Manchester Airports Group

Climate Change Adaptation Progress Report

For East Midlands, London Stansted and Manchester Airports

December 2021

Report submitted to the Department for Environment, Food and Rural Affairs (Defra) by Manchester Airports Group for East Midlands, Manchester and London Stansted Airports

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Introduction

Purpose and scope

Over the last decade MAG has published two Climate Change Adaptation Reports, identifying and evaluating risks to our airports from the physical impacts of climate change. The reports, which are required to be submitted to the Department for Environment, Food and Rural Affairs (DEFRA), include comprehensive coverage of how the projected changes in climate may impact our business. They also explore the actions we can take to minimise risk and unlock any opportunities which arise from climate change.

Since our first Climate Change Adaptation Report was published in 2011 MAG has acquired London Stansted Airport. We no longer own Bournemouth and Humberside airports, which were not included within the scope of the Adaptation Reporting Power of the Climate Change Act and so had not previously submitted Climate Change Adaptation Reports. In response to our refreshed operating model, our 2021 Climate Change Adaptation Report is the first holistic report covering all three airports. This report outlines the progress made at East Midlands, Stansted and Manchester Airports and should be read in conjunction with previous reports published in 2011, 2015 and 2016.

Timeline of our airports' adaptation reporting to date:

- 2011 – MAG published its first Climate Change Adaptation Report for East Midlands and Manchester Airport. Separately BAA published their Airport Climate Change Adaptation Plan for Stansted Airport.
- 2015 – MAG published its second Climate Change Adaptation Report for East Midlands and Manchester Airport[1].
- 2016 – MAG published its first Climate Change Adaptation Report for Stansted Airport[2].
- 2021 – MAG published this Climate Change Adaptation Report for East Midlands, Stansted and Manchester Airports.

As well as preparing for climate change, we are also engaged in climate change mitigation. MAG has been dedicated to reducing the carbon intensity of our airport operations for over 15 years. In 2006, MAG became the first UK airport operator to commit to make its own operations carbon neutral. We achieved that objective in 2012 when our airports at Bournemouth, East Midlands and Humberside became the first in the UK to become carbon neutral. Since then, Manchester, and later Stansted, have achieved this outcome, making MAG the only carbon neutral airport group in the UK. Our airports are each independently certified to Level 3+ (Neutrality) of the Airport Carbon Accreditation programme. This achievement not only recognises our carbon neutral status, but also demonstrates the progress we have made in reducing our direct carbon emissions and working with partners to minimise emissions indirectly associated with our business. Each of our airports take their approach to environmental management seriously and are ISO 14001 certified, with London Stansted Airport also certified to ISO 50001 for energy management. Our approach to decarbonisation has been multi-award winning and, earlier this year, MAG was recognised as the highest performing transport organisation in the Financial Times' 2021 assessment of European Climate Leaders.

[1] MAG (2015). Climate Change Adaptation Progress Report For East Midlands and Manchester Airports. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/488080/climate-adrep-manchester-airport-group.pdf

[2] London Stansted Airport (2016). Climate Change Adaptation Progress Report For London Stansted Airport. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/566149/climate-adrep-stansted.pdf

Last year we published our Corporate Social Responsibility Strategy for 2020 – 2025, 'Working together for a brighter future'[3]. Our Strategy features three strategic priorities, including 'Zero Carbon Airports' which focuses on making our airport operations net zero carbon no later than 2038. Our CSR Strategy is guiding our transition to net zero, and therefore we are maintaining a stronger focus on physical and operational risks to the business in this Adaptation Report, as opposed to transition risks.

Our decision making will be increasingly influenced by climate risks and exposures identified over the short, medium and long term. Such risks are identified in this report and previous Adaptation Reports. We recognise the importance of the Task Force on Climate-related Financial Disclosures (TCFD) and are committed to implementing the recommendations in full. This year we have enhanced our annual reporting[4] by aligning it with recommendations made by the TCFD.

The impact of the COVID-19 pandemic has been severe, with international travel restricted and passenger numbers down over 99% in the initial phase of the lockdown. The last 18 months have been a testing period for MAG, our colleagues, our communities and the wider aviation industry. Despite the unprecedented challenges of the pandemic on our business, we remain committed to eliminating our residual carbon emissions and reaching net zero by 2038. We are confident that, by demonstrating leadership, driving change and collaborating with the wider aviation industry and UK Government, we will succeed in a sustainable recovery while also achieving these goals.

Furthermore, we remain committed to ensuring that we build our resilience to the physical impacts of climate change. This is demonstrated by the prioritisation of our participation in this voluntary round of adaptation reporting and the additional consideration we have given to interdependency risks with our business partners at a time when our business activities have been significantly disrupted by the global pandemic.

Manchester Airports Group

We are a leading UK based airport company operating Manchester, London Stansted and East Midlands Airports. Prior to the COVID-19 pandemic more than 60 million flew through our airports each year, MAG directly employed 6,500 people and our airports provided on-site employment for 40,000 people and an additional 90,000 jobs in the wider supply chain. MAG supports airports in the US where we operate a network of executive lounges.

MAG is privately managed on behalf of its shareholders, who include IFM Investors (35.5% ownership), Manchester City Council (35.5% ownership) and the nine other Greater Manchester local authorities (29% ownership).

We strongly support the Government's commitment to the principles of sustainable development in the aviation industry, striking a balance between economic, social and environmental considerations.

East Midlands Airport

East Midlands Airport connects over 4 million passengers each year (pre-pandemic) with more than 90 leisure and business destinations, ranging from Guernsey to Geneva and Fuerteventura to Florence. The airport supports a range of charter and scheduled flights and is also an important part of the European low-cost network as a major base for operators including Ryanair and Jet2.com.

East Midlands Airport is a strategically important cargo hub for the UK, handling more than 420,000 tonnes each year and is the second busiest cargo airport in the UK after London Heathrow. The airport is an

[3] MAG (2020). Working Together For A Brighter Future: Our Corporate Social Responsibility Strategy for 2020 – 2025. Available online: https://www.magairports.com/media/1635/csr-strategy-2020.pdf

[4] MAG (2021). Manchester Airports Holdings Limited: Annual report and consolidated financial statements for the year ended 31 March 2021. Available online: https://www.magairports.com/media/1721/mahl-fy21-final-signed-12072021.pdf

important UK base for three of the major global integrated freight airlines (DHL, UPS and FedEx) and the largest air hub of Royal Mail.

East Midlands Airport is well positioned in the centre of the UK with direct access to the national motorway system, with 90% of England and Wales within a 4-hour lorry drive. The airport's location and catchment area provide an opportunity for future growth and the development of passenger and cargo operations, with the airport a key component of the recently announced East Midlands Freeport.

East Midlands Airport is in a semi-rural setting in north-western Leicestershire, with the nearest cities being Leicester (17 miles southeast), Derby (12.5 miles northwest) and Nottingham (14 miles northeast). With the exception of Donington Park Circuit, which is at the western end of the runway, and the town of Castle Donington to the north, land use in the vicinity of the airport is predominantly agricultural in nature. It is bounded to the east by the M1 motorway and to the south by the A453, which provides the main access route. The nearest railway station is East Midlands Parkway, 4 miles away. The River Trent runs approximately 1.5 miles to the northwest of the airport, and the River Soar is at an estimated 1 mile to the east beyond the M1.

London Stansted Airport

Stansted Airport is the UK's fourth largest airport (pre-pandemic), connecting over 28 million passengers each year to over 200 destinations. It is the only major London airport with significant runway capacity, offering a European route network which is unrivalled in the UK, providing London with more visitors from Europe than any other airport. Stansted Airport is in a strategic location at the heart of the UK Innovation Corridor between North London and Cambridge, with 25 million people located within a two-hour drive. In 2021 the airport was granted planning permission to increase its maximum number of passengers from 35 to 43 million passengers.

Stansted's World Cargo Centre is designed to offer 55,000 sqm of warehouse and office space. The airport offers continuous delivery of service; 24 hours a day, 365 days a year.

Stansted Airport is in a semi-rural setting directly adjacent to the M11 motorway in Essex, a short distance from the town of Bishops Stortford to the west. The general character of the surroundings is semi-rural to rural. The National Trust Hatfield Forest is an extensive wooded area around 1 mile to the south of the airport. The Pincey Brook rises at the south-eastern part of the airport and flows south towards the village of Hatfield Park Farm and onwards to join the River Stort south of Sawbridgeworth.

The M11 motorway provides the main access route to the airport from the north and south, and the A120 connects it to Essex to the east. The airport is served by an extensive network of bus and coach operations that connect to London in the south and cities to the northwest, north and east. The airport also benefits from a rail connection to London Liverpool St, and rail services that connect the airport to Birmingham, Cambridge and Norwich amongst others. For on-airport travel, the Stansted Airport Transit System links the terminal to satellite buildings via an elevated rail transit system.

Manchester Airport

Manchester Airport is the third busiest airport in the UK (pre-pandemic), and the largest outside London, serving just under 30 million passengers each year before the pandemic. Over 70 airlines serve more than 210 destinations from the airport, including many long-haul routes only served from Manchester, outside of London – such as Singapore, Hong Kong, Atlanta and Addis Ababa. Manchester is the only airport in the UK, alongside London Heathrow, to have two full-length runways.

More than 22 million people live within a two-hour travel-time of Manchester Airport. The airport's scale, location and the strength of its catchment area provide significant opportunities for future growth and development.

As the global gateway in the North of England, the airport is an integral part of the Northern economy. The benefits that the airport brings are in the form of passenger and cargo connectivity, economic activity, inward investment, tourism and direct and indirect employment.

Manchester Airport is located in the southern extremities of Greater Manchester, 8 miles from the City Centre, and extends into Cheshire East. It is bordered to the north, northeast and northwest by suburban housing, to the west and south by open farmland and rural housing. The National Trust's Quarry Bank and Styal Country Park is to the east. The airport's second runway crosses the River Bollin, a tributary of the River Mersey, which runs in a tunnel beneath the airfield.

Vehicle access to the airport is via the M56 motorway and A555, with Junction 5 of the M56 and the A555 providing access to passenger terminals and the airport complex and the A538 and Junction 6 of the M56 serving the World Freight Terminal to the west of the airport. These roads bound the airport to the north, west and south and provide for extensive local and national bus and coach connections to the airport. Manchester Airport station is served by trains operated by Northern, TransPennine Express, and Transport for Wales which connect the airport to Manchester Piccadilly and Crewe train stations and onwards. The station is also a terminus for the Manchester Metrolink light rail network.

Progress in adapting for climate change

Overview

We recognise that climate change should not be considered in isolation or responded to by us alone. To this end, our understanding of interdependencies in relation to climate change has significantly advanced through extensive collaboration with key business partners and agencies, including through active contributions to local Resilience Development Groups and Resilience Forums at Manchester, East Midlands, and London Stansted Airports. These forums are important to MAG and enjoy support from the Department for Communities and Local Government and the Environment Agency.

Our previous Adaptation Reports identified a number of actions intended to help us better understand the likely impact of climate change and to prepare our business for a changing climate. We have made significant progress against these actions, and this is discussed later in this report.

We have also re-evaluated and supplemented our assessment of climate change risk at each of our airports. Our updated climate change risk registers reflect changes to our business processes for risk and assurance, progress against previously identified actions, changes at our airports and development in our understanding of climate change. In addition, we have increased the focus placed on off-airport risks, which often involve interdependencies with other organisations. In re-assessing our risks, we have taken account of the latest projections by the Met Office of the impact of climate change on the UK weather, the UK Climate Projections 2018 (UKCP18)[5].

Reviewing our assessment of climate change risk

Approach to risk assessment

In July 2021, a series of Risk Workshops brought together colleagues in key roles at Manchester, East Midlands and London Stansted Airports and from MAG's group-wide business support functions to review and revise each airport's climate change risk register.

In previous years, climate change adaptation risks have been assessed through in-person risk workshops, with the exception of the first-round reporting for Stansted Airport which was managed by external consultants who gathered information through 1-2-1 interviews. Adapting to restrictions due to the COVID-19 pandemic, this year we ran smaller, virtual workshops for internal stakeholders.

[5] https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

A total of five workshops focussed on strategic asset management, engineering, and operations at each of our airports, reviewing climate adaptation risks associated with infrastructure and airport operations respectively. Discussion centred on evaluating the effectiveness of current risk controls in managing future risks, identifying knowledge gaps, and improving our understanding of interdependencies.

Our updated risk assessments, which are provided in Appendix 1 – 3, follow a consistent methodology to our previous risk registers. Consistent with MAG's last Climate Change Adaptation Reports, our assessment considers the impact and likelihood of potential risk consequences on a scale of 1 (minimal) to 5 (critical). The impact and likelihood scores for each risk are multiplied to calculate risk exposure, therefore the maximum exposure rating for any risk is 25. To best identify areas where further control is necessary, our climate change risk registers baseline future risk against current net risk.

UK Climate Projections (UKCP)

Our risk assessments were based upon the UKCP18 Probabilistic (25km) climate change projections for England which form part of the UKCP18 land projections. These Probabilistic projections were chosen as they offered the best fit for our risk assessment purposes in that they cover the full range of climate change scenarios, are comparable with UKCP09 (which was used for our previous assessments) and, for a given scenario, provide information on known uncertainties. In keeping with the approach used in previous reporting rounds, we have used projections for average temperature and rainfall under a medium emission scenario (RCP6.0) and at 50% probability.

While the UKCP18 Probabilistic projections were identified as the best fit for our purposes, we also considered whether supplementary information should be used to reflect variation due to the geographic spread of our airports. Our assessment of the UKCP18 Regional (12km) projections for North West, Central and Eastern regions concluded that variability between regions would not be material to our assessment outcomes. As such, we considered it appropriate to use the Probabilistic projections for England as the basis for our assessments.

Recognising the higher materiality of maximum summer temperatures to our assessments and the importance of other weather projections, participants were provided with details of:

- UKCP18 Regional (12km) projection for summer maximum temperature, which is not available through the Probabilistic projections, for the Central England region.
- Information about disruptive weather events drawn from Met Office resources and UKCP18 Regional projections, which were found to be similar between the sites.

Tables 1, 2 and 3 show projected changes in temperature, rainfall and to disruptive weather, which were used as inputs to risk workshops. The use of consistent projections for all airports increased accessibility of our risk workshops, which included attendees from all three airports, ensuring participants were able to make a full contribution.

Table 1: Projected change in temperature used in risk rating

Temperature (oC)	2030s (2020-2039)	2050s (2040-2059)	2080s (2070-2089)
Mean annual	+0.8	+1.2	+2.4
Winter average	+0.8	+1.1	+2.0
Summer average	+1.0	+1.6	+3.1
Summer maximum	+2.6	+4.0	+6.0

Table 2: Projected change in rainfall used in risk rating

Rainfall	2030s (2020-2039)	2050s (2040-2059)	2080s (2070-2089)
Winter average	+5%	+6%	+13%
Summer average	-7%	-14%	-22%

Table 3: Summary of projected changes in other key climate variables used in risk rating

Variable	Change
Storms	Frequency of periods of intense Summer and Autumn rainfall projected to increase. No quantitative data.
Windspeed	Very small changes to seasonal average wind speed. Summer: <0.2m/s reduction. Winter: no change.
Wind direction	Very small changes to seasonal average wind direction overall (<0.2m/s).
Snow	Annual snowfall: 60-80% less. Slight reduction in projected surface snow (0.3mm).
Lightning	Frequency assumed to increase during Summer in line with increased temperatures, more frequent dry spells and predicted increase in Summer intense rainfall. No quantitative data.

Climate change adaptation risks

East Midlands Airport climate change adaptation risks

Our East Midlands risk workshops reviewed and largely endorsed the risks identified in 2015. In taking the opportunity to be more outward-looking in our approach, participants identified new risks, some of which have been assessed as significant. A copy of the climate change adaptation risk register for East Midlands Airport is provided at Appendix 1a. The key risks identified are:

- Physical damage to infrastructure due to increased frequency and severity of storm events including high winds, rain, lightning and snow; and
- Release of contaminated surface water due to increased frequency and intensity of winter rainfall events leading to overspill of balancing ponds containing de-icing chemicals.

Other risks include:

- Downstream flooding due to increased high intensity rainfall events leading to high outflows as a result of balancing pond capacities being exceeded;
- Difficulties in snow contingency planning due to variability and unpredictability of snow events; and
- Disruption to flight schedules as a result of adverse weather and sea level rise/storm surge en-route and at destination airports.

Eight new risks were identified since 2015. These were:

- Increased variability and unpredictability of snow events challenging snow contingency plans;
- Restrictions to airport water supplies due to prolonged drought conditions and lowering of the water table;
- Operational and reputational disruption caused by disruption to off-airport surface transportation;

- Damage to on and off-airport infrastructure due to an increase in storm events including high winds, rain, lightning and snow;
- Disruption to delivery of essential supplies to the airport due to off-airport transport and other impacts;
- Off-airport flooding due to insufficient balancing pond capacity at times of extreme rainfall leading to high outflows and impacts downstream;
- Operational disruption due to climate impacts at destination airports and weather en-route; and,
- Increased cost of insurance cover as a result of increased climate-related insurance claims nationally and internationally.

When reviewing the 2015 risk registers, risk workshop participants took the opportunity to strengthen the wording of a number of risks and ensure the list of risk control measures was accurate and complete. They also sought to identify interdependencies with external stakeholders and identify appropriate action to better address such risks.

Following discussion, the risk relating to the pollution of local watercourses by accumulated drainage system debris was removed from the risk register on the basis that this was adequately covered by another risk.

London Stansted Airport climate change adaptation risks

This is the first of MAG's Climate Change Adaptation Reports to include London Stansted Airport. As such, the airport's risk register has been aligned with the approaches taken at our other airports. Despite this necessitating a degree of change to the way in which risks are presented, workshop participants identified little change to underlying risks to the business. A copy of the climate change adaptation risk register for Stansted Airport is provided at Appendix 1b. At Stansted, key risks include:

- Physical damage to infrastructure due to increased frequency and severity of storm events including high winds, rain, lightning and snow; and
- Release of contaminated surface water due to increased frequency and intensity of winter rainfall events leading to overspill of balancing ponds containing de-icing chemicals.

Other risks include:

- Difficulties in snow contingency planning due to variability and unpredictability of snow events;
- General disruption to the schedule as a result of adverse weather en-route and at destination airports;
- Restrictions to airport water supplies due to more frequent and prolonged periods of drought;
- Structural damage to surfaces caused by increased water ingress and temperature fluctuations;
- Downstream flooding due to increased high intensity rainfall events leading to high outflows as a result of balancing pond capacities being exceeded; and
- Damage or disruption to off airport surface access.

One new risk was identified since 2015. This relates to increased cost of climate-related insurance.

When reviewing the 2015 risk registers, risk workshop participants strengthened the wording of a number of risks and ensured the list of risk control measures was accurate and complete. They also sought to identify interdependencies with external stakeholders and identify appropriate action to better address such risks.

Following discussion, three risks were removed from the risk register. These were:

- Seasonal changes to fog-related disruption;
- Increased longevity of wing tip vortex effect; and,
- Changes to the prevailing wind direction.

Other risks contained in the 2015 register have been amalgamated into rephrased risks presented in the 2021 register.

Manchester Airport climate change adaptation risks

Risk workshops at Manchester Airport recorded similar risks to those identified in 2015. However, in taking the opportunity to be more outward-looking in our approach, this year we have identified new risks. A copy of the climate change adaptation risk register for Manchester Airport is provided at Appendix 1c. Key risks identified are:

- Physical damage to infrastructure due to increased frequency and severity of storm events including high winds, rain, lightning and snow;
- Release of contaminated surface water due to increased frequency and intensity of winter rainfall events leading to overspill of balancing ponds containing de-icing chemicals; and
- Increases in serious airfield safety incidents due to more frequent and/or severe weather events such as high winds, intense rainfall and icy conditions.

Other risks include:

- General disruption to the schedule as a result of adverse weather en-route and at destination airports;
- Difficulties in snow contingency planning due to variability and unpredictability of snow events;
- Damage to airport electrical systems due to lightning strikes arising from increased frequency of summer storm events;
- Structural damage to surfaces caused by increased water ingress and temperature fluctuations;
- Increased bird strike risk as a result of changing wildlife control needs; and
- Downstream flooding due to increased high intensity rainfall events leading to high outflows as a result of balancing pond capacities being exceeded.

Eight new risks were identified since 2015. These were:

- Restrictions to airport water supplies due to prolonged drought conditions and lowering of the water table;
- Operational disruption due to staffing impacts caused by congestion and disruption to off-airport surface transportation;
- Increased variability and unpredictability of snow events challenges snow contingency plans;
- Damage to on and off-airport infrastructure due to an increase in storm events (high winds, rain, lightning and snow);
- Disruption to delivery of essential supplies to the airport due to off-airport transport and other impacts;
- Off-airport flooding due to insufficient balancing pond capacity at times of extreme rainfall leading to high outflows and impacts downstream;
- Disruption to flight schedules as a result of adverse weather and sea level rise/storm surge en-route and at destination airports; and
- Increased cost of insurance cover as a result of increased climate-related insurance claims nationally and internationally.

When reviewing the 2015 risk registers, risk workshop participants strengthened the wording of a number of risks and ensure the list of risk control measures was accurate and complete. They also sought to identify interdependencies with external stakeholders and identify appropriate action to better address such risks.

Following extensive discussion in the virtual workshops, no risks were removed from the risk register.

Required actions

Following the approach taken in our first and second rounds of adaptation reporting, actions have been assigned one of three categories:

- Maintain a **watching brief** in the short-term using the latest information on climate projections and the situation at the airport.

- **Action** needed to mitigate or adapt to a climate change risk.
- **Investigate** a risk to more fully understand it, its associated impacts and the likelihood it leads to risk.

Details of our new actions are included in our risk registers which are provided in Appendix 1.

Progress against previously identified actions

The progress we have made towards fulfilling the actions detailed in our first and second round climate change adaptation report is discussed below. Actions identified at East Midlands, London Stansted and Manchester Airports are considered separately.

Some of the actions we previously identified have now been closed, and others remain open.

Climate change adaptation progress at East Midlands Airport

Table 4. Summary progress against actions identified for East Midlands Airport in previous climate change adaptation report, with reference to actions identified in 2021 risk assessment (see Appendix 1)

East Midlands Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on the risk of thermal expansion of temporary building infrastructure, such as concrete and steel, leading to failures and reduced longevity.	Asset monitoring and data collection in place through asset management system which tracks failures and identifies trends in asset failure. Additionally, research has been undertaken into alternative construction methods and materials to combat the impact of heat.	**Closed** See related actions: CCA01.2021.G1 CCA01.2021.G2
Consider the impact of future climate variables on the condition of the runway and aprons as part of the proposed runway refurbishment project.	Runway resurfacing has been completed. The condition of the runway and aprons are assessed on an on-going basis through reactive audits and maintenance undertaken by the Asset Maintenance team. We are confident that our asset standards and renewal programmes are adequate to mitigate risks in this area.	**Closed**
Maintain a watching brief on the risk of landside surface and sub-surface structural damage to bituminous surfaces, such as car parks, landside roads caused by extreme heat.	This risk is monitored, and action informed by a number of ongoing actions. These include the collection and analysis of asset health data, audits and planned maintenance.	**Retain watching brief** Ref: CCA02.2021.G1
Escalate the issues regarding increased ground movement and the related risk of asset damage and instability that were identified during the annual 'CAP 232' [now CAP 1732] survey to the Head of Engineering. Revise and adapt maintenance regime as required.	Annual surveys undertaken in accordance with Civil Aviation Authority 'CAP1732'. Infrastructure issues are also considered as part of planned and reactive audits and maintenance.	**Closed** See related action: CCA02.2021.G2
Review the need for additional surface water drainage system capacity, including capacity for developments, and deliver capacity where a requirement identified. Deliver sustainable drainage solutions as part of future site developments.	The airport is currently reviewing its drainage systems with significant work planned. This is expected to include changes to the flow diversion at the eastern apron. Asset standards updated to require on-stie attenuation for new developments.	**Open** Ref: CCA05.2021.E1 See related action: CCA01.2021.G1
Model the impact of future developments on the drainage system capacity and implement controls where requirements are identified. Deliver sustainable drainage solutions as part of future site development.	A full review of the existing drainage network is planned for FY23 to improve data capture and inform decisions on future improvements to the system. Furthermore, surface water drainage asset standards have been updated and now require on site attenuation for any new developments.	**Closed** See related actions: CCA01.2021.G1 CCA05.2021.E1

East Midlands Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on the increased risk of food damage to aircraft navigation systems/buildings and instrument landing systems.	Daily checks are performed on equipment, cabin and antenna structures. The design of cabins and the equipment used allows for elevation above ground level which mitigates against water ingress/flooding. Cabin structures are assessed on a regular basis. Engineers monitor and record asset condition of the functional system during planned maintenance visits. Asset health is also audited by internal compliance and CAA Engineering Inspector.	**Closed** See related actions: CCA01.2021.G1 CCA05.2021.G1 CCA05.2021.E1 CCA08.2021.G1 CCA08.2021.G2 CCA08.2021.G3
Develop Performance Based Navigation (PBN) arrival and departure routes as part of future Airspace Strategy to address the risk of extremities of wet and dry conditions affecting ground reflection or navigational aids.	Future Airspace Project has commenced and will deliver PBN procedures. On-airport infrastructure, such as instrument landing system (ILS), will still be required. Equipment choice allows for large deviations of the water table. French drains installed in the beam forming area, the airport has fire hydrants in locations near to Glidepath beam forming area which allows for rapid rehydration of arid areas.	**Open** Ref: CCA08.2021.G2
Maintain a watching brief on the increased risk of fire due to hotter, dryer summers and increased incidence of lightning in the summer months.	Airport Rescue and Firefighting Service has procedures in place to respond to any incidents relating to fire. Operational personal monitoring airfield 24/7.	**Retain watching brief** Ref: CCA09.2021.G1
Revise and adapt the runway inspection regime to mitigate the risk of increased build-up of rubber on the runway.	Regular runway inspections and friction testing allow asset health to be monitored, recorded and analysed. Rubber removal takes place as required to ensure adequate friction available to maintain safe operations. Airfield safety is regulated and inspected by the Civil Aviation Authority.	**Retain watching brief** Ref: CCA11.2021.G1
Research the risk regarding a potential increase in disease vectors at the airport as a result of climate change to fully understand the risk, existing controls and those that may be required.	Reviews are constantly undertaken with The UK Health Security Agency and the local resilience forums to identify emerging issues.	**Retain watching brief** Ref: CCA12.2021.G1
Maintain a watching brief on the additional measures that may be required to exercise an appropriate duty of care for the health and wellbeing of outside workers at times of extreme weather.	MAG Health & Safety polices in place for all employees, including risk assessments and safe systems of work.	**Retain watching brief** Ref: CCA13.2021.G1
Ensure that the thresholds for new plant and equipment as set out in the asset standards is aligned with predicted temperature increases during an asset's lifetime to ensure terminals have adequate cooling systems. Amend design standards where required to take account of climate change projections.	New cooling system and chillers installed in 2016, including new mechanisms to control temperature within terminal and immigration hall. New installations will be in accordance with our asset standards which were developed in 2018 and will be further reviewed to ensure alignment with the latest climate change projections.	**Retain watching brief** Ref: CCA14.2021.G1
Research the risk of increased noise complaints as a result of local residents opening windows at night due to hot weather causing in more detail to more fully understand the risk, existing controls and those that may be required.	The sound insulation grant scheme continues to meet planning obligations and will remain subject to periodic review, which will consider climate change impacts.	**Open** Ref: CCA15.2021.G1
Maintain a watching brief on the risk of pollution of local watercourses by debris accumulated in the drainage pipework following a prolonged dry spell.	Periodic inspections to identify debris conducted throughout the year with reactive maintenance work instructed to resolve. Further options to prevent accumulated debris will be identified as part of a project looking at the airport surface water drainage system in FY23.	**Closed** See related action: CCA02.2021.E1

East Midlands Airport action	Progress	Current status and reference to actions (see Appendix 1)
Revise and adapt the landscape management regime as required in response to changes to airfield habitats and wildlife control needs.	Wildlife hazard risk assessments are undertaken on an annual basis and will identify any future changes that require the management regime to be adapted accordingly.	**Retain watching brief** Ref: CCA16.2021.E1
Maintain a watching brief on the risk of increased rainfall and more frequent heavy rain events leading to increased airfield safety incidents.	This will be assessed as part of a wider project looking at the airport surface drainage system.	**Retain watching brief** Ref: CCA17.2021.E1
Maintain a watching brief on the risk of increased lightning events leading to asset damage, decreased ground handling performance, or a decrease in airfield/airspace availability.	Emergency and business continuity plans are in place for loss of services. Increased lightning events would impact on time performance due to mitigation measures implemented to ensure the safety of ramp workers.	**Retain watching brief** Ref: CCA18.2021.G1
Maintain a watching brief on the risk of increased local air quality pollutants, such as ozone, due to high temperatures/low dispersion condition	There are currently no ozone issues in the vicinity of the airport. Current compliance and anticipated (road traffic-related) nitrogen oxides (NOx) emission reductions suggest the likelihood of this risk is low.	**Closed** See related action: CCA20.2021.E1

Climate change adaptation progress at London Stansted Airport

Table 5. Summary progress against actions identified for London Stansted Airport in previous climate change adaptation report, with reference to actions identified in 2021 risk assessment (see Appendix 1)

London Stansted Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on the changes in distribution of pests and wildlife species.	Our Wildlife Hazard Management Plan continues to be implemented. We engage the services of an external agronomist and Wildlife Hazard Audits are conducted on site to ensure risks are kept to a minimum and any actions are addressed.	**Retain watching brief** Ref: CCA16.2021.S1
To mitigate against the risk of increased/heavy rainfall leading to local flooding, airfield flooding or pollutant release, complete surface water modelling, implement Flood Risk Assessment measures, and update the attenuation policy.	Surface Water modelling has been completed. Practical validation of the model is planned for FY22.	**Open** Ref: CCA05.2021.S1
Maintain a watching brief on seasonal changes to fog related disruption that could disrupt operations.	Work complete with National Air Traffic Services London Terminal Control to ensure that their Low Visibility Matrix is applied to Stansted Airport. 'Category 3' instrument landing system operations maintained. In the event of any poor visibility conditions experienced, scheduled breaks throughout the day enable de-congestion of built-up traffic.	**Closed**
In response to the increased risk of schedule interruption due to loss of power during storms, develop and implement an electrical site resilience strategy, and put operational contingencies in place.	Our site resilience strategy was reviewed in 2018 following a desktop exercise with key stakeholders. Updated incident management system implemented.	**Closed**
Maintain a watching brief on the risk of increased longevity of the wing tip vortex effect and the related potential increase in property damage.	The introduction of newer aircraft, with more efficient designs, has reduced vortices.	**Closed**

London Stansted Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on changes to the prevailing wind direction and the potential impact on the runway utilisation rate and schedules.	Long-term operational monitoring shows no change in runway utilisation. Airspace modernisation programmes will consider all options and be designed to the latest international aviation standards, including tailwind component negating the impact of the runway utilisation element of this risk. Further monitoring is required to understand the impact of changes to en route wind which could impact airline schedules.	**Closed**
Maintain a watching brief on the impact of increased lightning events on electricity supply systems and ground handling operational performance.	Back-up generators provide alternative power supplies. Fuel stock increased to mitigate risk of lightning strike. Bespoke weather forecasting contract provides us with early warning of thunderstorm activity.	**Retain watching brief** Ref: CCA18.2021.S1
Maintain a watching brief on the increased need for cooling to avoid overheating of aircraft on the stands.	Fixed electrical ground power is provided on each stand for every aircraft. In the event that this provision is unsuitable, local planning consents allow for use of an auxiliary power unit when the outside air temperature is above +20°C.	**Closed** See related action: CCA22.2021.G1
Maintain a watching brief on the increasing variability of snowfall and potential challenges to the airports winter contingency plans.	Winter Operations Plan reviewed at the end of each season, updated as required. Airfield de-icer supplier changed, increasing stock and improving product performance. Equipment regularly reviewed to respond to changes in demand.	**Retain watching brief** Ref: CCA23.2021.S1
Maintain a watching brief on the impact of extremities of wet and dry conditions affecting ground reflection navigation aids.	ILS grass areas maintained as part of the Wildlife Hazard Management Plan to ensure navigation aid compliance. Airfield drainage systems maintained to reduce impact of localised flooding.	**Retain watching brief** Ref: CCA08.2021.G1
Maintain a watching brief on the increased build-up of rubber on the runway.	Regular runway inspections and friction testing allow asset health to be monitored, recorded and analysed. Rubber removal takes place as required to ensure adequate friction available to maintain safe operations. Airfield safety is regulated and inspected by the Civil Aviation Authority.	**Closed** See related action: CCA11.2021.G1
Maintain a watching brief on the risk of remote impacts restricting the flow of essential supplies to the airport.	The airport has contingencies to ensure essential services are able to operate. We also have supply rationing polices in place in the event of disruption.	**Retain watching brief** Ref: CCA24.2021.S1
Maintain a watching brief on the impact of freezing/thawing on the integrity of surfaces and underground infrastructure.	This is a risk experienced at present, it will continue to be monitored. If the risk increases further, alternative treatments may be explored.	**Retain watching brief** Ref: CCA02.2021.G1
Maintain a watching brief on the impact of wind damage to operations and airport assets.	Airside assets designed to withstand strong winds (+100mph). Strong wind warning system in place to ensure aircraft and equipment safety.	**Retain watching brief** Ref: CCA19.2021.G1
Complete surface water modelling and a Flood Risk Assessment to identify if/where improvement works are required. Continue to monitor and stress test the Balancing Pond performance. Ensure site developments are assessed for additional impacts on the surface water drainage system.	Monitoring of balancing pond performance ongoing. Extreme weather conditions can overwhelm pond capacity in a short period of time. All site developments now required to include on-site attenuation to alleviate impacts on balancing ponds. Asset standards have been updated to reflect these additional requirements.	**Retain watching brief** Ref: CCA05.2021.G1
Sensitivity test the airport drainage infrastructure to ensure it is as robust as practicable to future climate extremes. Investigate and address risks of flooding to existing critical airport assets. Confirm the airport's attenuation policy.	Surface water modelling designed to address this risk is complete. The model needs external validation, scheduled for FY22.	**Closed** See related action: CCA05.2021.S1

London Stansted Airport action	Progress	Current status and reference to actions (see Appendix 1)
Monitor surface water drainage system performance and stress test predicted climate change performance. Liaise with the Environment Agency to identify any risk of flooding in a receiving watercourse and to determine their role in downstream flood management. Complete surface water modelling and take appropriate action.	Drainage capacity modelling and flood risk assessment has completed. Operational changes made to reduce impact of releasing contaminated surface water.	**Open** Ref: CCA05.2021.S2
To ensure continued security of water supply, develop a contingency and prioritisation plan with the water supply company, to include actions to ensure continued robustness of building design standards to future water resource constraints (BREEAM). Ensure adoption of demand management arrangements and water efficient technologies such as rainwater recycling as part of critical water use asset refurbishment and replacement projects.	Leak detection surveys undertaken to identify and address water wastage. Water efficiency measures have explored across the airport campus. Bathroom Asset Standards updated to include water efficiency measures as well as a requirement to assess waterless toilets/urinals.	**Closed**
Research aviation fuel spill clean-up options currently used at airports in warmer climates to commence to develop policies robust to air temperatures exceeding 38°C, and review fire water management procedures.	Comprehensive contingency plans in place and including COMAH controls for incidents and spillages of aviation fuels, Airport Fire and Rescue Service (ARFS) training and procedures for spill management audits by AFRS. Further research into impacts of air temperature increases required.	**Open** Ref: CCA10.2021.G1
Conduct research into the options currently used at airports in warmer climates for spill reporting and clean up.	Regular spill kit reviews conducted. Spill log and chemical storage log maintained, allowing trend analysis. Regular environmental audits, third party audits of operations and spill kits undertaken. Environmental management system certified to ISO14001, with regular independent audits of our system and operational controls/ legal compliance.	**Closed**
Ensure that the fire water demand assessment and related changes to the Fresh Water Pumping Station consider and address the potential for increased fire risk resulting from climate change, and review fire water management procedures.	Confirmed sufficient capacity available in fresh water pumping station and reservoirs. Fire management considered in development of new assets.	**Closed**
Maintain a watching brief on increased on-airport fire risk.	Possible increase in grass fires, lightning strikes and increased risk of flashpoint being reached for fuel spills identified. Airport Fire Service has procedures covering all fire incident types identified across the campus and are well resourced with vehicles and equipment.	**Closed**
Maintain a watching brief on increased wintery conditions that may pose a health and safety risk.	Winter Operations Plan required by the Civil Aviation Authority and updated after each season, includes safety requirements for third-party stakeholders.	**Retain watching brief** Ref: CCA13.2021.G1
Maintain a watching brief on impact of a changing climate on the health and wellbeing of outside workers.	MAG Health & Safety polices in place for all employees, including risk assessments and safe systems of work.	**Retain watching brief** Ref: CCA13.2021.G1
Maintain a watching brief on the risk of passenger overheating surface access transport.	Regular engagement with transport providers who are continually renewing their fleet with newer vehicle models. Stansted Express fleet replacement includes air conditioning.	**Retain watching brief** Ref: CCA26.2021.S1

London Stansted Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on the risk of increased ground movement caused by prolonged drought conditions leading to airside and landside surface sub-surface structural damage.	Annual surveys undertaken in accordance with Civil Aviation Authority 'CAP1732'. Also considered as part of audits, inspections and maintenance.	**Retain watching brief** Ref: CCA02.2021.G2
Review building design standards to ensure robustness to future temperature change. Ensure design and development of London Stansted's long term master plan manages risks from future climate change.	Heating, ventilation and air conditioning (HVAC) climate control considered in the design phase of any planning for new or major changes to the buildings. Asset standard for Mechanical Building Services issued in 2018 covers building ventilation and air conditioning. Standard to be updated to take account of future changes to climate projections.	**Retain watching brief** Ref: CCA14.2021.G1
Maintain a watching brief on climate-related offsite impacts and the impact on the flow of people (passengers, crew and staff) to the airport	Regular meetings with stakeholders including local authorities, Transport for London and transport operators as part of Transport Forum, providing insight into any impacts on surface access flow.	**Retain watching brief** Ref: CCA26.2021.S2
Maintain a watching brief on Sea Level Rise and storm surge risks that will cause a loss of low-lying destination airports.	Further assessment required. We note research in this area by third parties including Eurocontrol, Airports Council International and United Nation's International Civil Aviation Organisation.	**Retain watching brief** Ref: CCA27.2021.G1
(30) Maintain a watching brief on the Sea Level Rise and storm surge risks to London, which would impact transport infrastructure and utility supply systems.	Separate climate risk assessments undertaken by transport and utility organisations. Awaiting submission of Third-Round reports by other organisations.	**Retain watching brief** Ref: CCA26.2021.S2
(31) Complete a comprehensive review of our noise insulation scheme in our sustainable development plan to ensure it considers increase in hot nights when residents are likely to keep windows open.	The sound insulation grant scheme continues to meet planning obligations and will remain subject to periodic review, which will consider climate change impacts.	**Open** Ref: CCA15.2021.G1
(32) Maintain a watching brief on the risk of an increase in disease vectors at the airport.	Reviews are constantly undertaken with The UK Health Security Agency and the local resilience forums to identify emerging issues.	**Retain watching brief** Ref: CCA12.2021.G1

Climate change adaptation progress at Manchester Airport

Table 6. Summary progress against actions identified for Manchester Airport in previous climate change adaptation report, with reference to actions identified in 2021 risk assessment (see Appendix 1)

Manchester Airport action	Progress	Current status and reference to actions (see Appendix 1)
Ensure building specifications consider future climate change predictions.	Group Asset Standards introduced in 2018. A review is required to ensure these have adequately considered climate change projections.	**Open** Ref: CCA01.2021.G1
Maintain a watching brief on airfield surface and sub-surface structural damage to the runway and aprons caused by extreme heat.	Infrastructure issues considered as part of planned and reactive audits and maintenance.	**Retain watching brief** Ref: CCA02.2021.G1
Maintain a watching brief on the risk of landside surface and sub-surface structural damage to bituminous surfaces, such as car parks, landside roads caused by extreme heat.	Routine asset monitoring and data collection within Maximo, the asset management system, tracks failures and identifies trends in asset failure. We have undertaken research into alternative construction methods and materials to combat the impact of heat.	**Closed** See related action: CCA02.2021.G1
Maintain a watching brief on the risk of increased ground movement, leading to instability of surrounding objects, buildings and structures.	Asset monitoring and data collection in place through asset management system which tracks failures and identifies trends in asset failure.	**Retain watching brief** Ref: CCA02.2021.G2

Manchester Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on the risk of increased ground movement due to clay soil changes on which the airport is built.	Asset monitoring and data collection in place through asset management system which tracks failures and identifies trends in asset failure.	**Retain watching brief** Ref: CCA02.2021.G2
Prepare a business case to increase the capacity of surface water drainage system balancing ponds. Consider surface water capacity as part of the [Manchester Airport Transformation Programme, 'MAN-TP']. Consider standard design requirements as part of future development design criteria.	Project to improve capacity of the balancing ponds has been completed. Further projects under investigation or in planning. Ongoing monitoring of surface water attenuation performance. Asset standards updated to require on-stie attenuation for new developments.	**Retain watching brief** Ref: CCA05.2021.G1
Incorporate climate change as part of reviews undertaken with air navigation service provider (ANSP). Develop Performance Based Navigation (PBN) arrival and departure routes as part of future airspace strategy.	Safety case for navigational equipment considers operating temperatures. Airspace modernisation programme underway to remove dependence upon the on-airport 'DVOR' navigational aid and introduce PBN procedures. Further consideration given in NATS' climate risk assessments.	**Open** Ref: CCA08.2021.G2
Maintain a watching brief on an increased risk of fire due to hotter, dryer summers and increased incidence of lightning in summer	Airfield operations and air traffic control procedures in place to identify and alert Airport Fire Service to fires. Fire service procedures in place to respond to incidents relating to fire.	**Closed** See related action: CCA09.2021.G1
Maintain a watching brief on the risk of an increase of build-up of rubber on runway.	Regular runway inspections and friction testing allow asset health to be monitored, recorded and analysed. Rubber removal takes place as required to ensure adequate friction available to maintain safe operations. Airfield safety is regulated and inspected by the Civil Aviation Authority.	**Retain watching brief** Ref: CCA11.2021.G1
Research the risk of increased disease vectors at the airport due to a change in distribution in more detail to more fully understand the risk, existing controls and additional controls that may be required.	Reviews are constantly undertaken with The UK Health Security Agency and the local resilience forums to identify emerging issues.	**Retain watching brief** Ref: CCA12.2021.G1
Maintain a watching brief on the health and wellbeing of outside workers.	MAG Health & Safety polices in place for all employees, including risk assessments and safe systems of work.	**Retain watching brief** Ref: CCA13.2021.G1
Ensure that the thresholds for new plant and equipment as set out in the asset standards is aligned with predicted temperature increases during an asset's lifetime to ensure terminals have adequate cooling systems. Amend design standards where required to take account of climate change projections.	Heating, ventilation and air conditioning (HVAC) climate control considered in the design phase of any planning for new or major changes to the buildings. Asset standard for Mechanical Building Services issued in 2018 covers building ventilation and air conditioning. Standard to be updated to take account of future changes to climate projections.	**Retain watching brief** Ref: CCA14.2021.G1
Research the risk of increased noise complaints as a result of local residents opening windows at night due to hot weather causing in more detail to more fully understand the risk, existing controls and those that may be required.	The sound insulation grant scheme continues to meet planning obligations and will remain subject to periodic review, which will consider climate change impacts.	**Open** Ref: CCA15.2021.G1
Revise and adapt the habitat management regime as required to meet any changes to airfield habitats and related wildlife control needs.	Wildlife hazard risk assessments are undertaken on an annual basis and will identify any future changes that require the management regime to be adapted accordingly.	**Retain watching brief** Ref: CCA16.2021.M1

Manchester Airport action	Progress	Current status and reference to actions (see Appendix 1)
Maintain a watching brief on the impacts of increased rainfall and heavy rain events on airfield safety.	Winter Operations Plan expanded to include all types of weather-related events and threats. The airfield drains well, apart from one area on runway 05L/23R. Well established and tested low visibility procedures and in-depth understanding of pavement anti-icing fluid performance, particularly on saturated surfaces.	**Retain watching brief** Ref: CCA17.2021.M1
Maintain a watching brief on the risk of increased lightning events, leading to asset damage, decreased ground handling performance and decreased airfield/airspace availability.	Winter Operations Plan expanded to include all types of weather-related events and threats. Bespoke weather forecasting service includes lighting proximity warnings.	**Retain watching brief** Ref: CCA18.2021.M1
Maintain a watching brief on the risk of increased local air quality pollutants, such as ozone, due to high temperatures/low dispersion condition.	Air quality monitoring near to Manchester Airport recorded exceedances of the short-term air quality objective for ozone. However, the number of occurrences has reduced over recent years. Air quality improvements targeting oxides of nitrogen (NOx), including the phase out of petrol and diesel vehicles as well as the introduction of the Greater Manchester Clean Air Zone, are expected to lead to a reduction in the atmospheric formation of ozone. The results of air quality monitoring near to the airport are published annually on the airport website.	**Open** Ref: CCA20.2021.M1
Review historic data relating to aircraft performance in high temperatures and identify potential issues for escalation, such as longer aircraft take-off run and reduced aircraft engine efficiency.	Modern aircraft designed to operate within a wide-ranging envelope of operational conditions. Considering increased temperatures, meteorological conditions in Manchester are well within the capabilities of aircraft which have been proven to operate in warmer climates.	**Retain watching brief** Ref: CCA21.2021.M1
Maintain a watching brief over the need for additional cooling to maintain cabin comfort during turnround at times of high ambient temperatures	Operational procedures permit use of aircraft auxiliary power units in warmer temperatures, maintaining cabin comfort. The installation of pre-conditioned air was considered within MAN-TP business case, and it was decided not to install at this time.	**Open** Ref: CCA22.2021.G1

Interdependencies

Our first-round adaptation report identified a number of interdependencies. These were considered as part of our 2015 and 2021 climate change risk register review. Attendees of the risk workshops and virtual meetings did not identify any further interdependencies and felt those detailed in our first-round climate change adaptation report remain relevant.

Our membership of Sustainable Aviation and Airports Council International enables us to share our learning and reflect on actions taken by others. We also have strong links with both NATS and Eurocontrol who are responsible for the movement of aircraft within the UK and Europe respectively.

In addition to our aviation sector business partners, we work with our supply chain partners and other infrastructure providers on climate change adaptation. This includes our relationship with electricity distribution network operators, internet service providers, and ground transport operators such as National Highways, Network Rail, Transport for London, and Transport for Greater Manchester. We are also actively engaged with local authorities and planning authorities on resilience including climate change adaptation.

We strongly believe that a collaborative approach is required to enable our airports to fully prepare for climate change and to support our communities and wider industry peers. This is an opportunity for us to be part of the solution to climate change and help to mitigate its impact on the UK by maintaining the crucial

transport links that we provide. MAG has developed a better understanding of how our climate change adaptation actions will impact upon other stakeholders, and the roles other stakeholders have in enabling us to prepare for a changing climate. Through Local Resilience Forums and our established relationships with Local Authorities, the Environment Agency, water supply companies, transport providers and others we are working to better understand and address these interdependencies.

Monitoring and review

The climate change risk registers for our airports contribute to our corporate assessment of risk. An overall assessment of the risk climate change poses to MAG is included within our corporate risk register. This ensures that climate change risk is discussed at the highest level within the organisation.

Climate change is at the forefront of our approach to having a sustainable business and, as a result, our governance will be increasingly influenced by climate risks and exposures identified over the short, medium and long term that are identified in this report and previous Adaptation Reports. Alongside this, we will continue to refine and develop our approach to TCFD as we progress our understanding of the financial risks and opportunities of climate change to our business. We will meet the recommendations in full, ahead of forthcoming mandatory reporting.

In the interim period, progress against the actions identified in our climate change adaptation risk registers will be regularly reviewed. In addition to maintaining positive working relationships with our infrastructure partners, we will continue to monitor and identify any new or emerging interdependencies and conduct scenario analysis to ensure that we are considering every possible risk to the business going forward.

Appendix 1: Climate change adaptation risk registers

Appendix 1a: East Midlands Airport climate change adaptation risk register

East Midlands Airport climate change adaptation risk register (2021)																					
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA01	Summer temperature	**Thermal expansion** of building infrastructure, such as concrete and steel, leading to failures and reduced lifespan.	There is a current lack of knowledge around the vulnerability of the airport buildings design to the projected future temperatures.	- Financial costs of repair/replacement - Operational disruption - Airport closure - Reputational damage	2	2	4	- Structural inspections - Asset maintenance schemes - Capex plans that align to assets - Conformance with asset standards and Building Regulations	CCA01.2021.G1 Action: Ensure specifications for future developments and asset renewals consider climate change predictions. CCA01.2021.G2 Action: Seek specialist advice to ensure risk assessment is valid.	2	2	4	2	3	6	3	3	9	
CCA02	Summer temperature, Summer rainfall, Winter rainfall	**Structural damage to airside** runway, aprons and airfield subsurface caused by extreme heat or water ingress.	It is known that a combination of water ingress and temperature fluctuations causes deterioration in these surfaces.	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Operational disruption - Airport closure - Reputational damage	2	3	6	- Conformance to asset standards and Building Regulations - Management and maintenance plans - Remedial capabilities and ability to respond to issues on the runway quickly	CCA02.2021.G1 Watching brief: Impact of water ingress freeze/thaw and heat. CCA02.2021.G2 Watching brief: Increased ground movement leading to structural damage. See CCA01.2021.G1	2	3	6	2	4	8	3	4	12	Life cycle for a runway surface is 12-15 years so it will have been replaced a number of times over these time horizons.

East Midlands Airport climate change adaptation risk register (2021)																				
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA03	Summer temperature, Summer rainfall, Winter rainfall	**Structural damage to landside** bituminous surfaces/subsurface such as car parks and landside roads caused by extreme heat or water ingress.	It is known that a combination of water ingress and temperature fluctuations causes deterioration in these surfaces.	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Operational disruption - Reputational damage - Cost of claims for damage/injury - Disruption to surface access to the airport	1	2	2	- Conformance to asset standards and Building Regulations - Management and maintenance plans - Remedial capabilities and ability to respond to issues quickly	See CCA01.2021.G1 See CCA02.2021.G1	1	1	1	1	3	3	1	4	4	
CCA04	Summer temperature, Summer rainfall, Winter rainfall	**Damage to buildings and belowground structures** and utilities due to increased ground movement.	Risk expected due to warmer, dryer summers and increased variance between summer and winter soil moisture levels particularly for clay soils	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Increased inspection and maintenance needs - Operational disruption - Reputational damage - Potential health and safety risk related to energy systems	1	1	1	- Inspection and maintenance programme - Conformance to asset standards and Building Regulations	See CCA01.2021.G1 See CCA02.2021.G2	1	1	1	1	2	2	1	3	3	

East Midlands Airport climate change adaptation risk register (2021)																				
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA05	Winter rainfall, Summer rainfall	**Release of contaminated surface water** in contravention of environmental permits as a result of storm event, including exceeding balancing pond capacity.	Airfield run-off is held in balancing ponds to allow for degradation of de-icing chemicals to acceptable concentrations prior to discharge. A significant rainfall event during winter de-icing season could flush de-icer out of the ponds.	- Regulatory notification/fines - Reputational damage - Off-airport environmental impacts - Restrictions on future on-airport development - Requirement for airport infrastructure development (e.g. de-icing pads)	3	3	9	- Pollution control system design capacity - Agreed contingency plans - Elimination of clean rainwater to reduce capacity requirement - Monitoring and management systems	CCA05.2021.G1 Watching brief: Drainage system capacity in light of updated climate projections and site developments. CCA05.2021.E1 Action: Complete review of drainage system, identifying and implementing improvements. See CCA01.2021.G1	2	3	6	4	4	16	4	4	16	
CCA06	Winter rainfall	**On-airport flooding** due to insufficient on-airport drainage capacity leading to schedule disruption and damage to below ground infrastructure.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding on the airport campus if the drainage system is unable to cope.	- Financial costs of repair/replacement - Operational disruption - Reputational damage	1	3	3	- Inspection and maintenance programme - Flood detection - Conformance to asset standards and Building Regulations	See CCA01.2021.G1 See CCA05.2021.G1 See CCA05.2021.E1	1	3	3	1	3	3	2	3	6	Risk of flooding is anticipated to increase in line with the projected increase in rainfall, but be offset by investment in drainage systems.

East Midlands Airport climate change adaptation risk register (2021)																				
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA07	Winter rainfall	**Off-airport flooding** due to insufficient balancing pond capacity at times of extreme rainfall leading to high outflows and impacts downstream.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding off the airport campus if the drainage system is unable to cope.	- Flooding of downstream properties and infrastructure - Cost of putting in place emergency arrangements - Reputational damage - Cost and operational disruption of retrofitting systems - Environmental permit and planning obligation changes - Cost of claims for damage/injury	2	3	6	- Input to Environment Agency contingency planning - Relationship with local authorities - Surface water attenuation for new developments	CCA007.2021.E1 Action: Continue to liaise with Local Authority and Environment Agency over flood contingency planning. See CCA01.2021.G1 See CCA05.2021.G1 See CCA05.2021.E1	2	2	4	2	3	6	2	4	8	Higher risk of flooding over time. Potential for significant cost or planning conditions in future development. Airport could be held responsible by stakeholders for flooding.

East Midlands Airport climate change adaptation risk register (2021)																				
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA08	Summer rainfall, Winter rainfall	**Misalignment of navigational aids**, communications and surveillance systems due to extreme changes in wet/ dry surface conditions.	Extreme raising and lowering of the water table may lead to incorrect instrument alignment.	- Financial costs of repair/replacement - Operational disruption - Reduced aircraft movements - Increase in aircraft safety incidents - Reputational damage	3	1	3	- Inspection and maintenance programme	CCA08.2021.G1 Watching brief: Changes to ground conditions affecting navigation aids. CCA08.2021.G2 Action: Develop Performance Based Navigation (PBN) arrival and departure routes as part of future airspace strategy. CCA08.2021.G3 Watching brief: Monitor for new technology to move away from ground-based approach. See CCA01.2021.G1	3	1	3	3	1	3	3	1	3	No change in scores anticipated over time as risk can be managed through current controls. New technology could reduce risk in the 2050s and 80s.

East Midlands Airport climate change adaptation risk register (2021)																				
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA09	Summer temperature, Summer rainfall, Lightning	**Schedule disruption** due to low visibility or structural damage caused by off-airport vegetation fires.	Grass and vegetation fires could cause poor visibility due to smoke and possible fire damage to infrastructure servicing the airport.	- Minor operational disruption	2	2	4	- Local authority and airport fire services - Air traffic control procedures to redirect aircraft where required - Communications with local emergency services and responder networks - External communication channels to alert passengers of schedule disruption	CCA09.2021.G1 Watching brief: On frequency and type of on and off-airport fires.	2	2	4	2	2	4	2	2	4	Land surrounding EMA is expected to become more developed over this time period. This will reduce the amount of vegetation around the airport that could catch fire.

East Midlands Airport climate change adaptation risk register (2021)																				
Risk code	Climate variable	Risk (including indirect and interdependency risks)	Narrative	Potential consequences (functions, service, assets affected)	Current			Current control measures/strategy	Further planned actions (in next 5 years)	Current post control			2050 + post control			2080 + post control			Narrative on horizon scores
					Impact	Likelihood	ARP 3 risk score			Impact	Likelihood	ARP 3 risk score	Impact	Likelihood	ARP3 risk score	Impact	Likelihood	ARP3 risk score	
CCA10	Summer temperature	**Operational disruption, asset damage and employee safety risks** due to increased risk of on-airport fires.	Increased chance of fire from dry vegetation, waste and litter.	- Financial costs of repair/replacement - Operational disruption - Increase in aircraft safety incidents - Reputational damage - Increase in accident/incident frequency	2	2	4	- Airport fire service - Airfield and landscape management plans - Asset standards that minimise fire risk and damage potential - Mitigation measures are reviewed annually and aligned with regulations	CCA10.2021.G1 Investigate: Impacts of increased temperature on fuel spill and associated fire risk. See CCA09.2021.G1	2	2	4	2	2	4	2	2	4	Moving from kerosene to sustainable aviation fuel, electric or hydrogen-fuelled aircraft could reduce the fire risk. Although there is a recognised increased chance of aircraft fuel venting, this is not anticipated to increase fire risk because projected temperatures are below the auto-ignition threshold and procedures are in place to prevent exposure to ignition sources.

East Midlands Airport climate change adaptation risk register (2021)																			
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CCA11	Summer temperature	**Increased runway closure / maintenance** requirement due to build-up of rubber on runway surface.	Requirement to maintain appropriate friction level drives the need for regular runway maintenance.	- Operational disruption - Aircraft safety incident - Increased cost of rubber removal - Degradation/ decreased lifetime of the runway through increased cleaning activity	1	1	1	- Inspection and maintenance programme - Friction monitoring - Rubber removal contract in place	CCA11.2021.G1 Watching brief: Rubber cleaning frequency and technological advances in aircraft tyres and runway material. See CCA01.2021.G1	1	1	1	1	1	1	1	1	1	A number of technological advances are expected to take place over the time horizons that will reduce this risk. UK temperatures not expected to exceed those already experienced at other global airports.
CCA12	Summer temperature, Winter temperature, Summer rainfall, Winter rainfall	**Increase in disease vectors and hence incidence of "tropical" diseases** at and around the airport resulting from climate change providing a newly hospitable environment for imported species.	Potential increase in disease vectors such as mosquitos leading to increase in certain diseases such as West Nile Virus.	- Employee and public health impact - Reputational damage	1	1	1	- On-going liaison with Local Resilience Forum and The UK Health Security Agency - Occupational health department	CCA12.2021.G1 Watching brief: On the risk of an increase in disease vectors.	1	1	1	1	1	1	1	3	3	Expected to increase over time, warmer winter temperatures will reduce natural seasonal mitigation, with an increased likelihood in the 2080s. This would be a national challenge but it is acknowledged that it is something that airports have a role in managing.

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CCA13	Summer temperature, Winter temperature, Winter rainfall	**Impact to health and wellbeing** of outside workers during extreme weather events due to inadequate PPE and rostering processes.	Heat exhaustion, dehydration and sunburn during extended hot spells in summer and hypothermia, slips/trips in icy or wet conditions during winter.	- Increase in accident/incident frequency - Reputational damage - Reduced productivity due to exhaustion and the need for respite - Need to increase staffing levels to maintain productivity	2	2	4	- Occupational health department - Health and safety risk assessment process, including provision of PPE, increased breaks and sun protection where required - Communication of weather forecasts to on-airport community - Operational procedures, including Winter Operations Plan	CCA13.2021.G1 Watching brief: Health, safety and wellbeing measures required to manage impact of changes to temperature and rainfall on outside workers.	1	1	1	1	2	2	1	3	3	Increase in likelihood from the 2050s, but the impact is anticipated to be unchanged as risk can be managed by applying current controls.
CCA14	Summer temperature	**Decrease in passenger and staff comfort** within airport buildings caused by inadequate cooling systems.	Heat exhaustion, dehydration and unworkable conditions for colleagues and passengers within those areas.	- Decline in revenue and passenger numbers - Reputational damage - Increased staff absence - Increase in staff and passenger ill-health	1	1	1	- Heating, ventilation and air-conditioning systems - Ongoing HVAC maintenance programme - Capital plans for new and replacement assets - Conformance to asset standards and Building Regulations	CCA14.2021.G1 Watching brief: Asset standards for heating, ventilation and air conditioning to be reviewed when updated climate change projections released. See CCA01.2021.G1	1	1	1	1	1	1	1	1	1	Asset standards, maintenance and capital plans will ensure that HVAC systems continue to maintain comfortable environments.

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CCA15	Summer temperature	**Increased community complaints** due to greater disturbance from aircraft operations, particularly on warm nights when residents' windows are open or due to wing tip vortex damage.	Aircraft operations give rise to noise which can be disturbing to local communities. Warmer temperatures are known to result in higher complaint numbers.	- Requirement for, and cost of, additional noise mitigation - Imposition of operational restrictions - Reputational damage	2	1	2	- Noise Action Plan - Sound Insulation Grant Scheme - Community engagement - Input to local planning policy by providing noise contours and responding as a statutory consultee	CCA15.2021.G1 Action: Consider climate change impacts during future review of sound insulation grant scheme.	2	1	2	2	1	2	2	2	4	This risk could increase with further development closer to the airport.
CCA16	Summer temperature, Summer rainfall, Winter temperature, Winter rainfall	**Changes to wildlife control** required due to changing airfield habitats.	Wildlife strikes pose a threat to aviation safety. Climate change could lead to different habitat, wildlife species and behaviour.	- Increasing wildlife strike risk/operational safety incidents - Reputational damage - Operational disruption	1	1	1	- Wildlife and airfield grassland management plan in place - Habitat management regime in line with Civil Aviation Authority 'CAP 772' requirements - Wildlife management operators	CCA16.2021.E1 Watching brief: Changes in distribution of wildlife species.	1	1	1	1	1	1	1	1	1	

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CCA17	Winter rainfall, Summer rainfall, Winter temperature	**Increase in serious airfield safety incidents** due to severe weather events.	Severe weather presents a risk to aviation safety.	- Aircraft/vehicle collision - Operational disruption - Health & Safety incidents - Increased runway excursion - Need for increased runway grooving	2	5	10	- Winter operations plan and activities - Safety management system requirement for risk assessments	CCA17.2021.E1 Watching brief: On changes to airfield safety procedures due to climate change.	2	5	10	2	5	10	2	5	10	
CCA18	Lightning	**Damage to assets and operational disruption** due to an increase in lightning events.	Lightning presents a risk of building and infrastructure damage, including to electrical, communications and navigational systems. Lightning damage and safety procedures during storm events are known to lead to operational disruption.	- Financial costs of repair/replacement - Operational disruption - Reputational damage - Health & Safety incidents - Damage to the surface of the runway, navigational systems and other assets	2	4	8	- Inspection, maintenance and repair capabilities - Conformance to asset standards and Building Regulations - Equipment design incl. contingency features such as lightning protection - Operational procedures - UPS to critical systems	CCA18.2021.G1 Investigate: Lightning detection and prediction technology. CCA18.2021.E1 Watching brief: On impact of increased lightning events on electricity supply systems and ground handling operational performance.	2	4	8	2	4	8	2	4	8	

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CCA19	Storms	**Damage to on and off-airport infrastructure** due to an increase in storm events (high winds, rain, lightning and snow).	Storm events, including high winds and intense rainfall, have the potential to cause damage to infrastructure.	- Operational disruption - Financial costs of repair/replacement - Disruption to airport surface access, particularly public transport - H&S incident - Reputational damage	3	4	12	- Inspection, maintenance and repair capabilities - Conformance to asset standards and Building Regulations - Asset renewal strategy	CCA19.2021.G1 Watching brief: On impact of wind damage to airport assets. See CCA01.2021.G1	2	4	8	4	4	16	4	4	16	
CCA20	Summer temperature	**Poor local air quality** due to increased frequency of low dispersion conditions, particularly during prolonged hot spells.	Air quality is an important public health issue which is interdependent with climatic conditions.	- Reputational damage - Increased local, regional or national controls on air emissions - Increased absence of vulnerable staff - Increase in ill-health of vulnerable passengers or community members	1	1	1	- Airport air quality monitoring - Engagement with local authority environmental health teams - Airport Sustainable Development Plan	CCA20.2021.E1 Action: Continue to monitor and report air quality at the airport, engaging local authority environmental health teams to identify and resolve issues.	1	1	1	2	1	2	2	1	2	Increased impact in future years due to anticipated increase in stakeholder interest in this issue.

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CCA21	Summer temperature	Impact of climate change on **aircraft performance.**	Due to reduced air density, the take-off performance of aircraft degrades in warmer conditions. In extreme circumstances this can reduce aircraft payload or range.	- Reduction in aircraft payload with consequential financial impact - Inability to operate certain aircraft type/route combinations - Lower efficiency on approach and departure, increased emissions - Increased noise impacts - Potential capital investment required to extend the runway - Current safeguarding measures could be insufficient for future performance - Reputational damage - Potential to limit growth opportunities	2	1	2	- Weather reporting to enable adjustments to be made to operating capabilities - Communications with new operators - Community engagement programme	CCA21.2021.E1 Watching brief: On instances of range/payload limitation.	2	1	2	2	1	2	2	2	4	Current aircraft operate to countries that are experiencing projected temperatures today. Assumed that future and emerging aircraft technology will be designed to a changing climate.

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CCA22	Summer temperature	**Increased need for aircraft cabin cooling and energy** to cool aircraft interior on stand in order to maintain comfortable cabin conditions during turnaround.	Warmer temperatures will require increased use of aircraft auxiliary power units (APU) or installation of pre-conditioned air (PCA). Installation of PCA is a significant infrastructure project and investment. APU use currently discouraged for noise and emissions reasons.	- Cost of installation, operation and maintenance of PCA - Increased workplace exposure to combustion gases - Impact on noise local air quality	2	2	4	- Asset strategy - APU use permitted on warmer days - Noise action plan	CCA22.2021.G1 Investigate: The temperature conditions under which there will be a requirement for PCA and energy system implications.	2	1	2	2	3	6	2	4	8	Increasing number of days when cabin cooling required. Greater utility demand from cooling with (PCA). Technology developments could mean aircraft are better at cooling.
CCA23	Winter temperature	**Increased variability and unpredictability of snow events** challenges snow contingency plans.	As the frequency of snow events decrease it is more difficult to assess the cost-benefit of investing in snow clearance equipment and contingency planning.	- Potential large investment in equipment that is not used, or significant disruption when an infrequent snow event occurs due to inadequate equipment and processes - Reputational damage - Operational disruption	3	3	9	- Winter operations plan and activities - Communication of weather forecasts to on-airport community	CCA23.2021.E1 Watching brief: Increasing variability of snowfall and potential challenges to winter contingency plans.	4	2	8	4	2	8	4	2	8	Increase in passenger numbers could mean there will be less resilience built-in

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CCA24	Summer temperature, Winter rainfall, Storms	**Disruption to delivery of essential supplies** to the airport due to off-airport transport and other impacts.	Extreme weather events including prolonged hot spells, high winds, snow and flooding can disrupt road and rail networks.	- Operational disruption - Short-term shortages of supplies - Reputational damage - Lost revenue	2	2	4	- Multiple suppliers for key supplies of food/drink - Contractual levers available to secure supply - Ongoing engagement with Highways England and Network Rail to manage disruption to surface access	CCA24.2021.E1 Watching brief: Disruption to delivery of essential supplies to the airport. CCA24.2021.E2 Action: Continued engagement with transport partners to manage disruption to surface access.	2	2	4	2	3	6	2	3	6	Significant infrastructure improvement is required to mitigate the potential for disruption, which is outside of MAG's control. Future planning standards could improve and reduce the risk but it is not possible to determine at present.
CCA25	Summer rainfall, Winter rainfall, Summer temperature	**Restrictions to airport water supplies** due to prolonged drought conditions and lowering of water table.	Potential for water supplier drought orders to limit the availability or use of mains water.	- Prohibition of certain non-critical activities such as washing - Financial impact arising from need to obtain alternative sources of water - Reputational impact - Asset renewal to introduce water efficient equipment	2	2	4	- Leak detection and repair programme - Distribution system maintenance / upgrade - Conformance to asset standards and Building Regulations - Asset renewal strategy - Ongoing dialogue with water companies	CCA25.2021.E1 Watching brief: On water scarcity issues with a view to preparing drought management plan when required.	1	3	3	2	2	4	2	3	6	

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CCA26	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature	**Damage or disruption to off-airport surface access** leading to impacts on passenger and staff journeys to/from airport.	Extreme weather events including prolonged hot spells, high winds, snow and flooding can disrupt public transport and road networks. Although this would not be MAG's responsibility, the risk is that access to the airport is perceived as unreliable.	- Operational disruption created by impacts on rosters - Reputational impact	2	2	4	- Multiple surface access options are available - Weather forecasting and pre-emptive planning - Monitoring of transport networks through communications from transport organisations - Procedures in place at airport to respond - Communications process for customers and staff - Engagement with local resilience forums regarding transport and network issues	CCA26.2021.E1 Watching brief: Climate-related offsite impacts on the flow of people to the airport. See CCA24.2021.E2	2	1	2	2	3	6	2	3	6	Expectation that demand will continue to be proactively managed in response to this risk. Anticipated decrease in frost events will have beneficial impact - most significant is expected to be in relation to summer temperature and rainfall.
CCA27	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature	**Disruption or changes to schedule due to en-route weather and sea level rise/storm surge**, including origin and destination airports.	Disruptive weather and sea-level rise/storm surges have the potential to cause disruption at origin/destination airports and en-route requiring temporary or permanent changes flight schedules.	- Operational disruption - Redistribution of market share to alternative routes	2	4	8	- Existing arrangements for diversion airports in case of disruption in-flight - European network management - Operational disruption and resilience plans	CCA27.2021.G1 Watching brief: Impact of sea level rise and storm surge on origin and destination airports. CCA27.2021.E1 Watching brief: Impact of extreme weather on schedules.	2	4	8	3	4	12	4	4	16	Changes to route networks due to sea level rise/storm surge expected to manifest gradually in later time periods and allow market redistribution.

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CCA28	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature, Storms, Snow	**Increased climate-related insurance claims** nationally and internationally.	Increased severity and frequency of extreme weather events of all types are likely to lead to increased damage, disruption and therefore insurance claims. As part of a global risk pool, MAG insurance costs increase as a result of natural disaster / catastrophe globally.	- Increased cost of insurance cover for operational disruption and infrastructure damage - Increased limitations to the availability and/or scope of insurance cover - Increased costs across the whole MAG insurance portfolio as insurers look to recoup losses incurred globally	1	4	4	-MAG has two brokers who negotiate with insurers on our behalf - Insurance team and senior management engage insurers annually to inform them of the robust controls to prevent and manage claims -MAG Insurance engages the Board and Audit Committee on strategic decision making to influence premium spend i.e. sums insured and deductibles	CCA28.2021.G1 Action: Develop insurance strategies to manage climate change risk.	1	3	3	1	4	4	1	4	4	

Appendix 1b: London Stansted Airport climate change adaptation risk register

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CCA01	Summer temperature	**Thermal expansion** of building infrastructure, such as concrete and steel, leading to failures and reduced lifespan.	There is a current lack of knowledge around the vulnerability of the airport buildings design to the projected future temperatures.	- Financial costs of repair/replacement - Operational disruption - Airport closure - Reputational damage	2	2	4	- Structural inspections - Asset maintenance schemes - Capex plans that align to assets - Conformance with asset standards and Building Regulations	CCA01.2021.G1 Action: Ensure specifications for future developments and asset renewals consider climate change predictions. CCA01.2021.G2 Action: Seek specialist advice to ensure risk assessment is valid.	2	2	4	2	3	6	3	3	9	
CCA02	Summer temperature, Summer rainfall, Winter rainfall	**Structural damage to airside** runway, aprons and airfield subsurface caused by extreme heat or water ingress.	It is known that a combination of water ingress and temperature fluctuations causes deterioration in these surfaces.	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Operational disruption - Airport closure - Reputational damage	2	3	6	- Conformance to asset standards and Building Regulations - Management and maintenance plans - Remedial capabilities and ability to respond to issues on the runway quickly	CCA02.2021.G1 Watching brief: Impact of water ingress freeze/thaw and heat. CCA02.2021.G2 Watching brief: Increased ground movement leading to structural damage. See CCA01.2021.G1	2	3	6	2	4	8	3	4	12	Life cycle for a runway surface is 12-15 years so it will have been replaced a number of times over these time horizons.

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CCA03	Summer temperature, Summer rainfall, Winter rainfall	**Structural damage to landside** bituminous surfaces/subsurface such as car parks and landside roads caused by extreme heat or water ingress.	It is known that a combination of water ingress and temperature fluctuations causes deterioration in these surfaces.	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Operational disruption - Reputational damage - Cost of claims for damage/injury - Disruption to surface access to the airport	1	2	2	- Conformance to asset standards and Building Regulations - Management and maintenance plans - Remedial capabilities and ability to respond to issues quickly	See CCA01.2021.G1 See CCA02.2021.G1	1	1	1	1	3	3	1	4	4	
CCA04	Summer temperature, Summer rainfall, Winter rainfall	**Damage to buildings and belowground structures** and utilities due to increased ground movement.	Risk expected due to warmer, dryer summers and increased variance between summer and winter soil moisture levels particularly for clay soils	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Increased inspection and maintenance needs - Operational disruption - Reputational damage - Potential health and safety risk related to energy systems	1	1	1	- Inspection and maintenance programme - Conformance to asset standards and Building Regulations	See CCA01.2021.G1 See CCA02.2021.G2	1	1	1	1	2	2	1	3	3	

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CCA05	Winter rainfall, Summer rainfall	**Release of contaminated surface water** in contravention of environmental permits as a result of storm event, including exceeding balancing pond capacity.	Airfield run-off is held in balancing ponds to allow for degradation of de-icing chemicals to acceptable concentrations prior to discharge. A significant rainfall event during winter de-icing season could flush de-icer out of the ponds.	- Regulatory notification/fines - Reputational damage - Off-airport environmental impacts - Restrictions on future on-airport development - Requirement for airport infrastructure development (e.g. de-icing pads)	3	3	9	- Pollution control system design capacity - Input to water company strategic plan - Agreed contingency plans - Elimination of clean rainwater to reduce capacity requirement - Monitoring and management systems	CCA05.2021.G1 Watching brief: Drainage system capacity in light of updated climate projections and site developments. CCA05.2021.S1 Action: Complete validation of drainage model during FY22. CCA05.2021.S2 Action: Share results of drainage modelling with Environment Agency and Local Authorities, working to minimise risk of pollution and/or flooding downstream. See CCA01.2021.G1	2	3	6	3	4	12	3	4	12	

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CCA06	Winter rainfall	**On-airport flooding** due to insufficient on-airport drainage capacity leading to schedule disruption and damage to below ground infrastructure.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding on the airport campus if the drainage system is unable to cope.	- Financial costs of repair/replacement - Operational disruption - Reputational damage	1	3	3	- Inspection and maintenance programme - Flood detection - Conformance to asset standards and Building Regulations	See CCA01.2021.G1 See CCA05.2021.G1 See CCA05.2021.S1	1	3	3	1	3	3	2	3	6	Risk of flooding is anticipated to increase in line with the projected increase in rainfall, but be offset by investment in drainage systems.
CCA07	Winter rainfall	**Off-airport flooding** due to insufficient balancing pond capacity at times of extreme rainfall leading to high outflows and impacts downstream.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding off the airport campus if the drainage system is unable to cope.	- Flooding of downstream properties and infrastructure - Cost of putting in place emergency arrangements - Reputational damage - Cost and operational disruption of retrofitting systems - Environmental permit and planning obligation changes - Cost of claims for damage/injury	2	3	6	- Input to Environment Agency contingency planning - Relationship with local authorities - Surface water attenuation for new developments	CCA007.2021.S1 Action: Continue to liaise with Local Authority and Environment Agency over flood contingency planning. See CCA01.2021.G1 See CCA05.2021.G1 See CCA05.2021.S1	2	2	4	2	3	6	2	4	8	Higher risk of flooding over time. Potential for significant cost or planning conditions in future development. Airport could be held responsible by stakeholders for flooding.

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CCA08	Summer rainfall, Winter rainfall	**Misalignment of navigational aids**, communications and surveillance systems due to extreme changes in wet/ dry surface conditions.	Extreme raising and lowering of the water table may lead to incorrect instrument alignment.	- Financial costs of repair/replacement - Operational disruption - Reduced aircraft movements - Increase in aircraft safety incidents - Reputational damage	3	1	3	- Inspection and maintenance programme	CCA08.2021.G1 Watching brief: Changes to ground conditions affecting navigation aids. CCA08.2021.G2 Action: Develop Performance Based Navigation (PBN) arrival and departure routes as part of future airspace strategy. CCA08.2021.G3 Watching brief: Monitor for new technology to move away from ground-based approach. See CCA01.2021.G1	3	1	3	3	1	3	3	1	3	No change in scores anticipated over time as risk can be managed through current controls. New technology could reduce risk in the 2050s and 80s.

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CCA09	Summer temperature, Summer rainfall, Lightning	**Schedule disruption** due to low visibility or structural damage caused by off-airport vegetation fires.	Grass and vegetation fires could cause poor visibility due to smoke and possible fire damage to infrastructure servicing the airport.	- Minor operational disruption	2	2	4	- Local authority and airport fire services - Air traffic control procedures to redirect aircraft where required - Communications with local emergency services and responder networks - External communication channels to alert passengers of schedule disruption	CCA09.2021.G1 Watching brief: On frequency and type of on and off-airport fires.	2	2	4	2	2	4	2	2	4	

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CCA10	Summer temperature	**Operational disruption, asset damage and employee safety risks** due to increased risk of on-airport fires.	Increased chance of fire from dry vegetation, waste and litter.	- Financial costs of repair/replacement - Operational disruption - Increase in aircraft safety incidents - Reputational damage - Increase in accident/incident frequency	2	2	4	- Airport fire service - Airfield and landscape management plans - Asset standards that minimise fire risk and damage potential - Mitigation measures are reviewed annually and aligned with regulations	CCA10.2021.G1 Investigate: Impacts of increased temperature on fuel spill and associated fire risk. See CCA09.2021.G1	2	2	4	2	2	4	2	2	4	Moving from kerosene to sustainable aviation fuel, electric or hydrogen-fuelled aircraft could reduce the fire risk. Although there is a recognised increased chance of aircraft fuel venting, this is not anticipated to increase fire risk because projected temperatures are below the auto-ignition threshold and procedures are in place to prevent exposure to ignition sources.

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CCA11	Summer temperature	**Increased runway closure / maintenance** requirement due to build-up of rubber on runway surface.	Requirement to maintain appropriate friction level drives the need for regular runway maintenance.	- Operational disruption - Aircraft safety incident - Increased cost of rubber removal - Degradation/ decreased lifetime of the runway through increased cleaning activity	1	1	1	- Inspection and maintenance programme - Friction monitoring - Rubber removal contract in place	CCA11.2021.G1 Watching brief: Rubber cleaning frequency and technological advances in aircraft tyres and runway material. See CCA01.2021.G1	1	1	1	1	1	1	1	1	1	A number of technological advances are expected to take place over the time horizons that will reduce this risk. UK temperatures not expected to exceed those already experienced at other global airports.
CCA12	Summer temperature, Winter temperature, Summer rainfall, Winter rainfall	**Increase in disease vectors and hence incidence of "tropical" diseases** at and around the airport resulting from climate change providing a newly hospitable environment for imported species.	Potential increase in disease vectors such as mosquitos leading to increase in certain diseases such as West Nile Virus.	- Employee and public health impact - Reputational damage	1	1	1	- On-going liaison with Local Resilience Forum and The UK Health Security Agency - Occupational health department	CCA12.2021.G1 Watching brief: On the risk of an increase in disease vectors.	1	1	1	1	1	1	1	3	3	Expected to increase over time, warmer winter temperatures will reduce natural seasonal mitigation, with an increased likelihood in the 2080s. This would be a national challenge but it is acknowledged that it is something that airports have a role in managing.

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CCA13	Summer temperature, Winter temperature, Winter rainfall	**Impact to health and wellbeing** of outside workers during extreme weather events due to inadequate PPE and rostering processes.	Heat exhaustion, dehydration and sunburn during extended hot spells in summer and hypothermia, slips/trips in icy or wet conditions during winter.	- Increase in accident/incident frequency - Reputational damage - Reduced productivity due to exhaustion and the need for respite - Need to increase staffing levels to maintain productivity	2	2	4	- Occupational health department - Health and safety risk assessment process, including provision of PPE, increased breaks and sun protection where required - Communication of weather forecasts to on-airport community - Operational procedures, including Winter Operations Plan	CCA13.2021.G1 Watching brief: Health, safety and wellbeing measures required to manage impact of changes to temperature and rainfall on outside workers.	1	1	1	1	2	2	1	3	3	Increase in likelihood from the 2050s, but the impact is anticipated to be unchanged as risk can be managed by applying current controls.
CCA14	Summer temperature	**Decrease in passenger and staff comfort** within airport buildings caused by inadequate cooling systems.	Heat exhaustion, dehydration and unworkable conditions for colleagues and passengers within those areas.	- Decline in revenue and passenger numbers - Reputational damage - Increased staff absence - Increase in staff and passenger ill-health	1	1	1	- Heating, ventilation and air-conditioning systems - Ongoing HVAC maintenance programme - Capital plans for new and replacement assets - Conformance to asset standards and Building Regulations	CCA14.2021.G1 Watching brief: Asset standards for heating, ventilation and air conditioning to be reviewed when updated climate change projections released. See CCA01.2021.G1	1	1	1	1	1	1	1	1	1	Asset standards, maintenance and capital plans will ensure that HVAC systems continue to maintain comfortable environments.

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CCA15	Summer temperature	**Increased community complaints** due to greater disturbance from aircraft operations, particularly on warm nights when residents' windows are open or due to wing tip vortex damage.	Aircraft operations give rise to noise which can be disturbing to local communities. Warmer temperatures are known to result in higher complaint numbers.	- Requirement for, and cost of, additional noise mitigation - Imposition of operational restrictions - Reputational damage	2	1	2	- Noise Action Plan - Sound Insulation Grant Scheme - Community engagement - Input to local planning policy by providing noise contours and responding as a statutory consultee	CCA15.2021.G1 Action: Consider climate change impacts during future review of sound insulation grant scheme.	2	1	2	2	1	2	2	2	4	This risk could increase with further development closer to the airport.
CCA16	Summer temperature, Summer rainfall, Winter temperature, Winter rainfall	**Changes to wildlife control** required due to changing airfield habitats.	Wildlife strikes pose a threat to aviation safety. Climate change could lead to different habitat, wildlife species and behaviour.	- Increasing wildlife strike risk/operational safety incidents - Reputational damage - Operational disruption	1	1	1	- Wildlife and airfield grassland management plan in place - Habitat management regime in line with Civil Aviation Authority 'CAP 772' requirements - Wildlife management operators	CCA16.2021.S1 Watching brief: Changes in distribution of wildlife species.	1	1	1	1	1	1	1	1	1	

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CCA17	Winter rainfall, Summer rainfall, Winter temperature	**Increase in serious airfield safety incidents** due to severe weather events.	Severe weather presents a risk to aviation safety.	- Aircraft/vehicle collision - Operational disruption - Health & Safety incidents - Increased runway excursion - Need for increased runway grooving	2	5	10	- Winter operations plan and activities - Safety management system requirement for risk assessments	CCA17.2021.S1 Watching brief: On changes to airfield safety procedures due to climate change.	2	5	10	2	5	10	2	5	10	
CCA18	Lightning	**Damage to assets and operational disruption** due to an increase in lightning events.	Lightning presents a risk of building and infrastructure damage, including to electrical, communications and navigational systems. Lightning damage and safety procedures during storm events are known to lead to operational disruption.	- Financial costs of repair/replacement - Operational disruption - Reputational damage - Health & Safety incidents - Damage to the surface of the runway, navigational systems and other assets	2	4	8	- Inspection, maintenance and repair capabilities - Conformance to asset standards and Building Regulations - Equipment design incl. contingency features such as lightning protection - Operational procedures - UPS to critical systems	CCA18.2021.G1 Investigate: Lightning detection and prediction technology. CCA18.2021.S1 Watching brief: On impact of increased lightning events on electricity supply systems and ground handling operational performance.	2	4	8	2	4	8	2	4	8	

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CCA19	Storms	**Damage to on and off-airport infrastructure** due to an increase in storm events (high winds, rain, lightning and snow).	Storm events, including high winds and intense rainfall, have the potential to cause damage to infrastructure.	- Operational disruption - Financial costs of repair/replacement - Disruption to airport surface access, particularly public transport - H&S incident - Reputational damage	3	4	12	- Inspection, maintenance and repair capabilities - Conformance to asset standards and Building Regulations - Asset renewal strategy	CCA19.2021.G1 Watching brief: On impact of wind damage to airport assets. See CCA01.2021.G1	2	4	8	4	4	16	4	4	16	
CCA20	Summer temperature	**Poor local air quality** due to increased frequency of low dispersion conditions, particularly during prolonged hot spells.	Air quality is an important public health issue which is interdependent with climatic conditions.	- Reputational damage - Increased local, regional or national controls on air emissions - Increased absence of vulnerable staff - Increase in ill-health of vulnerable passengers or community members	1	1	1	- Airport air quality monitoring - Engagement with local authority environmental health teams - Airport Sustainable Development Plan	CCA20.2021.S1 Action: Continue to monitor and report air quality at the airport, engaging local authority environmental health teams to identify and resolve issues.	1	1	1	2	1	2	2	1	2	Increased impact in future years due to anticipated increase in stakeholder interest in this issue.

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CCA21	Summer temperature	Impact of climate change on **aircraft performance.**	Due to reduced air density, the take-off performance of aircraft degrades in warmer conditions. In extreme circumstances this can reduce aircraft payload or range.	- Reduction in aircraft payload with consequential financial impact - Inability to operate certain aircraft type/route combinations - Lower efficiency on approach and departure, increased emissions - Increased noise impacts - Potential capital investment required to extend the runway - Current safeguarding measures could be insufficient for future performance - Reputational damage - Potential to limit growth opportunities	1	1	1	- Weather reporting to enable adjustments to be made to operating capabilities - Communications with new operators - Community engagement programme	CCA21.2021.S1 Watching brief: On instances of range/payload limitation.	1	1	1	1	1	1	1	1	1	Current aircraft operate to countries that are experiencing projected temperatures today (may change if more long-haul routes operated. Assumed that future and emerging aircraft technology will be designed to a changing climate.

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CCA22	Summer temperature	**Increased need for aircraft cabin cooling and energy** to cool aircraft interior on stand in order to maintain comfortable cabin conditions during turnaround.	Warmer temperatures will require increased use of aircraft auxiliary power units (APU) or installation of pre-conditioned air (PCA). Installation of PCA is a significant infrastructure project and investment. APU use currently discouraged for noise and emissions reasons.	- Cost of installation, operation and maintenance of PCA - Increased workplace exposure to combustion gases - Impact on noise local air quality	2	2	4	- Asset strategy - APU use permitted on warmer days - Noise action plan	CCA22.2021.G1 Investigate: The temperature conditions under which there will be a requirement for PCA and energy system implications.	2	1	2	3	3	9	3	4	12	Increasing number of days when cabin cooling required. Greater utility demand from cooling with (PCA). Technology developments could mean aircraft are better at cooling.
CCA23	Winter temperature	**Increased variability and unpredictability of snow events** challenges snow contingency plans.	As the frequency of snow events decrease it is more difficult to assess the cost-benefit of investing in snow clearance equipment and contingency planning.	- Potential large investment in equipment that is not used, or significant disruption when an infrequent snow event occurs due to inadequate equipment and processes - Reputational damage - Operational disruption	3	3	9	- Winter operations plan and activities - Communication of weather forecasts to on-airport community	CCA23.2021.S1 Watching brief: Increasing variability of snowfall and potential challenges to winter contingency plans.	4	2	8	4	2	8	4	2	8	Increase in passenger numbers could mean there will be less resilience built-in

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CCA24	Summer temperature, Winter rainfall, Storms	**Disruption to delivery of essential supplies** to the airport due to off-airport transport and other impacts.	Extreme weather events including prolonged hot spells, high winds, snow and flooding can disrupt road and rail networks.	- Operational disruption - Short-term shortages of supplies - Reputational damage - Lost revenue	2	2	4	- Multiple suppliers for key supplies of food/drink - Contractual levers available to secure supply - Ongoing engagement with Highways England and Network Rail to manage disruption to surface access	CCA24.2021.S1 Watching brief: Disruption to delivery of essential supplies to the airport. CCA24.2021.S2 Action: Continued engagement with transport partners to manage disruption to surface access.	2	2	4	2	3	6	2	3	6	Significant infrastructure improvement is required to mitigate the potential for disruption, which is outside of MAG's control. Future planning standards could improve and reduce the risk but it is not possible to determine at present.
CCA25	Summer rainfall, Winter rainfall, Summer temperature	**Restrictions to airport water supplies** due to prolonged drought conditions and lowering of water table.	Potential for water supplier drought orders to limit the availability or use of mains water.	- Prohibition of certain non-critical activities such as washing - Financial impact arising from need to obtain alternative sources of water - Reputational impact - Asset renewal to introduce water efficient equipment	2	3	6	- Leak detection and repair programme - Distribution system maintenance / upgrade - Conformance to asset standards and Building Regulations - Asset renewal strategy - Ongoing dialogue with water companies	CCA25.2021.S1 Action: Develop an airport Water Drought Management Plan to respond to the four levels of drought trigger.	1	3	3	4	3	12	4	4	16	

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CCA26	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature	**Damage or disruption to off-airport surface access** leading to impacts on passenger and staff journeys to/from airport.	Extreme weather events including prolonged hot spells, high winds, snow and flooding can disrupt public transport and road networks. Although this would not be MAG's responsibility, the risk is that access to the airport is perceived as unreliable.	- Operational disruption created by impacts on rosters - Reputational impact	2	3	6	- Multiple surface access options are available - Weather forecasting and pre-emptive planning - Monitoring of transport networks through communications from transport organisations - Procedures in place at airport to respond - Communications process for customers and staff - Engagement with local resilience forums regarding transport and network issues	CCA26.2021.S1 Watching brief: Passenger comfort on public transport to and from the airport due to increasing temperatures. CCA26.2021.S2 Watching brief: Climate-related offsite impacts on the flow of people to the airport. See CCA24.2021.S2	2	2	4	2	3	6	2	3	6	Expectation that demand will continue to be proactively managed in response to this risk. Anticipated decrease in frost events will have beneficial impact - most significant is expected to be in relation to summer temperature and rainfall.

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CCA27	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature	**Disruption or changes to schedule due to en-route weather and sea level rise/storm surge**, including origin and destination airports.	Disruptive weather and sea-level rise/storm surges have the potential to cause disruption at origin/destination airports and en-route requiring temporary or permanent changes flight schedules.	- Operational disruption - Redistribution of market share to alternative routes	2	4	8	- Existing arrangements for diversion airports in case of disruption in-flight - European network management - Operational disruption and resilience plans	CCA27.2021.G1 Watching brief: Impact of sea level rise and storm surge on origin and destination airports. CCA27.2021.S1 Watching brief: Impact of extreme weather on schedules.	2	4	8	3	4	12	4	4	16	Changes to route networks due to sea level rise/storm surge expected to manifest gradually in later time periods and allow market redistribution.
CCA28	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature, Storms, Snow	**Increased climate-related insurance claims** nationally and internationally.	Increased severity and frequency of extreme weather events of all types are likely to lead to increased damage, disruption and therefore insurance claims. As part of a global risk pool, MAG insurance costs increase as a result of natural disaster / catastrophe globally.	- Increased cost of insurance cover for operational disruption and infrastructure damage - Increased limitations to the availability and/or scope of insurance cover - Increased costs across the whole MAG insurance portfolio as insurers look to recoup losses incurred globally	1	4	4	-MAG has two brokers who negotiate with insurers on our behalf - Insurance team and senior management engage insurers annually to inform them of the robust controls to prevent and manage claims -MAG Insurance engages the Board and Audit Committee on strategic decision making to influence premium spend i.e. sums insured and deductibles	CCA28.2021.G1 Action: Develop insurance strategies to manage climate change risk.	1	3	3	1	4	4	1	4	4	

Appendix 1c: Manchester Airport climate change adaptation risk register

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CCA01	Summer temperature	**Thermal expansion** of building infrastructure, such as concrete and steel, leading to failures and reduced lifespan.	There is a current lack of knowledge around the vulnerability of the airport buildings design to the projected future temperatures.	- Financial costs of repair/replacement - Operational disruption - Airport closure - Reputational damage	2	2	4	- Structural inspections - Asset maintenance schemes - Capex plans that align to assets - Conformance with Asset Standards and Building Regulations	CCA01.2021.G1 Action: Ensure specifications for future developments and asset renewals consider climate change predictions. CCA01.2021.G2 Action: Seek specialist advice to ensure risk assessment is valid.	2	2	4	2	3	6	3	3	9	
CCA02	Summer temperature, Summer rainfall, Winter rainfall	**Structural damage to airside** runway, aprons and airfield subsurface caused by extreme heat or water ingress.	It is known that a combination of water ingress and temperature fluctuations causes deterioration in these surfaces.	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Operational disruption - Airport closure - Reputational damage	2	3	6	- Conformance to Asset standards and Building Regulations - Management and maintenance plans - Remedial capabilities and ability to respond to issues on the runway quickly	CCA02.2021.G1 Watching brief: Impact of water ingress freeze/thaw and heat. CCA02.2021.G2 Watching brief: Increased ground movement leading to structural damage. See CCA01.2021.G1	2	3	6	2	4	8	3	4	12	Life cycle for a runway surface is 12-15 years so it will have been replaced a number of times over these time horizons.

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CCA03	Summer temperature, Summer rainfall, Winter rainfall	**Structural damage to landside** bituminous surfaces/subsurface such as car parks and landside roads caused by extreme heat or water ingress.	It is known that a combination of water ingress and temperature fluctuations causes deterioration in these surfaces.	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Operational disruption - Reputational damage - Cost of claims for damage/injury - Disruption to surface access to the airport	1	2	2	- Conformance to asset standards and Building Regulations - Management and maintenance plans - Remedial capabilities and ability to respond to issues quickly	See CCA01.2021.G1 See CCA02.2021.G1	1	1	1	1	3	3	1	4	4	
CCA04	Summer temperature, Summer rainfall, Winter rainfall	**Damage to buildings and belowground structures** and utilities due to increased ground movement.	Risk expected due to warmer, dryer summers and increased variance between summer and winter soil moisture levels particularly for clay soils	- Financial costs of repair/replacement - Accelerated asset deterioration/reduced lifespan - Increased inspection and maintenance needs - Operational disruption - Reputational damage - Potential health and safety risk related to energy systems	1	1	1	- Inspection and maintenance programme - Conformance to asset standards and Building Regulations	See CCA01.2021.G1 See CCA02.2021.G2	1	1	1	1	2	2	1	3	3	

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CCA05	Winter rainfall, Summer rainfall	**Release of contaminated surface water** in contravention of environmental permits as a result of storm event, including exceeding balancing pond capacity.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding on the airport campus if the drainage system is unable to cope.	- Regulatory notification/fines - Reputational damage - Off-airport environmental impacts - Restrictions on future on-airport development - Requirement for airport infrastructure development (e.g. de-icing pads)	3	3	9	- Pollution control system design capacity - Input to water company strategic plan - Agreed contingency plans - Elimination of clean rainwater to reduce capacity requirement - Monitoring and management systems	CCA05.2021.G1 Watching brief: Drainage system capacity in light of updated climate projections and site developments. See CCA01.2021.G1	2	3	6	3	4	12	3	4	12	

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CCA06	Winter rainfall	**On-airport flooding** due to insufficient on-airport drainage capacity leading to schedule disruption and damage to below ground infrastructure.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding on the airport campus if the drainage system is unable to cope.	- Financial costs of repair/replacement - Operational disruption - Reputational damage	1	3	3	- Inspection and maintenance programme - Flood detection - Conformance to asset standards and Building Regulations	See CCA01.2021.G1 See CCA05.2021.G1	1	3	3	1	3	3	2	3	6	Risk of flooding is anticipated to increase in line with the projected increase in rainfall, but be offset by investment in drainage systems.
CCA07	Winter rainfall	**Off-airport flooding** due to insufficient balancing pond capacity at times of extreme rainfall leading to high outflows and impacts downstream.	Airport drainage is held in balancing ponds, more intense rainfall could lead to flooding off the airport campus if the drainage system is unable to cope.	- Flooding of downstream properties and infrastructure - Cost of putting in place emergency arrangements - Reputational damage - Cost and operational disruption of retrofitting systems - Environmental permit and planning obligation changes - Cost of claims for damage/injury	2	3	6	- Input to Environment Agency contingency planning - Relationship with local authorities - Surface water attenuation for new developments	CCA007.2021.M1 Action: Continue to liaise with Local Authority and Environment Agency over flood contingency planning. See CCA01.2021.G1 See CCA05.2021.G1	2	2	4	2	3	6	2	4	8	Higher risk of flooding over time. Potential for significant cost or planning conditions in future development. Airport could be held responsible by stakeholders for flooding.

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CCA08	Summer rainfall, Winter rainfall	**Misalignment of navigational aids**, communications and surveillance systems due to extreme changes in wet/ dry surface conditions.	Extreme raising and lowering of the water table may lead to incorrect instrument alignment.	- Financial costs of repair/replacement - Operational disruption - Reduced aircraft movements - Increase in aircraft safety incidents - Reputational damage	3	1	3	- Inspection and maintenance programme	CCA08.2021.G1 Watching brief: Changes to ground conditions affecting navigation aids. CCA08.2021.G2 Action: Develop Performance Based Navigation (PBN) arrival and departure routes as part of future airspace strategy. CCA08.2021.G3 Watching brief: Monitor for new technology to move away from ground-based approach. See CCA01.2021.G1	3	1	3	3	1	3	3	1	3	No change in scores anticipated over time as risk can be managed through current controls. New technology could reduce risk in the 2050s and 80s.

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CCA09	Summer temperature, Summer rainfall, Lightning	**Schedule disruption** due to low visibility or structural damage caused by off-airport vegetation fires.	Grass and vegetation fires could cause poor visibility due to smoke and possible fire damage to infrastructure servicing the airport.	- Minor operational disruption	2	2	4	- Local authority and airport fire services - Air traffic control procedures to redirect aircraft where required - Communications with local emergency services and responder networks - External communication channels to alert passengers of schedule disruption	CCA09.2021.G1 Watching brief: On frequency and type of on and off-airport fires.	2	2	4	2	2	4	2	2	4	

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CCA10	Summer temperature	**Operational disruption, asset damage and employee safety risks** due to increased risk of on-airport fires.	Increased chance of fire from dry vegetation, waste and litter.	- Financial costs of repair/replacement - Operational disruption - Increase in aircraft safety incidents - Reputational damage - Increase in accident/incident frequency	2	2	4	- Airport fire service - Airfield and landscape management plans - Asset standards that minimise fire risk and damage potential - Mitigation measures are reviewed annually and aligned with regulations	CCA10.2021.G1 Investigate: Impacts of increased temperature on fuel spill and associated fire risk. See CCA09.2021.G1	2	2	4	2	2	4	2	2	4	Moving from kerosene to sustainable aviation fuel, electric or hydrogen-fuelled aircraft could reduce the fire risk. Although there is a recognised increased chance of aircraft fuel venting, this is not anticipated to increase fire risk because projected temperatures are below the auto-ignition threshold and procedures are in place to prevent exposure to ignition sources.

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CCA11	Summer temperature	**Increased runway closure/maintenance** requirement due to build-up of rubber on runway surface.	Requirement to maintain appropriate friction level drives the need for regular runway maintenance.	- Operational disruption - Aircraft safety incident - Increased cost of rubber removal - Degradation/ decreased lifetime of the runway through increased cleaning activity	1	1	1	- Inspection and maintenance programme - Friction monitoring - Rubber removal contract in place	CCA11.2021.G1 Watching brief: Rubber cleaning frequency and technological advances in aircraft tyres and runway material. See CCA01.2021.G1	1	1	1	1	1	1	1	1	1	A number of technological advances are expected to take place over the time horizons that will reduce this risk. UK temperatures not expected to exceed those already experienced at other global airports.
CCA12	Summer temperature, Winter temperature, Summer rainfall, Winter rainfall	**Increase in disease vectors and hence incidence of "tropical" diseases** at and around the airport resulting from climate change providing a newly hospitable environment for imported species.	Potential increase in disease vectors such as mosquitos leading to increase in certain diseases such as West Nile Virus.	- Employee and public health impact - Reputational damage	1	1	1	- On-going liaison with Local Resilience Forum and The UK Health Security Agency - Occupational health department	CCA12.2021.G1 Watching brief: On the risk of an increase in disease vectors.	1	1	1	1	1	1	1	3	3	Expected to increase over time, warmer winter temperatures will reduce natural seasonal mitigation, with an increased likelihood in the 2080s. This would be a national challenge but it is acknowledged that it is something that airports have a role in managing.

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CCA13	Summer temperature, Winter temperature, Winter rainfall	**Impact to health and wellbeing** of outside workers during extreme weather events due to inadequate PPE and rostering processes.	Heat exhaustion, dehydration and sunburn during extended hot spells in summer and hypothermia, slips/trips in icy or wet conditions during winter.	- Increase in accident/incident frequency - Reputational damage - Reduced productivity due to exhaustion and the need for respite - Need to increase staffing levels to maintain productivity	2	2	4	- Occupational health department - Health and safety risk assessment process, including provision of PPE, increased breaks and sun protection where required - Communication of weather forecasts to on-airport community - Operational procedures, including Winter Operations Plan	CCA13.2021.G1 Watching brief: Health, safety and wellbeing measures required to manage impact of changes to temperature and rainfall on outside workers.	1	1	1	1	2	2	1	3	3	Increase in likelihood from the 2050s, but the impact is anticipated to be unchanged as risk can be managed by applying current controls.

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CCA14	Summer temperature	**Decrease in passenger and staff comfort** within airport buildings caused by inadequate cooling systems.	Heat exhaustion, dehydration and unworkable conditions for colleagues and passengers within those areas.	- Decline in revenue and passenger numbers - Reputational damage - Increased staff absence - Increase in staff and passenger ill-health	1	1	1	- Heating, ventilation and air-conditioning systems - Ongoing HVAC maintenance programme - Capital plans for new and replacement assets - Conformance to asset standards and Building Regulations	CCA14.2021.G1 Watching brief: Asset standards for heating, ventilation and air conditioning to be reviewed when updated climate change projections released. See CCA01.2021.G1	1	1	1	1	1	1	1	1	1	Asset standards, maintenance and capital plans will ensure that HVAC systems continue to maintain comfortable environments.
CCA15	Summer temperature	**Increased community complaints** due to greater disturbance from aircraft operations, particularly on warm nights when residents' windows are open or due to wing tip vortex damage.	Aircraft operations give rise to noise which can be disturbing to local communities. Warmer temperatures are known to result in higher complaint numbers.	- Requirement for, and cost of, additional noise mitigation - Imposition of operational restrictions - Reputational damage	2	1	2	- Noise Action Plan - Sound Insulation Grant Scheme - Community engagement - Input to local planning policy by providing noise contours and responding as a statutory consultee	CCA15.2021.G1 Action: Consider climate change impacts during future review of sound insulation grant scheme.	2	1	2	2	1	2	2	2	4	This risk could increase with further development closer to the airport.

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CCA16	Summer temperature, Summer rainfall, Winter temperature, Winter rainfall	**Changes to wildlife control** required due to changing airfield habitats.	Wildlife strikes pose a threat to aviation safety. Climate change could lead to different habitat, wildlife species and behaviour.	- Increasing wildlife strike risk/operational safety incidents - Reputational damage - Operational disruption	3	2	6	- Wildlife and airfield grassland management plan in place - Habitat management regime in line with Civil Aviation Authority 'CAP 772' requirements - Wildlife management operators	CCA16.2021.M1 Watching brief: Changes in distribution of wildlife species.	3	2	6	3	2	6	3	2	6	
CCA17	Winter rainfall, Summer rainfall, Winter temperature	**Increase in serious airfield safety incidents** due to severe weather events.	Severe weather presents a risk to aviation safety.	- Aircraft/vehicle collision - Operational disruption - Health & Safety incidents - Increased runway excursion - Need for increased runway grooving	2	5	10	- Winter operations plan and activities - Safety management system requirement for risk assessments	CCA17.2021.M1 Watching brief: On changes to airfield safety procedures due to climate change.	2	5	10	2	5	10	2	5	10	

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CCA18	Lightning	**Damage to assets and operational disruption** due to an increase in lightning events.	Lightning presents a risk of building and infrastructure damage, including to electrical, communications and navigational systems. Lightning damage and safety procedures during storm events are known to lead to operational disruption.	- Financial costs of repair/replacement - Operational disruption - Reputational damage - Health & Safety incidents - Damage to the surface of the runway, navigational systems and other assets	2	4	8	- Inspection, maintenance and repair capabilities - Conformance to asset standards and Building Regulations - Equipment design incl. contingency features such as lightning protection - Operational procedures - UPS to critical systems	CCA18.2021.G1 Investigate: Lightning detection and prediction technology. CCA18.2021.M1 Watching brief: On impact of increased lightning events on electricity supply systems and ground handling operational performance.	2	4	8	2	4	8	2	4	8	
CCA19	Storms	**Damage to on and off-airport infrastructure** due to an increase in storm events (high winds, rain, lightning and snow).	Storm events, including high winds and intense rainfall, have the potential to cause damage to infrastructure.	- Operational disruption - Financial costs of repair/replacement - Disruption to airport surface access, particularly public transport - H&S incident - Reputational damage	3	4	12	- Inspection, maintenance and repair capabilities - Conformance to asset standards and Building Regulations - Asset renewal strategy	CCA19.2021.G1 Watching brief: On impact of wind damage to airport assets. See CCA01.2021.G1	2	4	8	4	4	16	4	4	16	

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CCA20	Summer temperature	**Poor local air quality** due to increased frequency of low dispersion conditions, particularly during prolonged hot spells.	Air quality is an important public health issue which is interdependent with climatic conditions.	- Reputational damage - Increased local, regional or national controls on air emissions - Increased absence of vulnerable staff - Increase in ill-health of vulnerable passengers or community members	1	3	3	- Airport air quality monitoring - Engagement with local authority environmental health teams - Airport Sustainable Development Plan - Greater Manchester air quality management plan	CCA20.2021.M1 Action: Continue to monitor and report air quality at the airport, engaging local authority environmental health teams to identify and resolve issues.	1	3	3	2	3	6	2	3	6	Increased impact in future years due to anticipated increase in stakeholder interest in this issue. Existing air quality management area adjacent to airport.

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CCA21	Summer temperature	Impact of climate change on **aircraft performance.**	Due to reduced air density, the take-off performance of aircraft degrades in warmer conditions. In extreme circumstances this can reduce aircraft payload or range.	- Reduction in aircraft payload with consequential financial impact - Inability to operate certain aircraft type/route combinations - Lower efficiency on approach and departure, increased emissions - Increased noise impacts - Potential capital investment required to extend the runway - Current safeguarding measures could be insufficient for future performance - Reputational damage - Potential to limit growth opportunities	2	1	2	- Weather reporting to enable adjustments to be made to operating capabilities - Communications with new operators - Community engagement programme	CCA21.2021.M1 Watching brief: On instances of range/payload limitation.	2	1	2	2	1	2	2	2	4	Current aircraft operate to countries that are experiencing projected temperatures today. Assumed that future and emerging aircraft technology will be designed to a changing climate.

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CCA22	Summer temperature	**Increased need for aircraft cabin cooling and energy** to cool aircraft interior on stand in order to maintain comfortable cabin conditions during turnaround.	Warmer temperatures will require increased use of aircraft auxiliary power units (APU) or installation of pre-conditioned air (PCA). Installation of PCA is a significant infrastructure project and investment. APU use currently discouraged for noise and emissions reasons.	- Cost of installation, operation and maintenance of PCA - Increased workplace exposure to combustion gases - Impact on noise local air quality	2	2	4	- Asset strategy - APU use permitted on warmer days - Noise action plan	CCA22.2021.G1 Investigate: The temperature conditions under which there will be a requirement for PCA and energy system implications.	2	1	2	2	3	6	2	4	8	Increasing number of days when cabin cooling required. Greater utility demand from cooling with (PCA). Technology developments could mean aircraft are better at cooling.
CCA23	Winter temperature	**Increased variability and unpredictability of snow events** challenges snow contingency plans.	As the frequency of snow events decrease it is more difficult to assess the cost-benefit of investing in snow clearance equipment and contingency planning.	- Potential large investment in equipment that is not used, or significant disruption when an infrequent snow event occurs due to inadequate equipment and processes - Reputational damage - Operational disruption	3	3	9	- Winter operations plan and activities - Communication of weather forecasts to on-airport community	CCA23.2021.M1 Watching brief: Increasing variability of snowfall and potential challenges to winter contingency plans.	4	2	8	4	2	8	4	2	8	Increase in passenger numbers could mean there will be less resilience built-in

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CCA24	Summer temperature, Winter rainfall, Storms	**Disruption to delivery of essential supplies** to the airport due to off-airport transport and other impacts.	Extreme weather events including prolonged hot spells, high winds, snow and flooding can disrupt road and rail networks.	- Operational disruption - Short-term shortages of supplies - Reputational damage - Lost revenue	2	2	4	- Multiple suppliers for key supplies of food/drink - Contractual levers available to secure supply - Ongoing engagement with Highways England and Network Rail to manage disruption to surface access	CCA24.2021.M1 Watching brief: Disruption to delivery of essential supplies to the airport. CCA24.2021.M2 Action: Continued engagement with transport partners to manage disruption to surface access.	2	2	4	2	3	6	2	3	6	Significant infrastructure improvement is required to mitigate the potential for disruption, which is outside of MAG's control. Future planning standards could improve and reduce the risk but it is not possible to determine at present.
CCA25	Summer rainfall, Winter rainfall, Summer temperature	**Restrictions to airport water supplies** due to prolonged drought conditions and lowering of water table.	Potential for water supplier drought orders to limit the availability or use of mains water.	- Prohibition of certain non-critical activities such as washing - Financial impact arising from need to obtain alternative sources of water - Reputational impact - Asset renewal to introduce water efficient equipment	2	2	4	- Leak detection and repair programme - Distribution system maintenance / upgrade - Conformance to asset standards and Building Regulations - Asset renewal strategy - Ongoing dialogue with water companies	CCA25.2021.M1 Watching brief: On water scarcity issues with a view to preparing drought management plan when required.	1	3	3	2	2	4	2	3	6	

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CCA26	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature	**Damage or disruption to off-airport surface access** leading to impacts on passenger and staff journeys to/from airport.	Extreme weather events including prolonged hot spells, high winds, snow and flooding can disrupt public transport and road networks. Although this would not be MAG's responsibility, the risk is that access to the airport is perceived as unreliable.	- Operational disruption created by impacts on rosters - Reputational impact	1	3	3	- Multiple surface access options are available - Weather forecasting and pre-emptive planning - Monitoring of transport networks through communications from transport organisations - Procedures in place at airport to respond - Communications process for customers and staff - Engagement with local resilience forums regarding transport and network issues	CCA26.2021.M1 Watching brief: Climate-related offsite impacts on the flow of people to the airport. See CCA24.2021.M2	1	2	2	2	3	6	2	3	6	Expectation that demand will continue to be proactively managed in response to this risk. Anticipated decrease in frost events will have beneficial impact - most significant is expected to be in relation to summer temperature and rainfall.
CCA27	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature	**Disruption or changes to schedule due to en-route weather and sea level rise/storm surge**, including origin and destination airports.	Disruptive weather and sea-level rise/storm surges have the potential to cause disruption at origin/destination airports and en-route requiring temporary or permanent changes flight schedules.	- Operational disruption - Redistribution of market share to alternative routes	2	4	8	- Existing arrangements for diversion airports in case of disruption in-flight - European network management - Operational disruption and resilience plans	CCA27.2021.G1 Watching brief: Impact of sea level rise and storm surge on origin and destination airports. CCA27.2021.M1 Watching brief: Impact of extreme weather on schedules.	2	4	8	3	4	12	4	4	16	Changes to route networks due to sea level rise/storm surge expected to manifest gradually in later time periods and allow market redistribution.

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CCA28	Summer rainfall, Winter rainfall, Summer temperature, Winter temperature, Storms, Snow	**Increased climate-related insurance claims** nationally and internationally.	Increased severity and frequency of extreme weather events of all types are likely to lead to increased damage, disruption and therefore insurance claims. As part of a global risk pool, MAG insurance costs increase as a result of natural disaster / catastrophe globally.	- Increased cost of insurance cover for operational disruption and infrastructure damage - Increased limitations to the availability and/or scope of insurance cover - Increased costs across the whole MAG insurance portfolio as insurers look to recoup losses incurred globally	1	4	4	-MAG has two brokers who negotiate with the insurance market on our behalf - Insurance team and senior management engage insurers annually to inform them of the robust controls to prevent and manage claims -MAG Insurance engages the Board and Audit Committee on strategic decision making to influence premium spend i.e. sums insured and deductibles	CCA28.2021.G1 Action: Develop insurance strategies to manage climate change risk.	1	3	3	1	4	4	1	4	4	