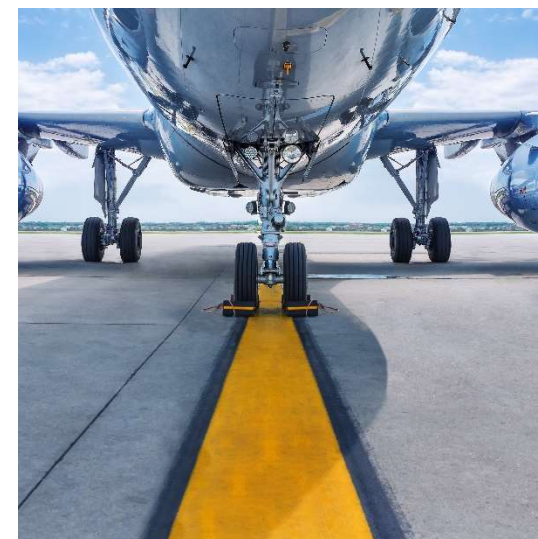
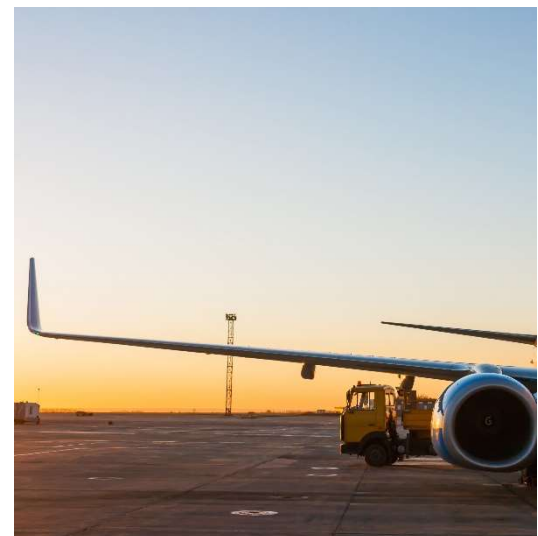


Heathrow Airport Ltd

Climate Change Adaptation Report

Third Round Progress Report



Executive Summary

Purpose

This report represents Heathrow's response to the third round of UK adaptation reporting administered by the Department for Environment, Food and Rural Affairs' (Defra) and provides an updated preliminary climate risk assessment. The report includes an update on Heathrow's approach to climate risk and climate adaptation since the previous Climate Change Adaptation Report (CCAR) in 2016 and outlines how Heathrow will further strengthen management of climate risk over the next reporting period.

Heathrow has adopted and implemented the recommendations of the Taskforce for Climate-related Financial Disclosures (TCFD) to guide the company's overall approach to managing climate risk. The scope of this CCAR includes physical climate risks. Transition risks will be covered in detail in Heathrow's 2021 TCFD disclosure and are therefore not considered in detail here.

Approach

Heathrow has committed to net zero emissions and contributing to efforts within the aviation industry and at national and international levels to minimise the extent to which climate change will impact on all our lives. Heathrow also recognises the physical risks of climate change, and it is therefore important that the right steps are taken on climate change adaptation too.

Physical climate risks have been identified and assessed using an assessment framework which considers thresholds for impact, the likelihood of events and the severity of impacts. The framework is aligned to sector guidance from the Airport Operators Association (AOA) and guidance from the Climate Change Committee (CCC) and Defra. The latest available UK Climate Projections (UKCP18) published data sources and scenario analyses have been used.

The assessment considers baseline (current) and future climate change risks. The period 1981 – 2000 is used to represent baseline conditions. The short-term future includes risks expected to be present in the 2030s (2021-2040) and the longer-term future considers risks in the 2070s (2061-2080).

Physical climate risks

The key baseline or current climate-related physical risks to Heathrow Airport are:

- **High levels of precipitation** can lead to drainage infrastructure becoming overwhelmed and lead to both surface and ground water flooding events.
- **Low temperatures** can challenge winter contingency plans and lead to increased de-icing requirements which may disrupt operations or increase the load on pollution management systems.

Climate projections for the UK show that climate change is projected to lead to an increasing likelihood of warmer winters, high temperatures in the summer and extreme rainfall events.

In the short-term future at Heathrow, an increased likelihood of extreme rainfall events will heighten the risk of drainage infrastructure being overwhelmed and groundwater flooding. Hotter summer days may directly increase the risk to the integrity and performance of airfield structures

such as runway and apron tarmac. No change in the likelihood and risk of extreme cold events is expected.

In the longer-term future at Heathrow, the risk of surface and ground water flooding remains elevated. The likelihood of higher temperatures increases further with a potential risk to cause damage to airfield structures including airfield tarmac and surface access routes; cause delays to construction and maintenance work, and operational activities, due to peak temperatures; reduce thermal comfort, impacting passengers and staff inside airport buildings; increase the risk of fire from combustible materials; and indirectly increase the risk of communicable disease and epidemics. However, the likelihood of extreme cold events is reduced. The increased likelihood of extreme temperatures and rainfall events increases the risk of compound events, which may include other weather events such as lightning storms, resulting in disruption to flights and airport operations over periods of a few hours or days.

Future actions

Heathrow has taken action to respond to these risks which were covered in previous CCAR reports and that will continue. Heathrow's approach will need to evolve as the understanding of physical risks of climate change mature and additional actions will be needed to remain resilient. Heathrow will be guided by the TCFD recommendations and continue to embed climate risk into normal business risk management, business planning and decision-making.

In the next reporting cycle, Heathrow will direct efforts into three focus areas to further strengthen management of climate risk and improve climate resilience:

- **Risk framework:** continue to integrate climate risk into Heathrow's internal risk management framework to ensure risks are managed as part of normal business process and inform business decision-making.
- **Risk assessment:** work with Heathrow's different Business Units (BUs) to review and validate the preliminary climate physical risk assessment and embed into functional risk registers, conduct further operational assessment and modelling to fully understand risks, and provide a robust platform to test the effectiveness of current mitigation levels. In this current round of reporting, Heathrow has broadened the scope to consider the indirect risk to Heathrow from climate related impacts at origin and destination airports for the first time. We will continue to develop an understanding of these risks and include the latest assessment in future climate reporting cycles.
- **Planning and delivery:** Review the current level of mitigation based on the updated risk assessment and set actions to strengthen mitigation where necessary. As a regulated business, capital investment forms part of Heathrow's regulatory settlement with the Civil Aviation Authority (CAA), the economic regulator for Heathrow. Where mitigation requires investment in the forthcoming settlement period, 2022-26, Heathrow will develop the business case and follow the relevant capital processes. Investment beyond 2026 will be built into future regulatory business plans and included as part of regulatory negotiations.

Heathrow has included £188m of investment for addressing climate change in its latest business plan for the period 2022-26 and signalled a need to invest in addressing physical climate risk. Investment in the period is targeted at reducing Heathrow's carbon emissions and

therefore addressing transition climate risks primarily. The level of investment in the settlement will be determined by the CAA in its final settlement due in 2022.

Heathrow's adaptation planning will be guided by the recommendations of UK Government's third Climate Change Risk Assessment (CCRA3), including:

- Implement actions which support adaptation at a network level as well as for individual assets.
- Using common formalised standards of resilience to help build systemic resilience across the whole infrastructure system.
- Improve arrangements for sharing data and information between transport and other sectors to help increase preparedness across geographical and organisational boundaries.
- Enhance adaptation strategies to identify areas most vulnerable to flooding, as well as parts of the network crucial for emergency services.
- Integrate green infrastructure solutions into developments, alongside implementing green Sustainable Drainage Systems (SuDS) to help reduce surface water flood risk.
- Ongoing monitoring and maintenance of assets to spot problems in enough time to act.

Glossary, Acronyms and Abbreviations

Term	Definition
Adaptation	The process of adjustment in a design or operational procedure to respond to the projected impacts of climate change, to moderate harm or exploit beneficial opportunities.
AOA	Airport Operators Association
AR5	Fifth Assessment Report
AR6	Sixth Assessment Report
ATM	Air transport movements
CCAR	Climate Change Adaptation Report
CCC	The Climate Change Committee
CCRA	Climate Change Risk Assessment
CIBSE	The Chartered Institution of Building Services Engineers
Climate	Climate is defined as the average weather over a period ranging from months to thousands or millions of years. Weather factors considered in climate are surface variables such as temperature, precipitation, and wind.
Climate change	The United Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: ' <i>a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods</i> '. While climate change can be attributable to natural causes, the UNFCCC distinguish climate change as related to human activities altering the atmospheric composition and climate variability.
Climate change impact	An impact from a climate hazard which affects the ability of the receptor or asset to maintain its function or purpose.
Climate hazard	A weather or climate related event which has potential to do harm to environmental or community receptors or assets, for example increased winter precipitation.
Consequence	Any effect on the receptor or asset as a result of the climate hazard having an impact.
Extreme weather event	A weather event that is as rare as or rarer than the 10 th or 90 th percentile of a probability density function estimated from observations for a specific place and time of year.
Greenhouse Gas (GHG) emissions	GHG emissions are determined by the Kyoto Protocol (1997) to include seven gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride.
Heatwave	A heatwave is an extended period of hot weather relative to the expected conditions of the area at that time of year, which may be accompanied by high humidity. A UK heatwave threshold is met when a location records a period of at least three consecutive days with daily maximum temperatures meeting or exceeding the heatwave temperature threshold.

Term	Definition
IPCC	Intergovernmental Panel on Climate Change
NDCs	Nationally determined contributions
Net zero GHG emissions	Net zero GHG emissions are achieved when GHG emissions to the atmosphere are balanced by anthropogenic removals.
PCS	Pollution Control System
RCP	Representative Concentration Pathways
RCP4.5	Medium emissions scenario. This scenario uses a Representative Concentration Pathway defined by the Intergovernmental Panel on Climate Change's latest 5th Assessment Report. Representative Concentration Pathway 4.5 specifies the concentration of greenhouse gases that would result in 4.5 W/m ² radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is likely to be 1.1°C to 2.6°C under RCP4.5.
RCP8.5	High/worst-case emissions scenario. This scenario uses a Representative Concentration Pathway defined by the Intergovernmental Panel on Climate Change's latest 5th Assessment Report. Representative Concentration Pathway 8.5 specifies the concentration of greenhouse gases that would result in 8.5 W/m ² radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is likely to be 2.6°C to 4.8°C under RCP8.5.
Representative Concentration Pathway (RCP)	Future pathways based on emissions and concentrations of greenhouse gases. Each RCP provides only one of many possible scenarios that could lead to specific forcing mechanisms.
SAF	Sustainable Aviation Fuel
SBTs	Science-based Targets
TCFD	The Task Force on Climate-related Financial Disclosures
UK Carbon Budget	The UK Carbon budgets were introduced under the Climate Change Act (2008). Each carbon budget provides a five-year, statutory cap on total greenhouse gas emissions, which should not be exceeded, in order to meet the UK's emission reduction commitments. So far, five carbon budgets have been set in law, covering the period from 2008 to 2032. These limit UK GHG emissions from all sources, excluding international aviation and shipping.
UKCP	UK Climate Projections
UKCP18	UK Climate Change Projections 2018. UK Climate Projections 2018 is the most up-to-date assessment of how the climate of the UK may change over the 21st century, recently updated in 2018. UK Climate Projections 2018 uses climate science to provide observations and climate change projections for the UK and globally until 2100.
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply
Vulnerability	The propensity or predisposition of a system or receptor to be adversely affected. This encompasses the sensitivity of the system or receptor and its capacity to cope and adapt.

Term	Definition
Weather	Short term variations in the state of the atmosphere at a particular place and time in regard to heat, cloudiness, dryness, sunshine, winds, rain, etc.

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1. Introduction

1.1. Climate change – latest position

- 1.1.1. Climate change is regarded as one of the most significant threats of our times, with the UK's Chief Scientific Advisor warning that climate change is a far bigger and potentially deadlier problem than coronavirus¹. In August 2021, the Intergovernmental Panel on Climate Change (IPCC) released the contribution of Working Group I to the Sixth Assessment Report (AR6)². This report concluded that observed warming of the climate system is unequivocal, indisputably influenced by human activity and recognised at regional and local scales. The need for planning and delivering adaptation measures has never been more urgent.
- 1.1.2. Efforts to limit greenhouse gas (GHG) emissions today will have a large effect on the extent to which climate change affects society in future decades. The Paris Agreement, adopted in 2015³ calls for global emissions to peak as early as possible, before falling to net zero by the middle of this century. This legally binding international treaty on climate change marked a commitment by some 196 countries to limit global temperature rise to less than 2°C, preferably 1.5°C, above pre-industrial levels. As part of this commitment, each country was required to submit climate action plans, known as nationally determined contributions (NDCs), by 2020. The UK's NDC aims to reduce UK economy-wide GHG emissions by at least 68% by 2030 compared to 1990 levels. The Paris Agreement also acknowledges the role of adaptation to the adverse impacts of climate change, calling for an increased ability to foster climate resilience.
- 1.1.3. Acting on climate change has become an increasingly clear priority in the UK. In July 2019, the UK government passed legislation⁴ to enshrine 'net zero' GHG emissions by 2050 into law, becoming the first major global economy to do so⁵. In 2021, following the release of the UK's Sixth Carbon Budget⁶, the UK updated its NDC with a commitment to reduce GHG emissions by at least 78% by 2035 relative to 1990 levels. This reduction includes emissions from international aviation and shipping.
- 1.1.4. The recent Conference of the Parties (COP 26) held in Glasgow in November 2021, resulted in almost 200 countries agreeing on: the acceleration of action on climate change

¹ Speaking at the United Nations (UN) climate summit COP 26 in Glasgow, 09 Nov 2021.

² IPCC (2021). AR6 Working Group I Contribution to the Sixth Assessment Report, The physical science basis [online]. Available at: <https://www.ipcc.ch/report/ar6/wg1/> [Accessed 28 Sept 2021].

³ UNFCCC (2015). The Paris Agreement [online]. Available at: <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement> [Accessed 28 Sept 2021].

⁴ The Climate Change Act 2008 (2050 Target Amendment), [online]. Available at: <https://www.legislation.gov.uk/ukpga/2008/27/contents>

⁵ UK Government (2019). UK becomes first economy to pass net zero emissions into law [online]. Available at: <https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law> [Accessed 28 Sept 2021].

⁶ UK Government (2021). UK enshrines new target in law to slash emissions by 78% by 2035 [online]. Available at: <https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035> [Accessed 28 Sept 2021].

this decade to reduce emissions (mitigation); helping those already impacted by climate change (adaption); enabling countries to deliver on their climate goals (finance); and working together to deliver even greater action (collaboration)^{7,8}. This agreement is in the form of the Glasgow Climate Pact which reaffirms the long-term goal to limit global warming to 1.5°C above pre-industrial levels and resolves to pursue efforts to achieve this, recognising that limiting global warming to 1.5°C *“requires rapid, deep and sustained reductions in global greenhouse gas emissions, including reducing global CO₂ emissions by 45% by 2030 relative to the 2010 level and to net zero around mid-century, as well as deep reductions in other greenhouse gases”*. At COP 26, 18 nations (including the UK and representing 40% of global aviation emissions) also signed a new declaration in support of the development on emissions targets for aviation that are aligned with the Paris Agreement’s 1.5°C temperature pathway³.

- 1.1.5. As highlighted in AR6², historic GHG emissions have already committed us to some degree of climate change, evidenced globally today and continuing in the coming decades. In the UK, future climate projections suggest increasing temperatures, increased rainfall patterns and flood risk, and more extreme weather events⁹.
- 1.1.6. Part 4 of the Climate Change Act 2008⁴ requires the UK Government to publish a Climate Change Risk Assessment (CCRA), every five years¹⁰. The third CCRA report (CCRA3)¹¹ was published in 2021 and based on independent technical advice provided by the Climate Change Committee (CCC)¹⁰. One of the key findings of the CCC was the widening gap between the level of risk faced, and the level of adaptation underway in the UK. According to the CCC, adaptation action has failed to keep pace with the worsening reality of climate risk and the Government must lead the way in mobilising capacity and resources to better risk responses. Among the principles endorsed by the CCC are a better understanding of threshold effects, assessment of risks in a scenario of ~4°C of global warming by the end of the 21st century (a “4°C scenario”), consideration of climate opportunities and integration of climate adaptation.
- 1.1.7. The climate in a “4°C scenario” is likely to result in disruption and damage to infrastructure and loss of essential services. This may impede economic activity and cause societal and environmental impacts. Being part of the UK’s nationally important infrastructure, the resilience of Heathrow Airport need to be assessed and actions taken to adapt to climate change and avoid such impacts.

⁷ Glasgow Climate Pact dated 13 Nov 2021 [online]. Available at: https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf [Accessed 01 Dec 2021].

⁸ Decision -/CMA.3 Guidance on cooperative approaches referred to in Article 6, paragraph 2, of the Paris Agreement, advanced unedited version [online]. Available at: https://unfccc.int/sites/default/files/resource/cma3_auv_12a_PA_6.2.pdf [Accessed 01 Dec 2021].

⁹ Met Office (2018). UK Climate Projections (UKCP) [online]. Available at: <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index> [Accessed 28 Sept 2021].

¹⁰ CCC (2021). Independent Assessment of UK Climate Risk (2021) [online]. Available at: <https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/> [Accessed 28 Sept 2021].

¹¹ UK Climate Risk (2021). UK Climate Risk Independent Assessment (CCAR3) [online]. Available at: <https://www.ukclimaterisk.org/independent-assessment-ccra3/technical-report/> [Accessed 15 Dec 2021].

1.2. Heathrow's approach to climate change

- 1.2.1. Climate change is an existential risk to aviation and Heathrow. Nonetheless, during the COVID-19 pandemic, the worst crisis in the aviation sector's history, momentum on addressing climate change has continued to build and progress has been made. The aviation industry is clear what action must be taken and how long there is to turn plans into action. The focus now is to place climate change at the centre of the industry's recovery and accelerate progress towards achieving net zero during this decade.
- 1.2.2. Reducing Heathrow's carbon footprint is a significant challenge and requires action across the whole airport community. Heathrow must lead by example and invest to put in place the enabling interventions, supported by the right policies, standards, and incentives, that allow airlines, airport partners and passengers to cut their emissions too.
- 1.2.3. Heathrow and the sector must also consider the physical impacts of a warming climate, including more extreme weather events, which could affect airport infrastructure and operations as well as the airport's key destinations, and cause significant harm to the global economy.
- 1.2.4. Climate change ultimately represents a risk to current and future consumers, limiting consumer choice, increasing costs, and stretching our resilience.

Net zero

- 1.2.5. Heathrow has developed a Net Zero Plan, which will be published in early 2022, and consulted with airlines, partners policymakers and environmental groups. The Net Zero Plan sets out clear goals and strategies for reducing the airport's carbon footprint and there is strong strategic alignment with airlines and the broader industry.
- 1.2.6. In 2020 the UK aviation sector set a goal for net zero emissions and published a road map to get there¹³. In late 2021 the International Air Transport Association (IATA) announced the same goal, the first complete sector to do so. Heathrow continues to work closely with airlines and other partners to build a strong coalition to advocate for and influence industry action, whilst making sure Heathrow cuts emissions we directly control and enable others to do the same.
- 1.2.7. Heathrow's Net Zero Plan has two goals and eight solutions to deliver net zero emissions in-the-air and on-the-ground:

Goal 1: Net zero in-the-air:

- Use less fossil fuel by operating more efficiently and by modernising airspace.
- Use less fossil fuel by improving conventional aircraft and engines.
- Introduce changes to fuel - to low carbon "Sustainable Aviation Fuel" (SAF) dropped into today's planes.

¹³ Sustainable Aviation (2020). DECARBONISATION ROAD-MAP: A PATH TO NET ZERO - A plan to decarbonise UK aviation [online]. Available at: https://www.sustainableaviation.co.uk/wp-content/uploads/2020/02/SustainableAviation_CarbonReport_20200203.pdf [Accessed 12 Jan 2022].

- Facilitate the change to new zero emission aircraft.

Goal 2: Net zero on-the-ground:

- Enable net zero surface access transport for passengers and colleagues.
- Leverage Heathrow's procurement role to deliver a net zero supply chain.
- Shift airport vehicles to zero carbon.
- Get the airport's buildings and infrastructure to zero carbon.

Climate resilience

- 1.2.8. Heathrow is committed to responding to the operational resilience of the airport for all its stakeholders, including passengers, colleagues, partners, and investors. Heathrow is working with airport partners to ensure that the airport plays its role in respecting environmental limits and adapting to the effects of a changing climate.
- 1.2.9. Heathrow's commitment to managing climate change adaptation and resilience is illustrated by the assessment and reporting which accompanied the first and second round Climate Change Adaptation Reports (CCAR) in 2011 and 2016^{14,15}.
- 1.2.10. The 2011 CCAR highlighted the risks that were a priority for adaptation action at Heathrow Airport. These risks included impacts to airfield operations, surface access (roads and car parks), airport terminal operations, and airport cargo from increased flood risk at Heathrow Airport, and to snow/winter conditions. The 2016 CCAR detailed the actions that were undertaken to mitigate these risks, and the benefits which had been experienced. This third round CCAR provides an updated assessment of the climate-related risks and the measures we plan to take to increase resilience to them, representing Heathrow's increased ambition to prepare for the impacts of climate change.

Addressing climate risks

- 1.2.11. Heathrow's focus on delivering its net zero goals and adapting to the physical effects of climate change is designed to respond to the company's material climate risks. Heathrow has implemented the recommendations of the Task force for Climate-related Financial Disclosures (TCFD)¹⁶ which is guiding and supporting this approach.
- 1.2.12. Key elements in Heathrow's overall management of climate change include:

¹⁴ HAL (2011). Heathrow Airport - Climate Change Adaptation Reporting Power Report, [online]. Available at: https://climate-adapt.eea.europa.eu/metadata/case-studies/assessing-adaptation-challenges-and-increasing-resilience-at-heathrow-airport/doc1_cca-report-heathrow_may2011.pdf/@download/file/Doc1_CCA%20Report%20Heathrow_May2011.pdf [Accessed 05 Nov 2021].

¹⁵ HAL (2016). Climate Change Adaptation and Resilience Progress Report, [online]. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/566147/climate-adrep-heathrow.pdf [Accessed 05 Nov 2021]

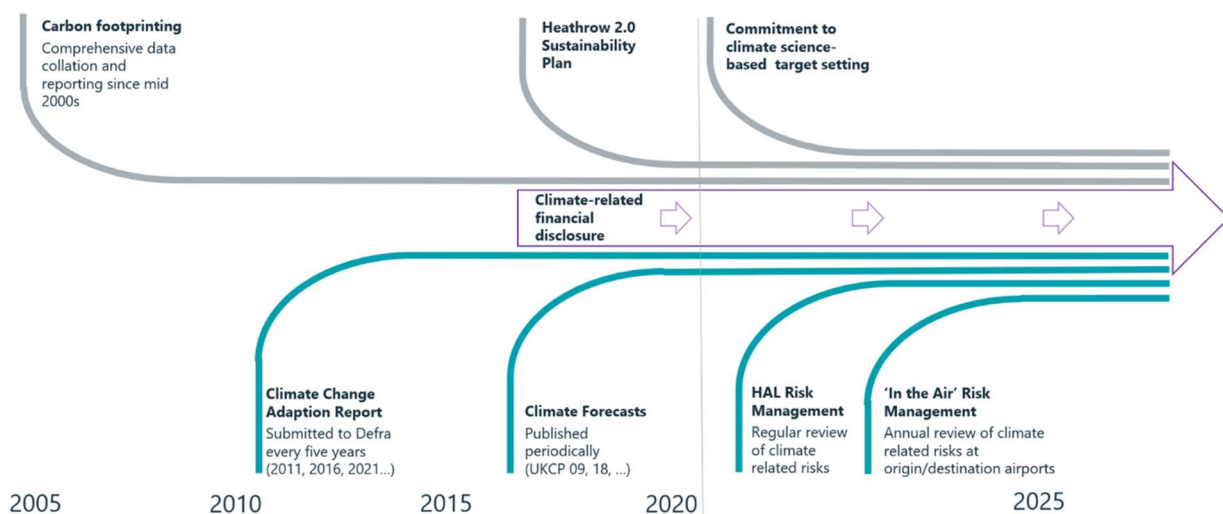
¹⁶ Task Force on Climate Related Financial Disclosures (2017). Recommendations of the Task Force on Climate-related

Financial Disclosures [online], Available at: <https://assets.bbhub.io/company/sites/60/2021/10/FINAL-2017-TCFD-Report.pdf> [Accessed 1 Jan 2022].

- **Measuring and reporting** emissions of GHGs (the “carbon footprint”), in accordance with best practice, the Airports Council International Airport Carbon Accreditation Scheme¹⁷ and the GHG Corporate Protocol¹⁸.
- **Decarbonising** to reduce emissions of GHGs by delivering Heathrow’s Net Zero Plan.
- **Adapting** to climate change by ensuring assets and operations remain resilient.
- **Disclosing** climate-related financial information as part of regular reporting to investors, the market and the regulator.

- 1.2.13. The individual components of Heathrow’s carbon management are merging on a pathway to deliver a resilient net zero airport, informed by the contribution Heathrow, airlines and other business partners are making to reduce carbon emissions; an appreciation of the transitional risks to Heathrow’s business along this pathway, and an understanding of the physical impacts of climate change. This pathway is illustrated in **Figure 1.1**.
- 1.2.14. Heathrow has been active with these workstreams for many years, building up significant knowledge and experience to support the decisions needed to meet the climate related objectives of being net zero and resilient, whilst retaining its economic role as nationally important infrastructure.

Figure 1.1 Merging workstreams towards addressing material climate risks



¹⁷ Airports Council International (2021). Airport Carbon Accreditation Scheme, [online]. Available at: <https://www.airportcarbonaccreditation.org/> [Accessed 05 Nov 2021].

¹⁸ World Resources Institute and World Business Council for Sustainable Development (2004). The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard [online]. Available at: <https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf> [Accessed 15 Dec 2021].

2. About this Report

- 2.1.1. This CCAR has been prepared at the request of Defra because Heathrow is considered a critical asset to the UK economy. This request is made in accordance with Section 62 of the Climate Change Act 2008¹⁹ and will be used to continue the mapping of climate change risks across the UK as well as assess the levels of preparedness across key sectors.
- 2.1.2. This CCAR represents Heathrow's response to the third round of UK adaptation reporting and provides an updated climate risk assessment. This includes an assessment of Heathrow's functional resilience to the current and future predicted effects of climate change and proposals for adapting to climate change. This updated climate risk assessment has been undertaken in accordance with statutory guidance from the Secretary of State²⁰ and sector guidance from the Airport Operators Association (AOA)²¹.
- 2.1.3. The objectives of this CCAR report are to provide:
- Information on progress in adapting to climate change since 2016.
 - An updated risk assessment based on UK Climate Projections 2018 (UKCP18)²² for physical risks.
 - An increase in the scope of the risk assessment, including consideration of "in-the-air" risk at Heathrow's origin and destination airports.
 - Updated risk register and recommended future actions.
- 2.1.4. In addition to fulfilling the requirements of the Secretary of State, the outcomes of this third CCAR form the basis for disclosing the physical risks of climate change as part of Heathrow's financial disclosure aligned to meet the objectives of TCFD²³. As illustrated in **Figure 1.1**, Heathrow is working to assess transition and physical climate risks on an ongoing basis through embedding climate resilience within their business management, using the annual TCFD disclosure and applying the TCFD recommendations to provide the content that is shared through its CCAR submission to Defra every five years.
- 2.1.5. Within the 2016 CCAR Progress Report¹⁵, Heathrow reported on progress against individual actions detailed in the 2011 CCAR¹⁴. As highlighted in **Section 1.2**, Heathrow is making progress in cutting GHG emissions and playing a part in minimising the worst

¹⁹ Climate Change Act 2008 (as amended) [online]. Available at: <https://www.legislation.gov.uk/ukpga/2008/27> [Accessed 17 Dec 2021].

²⁰ Department for Environment, Food & Rural Affairs (2018). Climate change adaptation reporting: third round, [online]. Available at: <https://www.gov.uk/government/publications/climate-change-adaptation-reporting-third-round> [Accessed 05 Nov 2021].

²¹ AOA. ARP3 Template V1.2.

²² Met Office (2018). UK Climate Projections (UKCP) [online]. Available at: <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index> [Accessed 28 Sept 2021].

²³ TCFD (2017). Recommendations of the Task Force on Climate-related Financial Disclosures [online]. Available at: <https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf> [Accessed 05 Nov 2021].

effects of climate change, whilst also increasing operational resilience to potential future climate conditions.

- 2.1.6. This report, under the third round of adaptation reporting, incorporates the increased scientific understanding of the last decade, described in **Section 1.1**, including new UKCP18 datasets published by the Met Office.

3. Profile of Heathrow Airport

- 3.1.1. This report covers all airport operations at Heathrow Airport, interfaces with surface access and utilities, and a first step consideration of in-the-air risk at origin and destination airports. Baseline or current conditions are based on the current airport configuration. Climate change risks associated with the short-term and longer-term scenarios are described and assessed more generally, reflecting potential future changes to airport configuration which are undefined at this time.
- 3.1.2. The airport at Heathrow occupies a 1,227-hectare site in West London containing two runways and four operational terminals. Heathrow is the UK's sole hub airport and serves 203 destinations in 84 countries. In 2019, 80.9 million passengers travelled through Heathrow, using 80 airlines. In the same year, 1.59 million metric tonnes of cargo were either loaded or unloaded at the airport (see **Figure 3.1**).

Figure 3.1 Heathrow in context (2019)



Data are provided for 2019 as this was the last normal operating year before the impact of COVID-19.

Taken from the Heathrow's Annual Report and Financial Statements 2020²⁴.

²⁴ HAL (2020). Annual Report and Financial Statements 2020, [online]. Available at: <https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/investor/reports-and-presentations/annual-accounts/airport-ltd/Heathrow-Airport-Limited-31-Dec-2020.pdf> [Accessed 11 Nov 2021].

4. Approach to Climate Risk

4.1. Taskforce for Climate-related Financial Disclosures

- 4.1.1. Climate change is the biggest medium to long-term risk for Heathrow and is one of the company's strategic priorities. Heathrow maintains a long-term view of climate risk and continues to strengthen its approach to climate risk, including implementation of the recommendations of TCFD¹⁶.
- 4.1.2. TCFD divides climate-related risks into two major categories – physical and transition risks:
- **Physical risks:** result from events (acute risks) or longer-term shifts (chronic risks) in climate patterns. They may cause direct damage to assets and indirect impacts due to supply chain disruptions.
 - **Transition risks:** transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. These transitional changes may vary in speed and may have financial or reputational risks to organisations.
 - **Opportunities:** efforts to mitigate and adapt to climate change also produce opportunities for organisations, for example, through enhanced resource efficiency and cost savings, adoption of low-emission energy sources, development of new products and services, access to new markets, and increased operational resilience.
- 4.1.3. Heathrow published its first annual climate risk disclosure in 2019, describing the overall approach to climate risk management, highlighting the management focus on climate change, and providing an outline of the material financial climate risks that Heathrow faces and the mitigation in place. Heathrow has implemented or has progressed all areas necessary for the second disclosure to be considered a 'full disclosure'. There is further work to do, and Heathrow remains committed to improving its approach to assessing and managing climate-related financial risks and reporting on progress.
- 4.1.4. Transition risks and opportunities will be covered in detail in Heathrow's 2021 financial disclosure and are therefore not considered further in this report. The actions being taken to measure, report, manage and reduce emissions, and the actions being taken to adapt to climate change are all referred to and considered as part of the financial disclosure within the Annual Report²⁴.
- 4.1.5. TCFD implementation and reporting is contributing to Heathrow's efforts to develop operational resilience, building on findings of the CCAR cycles.

4.2. Enterprise risk management

- 4.2.1. Heathrow operates an enterprise risk management system that is embedded in the business. The key objective of Enterprise Risk Management, as set out in the company-wide Enterprise Risk Management policy, is to ensure that a robust risk management framework is maintained across Heathrow which identifies, evaluates and proportionately

manages risks, within its risk appetite/tolerance levels, to the achievement of Heathrow's strategies, priorities and business objectives.

- 4.2.2. The framework provides guidance on how risks should be identified, mitigated, reviewed, and reported within Heathrow.
- 4.2.3. Principal risks have been identified at an Executive level ensuring a comprehensive top-down approach to risk identification. A principal risk is a risk that has been identified by the Heathrow Board, its formal committees, the Executive Committee, or the Risk and Assurance Committee, as a significant risk that fundamentally affects the business' ability to deliver on its overarching objectives. Climate change transition and physical risks have been included as principal risks and managed accordingly.
- 4.2.4. Each Director will have a risk register specific to their department which is managed and reviewed by their senior leadership teams. As part of the Enterprise Risk Framework, roles and responsibilities are identified for a Risk Coordinator and Risk Sponsor. They will monitor the risk register and capture and evaluate more specific climate-related risks. These specific risks will be managed and monitored at a functional level and, where appropriate, escalated to the Risk & Assurance Committee as part of the quarterly governance and oversight process. These risk registers constitute an important tool to record, manage and respond to the effects of climate risks.
- 4.2.5. To inform this CCAR, Heathrow's risk registers have been reviewed for climate-related risks, supported by engagement with internal business unit risk owners.

4.3. Risk management and identification

- 4.3.1. The overall approach to risk management at Heathrow Airport is based on the principles, framework and process outlined in ISO 31000: Risk Management²⁵.
- 4.3.2. In the event of disruption, there is a requirement to have appropriate mitigation / contingency plans in place to minimise the impact and support business recovery as efficiently and effectively as possible. Heathrow has initiated a review of how risk management is including an evaluation of climate risks within different business areas. This work is ongoing and supports the CCAR process.

²⁵ ISO 31000:2018 Risk management. Guidelines [online]. Available at: <https://shop.bsigroup.com/products/risk-management-guidelines/tracked-changes> [Accessed 12 Jan 2022].

4.3.3. The stages of the climate change adaptation process in the context of the Enterprise Risk Management Framework are characterised below:

Risk assessment

- **Identify the problem and objectives** – This includes setting out the context and rationale for carrying out the CCAR and defining the objectives that it sets out to achieve (see **Section 1**).
- **Assess system characteristics** – The scope and boundaries of the system to be considered in the risk assessment is described in **Section 5**. Climate change impacts on the degradation of the service that the system provides (in this case passenger throughput, air transport movements (ATMs) etc.) will be considered.
- **Assess risks which could impact future operations** – Where possible, critical thresholds (i.e. a point beyond which the performance of an asset or a system suffers an intolerable shift, such as a safety temperature limit at which materials or infrastructure assets become unsafe due to vulnerabilities to damage) will be used to screen climate risks. However, where these are not available or easily defined, expert judgement will be used in combination with secondary evidence (see **Section 6**).

Risk treatment

- **Identify options to mitigate climate risks and exploit opportunities** – Adaptation options and solutions to enhance overall system resilience through strengthening climate change consideration within Heathrow’s risk management processes will be identified (see **Section 7**).
- **Develop and implement CCAR** - The adaptation plan will be implemented ensuring there is accountability for implementation by Heathrow management to ensure those actions identified are delivered. This process will consider the policies, processes and operational activities that climate change adaptation will be embedded into.

Monitor and review

- **Monitor the adaptation measures** – The progress of the measures within the CCAR will be monitored by Heathrow and used to inform and influence updates to the risk assessment. The Government adaptation reporting cycle is five-years and as part of this process, monitoring of progress in previous CCARs should be conducted. Heathrow is committed to embedding climate change within its continual risk management processes, ensuring that it becomes business as usual, supporting the annual climate-related financial disclosure and the CCAR cycle.

Communicate, consult, and improve

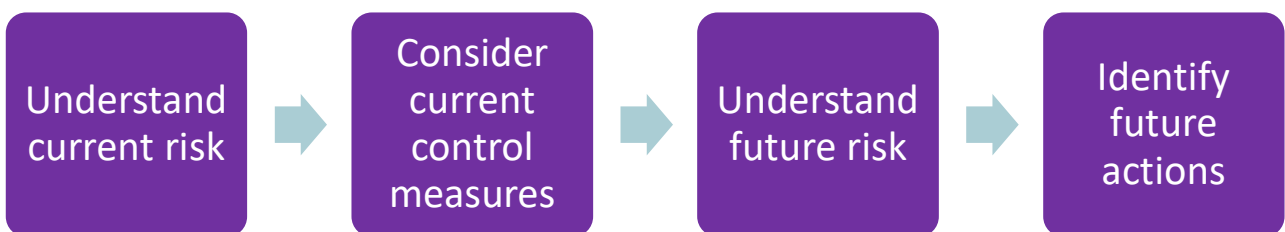
- **Report and communicate** – Progress against the CCAR will be reported at regular intervals by Heathrow and to respond to all legislative reporting requirements including, for example, future rounds of reporting under the Climate Change Act 2008¹⁹.
- **Circular cycle** – The process is a circular set of actions and the climate change adaptation process will continue. This CCAR represents the third cycle of this process.

5. Measurement of Physical Climate Risk

5.1. Quantifying physical risks

- 5.1.1. The approach to quantifying risk from climate variables and identifying adaptation measures to mitigate and reduce this risk is shown in **Figure 5.1**. This approach has the objective of ensuring that Heathrow Airport is operated to be resilient to climate change and is based on ISO 14090²⁷.

Figure 5.1 Methodology for assessing risk within the CCAR



5.2. Temporal scope

- 5.2.1. The CCAR considers three time periods over the 21st century for the physical risk assessment. These time periods have been guided by the available data within UKCP18 and AOA guidance²¹:
- **Baseline** – the period 1981 – 2000 to represent baseline or current conditions.
 - **Short-term future** – the period 2021-2040 (2030s) is used to understand short-term risks in the physical risk assessment.
 - **Longer-term future** – the period 2061-2080 (2070s) is used to assess long-term risks in the physical risk assessment.
- 5.2.2. This terminology is used throughout this report to describe current and future scenarios.

5.3. Threshold for impact

- 5.3.1. Climate hazards present varying levels of risk to Heathrow and the aviation sector more generally. Climate hazard impacts are likely to directly affect the airport (i.e., damages result from direct contact with the hazard) such as damage to airport infrastructure or flight delays and cancellations. Furthermore, there will be indirect effects (i.e., secondary

²⁷ ISO 14090:2019 Adaptation to climate change — Principles, requirements, and guidelines [online]. Available at: <https://www.iso.org/standard/68507.html> [Accessed 15 Dec 2021].

damages attributed to a hazard event, but not its direct impact), such as disruption that occurs within the wider aviation network, that have implications for Heathrow.

5.3.2. Impacts have the potential to affect:

- **Functionality** of the airport, i.e. the ability to transport cargo and passengers.
- **Performance** i.e. customer experience at the airport and the efficiency of processes.
- **Operations** (non-aviation), e.g. terminal building operations and safety procedures.

5.3.3. Where climate hazards have the potential to impact the functionality of the airport or safety protocols, there are often defined thresholds. These include safety thresholds beyond which it is unsafe to operate the airport under normal procedures.

5.3.4. Climate hazard events of the same type but varying magnitude may have different levels of impact on the airport. For example, low temperatures of around 0°C will cause minor delays due to increased demand for de-icing, while significantly lower temperatures may cause increased safety concerns, and temporary closure of the airport due to snow clearance efforts and de-icing becoming less effective. Where appropriate, multiple threshold values have been defined to represent these different levels of disruption to Heathrow, influenced by the magnitude of the climate event.

5.4. Climate projections

5.4.1. UKCP18 data²⁸ is used as the basis for climate change impact and adaptation assessments in the UK. UKCP18 is a climate projection tool produced by the Met Office providing projected changes in climate variables based on recent science and climate models.

5.4.2. Climate projections are based on a range of global GHG emission scenarios. UKCP18 includes some 12 different projections, each representing the output of a different climate model. Rather than use the output of each model individually, the outputs of all the models are used to generate an ensemble mean of projections of 20 year 'time-slices' (i.e. an average value over 20 year periods: *baseline / current*; *short-term future*; and *longer-term future*) for a range of key parameters. Note that while historical information has been considered, the baseline / current values are not validated against observed data, so any biases are carried forward to the future projections.

5.4.3. Climate scenarios and GHG emission pathways provide plausible representations of future states of the climate system, incorporating socio-economic, technological demographic and environmental development. These are used to force the climate models within UKCP18. The local and regional models are forced by a low ambition emission scenario,

²⁸ Met Office (2018). UK Climate Projections (UKCP) [online]. Available at: <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index> [Accessed 28 Sept 2021].

RCP8.5. The increase of global mean surface temperatures by the end of the 21st century relative to 1986-2005 is likely to be between 2.6°C to 4.8°C under RCP 8.5^{29,30}.

- 5.4.4. Airport operations need to be maintained during events with increased weather-related hazards and hence, assessing the risks under a low ambition climate scenario is deemed conservative but appropriate. This is in line with best practice approaches to climate change risk assessment, particularly with organisations with infrastructure or operation lifetimes exceeding 2050. For future planning and investments, Heathrow will utilise latest climate data and conduct more detailed assessment of risks.
- 5.4.5. Local climate projections provide the best representation of local effects within the climate models. The first and second CCARs prepared by Heathrow in 2011¹⁴ and 2016¹⁵ used the previous generation of climate projections, UKCP09, which provided data for local areas at a resolution of 25 km². The UKCP18 projections include datasets at 2.2 km², 12 km², 25 km² and 60 km² resolution. The 2.2 km² local projections were used in this assessment and are available on a daily temporal scale which is useful for examining the risk of extreme weather events over the coming decades.

5.5. Assigning likelihood

- 5.5.1. The likelihood of the climate change impact was determined based on the definitions in **Table 5.1**. A quantitative approach is used for physical climate risks where data availability is good for current and future projections. A qualitative approach has been used where data is more limited.

Table 5.1 Criteria used to assess likelihood of climate change impacts

Level	Score	Qualitative description	Quantitative description
Highly probable	5	Frequent. Event is expected to occur in most circumstances. Almost certain.	Climate projection ensemble mean for the percentage of years throughout the considered time-period with an event occurrence is greater than 80%
More than likely	4	Event will probably occur in most circumstances. Likely to happen. Can be anticipated.	Climate projection ensemble mean for the percentage of years throughout the considered time-period with an event occurrence is 50 - 80%
Less than likely	3	Occasional. Event should occur at some time. Possible to occur.	Climate projection ensemble mean for the percentage of years throughout the considered time-period with an event occurrence is 30 - 50%

²⁹ IPCC (2014). AR5 Synthesis Report: Climate Change 2014, [online]. Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf [Accessed 29 Oct 2021].

³⁰ The IPCC released the Working Group I contribution (The physical science basis) to the Sixth Assessment Report (AR6) in August 2021, predicting even greater global warming under the high emissions scenario, with up to a 6°C global temperature increase by 2100. As further Working Group contributions to AR6 are still to follow and findings are not yet reflected in assessments such as UKCP, projections from the Fifth Assessment Report AR5 are the basis of this assessment.

Level	Score	Qualitative description	Quantitative description
Unlikely	2	Remote. Event could occur at some time. Possible but not likely.	Climate projection ensemble mean for the percentage of years throughout the considered time-period with an event occurrence is 10 - 30%
Improbable	1	Event may occur in exceptional circumstances. Should virtually never occur.	Climate projection ensemble mean for the percentage of years throughout the selected time-period has an event occurrence is less than 10%

NB: The terminology for the qualitative likelihood in the above table is based on AOA guidelines.

5.6. Assigning consequence

5.6.1. The consequence (impact) of each physical climate risk was determined based on the definitions in **Table 5.2**. The consequence of physical risks was ranked on a scale from minimal, where a noticeable event occurs but is managed through normal activity, to a catastrophic event with devastating consequences. Knowledge, first-hand experience of current and recent past severe weather events and expert judgement was used to rank the extent to which climate and climate change hazards would impact on the operations at Heathrow.

Table 5.2 Criteria used to assess consequence of a physical climate change hazard event

Level	Score	Qualitative description
Catastrophic	5	A critical event with devastating consequences. Potential or actual disaster for the business. Loss of life.
Major	4	A large event that requires a high-level of engagement, special arrangements, and effective management. Crisis Management Teams activated.
Moderate	3	A significant event which requires prompt action to prevent escalation. Can usually be managed under normal circumstances
Minor	2	An event which can be managed via existing processes. Minor adverse consequences.
Minimal	1	Noticeable event but manageable or absorbed through normal activity

NB: The terminology for consequence (impact) in the above table is based on AOA guidelines.

5.7. Determining risk

5.7.1. The approach adopted by Heathrow to assessing risk is in line with the company's risk management framework described in **Section 4**. All risks have been assessed using a standardised approach for consistency based on the consequence and the likelihood of the event.

- 5.7.2. The risk rating is determined by multiplying the likelihood by the consequence rating as shown in **Table 5.3**. The risk score is used to determine the risk category as shown in the colouring used. The standard Heathrow risk management procedure defines three levels of risks from low, medium to high. In contrast, the AOA template²¹ utilises more conservative thresholds and implements four risk categories from minor, moderate, major to severe.
- 5.7.3. This risk appraisal was undertaken with consideration given to existing impacts as judged by operational experts at Heathrow to ensure agreement on current risk categorisation.

Table 5.3 Risk scoring, and categorisation used to assess risk levels for the risk assessment

Consequence →	1 Minimal	2 Minor	3 Moderate	4 Major	5 Catastrophic
Likelihood ↓					
5 Highly probable	5	10	15	20	25
4 More than likely	4	8	12	16	20
3 Less than likely	3	6	9	12	15
2 Unlikely	2	4	6	8	10
1 Improbable	1	2	3	4	5

NB: Risk categories are shown in the colouring used in the table above, where the risk score value is used to define the risk category. The cell colour represents the risk categories defined by the AOA where minor (green) risks are scored 1-3, moderate (yellow) risks are 4-9, major (red) risks are 10-16 and severe (dark red) risks are 20-25.

5.8. Accounting for uncertainty

- 5.8.1. Climate change projections are associated with considerable uncertainty associated with GHG emissions, model configurations, model bias, variability and non-linearities in the climate system. The impacts of climate hazard events at Heathrow Airport are also uncertain as these will depend on the nature of the impact, its timing, the warning provided and future adaptation decisions. These uncertainties have been accounted for in this assessment through a confidence rating.

The confidence in the likelihood and consequence of risks has been determined on a scale of 1 to 3 dependent on the criteria described in **Table 5.4**. Model certainty in future climate projections that have been assessed quantitatively have been based on the inter-quartile range (IQR) which describes the middle 50% of values and therefore represents

statistical dispersion in the model results. Climate hazard data and future projections associated with a high IQR have greater uncertainty between the model outputs.

Table 5.4 Criteria used for assessing confidence in the risk assessment

Likelihood → Consequence ↓	Qualitative information used	Low IQR > 50%	Medium 10% < IQR < 50%	High IQR < 10%
Low - Uncertain outcomes due to limited past exposure and/or research	Low	Low	Low	Low
Medium – Some understanding of impacts due to aviation sector research and/or experience	Low	Low	Medium	Medium
High – High levels of understanding due to experience of similar events at Heathrow and/or strong evidence across the aviation sector or linked sectors	Low	Low	Medium	High

6. Climate Risk Assessment

6.1. Understanding the risk

6.1.1. Physical risks at Heathrow Airport have been split into two broad categories:

- **Direct risks** which have an immediate effect on the airport (i.e. damages resulting from direct contact with the hazard) such as damage to airport infrastructure or delays/cancellations to flights. The direct risks considered in this assessment include:
 - ▶ Increases to maximum temperature (including daily temperature and seasonal variations).
 - ▶ Extreme winds (including mean wind speeds and wind gusts).
 - ▶ Rainfall / flooding.
 - ▶ Snowfall.
 - ▶ Extreme cold.
 - ▶ Fog.
 - ▶ Low cloud ceiling height.
 - ▶ Lightning / thunderstorms.
 - ▶ Compound events³³.
- **Indirect risks** where the effects occur within the wider aviation network or interdependencies but will have implications for Heathrow (i.e., damages resulting from the hazard event, but not its direct impact). The indirect risks considered in this assessment include:
 - ▶ Indirect risks of increased temperatures.
 - ▶ Interdependency risk from electrical and power (including gas and fuel) supply, water (including stormwater and wastewater) supply, waste supply, computational resources, communications, and the supply chain.
 - ▶ Indirect risks to the wider aviation sector, such as those affecting airports forming the origin or destination of flights to and from Heathrow (referred to as 'in-the-air' risks)³⁴.

³³ A compound event is when there is a link between either (i) two climate variables e.g. min temperature and max temperature; (ii) consecutive events e.g. dry period followed by storm event, (iii) physical and transition risks.

³⁴ If the operation of an origin or destination airport is vulnerable to physical climate change risks this can have a direct impact on passenger numbers or freight volumes at Heathrow. These indirect risks are assessed at a preliminary level as part of the climate-related financial disclosure for 2021 and will be subject to more detailed assessment next year.

- 6.1.2. A total of 17 direct risks have been identified potentially affecting Heathrow. These risks have been established at a high level based on a combination of Heathrow's previous CCARs, engagement with Heathrow staff, results from the UK Climate Risk Assessment, UKCP18 projections, sector specific risk assessments and professional judgement. The risks and thresholds used to determine impacts are described in the full risk register in **Table 6.1** along with current control measures. A further 11 indirect risks have also been identified and assessed for Heathrow. As described in **Section 5**, indirect risks are assessed on a qualitative basis only. These risks and control measures are described in **Table 6.2**.

Table 6.1 Direct physical risks identified at Heathrow

Risk code	Risk	Threshold	Narrative	Potential consequence	Control measures
Maximum temperature					
2021 R1	Infrastructure damage affecting the structural integrity of airfield structures such as runway / apron tarmac and terminals / airfield buildings	Increased risk of structural integrity impacts at Heathrow are more likely to occur above 32°C. At high temperature extremes, Heathrow implement control measures (including monitoring of the surface condition).	Under high temperatures there is a risk of structural damage to the surface and sub-surface of the runway and aprons caused by temperatures exceeding design standards i.e. melting, cracking. Although asphalt break-up is not a widespread issue on airport roads today, localised break-up of the surface can arise in areas which are subject to constant movement. UK tarmac standards (roads, aprons) begin to lose integrity once temperatures in the shade exceed 32°C. Tarmac itself is black, absorbs heat and can hit 80°C at such temperatures. Runway surfaces, based on current design standards, are intended to withstand far higher temperatures to be able to cope with aircraft braking. Terminals / airfield buildings may experience impacts on structural integrity depending on design.	<ul style="list-style-type: none"> Financial costs to repair damage. Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Airport closure. 	Heathrow's technical standards for airfield pavement are based on current industry best practice and construction materials that meet airfield pavement standards, meeting foreseeable temperature extremes. Surface conditions are monitored by operational teams to maintain safe operations. There is a routine inspection regime and maintenance programme. Both runways are resurfaced on a 10–14-year cycle, to the latest technical standards. Increases to temperature extremes will be incorporated into technical design standards and built into Heathrow's asset replacement programme. Terminals and other airfield buildings are designed for foreseeable temperature extremes and their performance is kept under review.
2021 R2	Impacts on the surface integrity of surface access routes leading to and around the airport	Increased risk of structural integrity impacts at Heathrow are more likely to occur above 32°C. At high temperature extremes, Heathrow implement control measures (including monitoring of the surface condition).	Under high temperatures there is a risk of structural damage to the surface and sub-surface of roads caused by temperatures exceeding design standards i.e. melting, cracking. UK tarmac standards (roads, aprons) begin to lose integrity once temperatures in the shade exceed 32°C. Hot weather can also cause thermal expansion of track, rail buckling and train derailment and heat stress on electricity provision. There is a risk of overheating on surface access transport from rising temperatures.	<ul style="list-style-type: none"> Financial costs to repair damage. Safety risks. Reputational damage. Loss / litigation potential. 	Heathrow's technical standards for the surface access routes for which Heathrow is responsible are based on current industry best practice and construction materials that meet industry standards, meeting foreseeable temperature extremes. Surface conditions are monitored by operational teams to maintain safe operations. There is a routine inspection regime and maintenance programme. Future increases to temperature extremes will be incorporated into technical standards as required. Surface access provision beyond the airport perimeter is the responsibility of public transport operators, local authorities and National Highways and Heathrow work with those organisations to maintain surface access connectivity and to respond to operational events.
2021 R3	Impacts on maximum take-off weight (MTOW)	MTOW is likely to only become an issue at temperatures over 35°C. The impact can be compounded when this coincides with high humidity. This is given the length of runways at the airport (Northern 3,901 m / Southern 3,658 m) and the elevation of the site (25 m AMSL). More detailed analysis is needed to develop a specific threshold and ensure it is appropriate for Heathrow Airport.	Reduced lift for departing aircraft due to 'thin air' and reduced engine efficiency in very hot weather, having impacts on MTOW and a possible degradation in overall airline freight carrying capacity.	<ul style="list-style-type: none"> Operational disruption. 	Managing the take-off weight of aircraft is the responsibility of airlines. The current generation of aircraft operate globally in more extreme climatic conditions than are experienced at Heathrow. Aircraft lift improves with every generation of aircraft and airlines retain control of the level of aircraft loads carried. It is not known to what extent new generation of aircraft (e.g. lighter aircraft) will influence the decision threshold, so this potential change has not been included in the assessment at this stage.
2021 R4	Impacts on thermal comfort of staff and passengers in terminal buildings and aircraft on stands	The Chartered Institution of Building Services Engineers (CIBSE) Guide A Environmental design ³⁵ suggests that inside building temperature in airports should not be >24°C in winter or >25°C in summer. Thermal comfort modelling is outside of the scope of this assessment.	Thermal comfort describes a person's state of mind in terms of whether they feel too hot or too cold. The temperature is difficult to define as it varies with the person's preference, clothing, activity level and the environment around them. Overheating of operationally critical buildings could impair performance of critical staff and breach regulated conditions. There are heat stress	<ul style="list-style-type: none"> Financial costs to repair damage. Safety risks. Reputational damage. Loss / litigation potential. 	Chilling plant and air conditioning units are operated across Heathrow to provide cooling and maintain indoor thermal comfort. Cooling plant and associated systems are designed for foreseeable temperature extremes, are subject to routine inspection and maintenance, and performance will be kept under review. To deliver Heathrow's Net Zero Plan, investment in decarbonising the airport's heat network is required. The current heating provision at Heathrow relies primarily on biomass and

³⁵ CIBSE (2015). Guide A Environmental design [online]. Available at: <https://www.cibse.org/knowledge/knowledge-items/detail?id=a0q2000008179JAAS> [Accessed 24 November 2021].

Risk code	Risk	Threshold	Narrative	Potential consequence	Control measures
			risks to staff, particularly those in highly physical roles. Thermal comfort can cause issues with specific areas of the airport becoming too hot with increased demand placed on air conditioning. In some areas air conditioning will need to be installed. Increased energy demand for cooling in the summer increases energy spend and emissions. The more significant operational issue is resilience of these cooling systems, not necessarily coinciding on a day of extreme temperature, due to the potential adverse impact in the event of failure.		natural gas. Zero carbon heating solutions may also provide an efficient way of meeting cooling needs too and this has been considered in options work to date. Heathrow has included capital investment for developing the scheme design for a zero-carbon heating solution in our latest business plan which covers the period from 2022-26. Although the Civil Aviation Authority (CAA), the economic regulator for Heathrow did not include this in their initial proposals, Heathrow continues to make the case for investment in decarbonising the airport, including heat, and we await the regulators final proposals in 2022. Heathrow has also included investment in upgrading Pre-Conditioned Air (PCA) provision at Heathrow in our latest business plan. Upgraded PCA units are more effective at cooling aircraft parked on stand during higher temperatures, allowing aircraft to switch off on board cooling provision which is the default option and effective where it is used globally in locations with higher temperatures than the UK today. Using PCA reduces aircraft carbon and other emissions on the ground and can contribute to improved air quality.
2021 R5	Delays to construction and maintenance works and impacts on operational activity	In <i>The Workplace (Health, Safety and Welfare) Regulations 1992</i> ³⁶ employers have a legal obligation to ensure the temperature is "reasonable". The Trades Union Congress (TUC) has called for a maximum temperature of 30°C to be set by employers. Thermal comfort modelling is outside the scope of this assessment. A threshold of 30°C outside air temperature has been used in this assessment.	Delays to construction and/or maintenance activities could cause safety concerns or for facilities to be closed for a longer duration placing increased pressure on other facilities. In terms of operational activity, to mitigate against safety concerns, more frequent breaks for operational workers may need to be scheduled, which would require increased resourcing. Investment in more air-conditioned vehicles to support safer working practices may also be necessary.	<ul style="list-style-type: none"> Financial costs due to programme delays. Safety risk. Environmental damage. 	Heathrow implement operating practices to address the risks to colleagues from working during periods of higher temperatures, guided by regulations, standards and recognised best practice. Heathrow will continue to review and update our approach where necessary to respond to future changes in the level of risk.
Extreme winds and wind direction					
2021 R6	High wind speeds or gusts leading to reduced capacity.	The threshold for disruptions due to winds is variable depending on the aircraft type and the runway conditions. Disruption to scheduled services is anticipated to occur when wind speeds are approximately 20 knots or wind gusts are ≥28 knots. Wind speed is used as the basis of this assessment and a threshold value of 20 knots is used.	Increased wind speed can lead to a decrease in controllability of aircraft during take-off and cause negative impacts on the take-off distance required, ultimately leading to delays.	<ul style="list-style-type: none"> Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Increased missed approaches. 	During times of high winds, standard operating procedures and precautions are followed to ensure safe operations. Heathrow has invested in time-based separation technology which allows the airport to maintain a higher landing rate in strong wind conditions than would otherwise be possible. The technology enables the distance between aircraft to be reduced but keeping the same time interval between aircraft as measured at the runway threshold. The reduction in aircraft separation distance can only be applied to aircraft once they are established on final approach so there remains some degradation in overall landing rate.
2021 R7	High wind speeds or gusts causing damage to high-sided structures	Major impacts are anticipated to occur when wind speeds are approximately 34 knots or wind gusts are ≥43 knots. Wind speed is used as the basis of this assessment and a threshold value of 34 knots is used.	High wind speeds could cause damage to high-sided structures at the airport, standing aircraft, vehicles, and injuries to staff. The operational impacts may include disruption and restrictions on airbridge use. High wind speeds can also lead to a suspension of working at height. Such conditions can also mean that there is a need to secure ground equipment.	<ul style="list-style-type: none"> Financial costs to repair damage. Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Airport closure. 	During times of high winds, standard operating procedures and precautions are followed to ensure safe operations. This may include suspending the use of airbridge and limit the opening of aircraft cargo doors, securing ground equipment and movable objects, suspending certain operational activities such as working at height and increasing the level of inspections.

³⁶ The Workplace (Health, Safety and Welfare) Regulations 1992 [online]. Available at: <https://www.legislation.gov.uk/uksi/1992/3004/contents/made> [Accessed 24 Nov 2021].

Risk code	Risk	Threshold	Narrative	Potential consequence	Control measures
2021 R8	Change in prevailing wind direction impacting take off procedures	The threshold for disruptions due to wind direction is variable depending on the aircraft type, runway conditions and air space congestion. More detailed analysis is needed to develop a specific threshold and ensure it is appropriate for Heathrow.	Changes to prevailing wind direction affect runway utilisation and schedules. Due to the east-west orientation of its runway, Heathrow is vulnerable to changes in wind direction and speeds, and disruptions caused by crosswinds.	<ul style="list-style-type: none"> • Safety risks. • Reputational damage. • Loss / litigation potential. • Operational disruption. • Increased missed approaches. 	The runways at Heathrow are orientated according to the most common wind patterns experienced in the UK. During times of cross winds, standard operating procedures and precautions are followed to ensure safe operations. This includes Air Traffic Control (ATC) procedures that increase the separation distance between aircraft. Time-based separation is not relevant as a control measure for cross winds. UKCP18 data shows no discernible pattern in wind direction in the short-term and longer-term future, however changes in this variable are uncertain and further assessment of the likelihood and potential impact of changing wind direction needs to be undertaken.
Rainfall / flooding					
2021 R9	Exceedance of drainage infrastructure capacity associated with surface (pluvial) flooding events	Heathrow's Operational Flood Plan defines an extreme rainfall event as >25 mm per hour, and mitigating actions are then triggered. Further modelling work is required to enable a quantitative assessment using a threshold.	Past high rainfall events have resulted in standing water and reduced friction (and poor visibility) on runways, aprons, and taxiways, creating hazardous conditions for vehicles and planes. These events could cause minor disruption to flight schedules due to a risk of aircraft aquaplaning. Localised flooding could occur if older drainage overwhelmed by heavy rainfall events, due to infrastructure not being designed for increased volume flows. Flooding of current surface water drainage provisions, and associated drainage collapse, and sewer surcharging are also possible. More severe flood events, which are likely to increase in frequency and intensity, have the potential to close the airport operations thereby affecting the functionality of the airport itself. Flooding on surface access roads may also impact the accessibility of the airport. Pollution Control System (PCS) may be challenged during episodes of extreme weather.	<ul style="list-style-type: none"> • Financial costs to repair damage. • Safety risks. • Environmental damage. • Reputational damage. • Loss / litigation potential. • Operational disruption. 	Heathrow's Operational Flood Plan has been developed to manage the impact of flooding on critical assets. The plan highlights vulnerable areas in the airport and prescribes responses to prolonged periods of medium to high rainfall and extreme rainfall events that can overwhelm drainage systems and cause water pooling. It grades early warning indicators from green to amber and red, with the latter classifications triggering counter measures which range from increased monitoring and inspections of potentially affected areas of the airport to the deployment of flood barriers and use of pumping equipment. Heathrow has completed a £30m investment project to upgrade one of the three major surface water catchments at the airport since the last CCAR in 2016. The investment was informed by a review of all three catchments in consultation with the Environment Agency and other stakeholders. The upgrades to the balancing reservoir of the Eastern Catchment incorporated the latest climate standards at the time of design and allow more flexible management of water flows from the airport to the receiving watercourse, and an increase in treatment capacity to reduce the impact of winter runoff on the receiving watercourse. An updated assessment of the airport drainage network to respond to significant rainfall events is planned in 2022 to inform future operational and investment planning.
2021 R10	Groundwater flooding events	Heathrow's Operational Flood Plan defines a red early warning for groundwater as Clockhouse Lane pit being >13.7 m AOD. Further modelling work is required to enable a quantitative assessment using a threshold.	Changes to groundwater levels affect asset integrity and could cause subsidence and water ingress damage to buildings and surfaces. Groundwater flooding can cause leaks in tunnels and basements. This risk can cause premature degradation of these assets and in extreme cases pose a risk to operations from sub surface infiltration incidents.	<ul style="list-style-type: none"> • Financial costs to repair damage. • Safety risks. • Environmental damage. • Reputational damage. • Loss / litigation potential. • Operational disruption. 	Design standards for new buildings address risks from water ingress / flooding. Heathrow's Operational Flood Plan has been developed to manage the impact of flooding on critical assets. Measures range from increased monitoring and inspections of potentially affected areas, flood barriers and the use of pumping equipment. Basements, tunnels, and other underground structures include measures to remove groundwater ingress where there is an identified risk and flood damage prevention measures, such as siting critical electrical assets on platforms.
Snowfall					
2021 R11	Increased snow hazard and de-icing requirements due to snowfall events.	When there is a higher than 30% risk of snow occurring, Heathrow's Snow Plan is implemented. The mitigations ensure that the airport can continue to operate.	Increasing variability of snowfall challenges winter contingency plans, de-icing supplies, and staff experience. Any prolonged period of extreme cold temperatures, and the associated meteorological hazards such as snowfall and blizzards, has the	<ul style="list-style-type: none"> • Financial costs associated with winter operation procedures. • Safety risks. • Environmental damage. 	Heathrow continues to review and update its winter operations plans, including its Snow Plan, annually in consultation with other key stakeholders including airlines and NATS. The Snow Plan sets out Heathrow's response to a snow event to ensure the continued safe operation of the airfield and to minimise disruption.

Risk code	Risk	Threshold	Narrative	Potential consequence	Control measures
		A critical threshold of ≥ 20 mm / 24 hr of lying snow is used to describe a moderate event, based on literature studies of other UK airport Adverse Weather Plans.	potential to disrupt Heathrow. Snow could cause delays and /or strategic cancellation of flights. There is likely to be increased pressure on critical de-icing equipment for aircraft resulting in reduced efficiency in operational procedures due to increased time to de-ice planes. Snow build-up may cause cancellation of flights and/or temporary closures of the airfield as snow clearance procedures are required to remove build up and prevent surfaces freezing.	<ul style="list-style-type: none"> Operational disruption. 	Operational learning and new insights are included in the annual review process. Heathrow's Snow Plan is reviewed annually prior to each winter season. Heathrow has invested significant capital and time in improving the resilience of the airport during a snow event. This includes additional equipment, a new operations centre, new processes for weather forecasting, enhanced command and control structure supported by a greater number of personnel. Heathrow continues to investigate enhancements to its snow clearance vehicle fleet in the fleet replacement strategy. Investment in the vehicle fleet has been included in Heathrow's business plan for the latest regulatory settlement, which was submitted to the CAA in 2021. Heathrow's response to snow events has improved significantly in the last 10 years. This type of event is challenging for airports and likely to lead to a temporary residual impact on normal airport operations.
Extreme cold					
2021 R12	Low temperatures	A response threshold to mitigate the impacts of cold weather is 0°C . At around this temperature de-icing procedures are triggered at Heathrow.	Low temperatures will reduce the runway friction impacting take-off procedures as directed by the airline procedures. There will be increased de-icing requirements which could lead to delays (and indirect water quality impacts). Fracture risk to underground infrastructure and surfaces from increased winter temperature variability and freeze / thaw damage. Increased energy demand for heating during winter extremes increases energy spend and emissions. Wintry conditions pose health and safety risks for passengers and staff.	<ul style="list-style-type: none"> Financial costs associated with winter operation procedures. Safety risks. Environmental damage. Reputational damage. Loss / litigation potential. Operational disruption. 	Heathrow continue to develop the Snow Plan, which also covers the response to low temperature events, improving and introducing new aircraft de-icing capabilities. A two-position de-icing pad has been constructed. This also enables a glycol recovery capability. Heathrow survey buried services / surfaces for condition. New services are not laid at shallow depths to avoid damage due to temperature extremes. Future demand is considered as part of the heating and cooling strategy. Heathrow have plans in place to clear paths and manage slip hazards in winter to ensure the safety of staff and passengers. Heathrow provide staff with appropriate protective clothing and equipment, adequate breaks, and accommodation.
2021 R13	Extreme low temperatures	Through interviews with Heathrow risk managers, -7°C was given as a threshold at which de-icer becomes less effective and the potential for disruption on the airfield increases.	In extreme low temperatures the effectiveness of de-icer is reduced, so multiple applications are required. This can lead to delays (and indirect water quality impacts). Planes may be grounded by ice at gates. Fracture risk to underground infrastructure and surfaces from increased winter temperature variability and freeze / thaw damage. Increased energy demand for heating during winter extremes increases energy spend and emissions. Wintry conditions pose health and safety risks for passengers and staff.	<ul style="list-style-type: none"> Increased financial costs associated with winter operation procedures. Increased safety risks. Increased environmental damage. Increased reputational damage. Increased loss / litigation potential. Major operational disruption. Airport closure. 	Heathrow continue to develop the Snow Plan, improving and introducing new aircraft de-icing capabilities. A two-position de-icing pad has been constructed. This also enables glycol recovery capability. Heathrow survey buried services / surfaces for condition. New services are not laid at shallow depths to avoid damage due to temperature extremes. Future demand is considered as part of the heating and cooling strategy. Heathrow have plans in place to clear paths and manage slip hazards in winter to ensure the safety of staff and passenger. Heathrow provide staff with appropriate protective clothing and equipment, adequate breaks, and accommodation.
Low visibility (including fog and low ceiling height)					
2021 R14	Risks associated with reduced visibility, increasing risk of accidents and collisions due to fog occurrences and low cloud ceiling height	Heathrow have a critical threshold of visibility of less than 350 m. In these conditions, judgements are made around activities that are safe and whether workers are safe to conduct their duties. It is beyond the scope of this assessment to determine the relationship between this and climate indices used to determine fog and cloud ceiling height, therefore a qualitative assessment	Seasonal changes to fog related disruption (increase in winter months and decrease for the remainder of the year). Poor visibility can reduce the capacity of an airport leading to ground delays, flight diversions, flight cancellations and extra operating costs.	<ul style="list-style-type: none"> Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Airport closure. 	Heathrow continue to monitor the trend of fog frequency. Low visibility procedures are in operation at the airport to deal with periods of fog and reduced visibility. This includes certain restrictions and implementing operational safeguarding processes.

Risk code	Risk	Threshold	Narrative	Potential consequence	Control measures
		of likelihood has been developed based on anecdotal and secondary evidence.	Low cloud ceiling height may cause reduced visibility at the airport having implications for take-off and landing operations.		
Lightning / thunderstorms					
2021 R15	Lightning strikes and associated fire risk	Literature data suggests that occurrences of lightning (or reports of lightning) within 5-8 miles of airports could have impacts on fuelling operations. The exact threshold for suspending ground operations and fuelling will be determined by airside operators. Lightning data is not currently available within UK climate projections and therefore a qualitative assessment has been provided based on secondary evidence.	Increased risk of schedule interruption from stormy conditions. Disruption to airfield operations from lightning i.e. refuelling suspension, changes to flight routing. Impacts of lightning on control systems and electricity supply. Power cuts and voltage spikes to parts of the airport without an Uninterruptible Power Supply (UPS) during electrical storms. Increased fire risk due to hotter temperatures combined with increased lightning and drought potential.	<ul style="list-style-type: none"> Financial costs to repair damage. Safety risks. Reputational damage. Loss / litigation potential. Airport closure. 	<p>Responding to lightning strikes is the responsibility of the flight crew. This may lead to changes in runway utilisation however this is outside of Heathrow's direct control. A temporary cessation of aircraft fuelling forms part of processes to respond to lightening activity at Heathrow.</p> <p>Heathrow have assessed the risk of increased fire risk and consider the airport fire main to be sufficient to mitigate risk.</p>
Compound events					
2021 R16	Blizzard risk (combined impact of snowfall, wind, and low temperatures)	Blizzards are a combination of meteorological hazards and are typically defined by the following conditions: Lying snow ≥ 100 cm; wind gust ≥ 17 m/s; $T_{\text{mean}} \leq 0$ °C. ³⁷ UK Climate Projections cannot be used to assess this threshold at the current time as they are not available in a spatially coherent format without error. A qualitative assessment has been provided based on secondary evidence.	Snow fall during blizzards could reduce the runway friction and these conditions therefore have the potential to cause delays and/or cancellations. Blizzards can reduce visibility to less than 100 m. When visibility is reduced to this level, ground operations become challenging.	<ul style="list-style-type: none"> Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Airport closure. 	Winter operation procedures are in place for snowfall and low visibility procedures will be implemented when necessary, as defined above for specific relevant risk events.
2021 R17	Risk of flight disruption due to the cumulative impact of other extreme weather events or impacts greater than current projections suggest	Compound events can occur when there is an interaction between two or more climate variables, and this interaction can exacerbate the impacts. Extreme weather encompasses a range of different meteorological phenomena and there is no one defined threshold value. Extreme weather is considered significantly different from the average or usual weather pattern. Values are determined based on secondary evidence and professional judgement; qualitative values are used.	Poor weather can cause runway and/or facilities closure leading to flight disruptions to passenger flights and cargo operations. This impact could also cause possible financial loss to airlines due to extended disruptions.	<ul style="list-style-type: none"> Financial costs associated with reduced movements. Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Airport closure. 	As defined above for specific relevant risk events.

³⁷ Juga, Ilkka & Vajda, Andrea. (2012). The effect of weather on transportation: Assessing the impact thresholds for adverse weather phenomena [online]. Available at: [\(PDF\) The effect of weather on transportation: Assessing the impact thresholds for adverse weather phenomena \(researchgate.net\)](#) [Accessed 24 Nov 2021].

Table 6.2 Indirect physical risks identified at Heathrow Airport

Risk code	Risk	Narrative	Potential consequence	Control measures
Maximum temperature				
2021 R18	Local ecosystem changes	An indirect effect of meteorological changes (including increased summer temperature, precipitation extremes and wind speed changes) may be changes to the local ecosystem at Heathrow. Risk could include increased presence of birds, including migratory birds, increasing the risk of wildlife-strike; increased rates of plant growth and longer summer seasons increasing maintenance operations such as grass cutting; increased risk of standing water in proximity to the airfield increasing presence of wildlife; or changes in propagation and migration of invasive species with wind speed changes increasing presence of wildlife. These impacts may ultimately lead to increased presence of wildlife on the airport itself which in turn is associated with an increased safety risk due to the potential for wildlife-strikes.	<ul style="list-style-type: none"> Financial costs to control wildlife. Safety risks. Environmental damage. Reputational damage. Operational disruption. 	Bird hazard management at Heathrow is kept under regular review and different strategies and procedures used to mitigate the risk to aircraft from bird strikes. Any changes in the distribution of birds or other wildlife species will be assessed as part of that process and changes made to the airport response if that is necessary.
2021 R19	Increased fire risk of combustible materials	Increased temperatures have an associated increase in the fire risk of combustible materials, especially if accompanied by a period of drought or low precipitation. Under <i>The Regulatory Reform (Fire Safety) Order 2005</i> ³⁸ , Fire Risk Assessments are required at many institutions including airports. Each airport is given a fire category which determines the type of aircraft the station has the capacity to deal with and the number of crew required to deal with emergencies, Heathrow Airport is fire category 10.	<ul style="list-style-type: none"> Financial costs of increased fire operations. Safety risks. Environmental damage. Reputational damage. Operational disruptions. Airport closure. 	A typical category 10 airport, such as Heathrow, operates out of two fire stations (located in the east and west of the airport) in order to achieve the three-minute response time to any location within the airport boundary which provides sufficient fire cover that will continue to be reviewed in response to changes in the future risk.
2021 R20	Increased risk of communicable disease and epidemics	Changes to the global distribution of disease could increase the likelihood and frequency of epidemics and pandemics. Many of the root causes of climate change (e.g. deforestation and dietary patterns) also increase the risk of pandemics by causing forced migration of animals due to habitat loss and increased risk of infection in new places or close interactions between wild animals and humans. The impacts of climate change on temperature, humidity and rainfall patterns will likely make the conditions more favourable for the spread of some infectious diseases including Lyme disease and mosquito-borne diseases such as malaria and dengue fever. The COVID-19 pandemic has shown that aviation as a sector is particularly vulnerable to pandemic risk. The prevalence of disease and pests including mosquitos may also have an impact on the desirability of flight destinations causing changes in the operational procedures.	<ul style="list-style-type: none"> Financial costs. Safety risks. Environmental damage. Operational disruptions. Airport closure. 	Pandemic risk is largely outside the control of any individual airport. Mitigations will be put in place to support the return of air travel following the COVID-19 pandemic in the near term. Heathrow have wider protocols in place to deal with and manage communicable diseases. Regular communications occur between Heathrow and Public Health England regarding potential risks. Heathrow has worked closely with Government on a risk-based approach to enable safe travel during the COVID-19 pandemic. Details are communicated to the wider community when required. Plans exist for a loss of resource as-a-consequence of an epidemic or pandemic.
2021 R21	Changes to high altitude air currents used by airlines	High altitude air currents (e.g. the North Atlantic jet stream) used by airlines may change course under influences of climate change resulting in adjusted flight paths and potentially longer (or shorter) flight times along some routes.	<ul style="list-style-type: none"> Financial costs. Safety risks. Operational disruptions. 	This is a general aviation risk and further industry research is required to fully understand the nature of the risk and the possible effects. This is a risk that Heathrow has included in its TCFD disclosure as a material physical risk.
Interdependency risk				
2021 R22	Interdependencies / cascade risk due to disruptions in the electrical and power (including gas and fuel) supply	Extreme weather events (especially wind and flooding events) could cause electrical distribution and power outage at the airport. Extreme wind conditions may cause disruptions and power outages to electricity. Thresholds are given for wind gusts > 25 m/s (~48 knots) causing fallen trees, electricity cuts and delays in air traffic while wind gusts > 32 m/s (~62 knots) will cause long-lasting power failures and closure of airfields.	<ul style="list-style-type: none"> Safety risks. Reputational damage. Loss / litigation potential. Operational disruption. Airport closure. 	<p>Heathrow consider climate change adaptation during the procurement process of utility suppliers.</p> <p>The electricity supply to the airport is designed to be as resilient as possible within the constraints and boundaries of our network. The local airport electricity distribution network is fed using multiple supply points from the Distribution Network Operator which provides a level of resilience to local interruption. Substations and infrastructure in the network have been designed with high levels of redundancy.</p>

³⁸ The Regulatory Reform (Fire Safety) Order 2005 [online]. Available at: <https://www.legislation.gov.uk/uksi/2005/1541/contents/made> [Accessed 24 Nov 2021].

Risk code	Risk	Narrative	Potential consequence	Control measures
				<p>Regular maintenance and resilience testing of the internal network is in place to retain a high-level confidence in delivery of energy resilience with a mandated >99% asset care.</p> <p>Fuel bunkering and emergency generation assets are retained at levels to allow the operation of standby operation while energy is restored.</p>
2021 R23	Interdependencies / cascade risk due to disruptions in water supply (including stormwater and wastewater)	Extreme weather events and decreased water availability as-a-result of changes in precipitation patterns could cause disruptions to the water supply at Heathrow Airport (including low water availability and droughts). This could impact operations at the airport especially if affecting safety services (e.g. fire services).	<ul style="list-style-type: none"> • Safety risks. • Reputational damage. • Loss / litigation potential. • Operational disruption. • Airport closure. 	<p>Heathrow has contingency procedures in place to maintain water supplies in the event of a supply disruption. These consider drought conditions and temporary interruptions to airport water supply points.</p> <p>As well as a potable water supply, Heathrow also abstracts groundwater directly through underground boreholes which supplies Terminals 2 and 5 and is used for cooling and toilet flushing.</p> <p>Deluge tanks are in place at high-risk infrastructure to mitigate fire risk. Non-potable water from balancing ponds is also a supply.</p>
2021 R24	Interdependencies / cascade risk due to disruptions in waste supply	Extreme weather events could impact waste suppliers at the airport, resulting in waste build up on site if adequate collections are not possible. Hazardous wastes could pose a safety / environmental risk.	<ul style="list-style-type: none"> • Safety risks. • Reputational damage. • Loss / litigation potential. • Operational disruption. • Airport closure. 	<p>There is provision within Heathrow's waste capacity to cope with short term disruptions. A level of resilience is built into the contract with Heathrow's waste supplier which includes contingencies to cover disruption to normal operations. Heathrow consider climate change adaptation during the procurement process of waste suppliers.</p> <p>The waste supplier has a standby team for dealing with the clean-up of hazardous spills or waste and provides remote support to fire service responders regarding containment of any hazardous spills.</p>
2021 R25	Interdependencies / cascade risk due to disruptions to services provided by site concessions and delivery partners	Extreme weather events could cause disruptions to site concessions and delivery partners, e.g. unavailability of staff, equipment failures etc. If these services are critical to the operation of the airport there could be flight schedule consequences. Challenges can include resource availability, changing regulation and unintended negative environmental consequences for carrying out everyday operations (e.g. pollution, waste, and resource overuse).	<ul style="list-style-type: none"> • Financial impacts. • Reputational damage. • Operational disruptions. • Airport closures. 	<p>Heathrow assess supplier risk and a broad range of resilience criteria as part of the procurement and supplier assessment process.</p> <p>As general good practice Heathrow will regularly review the availability of critical spares or critical personnel required for airport operations.</p> <p>Heathrow has a Responsible Procurement Policy and assesses the broader impacts of procurement activities on key sustainability criteria.</p>
Aviation sector risks				
2021 R26	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a short-term period (i.e. hours to days)	The impacts of extreme weather events may cause short-term (hours to days) impacts to the wider aviation sector, causing direct impacts to destination / origin airports that Heathrow Airport serves and therefore cascade impacts to Heathrow. The short-term impacts of extreme weather events, and the associated temporary closures might impact operations at Heathrow. Airlines may need to respond with flight cancellations and/or route changes depending on the nature of the impacts.	<ul style="list-style-type: none"> • Reputational damage. • Operational disruption. 	<p>Routes and destinations are within the control of the airlines, with Heathrow only having an influencing role. For short term disruptions at origin / destination airports, airlines will decide to cancel flights as necessary.</p>
2021 R27	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a medium-term period (i.e. weeks to months)	The impacts of extreme weather events may cause medium-term (weeks to months) impacts to the wider aviation sector, causing direct impacts to destination / origin airports that Heathrow Airport serves and therefore cascade impacts to Heathrow. Medium-term impacts may occur due to prolonged periods of extreme weather events, or associated repairs and closures as-a-result of these impacts. Airlines may need to respond with flight cancellations, route changes and/or the use of alternative nearby airports depending on the nature of the impacts.	<ul style="list-style-type: none"> • Financial impacts of commercial arrangements changing. • Reputational damage. • Operational disruption. 	<p>Routes and destinations are within the control of the airlines, with Heathrow only having an influencing role. For medium term disruptions at origin / destination airports, airlines will decide whether to re-route flights to a nearby location or to use alternative routes.</p>

Risk code	Risk	Narrative	Potential consequence	Control measures
2021 R28	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a long-term period	Long-term climate change impacts (e.g. sea level rise) have the potential to cause major disruption to origin / destination airports making these routes unviable. Loss of these airports may require routes to change.	<ul style="list-style-type: none">Financial impacts of commercial arrangements changing.Operational disruption.	Heathrow consults continually with airlines in developing its passenger and freight forecast models. The specific inclusion of climate change on markets is being considered.

6.2. Quantifying the risk

- 6.2.1. The headline risks for a baseline scenario (including consideration of current control measures), anticipated risk in the 2030s under RCP8.5 scenario and anticipated risk in the 2070s under RCP8.5 scenario are shown in **Table 6.3**. The future scenarios do not include any planned / potential future improvements to the resilience of Heathrow's infrastructure. The adaptation action plan in **Section 7** highlights actions that Heathrow is taking to improve the resilience of the airport.

Table 6.3 Preliminary quantification of the physical risks to Heathrow

Legend Likelihood: likelihood of the climate change impact was determined based on the definitions in Table 5.1. A quantitative approach is used for physical climate risks where data availability is good for current and future projections. Where data is more limited a qualitative approach has been used as indicated by <u>underlining</u> the likelihood in Table 4.3. Consequence: The consequence (impact) of each physical climate risk was determined based on the definitions in Table 5.2. Knowledge, first-hand experience of current and recent past severe weather events and expert judgement was used to rank the consequence. Risk score: The risk rating is determined by multiplying the likelihood by the consequence rating as shown in Table 5.3. This risk appraisal was undertaken with consideration given to existing impacts as judged by operational experts at Heathrow to ensure agreement on current risk categorisation.			Baseline				2030s				2070s			
			Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence
Code	Climate variable	Risk												
Direct physical risks														
2021 R1	Maximum temperature	Infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac	3	3	9	M	4	3	12	M	5	3	15	M
2021 R2	Maximum temperature	Impacts on the surface integrity of surface access routes leading to and around the airport	3	2	6	M	4	2	8	M	5	2	10	M
2021 R3	Maximum temperature	Impacts on maximum take-off weight	1	2	2	L	1	2	2	L	2	2	4	L
2021 R4	Maximum temperature	Impacts thermal comfort of staff and passengers in terminal buildings and aircraft on stands	3	3	9	M	3	3	9	M	4	3	12	M
2021 R5	Maximum temperature	Delays to construction / maintenance works and operational activity	1	3	3	M	2	3	6	M	4	3	12	M
2021 R6	Extreme winds and wind direction	High wind speeds or gusts impacting take off procedures	3	3	9	M	3	3	9	M	3	3	9	M
2021 R7	Extreme winds and wind direction	High wind speeds or gusts causing damage to high structures	1	3	3	M	1	3	3	M	1	3	3	M
2021 R8	Extreme winds and wind direction	Change in prevailing wind direction impacting take off procedures and air space management	<u>2</u>	3	6	<u>L</u>	<u>2</u>	3	6	<u>L</u>	<u>3</u>	3	9	<u>L</u>

Legend

Likelihood: likelihood of the climate change impact was determined based on the definitions in **Table 5.1**. A quantitative approach is used for physical climate risks where data availability is good for current and future projections. Where data is more limited a qualitative approach has been used as indicated by underlining the likelihood in **Table 4.3**.

Consequence: The consequence (impact) of each physical climate risk was determined based on the definitions in **Table 5.2**. Knowledge, first-hand experience of current and recent past severe weather events and expert judgement was used to rank the consequence.

Risk score: The risk rating is determined by multiplying the likelihood by the consequence rating as shown in **Table 5.3**. This risk appraisal was undertaken with consideration given to existing impacts as judged by operational experts at Heathrow to ensure agreement on current risk categorisation.

Code	Climate variable	Risk	Baseline				2030s				2070s			
			Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence
2021 R9	Rainfall / flooding	Exceedance of drainage infrastructure capacity associated with surface (pluvial) flooding events	<u>3</u>	4	12	<u>L</u>	<u>4</u>	4	16	<u>L</u>	<u>4</u>	4	16	<u>L</u>
2021 R10	Rainfall / flooding	Groundwater flooding events	<u>3</u>	4	12	<u>L</u>	<u>4</u>	4	16	<u>L</u>	<u>4</u>	4	16	<u>L</u>
2021 R11	Snowfall	Increased snow hazard and de-icing requirements due to a snowfall event.	3	3	9	M	2	3	6	M	1	3	3	M
2021 R12	Extreme cold	Low temperatures leading to increased de-icing requirements	5	2	10	H	5	2	10	M	3	2	6	M
2021 R13	Extreme cold	Extreme low temperatures leading to increased safety concerns, and temporary closure of the airport	2	4	8	M	1	4	4	M	1	4	4	H
2021 R14	Low visibility	Risks associated with reduced visibility, increasing risk of accidents and collisions due to fog occurrences and low ceiling height	<u>3</u>	3	9	<u>L</u>	<u>3</u>	3	9	<u>L</u>	<u>3</u>	3	9	<u>L</u>
2021 R15	Lightning / thunderstorms	Lightning strikes and associated fire risk	<u>2</u>	3	6	<u>L</u>	<u>3</u>	3	9	<u>L</u>	<u>3</u>	3	9	<u>L</u>
2021 R16	Compound events	Blizzard risk (combined impact of snowfall, wind, and low temperatures)	<u>2</u>	4	8	<u>L</u>	<u>2</u>	4	8	<u>L</u>	<u>1</u>	4	4	<u>L</u>
2021 R17	Compound events	Risk of flight disruption due to the cumulative impact of other extreme weather events or impacts greater than current projections suggest	<u>2</u>	4	8	<u>L</u>	<u>2</u>	4	8	<u>L</u>	<u>3</u>	4	12	<u>L</u>

Legend

Likelihood: likelihood of the climate change impact was determined based on the definitions in **Table 5.1**. A quantitative approach is used for physical climate risks where data availability is good for current and future projections. Where data is more limited a qualitative approach has been used as indicated by underlining the likelihood in **Table 4.3**.

Consequence: The consequence (impact) of each physical climate risk was determined based on the definitions in **Table 5.2**. Knowledge, first-hand experience of current and recent past severe weather events and expert judgement was used to rank the consequence.

Risk score: The risk rating is determined by multiplying the likelihood by the consequence rating as shown in **Table 5.3**. This risk appraisal was undertaken with consideration given to existing impacts as judged by operational experts at Heathrow to ensure agreement on current risk categorisation.

Code	Climate variable	Risk	Baseline				2030s				2070s			
			Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence
Indirect physical risks														
2021 R18	Maximum temperature	Local ecosystem changes	<u>2</u>	3	6	L	<u>3</u>	3	9	L	<u>3</u>	3	9	L
2021 R19	Maximum temperature	Increased fire risk of combustible materials	<u>3</u>	3	9	L	<u>3</u>	3	9	L	<u>4</u>	3	12	L
2021 R20	Maximum temperature	Increased risk of communicable disease and epidemics	<u>1</u>	5	5	L	<u>1</u>	5	5	L	<u>2</u>	5	10	L
2021 R21	Maximum temperature	Changes to high altitude air currents used by airlines	<u>1</u>	4	4	L	<u>2</u>	4	8	L	<u>2</u>	4	8	L
2021 R22	Interdependency risk	Interdependencies / cascade risk due to disruptions in the electrical and power (including gas and fuel) supply	<u>2</u>	3	6	L	<u>2</u>	3	6	L	<u>3</u>	3	9	L
2021 R23	Interdependency risk	Interdependencies / cascade risk due to disruptions in water supply (including stormwater and wastewater)	<u>1</u>	3	3	L	<u>1</u>	3	3	L	<u>3</u>	3	9	L
2021 R24	Interdependency risk	Interdependencies / cascade risk due to disruptions in waste supply	<u>1</u>	2	2	L	<u>1</u>	2	2	L	<u>2</u>	2	4	L
2021 R25	Interdependency risk	Interdependencies / cascade risk due to disruptions to services provided by site concessions and delivery partners	<u>2</u>	3	6	L	<u>2</u>	3	6	L	<u>2</u>	3	6	L

Legend

Likelihood: likelihood of the climate change impact was determined based on the definitions in **Table 5.1**. A quantitative approach is used for physical climate risks where data availability is good for current and future projections. Where data is more limited a qualitative approach has been used as indicated by underlining the likelihood in **Table 4.3**.

Consequence: The consequence (impact) of each physical climate risk was determined based on the definitions in **Table 5.2**. Knowledge, first-hand experience of current and recent past severe weather events and expert judgement was used to rank the consequence.

Risk score: The risk rating is determined by multiplying the likelihood by the consequence rating as shown in **Table 5.3**. This risk appraisal was undertaken with consideration given to existing impacts as judged by operational experts at Heathrow to ensure agreement on current risk categorisation.

Code	Climate variable	Risk	Baseline				2030s				2070s			
			Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence	Likelihood	Consequence	Risk score	Confidence
2021 R26	Aviation sector risks	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a short-term period (i.e. hours to days)	<u>4</u>	2	8	L	<u>4</u>	2	8	L	<u>5</u>	2	10	L
2021 R27	Aviation sector risks	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a medium-term period (i.e. weeks to months)	<u>2</u>	3	6	L	<u>2</u>	3	6	L	<u>3</u>	3	9	L
2021 R28	Aviation sector risks	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a long-term period	<u>1</u>	4	4	L	<u>1</u>	4	4	L	<u>2</u>	4	8	L

6.3. Summary

- 6.3.1. The risk register in **Table 6.3** includes all the identified climate change related risks at Heathrow. These risks have been ranked by score for the baseline, short-term future, and longer-term future scenarios. The risks with a score of ten or more (categorised as major to severe) are presented in **Table 6.4** providing a summary of the headline risks to the airport that require an adaptation response from Heathrow.
- 6.3.2. The key baseline or current climate-related physical risks to Heathrow are:
- **High levels of precipitation** can lead to drainage infrastructure becoming overwhelmed and lead to both surface and ground water flooding events.
 - **Low temperatures** can challenge winter contingency plans and lead to increased de-icing requirements which may disrupt operations or increase load on pollution management systems.
- 6.3.3. Climate projections for the UK show that climate change is projected to lead to an increasing likelihood of warmer winters, high temperatures in the summer and extreme rainfall events.
- 6.3.4. In the short-term future at Heathrow, an increased likelihood of rainfall events will increase the risk of drainage infrastructure being overwhelmed. Hotter summer days may directly increase the risk of airfield structures such as runway and apron tarmac being affected. No change in the likelihood and risk of extreme cold events is expected.
- 6.3.5. In the longer-term future at Heathrow, the risk of surface and ground water flooding remains elevated. The likelihood of higher temperatures increases further with a potential risk of damage to airfield structures including airfield tarmac and surface access routes; cause delays to construction /maintenance work and operational activity due to peak temperatures; reduce thermal comfort, impacting passengers and staff inside airport buildings; increase the risk of fire from combustible materials; and indirectly increase the risk of communicable disease and epidemics. However, the likelihood of extreme cold events is reduced. The increased likelihood of extreme temperatures and rainfall events increases the risk of compound events, which may include other weather events such as lightning storms, resulting in disruption to flights and airport operations over periods of a few hours or days.

Table 6.4 Headline risks requiring an adaption response

	Baseline (current situation)	2030s (short-term future)	2070s (longer-term future)
1	Exceedance of drainage infrastructure capacity associated with surface (pluvial) flooding events	Exceedance of drainage infrastructure capacity associated with surface (pluvial) flooding events	Exceedance of drainage infrastructure capacity associated with surface (pluvial) flooding events
2	Groundwater flooding events	Groundwater flooding events	Groundwater flooding events
3	Low temperatures leading to increased de-icing requirements	High temperatures leading to infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac	High temperatures leading to infrastructure damage affecting the structural integrity of airfield structures such as runway and apron tarmac
4	Score < 10	Low temperatures leading to increased de-icing requirements	High temperatures impacting thermal comfort of staff and passengers in terminal buildings and aircraft on stands
5	Score < 10	Score < 10	High temperatures causing delays to construction / maintenance works and operational activity
6	Score < 10	Score < 10	Risk of flight disruption due to the cumulative impact of other extreme weather events or impacts greater than current projections suggest
7	Score < 10	Score < 10	High temperatures increasing fire risk of combustible materials
8	Score < 10	Score < 10	High temperatures leading to impacts on the surface integrity of surface access routes leading to and around the airport
9	Score < 10	Score < 10	Higher temperatures increasing risk of communicable disease and epidemics
10	Score < 10	Score < 10	Interdependencies / cascade risk due to the wider aviation sector where disruptions occur over a short-term period (i.e. hours to days)

Note: Only risks categorised as major to severe with a score of 10 or more are included.

7. Adaptation Action Plan

7.1. Baseline actions

- 7.1.1. Since the last CCAR in 2016¹⁵, Heathrow has continued to maintain and improve the mitigations set out in that report and to review and improve operational plans and processes where appropriate.
- 7.1.2. Current control measures in place are described for each risk in **Table 6.1** and **Table 6.2**. Of particular note is the investment in reducing key surface water risks. This includes the £30m upgrade of the Eastern surface water catchment to respond to recommendations from a review of all three major surface water catchments at Heathrow increasing both treatment and storage capacity to handle winter rainfall surface water runoff, and operational flexibility to manage rainwater flows from the airport and discharge into the receiving water body.
- 7.1.3. This 2021 CCAR represents the start of Heathrow's latest risk review cycle (see **Section 4.3**). An update to the assessment of physical risks associated with climate change has been completed using the latest climate projections and the most up to date guidance. This risk assessment process will continue to be developed and refined to guide adaptation responses and evaluate the effectiveness of any mitigation implemented.

7.2. Short-term future actions

- 7.2.1. Future actions to be delivered before the fourth cycle of CCAR reporting in 2026 fall under three focus areas.

Risk framework: Embedding and managing climate risk

- Embedding climate risk effectively into Heathrow's risk management framework allows the business to make effective business decisions, informing operational practices and procedures, business plans, investment cases and the airport masterplan. Heathrow started to review and update the approach to climate risk management in 2019 to implement the recommendations of TCFD and will continue to develop, refine, and broaden the approach as described in **Section 4**.
- This includes the merging of individual components of Heathrow's carbon management on a pathway to deliver a resilient net zero airport, informed by the contribution Heathrow, airlines and other business partners are making to reduce carbon emissions; an appreciation of the transitional risks to Heathrow's business along this pathway, and an understanding of the physical impacts of climate change. (see **Figure 1.1**).

Risk assessment: Further understanding of climate risk and mitigation

- Heathrow will validate and refine this updated risk assessment to increase confidence; build more comprehensive understanding on the nature of the risk and the right level mitigation; and ensure Heathrow understands the priority areas for action and the

basis to develop solutions and business cases. This will be undertaken by continued dialogue with each functional business unit.

- Two specific short-term actions have been identified to improve the understanding of climate risk and mitigation at Heathrow:
 1. Stress testing the airport drainage model to determine critical thresholds and review existing response measures for managing surface water and groundwater events. This may also lead to identifying further capital investment to reduce the likelihood of critical thresholds being exceeded.
 2. Develop a better understanding of how climate change may impact on the global distribution of passenger demand and freight movements. This indirect risk will be considered as part of the ongoing development of Heathrow's business modelling and form part of the TCFD work.

Planning and delivery: Taking action in the short-term

- **Operational improvements** – using the outcome of the risk assessment review and validation process to update operational procedures and operational planning and ensure Heathrow's operational response is proportionate to the evolving risk.
- **Evolving standards** – review and update technical standards and asset system strategies to reflect the updated climate change risk assessment and ensure that the right level of mitigation is embedded into our future asset replacement programme and airport development.

This includes performance specifications for electrical switchgear operating at higher ambient temperatures and technical specifications for wearing surface materials (tarmac) on runways, aprons, and roads.

A change in the performance specification of building ventilation systems is expected to increase the requirement for fresh air infiltration in response to increased public health protection measures associated with COVID-19. This will have an impact on energy efficiency and may reduce the operating temperature range of ventilation systems which should be assessed.

- **Investment case** – Heathrow has improved climate resilience by designing and building to the latest climate standards and considering future climate conditions in climate linked investment projects such as upgrades to the airport surface water drainage system. As climate projections improve, Heathrow's understanding of climate risk matures, and additional mitigation is identified, it is likely that targeted investment to further improve adaptation to the impacts of climate change will become necessary. Heathrow will consider the need for investment in adaptation as part of the risk assessment validation and development, developing the business case for any investment that may be required in the forthcoming regulatory settlement period.

7.3. Longer-term future actions

- 7.3.1. Heathrow's adaptation planning will continue to be guided by the recommendations of CCRA311, the outcomes of future reporting, and updates in the scientific understanding of climate change. On-going and longer-term future actions will include:
- Implementing actions which support adaptation at a network level as well as for individual assets.
 - Using common formalised standards of resilience to help build systemic resilience across the whole infrastructure system.
 - Improving arrangements for sharing data and information between transport and other sectors to help increase preparedness across geographical and organisational boundaries.
 - Enhancing adaptation strategies to identify areas most vulnerable to flooding, as well as parts of the network crucial for emergency services.
 - Integrating green infrastructure solutions into developments, alongside implementing green Sustainable Drainage Systems (SuDS) to help reduce surface water flood risk.
 - On-going monitoring and maintenance of assets to spot problems in enough time to act.
 - Mainstreaming climate change adaptation into planning and design of new infrastructure, to avoid future retrofitting, alongside improved monitoring, maintenance practices and operations, to avoid lock-in.
 - On-going training of Heathrow staff to ensure issues relating to climate change, climate resilience and the need to adapt become part of everyday business and operational thinking.
- 7.3.2. Heathrow will continue to make a case for investment in adaptation, based on the latest assessment of risk, in its business plans for future regulated settlement periods.

7.4. Disclosure

- 7.4.1. In addition to providing CCARs to Defra every five years, Heathrow is committed to providing full climate-related financial disclosure as part of annual reporting. The risk assessment and actions to reinforce climate resilience will feed into this disclosure and will be reported accordingly.

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