10 Climate Change

The impact of climate change has been widely discussed in recent years, particularly in relation to flooding. However, for the highway network and its associated assets, it is important to consider the full range of impacts from climate change and the practical implications that has for maintaining Gloucestershire's network and improving resilience.

Whilst fully understanding the long term effect of climate change is a continually developing picture, there is widespread agreement on the trends occurring in weather and climatic patterns over the short to medium term (10-50 years). Given that different highway assets can have a wide range of lifecycles, from very short to very long, this is an appropriate timeframe to consider.

There are a number of recent publications which set out the picture for local transport networks in a bit more detail:

"Warming to the Idea" Climate South West (2010)

"Transport Resilience Review" Department for Transport (2014)

Weather and Climatic Patterns

The climatic patterns which are currently experienced in the South West and are expected to occur over the next 10-50 years is set out in the publication "Warming to the Idea" by Climate South West (2010). Some of the key messages are:

- We are already vulnerable to extreme weather. Climate change will make this worse. We need to plan for both current and future vulnerability.
- Further climate change is inevitable and unavoidable. Planning for the impacts will be more cost-effective than reacting to them.
- Most individuals are aware of extreme weather and climate change but this does not always extend to an understanding of the impacts and how to adapt.
- Extreme weather and climate change impacts should be integrated into planning, policy and decision making at all levels.

The future seasonal climate for the South West is likely to mean:

- Mean temperatures increasing with hotter summers and warmer winters.
- Overall precipitation levels remaining stable but with more extremes, including drier summers and wetter winters.
- Decrease in cloud cover and relative humidity.

Future Seasonal Climate

Figures in the table below show likely changes in future climate for the South West. **The 'central estimate' (i.e the value at the 50% probability level) under the medium emissions scenario is reported first, followed by the wider range of uncertainty in brackets**. Th bracketed wider range uses the minimum value at the 10% probability level, and the maximum value at the 90% probability level, across all three scenarios (IPCC SRES: B1.A1B.A1FI).

Season	2020s	2050s	2080s
Spring			
Mean temperature	Warmer by 1.2^{O} C (0.63 to 1.9° C)	Warmer by 2.1° C (1.0 to 3.6° C)	Warmer by 2.9°C (1.4 to 5.5°C)
Precipitation	Marginally wetter by 0.1% (-7.3 to +8.7%)	Marginally drier by -0.5% to +8.4%)	Wetter by 1.7% (-7.1 to +9.7%)
Cloud Cover	Decrease of -2.7% (-6.7 to + 2.2%)	Decrease of -3.9% (-8.7 to +0.5%)	Decrease of -4.6% (-11.3 to + 1.8%)
Relative humidity	Decrease of -1.2% (-3.8 to +0.9%)	Decrease of -2.0% (-6.2 to +1.0%)	Decrease of -2.5% (-8.6 to + 1.9%)
Summer			
Mean temperature	Warmer by 1.6°C (0.5 to 2.7°C)	Warmer by 2.7°C (1.1 to 5.1°C)	Warmer by 3.9°C (1.3 to 7.9°C)
Precipitation	Drier by 8% (-26.6 to +17.5%)	Drier by 20% (-44.5 to 16.1%)	Drier by 24% (-58.5 to 12.9%)
Cloud cover	Decrease of -5.7% (-14.2 to +4.5%)	Decrease of -10.6% (-22.9 to +2.0%)	Decrease of -14.9% (-33.9 to +1.3%)
Relative humidity	Decrease of -3.1% (-8.2 to +2.6%)	Decrease of -5.5% (-13.7 to +1.7%)	Decrease of -7.3% (-19.5 to + 1.9%)
Autumn			
Mean temperature	Warmer by 1.5°C (0.77 to 2.5°C)	Warmer by 2.7°C (1.4 to 4.1°C)	Warmer by 3.7°C (1.7 to 6.5°C)
Precipitation	Wetter by 1.5% (-12.1 to + 16%)	Wetter by 3.2% (-8.2 to + 14.9%)	Wetter by 4.0% (-7.1 to +15.6%)
Cloud cover	Decrease of -2.0% (-6.3 to +1.8%)	Decrease of -4.1% (-9.3 to +0.4%)	Decrease of -5.3% (-5.6 to +0.4%)
Relative humidity	Negligible decrease of -0.5% (-2.3 to +1%)	Decrease of -1.3% (-3.7 to +0.7%)	Decrease of -1.9% (-5.6 to +0.4%)
Winter			
Mean temperature	Warmer by 1.3°C (0.46 to 2.0°C)	Warmer by 2.1°C (0.8 to 3.5 C)	Warmer by 2.8°C (1.4 to 5.1°C)
Precipitation	Wetter by 7% (-3.1 to +19.6%)	Wetter by 17% (0.0 to +40.6%)	Wetter by 23% (5.2 to 73.5%)
Cloud cover	No change (-2.2 to +2.1%)	Negligible increase of 0.4% (-2.0 to +2.8%)	Negligible increase of 0.9% (-1.9 to +3.9%)
Relative humidity	Negligible decrease of (-0.1% (-0.6 to +0.5%)	Negligible decrease of -0.1% (-0.8 to +0.6%)	No change (-0.9 to +0.8%)
Annual			
Mean temperature	Warmer by 1.4°C (0.74 to 2.1°C)	Warmer by 2.5°C (1.3 to 4.0°C)	Warmer by 3.5°C (1.6 to 6.3°C)
Precipitation	No change (-4.8% to 6.0%)	No change (-6.0% to +6.4%)	Wetter by 1% (-7.2 to +9.6%)
Cloud cover	Decrease of -2.7% (-6.0 to +0.9%)	Decrease of -5.2% (-10.4 to -0.1%)	Decrease of -6.6% (-15.8 to 0.5%)
Relative humidity	Decrease of -1.2% (-2.9 to +0.4%)	Decrease of -2.4% (-5.6 to 0.03%)	Decrease of 3.1% (-8.3 to +0.1%)

Reproduced from Warming to the Idea

Impact on the South West and Gloucestershire

Given the variability of the factors outlined in the previous section there are a wide range of impacts, both positive and negative, that are relevant for the South West, and Gloucestershire, and these include:

- Increased flood risk in urban areas, requiring more use of sustainable urban drainage and other flood risk management measures in construction practices. New developments in flood plains will also need to be avoided, which may be a challenge given the ongoing need for extra housing.
- Increased flood risk to property in some areas. This may lead to increased insurance premiums, or difficulty in obtaining insurance cover in the future.
- More heavy rainfall will increase the risk of soil erosion and run-off from agricultural land, which could in turn increase local flood risk and harm water quality.
- Drainage systems will be put under increasing pressure by heavy rainfall, requiring design standards to be re-appraised for both new and engineering structures.
- Potential increase in storm damage, light-degradation, rain damage, fungal and beetle damage to historic buildings and structures, e.g. bridges.
- Some towns, cities and transport routes are susceptible to periodic flooding, causing major disruption to road transport, and the potential for flash flooding increasing the frequency of these events.
- Pressure on the capacity and management of transport infrastructure could increase if warmer summers attract more visitors to the South West.
- Increased temperatures may result in deformation of asphalt, failure of expansion joints, road surfaces melting etc.
- Changes in sea level – less impact than on some authorities in SW but with the Severn Estuary running through the centre of the county, tidal ranges will certainly be affected, as well as storm surges where the Severn Estuary is expected to see the largest change.
- River/coastal flooding and landslip threats
- Increased risk of flooding from increased rainfall
- Improvements and higher specification required for flood defences and urban drainage and rainwater disposal systems
- Improved road and rail infrastructure to provide alternative and diversionary routes in case of extreme climate events
- Expansion of sustainable urban drainage systems
- Commercial opportunities in flood defence and flood management
- Opportunity to integrate flood defences
- Increased scope for walking and cycling for everyday travel and tourists
- Less frost damage to roads from winter cold, less need for road salting
- Fewer ice/snow related accidents on roads and footpaths, and points failures on railways
- More extremes – heavy rainfall events, high winds, very hot spells – trees falling, vulnerability of some routes to storm damage, snow events, faster vegetation growth,
- Increased subsidence due to drying out of substrata (especially in clay areas)

Building Resilience

Often the impact of extreme weather is to restrict capacity e.g. flooding on roads – and is highly disruptive to users. Access to maintain the infrastructure is also more difficult, without unduly disrupting users. It is difficult and prohibitively expensive to strive for total physical resilience and so an economically rational approach needs to be taken. It is also worth noting that it is primarily maintenance expenditure, rather than capital expenditure, which determines the resilience of the network. For the county's local network this would include expenditure on areas such as maintaining grass verges, managing tree stock, maintaining embankments, gully emptying and grip cutting.

Often a road network has multiple options for diversion should one section be put out of use but it is important to analyse whether there are any single points, particularly on the strategic network, that would have a major impact if they failed. Often local knowledge of the network will enhance the relative ranking of importance of particular vulnerabilities. It is also helpful to think about end to end journeys and ensure that the analysis of the network takes into account how it integrates or links with the Highways Agency strategic network, as well as the rail and air terminals. For Gloucestershire this is particularly relevant in the context of the M5 and M50 motorways, the A417, the A40 and the A46 strategic network, as well as rail terminals in Gloucester and Cheltenham, plus smaller settlements, and Gloucestershire airport.

In relation to flooding events there are often many different bodies involved in planning for its impacts and actions to mitigate it and this presents a complex picture. However, for the highway authority there is a need to understand if there are parts of the network that are vulnerable, in addition to the usual focus on property flooding. For Gloucestershire, there are several locations on the network where flooding is a known issue e.g. A417 at Maisemore, and sections of the A48 when combined with high tidal events.

The extent of maintenance by neighbouring property owners to the highway asset can have a major impact on the resilience of the network. For example, trees on private land with the potential to fall on the highway, maintenance of ditches for carrying away surface water etc. Gloucestershire has a good record of keeping a focus on landowner responsibilities and this needs to be maintained going forwards.

The DfT Resilience Review emphasises the importance of learning from past experiences in terms of both planning for resilience and mitigation but also how to recover from events. This is evidenced by contingency plans and communication plans such as the adverse weather plan, emergency plans and communication strategies such as the use of Twitter or local radio. There is also a need to consider pre-planning of adequate resources ahead of potential seasonal disruption, or predicted weather events, such as putting in place salt supplies for winter maintenance, chainsaw operators or drainage contractors. It is also important to understand how vital good communications can be in managing a resilience situation.

What Next?

Gloucestershire County Council is part of the South West Local Transport Adaptation Task and Finish Group who are working on developing a toolkit to help local highway authorities to analyse their network to identify what risks and vulnerabilities exist and potential mitigation to address those. This will broadly follow the principles outlined above as part of the DfT's Resilience Review (2014). The approach involves:

- Identifying a strategic network to focus on resilience harnessing and using key local knowledge.
- Identifying the potential impacts on highway network assets.
- Identify any potential single points of failure.
- Applying a risk based approach to the network, network assets and service delivery in order to prioritise areas for further action.
- Taking a more specific look at particular parts of the network, resulting in an action plan for understanding vulnerabilities.
- Reviewing priorities for conserving and protecting threatened historical and natural heritage, taking into account sites that are vulnerable to climate change impacts. E.g. historic bridges.

Gloucestershire County Council intends to adopt the toolkit to develop a better understanding of network resilience over the coming years.