality pressures in Warwickshire. The approach will include:

- Supporting the use of or retrofitting of Sustainable Drainage Systems (SuDS) on Severn Trent Water projects and WCC transport project,
- Highlighting reports of property flooding from the sewer network to Severn Trent Water and work with them and other risk management authorities in resolving the problem, where appropriate,
- Ensuring new development meets or exceeds requirements for attenuating surface water runoff (with climate change uplifts applied).

Through this process the frequency of CSO spills can be reduced, producing improvements in water quality, while also reducing flood risk to properties.

[29] Department for Environment, Food and Rural Affairs. 2022. Storm Overflows Discharge Reduction Plan.
[30] Severn Trent Water. 2021. Climate Change Adaptation Report.

WL8 – Reinforce the LLFA role in integrating climate adaptation into flood risk management projects and as statutory consultee on major new developments with surface water drainage.

Climate Change Risks Addressed:

- In1, 2, 4, 5
- PB5
- Bu1

Action Owner:

Climate change adaptation officer and LLFA with support from external consultant

Actions:

1. Evaluate climate change impacts across the LLFA's responsibilities and activities.
2. Identify climate impact thresholds and climate trends and projections.
3. Develop LLFA specific adaptation action plan to cover ways to:
   a. Improve communication with stakeholders to reduce flood related risks, including those who operate critical infrastructure.
   b. Identify projects to reduce surface runoff across catchments and working with a variety of landowners.
   c. Develop education initiatives to support people's awareness of flood risk and their responsibilities in reducing it through personal property management
      i. Integrate climate risks (and climate adaptation) into planning responses and support to local authorities as statutory consultees for flood risk – technical advice related to Local Plans and SPDs, other guidance and strategies to encourage and mandate SuDS and Green Infrastructure.

Description and Purpose: The processes for incorporating climate change into development control and flood risk management projects is already well established and understood by the Lead Local Flood Authority (LLFA) and regularly updated through national planning and Environment Agency guidance.

This initiative refers to an internal process to mainstream climate resilience into the LLFA's operations and activities which will ultimately result in climate adaptation across the county.

WL9 – (priority initiative) Promote naturalisation of flood flow conditions by increasing coverage of floodplain woodlands, coupled with river and floodplain restoration.

Climate Change Risks Addressed:

- Ne2, 5, 6, 8
- In2, 4, 5
- PB1, 5, 9, 10, 13
- Bu1

Action Owner:

Ecology, Historic Environment and Landscape
With support from LLFA

Actions:

1. Through development of Nature Recovery Strategy and Natural Capital accounting approaches, map and identify suitable sites for riparian woodland and river restoration, assessing factors such as proximity to the water course, between the water course and adjacent land like agricultural land. Unsuitable sites include alongside flood embankments with a wind blow risk or near to bridges or culverts where woody debris could block the watercourse and exacerbate flooding.
2. Identify suitable land owned by WCC, including country parks, and identify land holdings of collaborative stakeholders.
3. Collaborate with partners.
4. Promote riparian woodland planting across Warwickshire to learn lessons and share knowledge gained.
5. Plant riparian woodland species such as deep-rooted Alder, in selected sites.

Description and Purpose: Over centuries our river systems and hydrological systems have been changed by human activity, as a result there is less capacity for infiltration and flow attenuation both in-stream, in the floodplain and in the catchment. These (primarily land use) changes result in higher peak flows and therefore greater flood risk. Climate change exacerbates this as rainfall intensity is increasing.

Re-connecting rivers with floodplains, and re-meandering streams provides space for floodwater, supporting attenuation of peak flows. Planting of riparian woodland has been shown to improve soil infiltration rates by 90% compared with heavily grazed pasture.31 Riparian woodland ultimately develops large woody debris in stream which promotes floodplain connectivity and provides benefits related to water quality and sediment dynamics. Planting in the floodplain slows floodplain flows in the event of a flood, by increasing floodplain 'roughness', catchment natural flood management-based approaches reduce surface runoff and promote infiltration, benefiting water resources.

Restoration projects have multiple benefits, improving water quality, reduce water temperature and increase biodiversity. Slowing flows and promoting infiltration also has climate adaptation benefits for water resources.

WCC can deliver projects like this within its own land holdings and also contribute by collaborating and supporting such projects with a range of stakeholders and landowners, providing technical inputs related to flood risk, and sharing knowledge and lessons learned to scale these efforts.

Existing opportunities include:

- Catchment-scale strategic partnerships
- Severn Trent Water's river restoration and environmental improvement program
- Supporting community flood risk management groups to implement natural flood risk management
- Working with landowners and other stakeholders to support development of restoration projects
- Linking with Initiative WL3 which will be working with receptive landowners
- Linking with Initiative WL2 to promote natural capital and ecosystem services approaches including flood risk mitigation and nutrient neutrality.

The River Severn Partnership Demonstrator Project on the Warwickshire Avon represents an opportunity to share ideas, implement projects, and learn lessons in riparian land management for climate adaptation.

WL10 – Work with and support community flood action groups sharing lessons learned to scale up community-based adaptation.

Climate Change Risks Addressed:

- Ne6, 8
- In2, 4
- PB5
- Bu1

Action Owner:

Lead Local Flood Authority (LLFA)

Actions:

1. WCC will work with the local flood risk groups and other stakeholders to share knowledge and lessons learnt between communities and scale up the successes of community flood risk management. This will include supporting community groups in becoming self-governing and well-informed groups, for example through provision of guidance, information, and local engagement.

Description and Purpose: Community-based adaptation to climate change is known to be a cost-effective and impactful method to adapt to a changing climate. Drawing on the community's wealth of knowledge and experience of living with flooding and having witnessed the changing severity and frequency of floods allows for a community-led, bottom-up approach to flood risk management which empowers residents and focusses on the priorities and needs of the community.

[31] Scottish Environment Protection Agency. 2015. Natural Flood Management Handbook.

A number of Flood Action Groups in Warwickshire have successfully brought together community members to take action on flooding by fundraising and working with landowners to implement natural flood management approaches upstream of high-risk areas. The successes of these community group, and lessons that have been learned, can be scaled up in other communities throughout Warwickshire.

WL11 (priority initiative) – Improve communication of Met Office forecasts and seasonal outlook to farmers through the local resilience forum.

Climate Change Risks Addressed:

- In1, 11, 13
- PB1, 2, 5, 9, 10, 12
- Bu1, 5

Action Owner:

Local Resilience Forum, using their links to the Met Office

Actions:

1. Discuss seasonal outlook forecasts with Met Office contacts.
2. Disseminate the information through appropriate channels to the farming community in the county.

Description and Purpose: Short term weather forecasting is readily accessible to farmers through the Met Office, and improvements in forecasting supports improved agricultural management, including the effectiveness (timing) of fertiliser application, which has water quality benefits. Seasonal forecasting is available but often overlooked and shall be used to identify drier or wetter than average growing seasons and inform the selection of crop types for better yields and more resilient agricultural output.

WL12 – Develop a demonstration farm for education and piloting climate adaptation, mitigation, and biodiversity in farming.

Climate Change Risks Addressed:

- Ne1, 2, 3, 4, 5, 6, 8, 9, 10

Action Owner:

Smallholdings management team with initial support from Climate Change adaptation officer in identifying potential partners.

Actions:

1. Include this proposal in an update to the smallholding strategy.
2. Identify potential partners and reach out to them for their interest (this proposal needs some input from an educational partner, but we believe it is an attractive proposition for an educational institution who rarely have access to agricultural land for scientific purposes).
3. Draft a memorandum of understanding (MOU) for the project with the identified partner.
4. Support the partner in drafting the objectives of the demonstrator project.
5. Develop a set of selection criteria to identify a suitable smallholding. Criteria will include, lease up for renewal, strategic location, size, productivity.
6. Secure a tenant who commits to developing a plan and running the farm in line with the objectives of the demonstrator project (including allowing for monitoring and reporting on progress).
7. Establish a baseline, then implement demonstration projects on farm, related to crop selection, regenerative farming, re-wilding of unproductive land, natural flood management.
8. Access funding for some of the projects through grants.

		9. Share knowledge, use the site for community education program.

Description and Purpose: Warwickshire is a predominantly rural county. Existing large-scale arable and livestock farming practices degenerate soils, increase surface runoff, impact water quality, and inhibit biodiversity. There is growing research in farming techniques which regenerate soils, reduce soil erosion, capture carbon, and promote on farm biodiversity. Furthermore, there is a need for the agricultural sector to adapt crop selection to changing climates. Unproductive areas can be set aside for woodland, wetland, or rewilding programs for climate change adaptation.

It is challenging for farmers in Warwickshire to take decisions to move away from traditional farming approaches without first-hand demonstration of the benefits. It is proposed to establish a demonstrator farm on one of WCCs smallholdings to promote regenerative farming and other adaptive farming practices which promote biodiversity. Also, to trial alternative crop species which may thrive in warmer temperatures or may be more resilient to drought and pests. DEFRA grants can be accessed for sustainable farming initiatives, and lessons learned in accessing funding can also be shared with the agricultural community.

The demonstrator farm can be operated as an educational farm with an academic partner – a local university or agricultural college – and opened to the public, schools, and the farming community. They would be able to set the objectives and monitor and report on the successes of the demonstrator farm.

Theme 3: Infrastructure, Places and People: Climate change adaptation initiatives

IPP1 – Develop a climate adaptation plan for our transport services.

Climate Change Risks Addressed:

- In1, 2, 6, 11,13
- PB2, 9
- Bu6

Action Owner:

Climate change adaptation officer and Transport and Highways

Actions:

1. Follow the UKCIP Wizard to develop a climate adaptation plan for transport services setting out steps to adapt transport planning and operations to climate change.

Description and Purpose: Building on the development of operational climate change adaptation plans for WCC's flood risk, public health, and fire and rescue services, apply the same methodology to transport planning and operations. The process follows UKCIP's Adaptation Wizard, firstly, identifying climate change impacts, and critical thresholds, then evaluating future climate change vulnerability to develop a climate adaptation action plan to cover transport planning, public transport, and maintenance of transport infrastructure.

IPP2 – Liaise with external transport owners and operators to support them with preparation of climate change adaptation plans.

Climate Change Risks Addressed:

- In1, 2, 6, 11,13
- PB2, 9
- Bu6

Action Owner:

Transport and Highways with support from the Climate change adaptation officer

Actions:

1. Make use of existing county-wide transport sector forums to bring climate risk assessment and adaptation planning to the attention of relevant stakeholders.
2. After developing a climate change risk assessment and adaptation plan for the council's transport services (under Initiative IPP1), provide guidance on the adaptation planning process, and support knowledge sharing across the county, particularly with respect to climate change information, projections, and risks.

Description and Purpose: Climate change impacts on transport infrastructure include, but are not limited to, flood and erosion related damage to road and rail, particularly at bridges and other structures; buckling of railways and melting or softening of tarmac in extreme heat, subsidence impacts due to abnormal groundwater levels during drought; issues related to safety and comfort of passengers on public transport during extreme heat.

Climate impacts to transport systems also have secondary impacts on emergency services, business continuity and the economy, education, waste collection and maintaining safety and operations.

As there are many complex risks and adaptation approaches which are specific to the various types of infrastructure and operations within the transport sector WCC will promote, encourage, and support owners and operator of transport infrastructure or services in the county to undertake a climate risk assessment and develop an

adaptation plan accordingly. This includes, for example: Network Rail, National highways, midlands connect, west midlands combined authority, rail operators, bus operators, and Local Authorities. Progress in climate adaptation planning among these stakeholders varies.

WCC will provide a supporting role by sharing local climate change information and risk assessments already undertaken (under initiative IPP1), as well as validating adaptation plans to ensure integration and alignment of adaptation strategies across the county's transport system.

IPP3 – Review and update council design guidelines to integrate climate resilience into the design and specification of new transport, public space and green infrastructure assets.

Climate Change Risks Addressed:

- Ne8
- In2, 4, 11, 13
- PB3, 5, 8
- Bu1

Action Owner:

Engineering Design Services and County Highways

Actions:

1. During any future updates to design guidelines, update them to include approaches to manage climate risks to the transport sector established under initiative IPP1 and IPP2.
2. To illustrate and apply best practice, incorporate resilience into design of future county Highways projects, incorporating SuDS design which manages surface water runoff from beyond the project boundary, provides shading to pedestrians and cyclists, incorporates more resilient surface and other materials.

Description and Purpose: The Warwickshire design guide covers street design, drainage and flood risk, and green infrastructure. Climate change uplift is already described in the SuDS design under drainage, but climate change will be considered in surfacing, establishing the Highways Resilient Network, pedestrian and cycle facilities, public transport stop provisions, structures, and green infrastructure and planting.

The design guide does not cover design of solid waste management assets, such as landfills, but climate change shall be incorporated into the design of landfills and associate infrastructure (leachate treatment etc.) on a case-by-case basis.

IPP4 – Upgrade drainage in critical locations at high risk of surface water flooding.

Climate Change Risks Addressed:

- Ne8
- In2, 4, 5
- PB5

Action Owner:

County Highways and LLFA

Actions:

1. Identify, prioritise, and upgrade drainage to reduce risk of surface water flooding on the Highways Resilient Network.
2. Trial retrofit SuDS on the highway network.

• Bu1		

Description and Purpose: The Highways Resilient Network identifies transport infrastructure which is given priority maintenance and other measures to maintain economic activity and access to key services during extreme weather.

Liaise with Lead Local Flood Authority (LLFA) to identify locations on the Highways Resilient Network at high-risk of surface water flooding, with frequent incidences of historic flooding. Develop projects to upgrade drainage in these areas, retrofitting suds where possible and appropriate, to ensure flooding issues are not passed downstream**.**

IPP5 – Support utilities' climate adaptation planning and implementation.

Climate Change Risks Addressed:

- In1, 2, 4, 5, 9, 10, 11, 13
- PB13, 14
- Bu3, 6

Action Owner:

Climate change adaptation officer through Local Resilience Forum who engage with resilience leads of utilities.

Actions:

1. Engage in utilities' climate resilience planning process.
2. Provide relevant inputs, possibly related to demand estimation (in growth areas), and climate risk assessment of specific critical assets in Warwickshire.
3. Support implementation of specific activities where necessary/relevant – likely related to demand management, communication and awareness, regional activities (catchment-based approaches), maintenance programmes, project development (planning support).

Description and Purpose: Western Power Distribution (National Grid) and Severn Trent Water assets are at risk from climate change; they both have climate adaptation plans (2011 and 2021, respectively). As key (local authority) stakeholders, and members of the local resilience forum, we will provide planning inputs and local climate risk information to support updates and implementation of utility climate adaptation planning to deliver resilience to climate related hazards in both power and water distribution systems.

IPP6 – Work with local authorities to integrate energy and water efficiency measures in local plan making and policy.

Climate Change Risks Addressed:

- In9, 10
- PB14
- Bu3

Action Owner:

Climate change adaptation officer

Actions:

1. Through local authority climate change working groups, support development of water and energy efficiency policy which goes beyond national requirements.
2. Suggest and support development of climate change Supplementary Planning Documents in districts where local policy is outdated.
3. Develop example policy wording for inclusion in policy documents.
4. Demonstrate water and energy efficiency best practice in council buildings.

Description and Purpose: Per capita energy and water demand reduction are critical to delivering resilience in supply systems, by developing a buffer between supply (availability) and demand. Through local plan development and policy, local authorities (districts) within Warwickshire are able to impose standards on new developments; these must be more ambitious than national minimum energy efficiency requirements set out in Building Regulations, Part L, and water use requirements set out in Building Regulations Part G.

Water Resources West have drafted an evidence paper for water efficiency policy for local Plan making.

IPP7 – Support public awareness around water use during drought and before drought onset.

Climate Change Risks Addressed:

- In9, 10
- PB14
- Bu3

Action Owner:

Climate change adaptation officer through Local Resilience Forum who engage with resilience leads of utilities.

Actions:

1. Support Severn Trent Water develop materials related to water consumption and reduction measures, targeted at both households and businesses.
2. Distribute materials based on agreed (annual) triggers through established channels (under public health and the Local Resilience Forum).

Description and Purpose: The frequency of severe drought in Warwickshire is expected to increase as a result of reduced annual rainfall, higher temperatures, and changing weather patterns. Water utilities, in coordination with the Environment Agency and the Met Office are responsible for defining drought, issuing alerts, and imposing restrictions and other measures. A more coordinated approach to informing public (households and businesses) of water availability, water efficiency, and household water use reduction measures would support drought resilience. Messaging will be issued annually or based on other triggers (low winter rainfall is the key drought metric in the UK).

IPP8 (priority initiative) – Work with districts to deliver best practice urban design for adaptation in town centre regeneration projects.

Climate Change Risks Addressed:

- Ne1, 6, 8, 10
- In2, 4, 13
- PB1, 2, 3, 5, 7, 10, 11
- Bu1

Action Owner:

Place-making (Communities) with support from LLFA

Actions:

1. Continue to work with districts to identify opportunities and funding for urban regeneration projects.
2. Incorporate adaptation and resilience into the design objectives and clearly stating desired urban resilience outcomes in the tender documentation for design services.
3. Share best practice and lessons learned with private and institutional developers, promoting compliance with and exceeding the requirements of the Warwickshire design standards for SuDS and green infrastructure.

Description and Purpose: Urban areas are exposed to climate change, most importantly increasing rainfall intensity, and increasing temperatures which exacerbates urban heat island effects. For example, urban areas with trees and vegetation are known to lower both surface and air temperatures through shading and evapotranspiration – shaded surfaces can be between 11 and 25°C lower than unshaded materials.

We support local authorities in developing urban regeneration projects through supporting access to funding and has influence over project design as the transport authority. WCC can influence urban regeneration projects as high-profile opportunities to implement the Warwickshire design guide and demonstrate innovation with respect to green, blue and other infrastructure for urban resilience, incorporating:

- Green and blue infrastructure to provide cool refuges for vulnerable people, shading, and temperature regulation

- A range of innovative SuDS features for both water quality and quantity management, over-designing to manage upstream runoff where possible
- Public drinking water sources
- Green roofs and green walls on public buildings
- Connections to nearby urban green/blue spaces

High impact statement projects will include urban river corridor restoration including daylighting of culverted urban streams, urban wetlands, or other urban water bodies. Benefits of incorporating blue and green infrastructure include climate adaptation through temperature regulation, flood risk reduction, water resources adaptation (infiltration and water quality), and also promote biodiversity, public health, public amenity, land value.

IPP9 – Promote tree planting in county highway verges on low-speed routes with high pedestrian and cycle traffic in coordination with tree planting programmes.

Climate Change Risks Addressed:

- Ne3, 8
- In2
- PB1, 2, 5, 10
- Bu1, 5

Action Owner:

County Highways

Actions:

1. Prioritise tree planting for climate adaptation benefit in low-speed high-traffic pedestrian and cycle routes where the benefits outweigh the costs associated with planting and maintenance.

Description and Purpose: To fulfil WWC's tree planting ambition (see initiative WL3), consideration will be given to all of WCC's land holdings. Road verges provide an opportunity for tree planting but are constrained by underground utilities, above ground street furniture and signage, and the maintenance requirement of trees adjacent to roads.

Due to these constraints this initiative will be targeted at low-speed routes with high pedestrian and cycle traffic to provide adaptation of non-motorised transport network. Climate adaptation benefit is for cooling for pedestrian and cycle ways, and can be integrated into SuDS design (e.g., tree pits).

IPP10 – Develop a climate adaptation plan for council services in public health.

Climate Change Risks Addressed:

- PB1, 2, 3, 5, 9, 10, 11,12, 13, 14

Action Owner:

Climate change adaptation officer and Public Health with support from external consultant

Actions:

1. Follow the UKCIP Wizard to develop a climate adaptation plan for public health services.
2. Based on improved understanding of climate change impacts, and impact thresholds, update risk assessments and the risk register.
3. Embed climate change into updates to WCC's Risk Management Framework.
4. Include climate change related risks in future annual risk profiles.

		5. To enable this, technical support will be provided by WCC's Climate Change Coordinator.
Description and Purpose: With support from UKCIP identifying climate change impacts, and critical thresholds, then evaluating future climate change vulnerability to develop a climate adaptation action plan to cover WCC's Public Health services to increase the resilience of vulnerable communities.		

IPP11 – Develop local heatwave plan for the county.		**Actions:**
Climate Change Risks Addressed: • In1, 13 • PB1, 2 • Bu5, 6	**Action Owner:** Public Health	1. Review national guidance. 2. Based on the specific vulnerabilities in Warwickshire develop a heatwave plan which includes sectoral responses to extreme heat; trigger temperatures for a range of different actions; and clearly identifies channels for communicating and disseminating materials. 3. Test the plan and validate it with the Local Resilience Forum
Description and Purpose: In July 2022, the UK experienced the hottest temperatures ever recorded, including the Met Office issuing the first red weather working for heat. Provisional figures for the Summer across June, July and August also show that the average temperature across the Summer was 17.1C, therefore tied with 2018 for the hottest Summer on record.[32] Extreme heat undermines the working capacity of individuals, resulting in lower productivity, and thus economic output. With extreme temperatures and hot Summer's becoming increasingly common, it is essential that local authorities prepare local heatwave plans to prepare citizens, businesses, and emergency services for heatwaves. Currently national heatwave planning guidance is issued to a variety of public stakeholders.		

IPP12 – Work with districts to update local policy and Local Plans to incorporate low-carbon temperature regulation measures in new homes and buildings.		**Actions:**
Climate Change Risks Addressed: • PB1, 2 • Bu5, 6	**Action Owner:** Climate change adaptation officer	1. Identify best practice in design and construction of homes and other buildings for low carbon or passive cooling / temperature regulation, for example BRSIA A New Guide to Low Carbon Cooling Solutions. 2. Through local climate change working group, share best practice and propose policy wording to incorporate low-carbon temperature regulation measures into new home development, and other buildings, which goes beyond minimum requirements set out in the building code. 3. Hold events with planning officers to develop knowledge of cooling measures and how to apply policy and encourage innovation.
Description and Purpose: Extreme heat in households primarily affects the most vulnerable people (e.g., young, and old). To reduce the need for air conditioning in new homes, which would be counter-productive to the WCC's GHG ambitions, new housing development will be designed and built with future climate in mind, taking into account the long lifespan of housing (100+ years). Generic guidance can be included in local policy but planning authorities and development control officers need to be better informed to work with developers and designers to deliver appropriate solutions to temperature regulation which go beyond Building Regulations, guidance is set out in the Building Regulations Approved Document O (2021). Considerations include: • Geometry, form, and orientation of buildings		

[32] BBC News. 2022. Heatwave: England has had joint hottest summer on record, Met Office says. Available: https://www.bbc.co.uk/news/uk-62758367

- Glazing area and specification
- Aspect and ventilation
- Thermal mass
- External shading and planting

Getting this right in new buildings now can reduce the likelihood of air conditioning installation in the future as temperature continues to increase.

IPP13 – Incorporate low-carbon cooling measures into new council buildings and extensions.

Climate Change Risks Addressed:

- PB1, 2
- Bu5, 6

Action Owner:

Property Management with support from climate change adaptation officer

Actions:

1. Incorporate low-carbon cooling measures into a checklist for the design of all new WCC buildings and extensions in line with IPP12
2. Encourage other institutions in Warwickshire which house the vulnerable to implement similar measures across their building stock, including hospitals and prisons.

Description and Purpose: New WCC buildings will be designed and built considering long-term temperature projections to ensure thermal comfort will be provided for the lifetime of the building, in line with IPP12. This is particularly important for buildings that will be inhabited by vulnerable groups, including care homes and schools. For buildings owned by WCC which house the most vulnerable, simple cooling measures to be retrofitted, including consideration of glazing and shading.

IPP14 – Launch a training initiative for businesses on climate risk assessment and action planning.

Climate Change Risks Addressed:

- Bu1, 3, 4, 5, 6, 7

Action Owner:

Climate Change adaptation officer

Actions:

1. Identify small and medium sized enterprises (SMEs) exposed to or sensitive to natural hazards (consider location, operations, personnel)
2. Prepare training on conducting climate risk assessment for a pilot site.
3. Deliver training to vulnerable businesses in coordination with CSW resilience team.

Description and Purpose: Climate risk assessments would provide insight on emerging risks and may expose vulnerabilities of a business, which may not have been considered - for example, how food premises might deal with increasing temperatures.

Once WCC has developed capacity for climate risk assessment and adaptation planning and established a database of resources related to climate change and climate impacts, services are to be offered to businesses to facilitate climate risk assessment and promote business continuity. Coventry Solihull and Warwickshire (CSW) resilience team provides a tool for business continuity assessment, and climate change will be integrated here.

Theme 4: Emergency Planning and Response: Climate change adaptation initiatives

ERP1 – Develop a climate adaptation plan for council fire and rescue and risk management services

Climate Change Risks Addressed:

- Ne5, 9, 10, 14
- In1, 13
- PB8, 9, 10
- Bu6

Action Owner:

Climate change adaptation officer and Fire and Rescue Services with support from external consultant

Actions:

1. Follow the UKCIP Wizard to develop a climate adaptation plan for transport services.
2. Based on improved understanding of climate change impacts, and impact thresholds, update risk assessments and the risk register.
3. Embed climate change into updates to WCC's Risk Management Framework.
4. Include climate change related risks in future annual risk profiles.
5. To enable this, technical support will be provided by WCC's Climate Change Coordinator.

Description and Purpose: With support from UKCIP, identify climate change impacts, and critical thresholds, then evaluate future climate change vulnerability to develop a climate adaptation action plan to cover WCC's Fire and Rescue services. Climate change impacts on WCC rescue services will include:

- More frequent wildfires during heatwaves and drought,
- More frequent and larger scale flooding.
- Indirect impacts include:
- Electric vehicle fires,
- Home battery fires.

Climate change will be embedded into WCC's Risk Management Framework and the annual Risk Profiles, and the direct and indirect impacts of climate change will be considered when assessing all risks, resulting in an updated risk assessment process and updates to the risk register. Knowledge of climate change and risk identification will have to be expanded.

ERP2 (priority initiative) – Incorporate climate change into tactical response planning.

Climate Change Risks Addressed:

- In1, 2, 4, 5, 6, 9, 11
- PB1, 2, 5, 9, 14
- Bu1, 5, 6

Action Owner:

Fire and Rescue Services with support from Climate change adaptation officer

Actions:

1. Incorporate the effects of climate change into tactical response planning and tactical training.
2. To enable this, technical support will be provided to the tactical planners by WCC's Climate Change Coordinator (adaptation officer).

Description and Purpose: In planning for tactical response, and undertaking training exercises, consider the compounding climate change impacts which might hamper response. For example, worst case climate change flood risk maps (use flood zone 2 as a proxy) will be considered in identifying access and egress to communities. Drought will reduce the availability of water supply for firefighting. Extreme heat may affect staff, coordination of response, transport, and affected communities.

Concurrency also needs to be embedded into tactical response planning, preparation and training as climate change will likely increase the likelihood of concurrent and related events (e.g., extreme heat, widespread fires, and drought) as well as concurrent and unrelated events (e.g., flooding and road traffic accidents). This requires consideration of contingency measures and obtaining support from surrounding areas.

ERP3 – Increase the network of private fire-fighting water sources across the county.

Climate Change Risks Addressed:

- Ne5, 10
- PB9

Action Owner:

Planning Delivery

Actions:

1. Engage with local authorities to include provision for firefighting water in new agricultural and industrial developments.
2. Incorporate locations of private water sources on new developments into the mobile data terminal in vehicles.

Description and Purpose: There is increasing and more widespread fire risk across Warwickshire due to climate change. We shall more directly require, through the planning system, fire-fighting water sources (or storage) for new agricultural and industrial developments.

ERP4 (priority initiative) – Incorporate climate change into the local resilience forum risk assessment process

Climate Change Risks Addressed:

- In1, 2, 5, 6, 10, 11, 13, 14
- PB1, 2, 4, 5, 8, 9, 10
- Bu1, 5, 6

Action Owner:

Local Resilience Forum WCC lead with support from Climate Change adaptation officer

Actions:

1. Support LRF / CSW to update the template for the (Warwickshire) National Risk Assessment
2. In the next round of risk assessments, update relevant assessments for climate change, considering risks and climate projections, encouraging collaboration and knowledge sharing with Category 2 responders and other stakeholders to identify climate risks and mitigation measures. Make use of the UK's Climate Change Risk Assessment.
3. Warwickshire council climate change team to support with projections and guidance on incorporating climate change and trends into risk assessment.
4. Any ongoing/planned training in risk assessment will include training on climate change, specifically projections across Warwickshire and how to incorporate these into risk assessment.

Description and Purpose: The UK National Risk Assessment process includes assessment at national level, which is downscaled to local government and communities. The Local Resilience Forum (LRF) is a multi-agency partnership with Category 1 responders including representatives from the local services including the emergency services (police, fire and rescue, and ambulance services) the Environment Agency, Public Health England, NHS trusts, and Category 2 responders including the Health and Safety Executive, highways, rail, water and power.

The Coventry Solihull and Warwickshire Resilience team coordinates the National Risk Assessment process for Warwickshire, calling on expertise from the LRF to undertake the risk assessments, where necessary.

The National Risk Assessment covers a number of risks where climate change shall be incorporated into the risk assessment process:

- Wildfire
- Fluvial flooding
- Surface water flooding
- Drought
- Heatwave

There are a number of other risks which must consider the impacts of climate change, e.g.:

- Reservoir failure
- Canal breach
- Bridge collapse
- Water systems failure
- Communication distribution failure
- Power distribution failure
- Air quality
- Storms
- Cold weather

Category 2 responders will provide useful information with respect to climate change impacts and resilience and will be involved in the risk assessment process. Improving collaboration and knowledge sharing between organisations will increase the resilience of the county.

ERP5 (priority initiative) – Support and strengthen early warning systems and communications of weather thresholds which trigger identified climate impacts and responses.

Climate Change Risks Addressed:

- In1, 2, 4, 13
- PB1, 2, 5, 9, 14
- Bu1, 5

Action Owner:

Local Resilience Forum WCC lead with support from Climate Change adaptation officer

Actions:

1. Strengthen links with Met Office who are available and willing to support with both climate change information and improvements to the early warning systems or communications.
2. Identify and address weaknesses in the communication system to the most vulnerable in the council.
3. Through the local resilience forum strengthen community-based warning to strengthen the communication of alerts to the most vulnerable.
4. Support improvement of impact-based forecasting by feeding back information on weather impacts to the Met Office Civil Contingencies Advisor.

Description and Purpose: Early warning systems integrate monitoring, forecasting, and predicting and communicating hazards.

The Met Office issues impact based weather warnings for:

- Fog
- Ice
- Rain
- Snow
- Wind
- Thunderstorm
- Lightning
- Extreme Heat (launched in June 2021)

Their function is to enable communities, businesses, the government, and services to take action to minimise the risk from hazards and prevent disaster. Input regarding impacts comes primarily from Met Office Civil Contingency Advisors. Often trained meteorologists, CCAs work closely with local resilience groups and local and central government to understand what sensitivities to weather exist.

The process of communicating weather warnings is through internet, local media, and local resilience channels, through Civil Contingency Advisors. As a result of climate changing increasing weather-related risks, undertake a review of the communication of warnings to the most vulnerable communities, households, businesses, and other organisations and identify areas for strengthening or additional communication channels, as technology and media (incl. social media) rapidly develops.
The National Emergency Alert System (alerts direct to mobile phones) is expected to be rolled out this year, so this can build on and be implemented in parallel with that initiative, at a local level.

The national resilience strategy which is expected to be published this year sets out expectations for public information and communications, and the role of the public.

ERP6 – Support the production of community risk management plans.

Climate Change Risks Addressed:

- PB5, 8, 9, 13
- Bu1, 6

Action Owner:

Local Resilience Forum WCC lead with support from Climate Change adaptation officer

Actions:

1. Support CSW Resilience Team in providing climate change information to communities for them to consider local climate risks in community emergency and resilience planning.

Description and Purpose: CSW resilience team encourages Parish and Town Councils to spend time considering the risks in their area and preparing locally for incidents and emergencies that may affect the community.

Community-based climate change planning and adaptation results in resilience activities specifically focused on the local context and risks to climate change. We can provide support to CSW in disseminating climate change and climate risk information to integrate climate change into the local resilience planning offer.
The National Resilience Strategy which is expected to be published this year sets out the role of community and ‘the public’ in strengthening local resilience.