EASTERN REGION

Managing Weather and Climate Change

2024-2029







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Foreword

Climate change projections suggest increasing average and maximum daily temperatures, drier Summers, wetter Winters, sea level rises and increased storminess. As we have seen in recent years, increasing storms and Winter rainfall brought a higher risk of flooding, subsidence, and coastal storm surges; heat caused soil desiccation and track buckling; high winds resulted in debris falling on to the track, and snow and cold weather presented frozen points and blocked routes. In CP6, Eastern made significant progress in improving the resilience of our most vulnerable assets. This included a targeted approach to drainage management at specific sites that had previously experienced the highest delays, as well as significantly improving the knowledge around our drainage assets.

In CP7 weather resilience continues to form an integral part of our asset management strategy, recognising the significant impact that the weather can have on the performance of the railway. A core aspect of our strategy is based around managing our assets as a whole system to provide greater resilience for drainage, track and earthworks assets. We are also improving resilience in high winds through overhead line refurbishment and an extensive programme of lineside vegetation management. Our programme of scour mitigation across vulnerable structures continues.

Our approach to asset resilience over the next five years aims to make best use of the resources available. As in other industries with large asset bases with long operational lives, the investment profile for asset renewals is not always smooth. In making trade-offs across our asset base, renewals investment has generally been targeted to the most vulnerable assets, with workbanks transitioning from more full renewals to a blend of full renewals and life extending interventions. This will result in more reactive interventions on existing assets. With improved monitoring to identify issues quickly we will have better operational mitigation and response to recovery.

Our plans deliver much resilience accrued as a secondary benefit when intervening on assets, as opposed to pure resilience schemes driven by known weather and climate-related challenges. As a result, tackling the more extreme, longer-term risks associated with climate change will be hugely challenging during the next control period so we are planning to enhance our intelligence, knowledge and planning using modelling and adaptation pathways for identifying work for 2029 and beyond.

Residual risk associated with this approach will be mitigated by applying more targeted refurbishment and maintenance interventions, with activities focussed on maintaining levels of safety and reliability. Risk will also be mitigated through increased operational restrictions during times of extreme adverse weather.

Managing the impact of weather remains a priority and this report outlines our plan.

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Executive Summary

This is Network Rail (NR) Eastern region's plan for managing extreme weather and our changing climate between 2024- 2029 or Control Period 7 (CP7). It explains how we plan to achieve a railway that is safe and more resilient to the effects of weather, now and in the future.

Eastern region (Eastern) is the largest region in the network and is made up of four routes: Anglia, East Coast, East Midlands and North & East. Every day in Eastern, 7,500 passenger services are carried along more than 6,000 miles of track. Our busy freight network moves over one million tonnes of freight every week and contains one of the busiest container ports in the UK.

Running our region's railway requires the effective management of a wide range of assets in all sorts of locations, geographies, and weathers. Planning for weather resilience and climate change adaptation in Eastern Region is a key part of CP7 and builds upon the work we did between 2019- 2024 (CP6). This is essential in a world which includes more weather shocks, such as heatwaves and extreme rainfall events, and gradual stressors, such as increased temperatures and rising sea levels. These frequent and more extreme weather conditions impact our ability to run the railway safely and on time. Increased storms and winter rainfall increases the risk of flooding, subsidence and coastal storm surges; heat causes soil desiccation and track buckling; high winds result in debris falling on to the track; and snow and cold weather result in frozen points and blocked routes. In the last decade we have experienced all of these events, and this has helped us to identify vulnerabilities across our assets, which were never designed with climate change in mind. This plan explains how we aim to:

- Minimise and mitigate consequences from weather events.
- Improve the weather resilience of our assets.
- Adopt technology such as remote condition monitoring.

Our plan brings operations management together with asset management. Predicting and managing weather events is as essential as improvements in how assets respond. Tools and guidance developed by the business will be adopted to assist with weather response, and to manage alerts and alarms triggered by remote condition monitoring instruments and weather forecasting tools. The topics covered by this plan align with international best practice as set out in standards such as ISO 55000:2014 Asset Management and ISO 14090:2019 Adaptation to climate change.

We will spend every penny of taxpayers' money wisely, which means that we must prioritise investment. We are focussing on building further intelligence of our diverse asset base so that we can improve its resilience to rainfall, flooding, heat and high wind speeds. We will refurbish our assets more often than we will renew (replace) them. Where we must replace, our new assets will be more weather resilient by design. To maintain current levels of service, we will invest in bespoke climate adaptation measures, resilience-building during routine renewals, and maintenance activities. Impacts from weather in Eastern costs around £26m per annum in delay costs and results in over 400,000 minutes delay to our service. The majority of this is due to wind, heat and rainfall. We will target vulnerable assets, for example, sites of repeated flooding. We will use adaptation pathways for parts of the network subject to significant stressors such as sea level rise. Adaptation pathways are

decision making approaches that support us to take the right actions at the right time to maximise weather resilience. It is global best practice and supports strategic, flexible and structured decision-making.

Our key priorities are to:

- Provide infrastructure to withstand the impact of current and future weather conditions.
- Deliver rapid recovery from the impacts of adverse and extreme weather events.
- Reduce the impacts of adverse and extreme weather on safety and performance over time.
- Leverage financial savings through reduced compensation payments and repair costs.
- Enhance reputation and trust in the railway's ability to manage weather events.
- Work together with train operating companies (TOCs) and freight operating companies (FOCs) to make safe train service plans during periods of extreme and adverse weather, using asset knowledge and timely weather forecasting data.

We have gained greater understanding of our risks through:

- Assessing our weather-related vulnerabilities
- Learning from recent events (Storm Arwen; the heatwave in July-August 2022; and an extended summer of dry weather)
- Reviewing past reports, such as T1009 Tomorrow's Railway and Climate Change Adaptation (TRaCCA); 2014 Department for Transport (DfT) Transport Resilience Review; National Infrastructure Commission reports; the Climate Change Risk Assessment CCRA3 and the National Adaptation Plan and RAIB investigation reports
- Investigating historical performance impacts
- Using regional climate change projections from UKCP18, the most up-to-date assessment of how the climate of the UK may change over the 21st century.

Figure 1 shows the scale of vulnerability Eastern currently face against each of the weather types across our asset, based on the number of moderate, high and very high-risk scores affecting our assets. The x axis shows the number of asset vulnerability modes against weather types with the colour showing the scale of the risk based on our corporate risk appetite. It shows that wet weather and heat are our greatest concerns.

Our highest risk across all weather types is track and drainage. However, our assets are interdependent and weather impacts on one can transfer onto others. For example, drainage failures affect geotechnical assets, and geotechnical failures affect Overhead Line Equipment (OLE).

From weather risk analyses, we created a Risk Register that help us make more detailed assessments of vulnerabilities in the four routes. This became the foundation for our budget proposals as shown below. The first column shows the scale of investment that has either been clearly identified as giving no additional resilience or at this stage has not been evaluated.

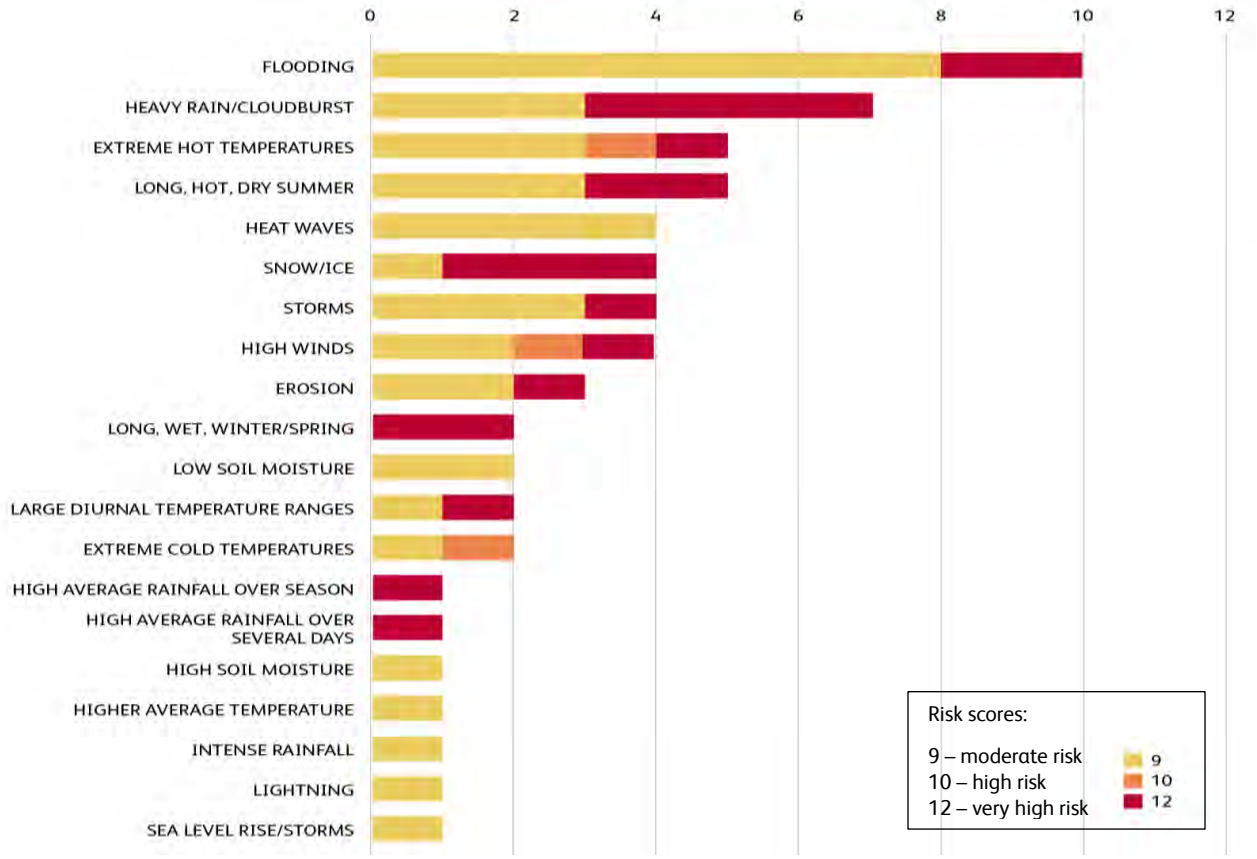


Figure 1 Number of risks assessed from moderate to high, focussed in Eastern.

£m	Total Renewals Investment in CP7	Primary Benefit	Secondary Benefit	Weather Resilience investment	No benefit to Weather	% WR investment of total plan
Anglia	1,099	104	272	376	723	34 %
East Coast	1,288	102	380	482	806	37 %
East Midlands	779	107	159	266	513	34 %
North and East	950	92	204	296	654	31 %
Regional	5	5	0	5	0	
Total	4,121	410	1,015	1,425	2,696	34 %

Figure 2: Eastern CP7 submission for primary or secondary weather resilience, RF11 FY24 Post-efficient

Whilst the absolute value of planned work and potential benefits to the weather resilience of Eastern region's railway is significant, a large proportion of this investment is our planned maintenance and renewals work. In particular, our response to adverse and extreme weather events will include a degree of targeted maintenance from forecast information, and before the adverse or extreme weather arrives to ensure vulnerable sites are prepared for the impending event, in line with a multi-discipline integrated weather management plan. This work although predominantly reactive in nature, forms a key part of managing risk, and reducing asset failure. In extreme conditions there is an increasing chance that operational

restrictions will be imposed. We prepare in advance of known weather threats to minimise the impacts.

Our CP7 plans have been developed to support the delivery of our funder and our stakeholders' key priorities and, therefore, include interventions that should enable us to minimise and mitigate the impact of extreme weather and climate change on the network and schemes that should improve the environmental sustainability of our business. However, recognising the broader funding context and pressures, we have had to make some tough choices and trade-offs about how we balance our spending in CP7 to provide the most value to our customers and the taxpayer. Whilst we cannot be certain of the future frequency of weather extremes, we know that the physical processes involved are those that will accelerate degradation of our assets. We expect it to become increasingly challenging to keep pace with the frequency and intensity of extreme weather events which we will be a significant factor in future control period planning.

This plan covers:

- **Our Climate Change Risk** and how this affects our service and assets.
- **Weather Resilience and Climate Change Adaptation Policy (WRCCA)**:
    - Key principles for CP7 that we will adopt to maintain a reliable railway.
    - Strategy and investment Plans across the four routes
- **Climate change projections** by the UK climate projections report UKCP18
- **Our response to weather and climate risks,** including the Lord Mair and Dame Slingo reports that followed the fatal derailment at Carmont and a review of hot weather performance in 2022.
- **Resources and implementation** including the governance arrangements that will underpin successful delivery of the Plan, including:
    - Assurance
    - Resourcing
    - Communication

1. Introduction

1.1 Overview

Our WRCCA plan sets out our CP7 approach to managing the short and medium-term impacts of today's weather events and for the long-term how we will use adaptation pathways to deliver resilience to climate change. Our plan includes the delivery of Mair and Slingo recommendations which are specific to our region. Our CP7 plans are predominantly refurbishing and life extending assets. Our plans focus on managing known risks from severe weather, reflecting the trade-offs we have made within our plan given the broader financial context, so pure climate resilience projects are not a major part of our plan. Although pure resilience schemes are limited in the plan our strategy does ensure that all new assets are built with resilience in mind.

As we go through CP7 we will develop improved modelling, mapping, and planning approaches to consider climate adaptation pathways and understand the longer-term impact of changing climate. This will include issues such as rising sea levels along the Eastern coastline and increasing temperatures across the Eastern region. Understanding our future scenarios and risks through adaptation pathway studies will help us deliver pure resilience and adaptation projects and highlight collaborative opportunities with third parties to manage common risks.

In CP6 our regional focus was on:

- Collaborative Partnerships: with lineside neighbours and other stakeholders on the reduction of flooding risks
- Advanced Monitoring Systems: establishing real time monitoring including CCTV and remote monitoring technology to provide early warning of incidents.
- Enhanced Asset Knowledge: Establishing standard operating procedures for critical risk sites and proactive management of drainage near tunnel portals.
- Infrastructure Upgrades: to address flood risk at numerous sites and track and signalling resilience to heat and other weather conditions.

Our approach in CP7 (2024-2029) is:

- We will provide £410m primary benefit from the activities we have planned in our work portfolio. This gives a contribution of improved weather resilience from around 10% of our renewals plan.
- The largest investments that contribute primarily to weather resilience in CP7 will be on Earthworks (£180m), Drainage (£87m), and Electrification (£92m)
- To minimise and mitigate events that cannot be fully contained. However, as noted above, we expect it to become increasingly challenging to keep pace with the frequency and intensity of extreme weather events which we will be a significant factor in future control period planning.
- Improve weather resilience of assets; improvements at repeat flood sites and create more robust seasonal resilience plans.
- Remote Condition Monitoring (RCM) and failure detection equipment (FDE) on drainage and earthwork assets to support proactive intervention to reduce delay and improve safety.

- Long-term investment strategies to target weather and climate impact for vulnerable assets.
- Investment in knowledge to allow the development of adaptation pathways for parts of the network subject to significant stressors, such as sea level rise.

1.2 Eastern Region

Figure 3: Eastern Region

Eastern is the largest region in the national rail network and is made up of four routes:

- Anglia
- East Coast (EC)
- East Midlands (EM)
- North & East (N&E)

The region stretches from the Scottish borders along the entire east coast of England to the Thames, covering the North East, Yorkshire, Lincolnshire, the East Midlands, Bedfordshire, Cambridgeshire, Essex, Norfolk and Suffolk, as well as parts of Greater London.

16 train operators run 7,500 passenger services every day along 25,817 km of track. Central to the UK freight rail network, Eastern moves more than 1 million tonnes of freight every week, covering 13 freight ports including Felixstowe, the busiest container port in the UK, and large freight flows from Immingham. The region is busy, operating some of the most congested rail lines in the country that transport millions of commuters to and from busy cities. The three stations managed by the region, London King's Cross, London Liverpool Street and Leeds, handle 221 million annual passenger journeys.

The Eastern region includes a very diverse range of rail track classification, topography and geology from very high tonnage on 125mph multiple track electrified railway to single track freight or passenger rural routes, and from low-lying and level coastal plains to steep terrain. The very diverse topography, from typically low-lying and gently undulating land in the south to the higher ground further north, significantly influences the weather conditions experienced. The nature of the topography is linked to the geology of the areas, and this plays an important role in determining in what way the weather ultimately impacts the

railway assets. For the most part, clay geologies dominate the south of the route, providing a gently undulating and low-lying topography. The impermeable ground and shallow gradients can encourage standing water which can remain in place for prolonged periods of time. This can render the railway earthworks assets vulnerable to the softening and weakening of the clays leading to an increased number of relatively slow-moving failures in embankments and cuttings. Heading north from London the topography becomes more variable passing through the Jurassic, Permian and Triassic strata. This includes coal measures around Yorkshire, Derbyshire, Nottinghamshire and Leicestershire and further north the Yorkshire Dales, North Yorkshire Moors and the coalfields of Northumberland and Durham. The extremely variable nature of geology towards the north of the route (cohesive and granular tills, coal measures, peat and alluvium) means the earthwork assets are vulnerable to various types of failures. The region can suffer from very high temperatures in the Summer and very low temperatures in the Winter. High Summer temperatures encourage impacts such as desiccation shrinkage of clay geologies as trees extract moisture from the ground. Conversely, the extreme cold weather promotes freeze-thaw processes in rock fractures causing increased weathering and rock falls.

1.3 Weather Impact

The railway routinely operates in a wide range of weather conditions. However, adverse and extreme weather can still cause significant disruption to our network, delaying passengers and incurring penalty costs.

We monitor the impact of weather events on the performance of our network using delay minutes and associated compensation costs payable to the train operating companies (Schedule 8 delay compensation costs). Incidents are recorded under 9 categories as follows.

- Adhesion – line contamination leading to traction loss, e.g. leaf fall, moisture, oils.
- Cold – ice accumulations on conductor rails, points and in tunnels.
- Flooding – standing or flowing water leading to asset damage or preventing trains from accessing the track.
- Fog – reduced visibility obscuring signals.
- Heat – high temperature impacts: rail buckles, Temporary Speed Restrictions (TSRs), overheated electrical components.
- Lightning strike – track circuit and signalling damage or power system failure.
- Snow – blocked lines and points failures.
- Subsidence – the impacts of landslips, rockfalls and sinkholes.
- Wind – trees and other items blown onto the track and into the overhead line equipment (OLE) or TSRs.

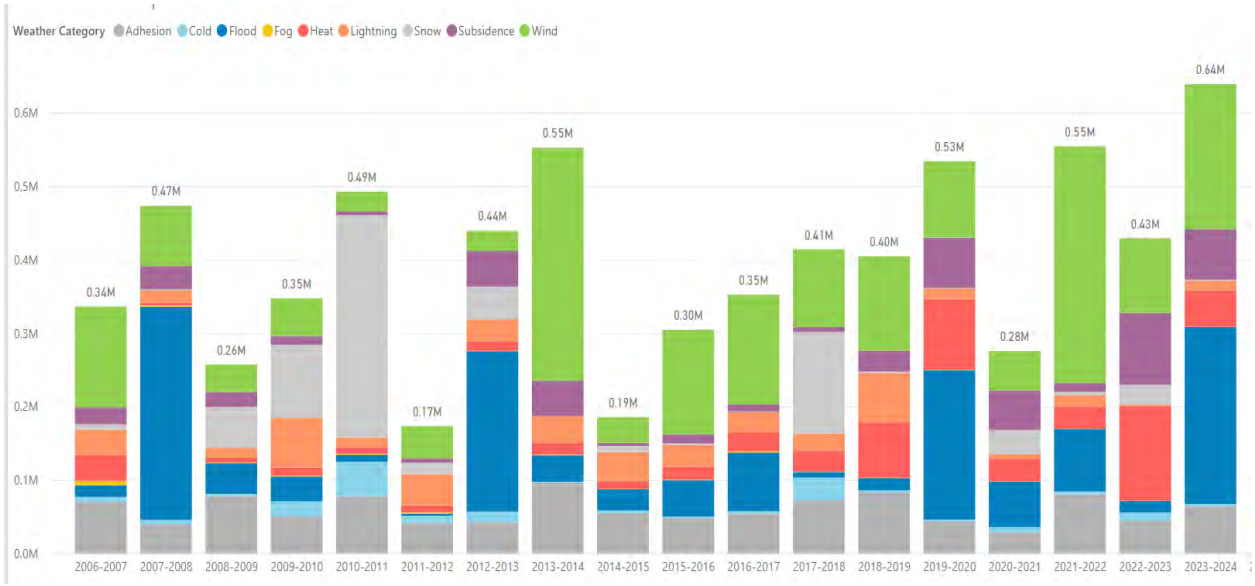


Figure 4: Schedule 8 Annual Delay Minutes (Millions)

This data includes the duration, location and cause of each disruption, providing a high degree of granularity to use in analysing weather impacts and trends. In the past 10 years (2013/14 to 2023/24) the average annual number of Schedule 8 delay minutes attributed to weather for Eastern network was 400k minutes, equating to an average annual cost of £26m.

Schedule 8 costs can be complex to understand as operational recovery and how fast the service is recovered has a big impact. Having robust and streamlined recovery processes and contingency plans makes a big difference and this can mask some of the asset vulnerabilities.

The impacts of severe weather events can be seen in the graph below, for example:

- Extreme rainfall impacts during 2007/08 and 2012/13, 2019/20 and Autumn of 2023 causing delays from flooding.
- Cold winters with heavy snowfalls in 2009 through to 2011 and 2017/18.
- Wind impacts in most years, but particularly bad storms in 2013/14 and 2016/17, 2021 and 2023 blowing debris onto the line causing cancellations and delays.
- Extreme heat in 2018/19 and 2022/23, causing cancellations and in extreme case closure of routes.

The graph below shows annual Eastern delay costs up to January 2024, noting that 23/24 is not a complete year.

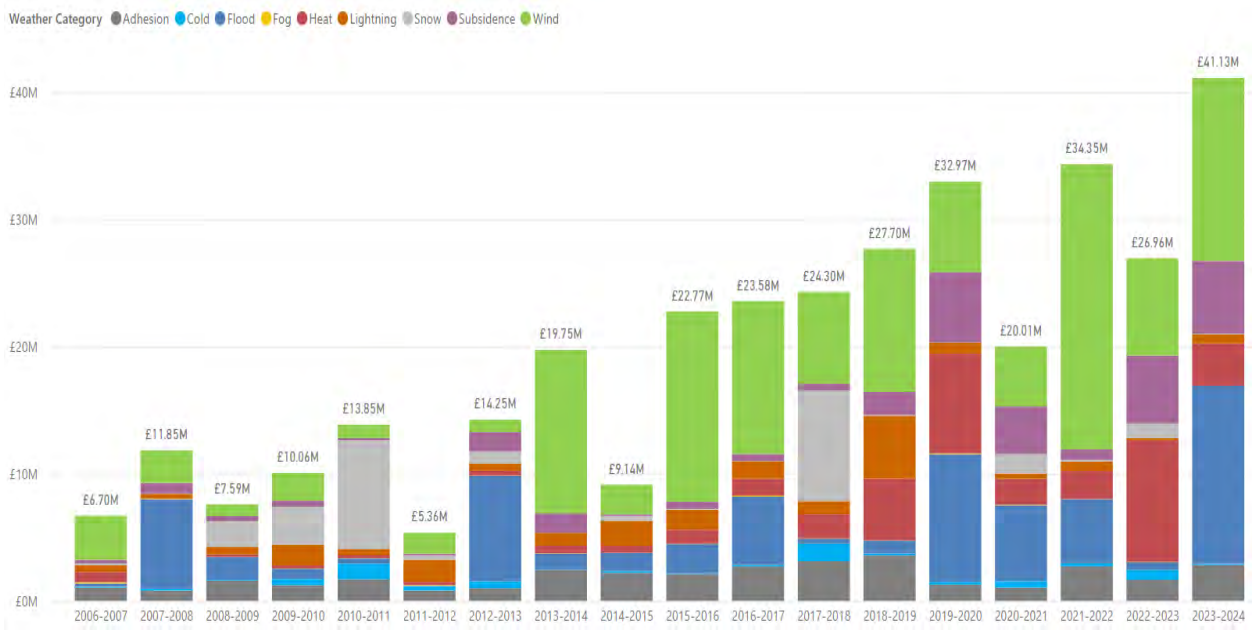


Figure 5 Schedule 8 Annual Delay Costs (Millions)

The costs of weather attributed delay payments and the wider socio-economic impacts of rail disruption on the UK economy justify continued investments to increase current weather resilience. Our collaborative approach to understanding weather impacts in the increasingly interdependent world of assets, society and the environment is key to a robust resilience response.

Across Eastern we are aiming to reduce the impact from heavy rainfall through addressing drainage issues at high-risk flood sites and reduce the impact from hot weather through increasing operational management. We are also improving our management of vegetation and increasing resilience in overhead lines, where affordable, to protect against wind damage. Heat is also impacting our earthworks, and we continue to monitor and improve our understanding of vulnerabilities from variations in soil moisture content which can affect the stability of our embankments and cuttings.

2. Managing weather resilience and climate change adaptation

2.1 Weather Resilience in Eastern

We recognise there are more asset vulnerabilities than we have been accustomed to in the past, and that 'new' weather climate hazards and vulnerabilities affect the safety and performance of the railway. We need to consider the exposure of our workforce in extreme weather conditions and maintenance and construction teams will need to adopt different working patterns so that routine safety inspections and renewals do not put our people at risk.

It is essential that we grow our asset intelligence, and one way is to utilise remote alert and alarm equipment to drive better decisions and safer responses during adverse and extreme weather. We are developing enhanced modelling techniques and adaptive planning tools to better predict future weather impact and to assist with optimising renewal design with appropriate consideration for climate change.

The railway system is a collection of differently aged assets, with many of our assets not designed to withstand the extreme weather conditions we are seeing today. Yet changes to both typical conditions and the frequency of extreme weather has created a need to mitigate safety risks and manage performance.

Eastern region has a devolved operating model, and both asset management and weather resilience management accountability is held within the four routes. Each route has a Route Infrastructure Engineer that is responsible for this CP7 Weather Resilience Plan and coordination across the region is handled by Asset Management Strategy.

The table below summarises activities that have been undertaken during CP6, where we have invested around £100m directly into providing more weather resilience for our asset base. It also shows that we are continuing to grow our knowledge and understanding of the vulnerabilities the railway faces and are looking at how we use technology to manage the risks going forward.

Weather Resilience Levers	CP6 Overview of Route Activity in Eastern
Neighbours and Catchments	• Management of vegetation • Working with 3rd parties on flood management
Monitoring	• Geotechnic Alert & Alarm systems e.g., tiltmeters and inclinometers • Real-time/remote monitoring of water levels including CCTV. • Train-borne systems e.g., Digital Lineside Inspection, Hubble • Remote Condition Monitoring (RCM) for signal cabling. • Anemometers to understand wind speed patterns. • Improved use of weather forecasting alerts for "at risk" earthworks breaching rainfall saturation thresholds.
Asset Knowledge	• Improved drainage knowledge - survey, inspection & analysis. • Earthwork management plans developed where necessary. • Identified earthworks at risk of desiccation.
Awareness & Implementation	• Improved first responder flood guidance/training. • Improved reporting & management of track assets during hot weather. • Improved management of at risk earthworks assets before and during adverse and extreme rainfall. • Better and more accessible drainage system information. • More site-specific flood management plans & standard operating procedures. • Desktop flood incident/risk reviews. • Development of a strategy for use of remote monitoring. • Best practice sharing across the organisation. • Relocation of critical equipment • Closer working between operational control & maintenance teams.
Asset Reliability & Resistance Improvements	• Flooding protection & resilience works. • Vegetation removal to reduce desiccation. • Crest drain refurbishment. • Rock netting installation • Increase in proactive Earthworks maintenance workbanks. • Scour protection. • Landslip mitigation works. • Removal of jointed track & timber layouts, & high-speed timber S&C • OLE Resilience refurbishments. • Overheating protection measures for electronic cabling & equipment • Heating to negate cold weather impact points

Figure 6: Overview of CP6 weather resilience activity

Best practice asset management[1] demands well-funded and resourced maintenance teams to act as our first line of defence, particularly in drainage and track. They carry out inspections and proactive maintenance, helping to deliver resilient assets that support freight and passenger rail services.

Eastern region is committed to supporting the improvement of weather and climate change resilience. The line of sight can be seen through our asset management system and policies from our Eastern Asset Management Policy, Asset Management Objectives and through the delivery of the route-specific intervention plans. We developed an understanding of our risks by:

- Assessing our weather-related vulnerabilities
- Learning from reviewing recent events (Storm Arwen, July-August 2022 heat wave and extended summer dry weather)
- Reviewing outputs of past reports eg. T1009 TRaCCA; 2014 DfT Transport Resilience Review; National Infrastructure Commission reports; the Climate Change Risk Assessment CCRA3 and the National Adaptation Plan
- Investigating historical performance impacts
- Use of UKCP18 regional climate change projections

Weather Resilience and Climate Change Adaptation 2019- 2024 (CP6)

Our understanding of the impact of weather and climate change has been enhanced during CP6. During this time, weather resilience was an integral part of our asset management and operational strategies, recognising the significant impact that the weather can have on safety and the performance of the railway. We focused on managing our drainage assets and started to introduce a systemic approach to provide greater resilience for track and earthwork assets. We are prioritising improved resilience in high winds and for the autumn leaf fall season through an extensive programme of lineside vegetation management. Our programme of scour (undermining) risk mitigation at bridges over watercourses also continues to improve resilience to more extreme flood flows. We invested around £100m in improving weather resilience and climate change, picking up vulnerable areas such as £30m in earthworks risk at Browney Curve and Hessel Foreshore. We have built a plan to address the recommendations from Carmont, Lord Robert Mair and Dame Slingo reports and have stood up a new team to focus on delivering the improvements needed. Since 2022 we have invested £12m opex addressing these recommendations in both asset intelligence, resources and issues with the assets and vegetation.

We consider the impacts on our railway in the following categories:

- Shocks – extreme events that are short lived but have major impact across multiple areas of our railway network. We can recover from them.
- Stressors – slow but permanent change over time that fundamentally changes the environment and context in which our railway operates.
- Systemic combinations – where combinations of hazards and impacts result in more extensive damage or disruption than the sum of similar single hazard/ impact events.

Over time the stressor environment will increase the frequency of our shock events. This will create new norms, making operational planning and response key to providing a reliable rail service, alongside fully funded and resourced maintenance teams and targeted asset investment to maintain current resilience levels in the face of ongoing change.

[1] See the ISO 55000 series of standards on Asset Management

Shock Impacts

To address shock impacts, we focus on predicting, preparing and recovering.

- **Major storm events:** These may include extreme rainfall, gale or storm force winds, tidal surge, snow fall and lightning. Major consequences at key infrastructure assets include:
    - Damage to river bridges susceptible to scour (undermining).
    - Earth slips at embankments and cuttings.
    - Trees and debris affecting overhead lines and blocking tracks.
    - Stations being damaged during flash floods.
    - Tidal surges, damaging parts of the network close to the coast.

  Risk reduction measures can include:
    - Enhanced inspection regimes.
    - Proactive maintenance targeted at higher risk locations before and during events.
    - Proactive and reactive investment in renewals.
    - Remote monitoring to detect asset failures.
    - Speed restrictions, and ultimately line closures.

  Where significant damage has occurred, recovery to normal operations can take months.

- **Heat waves and hot weather:** Heat waves and hot weather cause diverse impacts. Performance can be degraded, and welfare and productivity of outdoor workers can be affected. Risk reduction measures include:
    - Prohibition of track maintenance activity.
    - Speed restrictions or line closures for track or overhead line reasons.

  Modern track systems are resilient to high air temperatures for the Region (41° C+) but stretches of legacy systems remain, particularly on the East Coast Main Line. Some of Eastern's overhead line and electrical systems were constructed to historic weather-related design levels and are no longer fit for purpose. Therefore, legacy track and power systems can be less reliable than modern systems in the current climate.

Stressor Impacts

In addition to sudden, acute events like heat waves and storms, slow-onset climate change or prolonged weather systems can exacerbate the incidence of hazards. To address stressors, we must have more resilient, permanent solutions.

- **Prolonged Drought:** Periods of prolonged drought can lead to an increased wildfire risk, sometimes on the lineside. Even fires away from the railway are a hazard, as drifting smoke can cause problems with signal sighting problems and outdoor workers. Climate projections are for an increase in hot, dry summers.
  Drought can lead to desiccation, where clay embankments shrink. This often leads to a rapid loss of track geometry, resulting in track-quality related speed restrictions which can impact performance for many weeks. It can affect the position of overhead lines as OLE mast foundations move. Drought can lead to the desiccation of clay earthworks in southern parts of our region, affecting the East Coast Main Line and lines on both Anglia and East Midlands routes. Where ground water levels drop, peat beneath the railway compresses which causes impacts similar to those of desiccation, and recovery is also by

correcting track geometry. Routes with affected assets recognise that replacing geotechnical material is impractical and unaffordable, and instead aim to improve the prediction and response to drought conditions by using soil moisture parameters and historical statistics to predict the onset of track geometry problems and track remediation tamping plans to recover performance.

- **Sea level rise**: Ultimately, sea level rise may make parts of the current network uneconomic to maintain in the long term due to increasingly frequent and damaging flooding. Climate projections are that that sea level will rise significantly across the whole UK coast, for example, our climate change planning scenarios suggest sea levels in Anglia could rise by up to 67cm by the 2070s. When combined with the changes in storm intensity and frequency, the risk of storm surges around the whole coast is increased. Coastal infrastructure, such as that in Anglia, East Coast and North & East will be impacted by flooding and coastal erosion. Scour will be a serious hazard on some coastal and estuarine embankments.
  As well as the weather forecasting, and better operational plans to manage safety risk, we will continue to engage government, agencies and local bodies to understand how the railway can continue to serve. This will help us to understand both areas that may require enhanced protection as well as those where the practicability of continued investment is diminished. Development of adaptation pathways will guide the process of investment or the controlled withdrawal of services where they are demonstrably no longer viable.
- **Vegetation growth**: Work is planned to manage the risk of falling trees on tracks and overhead lines, but we are also faced with challenging new phenomena, such as species migration and ash dieback. It is estimated that over 90 % of ash trees will require removal. Climate change forecasts suggest that drier summers will affect tree health, potentially accelerating the spread of this, and other chronic tree diseases.

Risk reduction measures include vegetation management to maintain safety, minimise performance impact and contribute to our biodiversity targets. Work includes the removal or reduction of individual high-risk trees, to establish a safer vegetation profile. Vegetation is managed to reduce autumn leaf fall impact. In the future, greater attention will be given to establishing and maintaining fire breaks around lineside buildings, and to supporting biodiversity.

The Digitised Lineside Inspection (DLI) project
This technology will allow basic inspections of vegetation to be completed remotely using video footage collected from trains. Tree risk can be assessed using a combination of LiDAR (Laser Detection and Ranging) data to measure the trees, and hyperspectral data to measure tree health indicators. Anglia route has been trialling drone technology, combined with LiDAR to identify trees that could strike a train if they are blown over. We will deliver a digital twin early in CP7, a virtual lineside environment to allow us to identify areas of risk and opportunity.

Systemic combinations

Combinations of the above hazards and asset vulnerabilities are apparent and need to be addressed through appropriate planning, forecasting, and resourcing, for example:

- Desiccation of earthworks can result in track geometry and overhead line becoming rapidly out of specification.
- High winds are sometimes followed by floods, making it difficult for maintenance teams to access the rail to undertake reactive work to re-open lines.
- Extreme heat precautions for track and overhead lines result in degraded performance and timekeeping.

2.2 Eastern Weather Resilience and Climate Change Adaptation Policy

At the start of the planning process in 2021 Eastern developed a Weather Resilience and Climate Change Adaptation (WRCCA) Policy. It was built from the National policy, adapted to represent Eastern priorities and contained guidance for the Eastern Route Engineers who were building the renewals action plans. The policy sits with Asset Management Strategy although it was developed in conjunction with Regional Engineering. Assurance of its application was undertaken during the reviews of the CP7 plans. It sets out our approach to achieving our company's vision of 'Simpler, Better, Greener' railway for Britain and aims to create a railway that is safe and more resilient to the effects of weather, now and in the future.

Everyone who works in Eastern will apply the key principles in our WRCCA Policy.

Its aim is to:

1. Provide infrastructure which can withstand the impact of current and future weather conditions.
2. Deliver rapid recovery from the impacts of adverse and extreme weather events.
3. Reduce the impacts adverse and extreme weather have on safety and performance over time.
4. Leverage financial savings through reduced compensation payments and repair costs.
5. Enhance reputation and trust in the railway's ability to manage weather events.
6. Use asset knowledge and latest weather forecasting information to work in partnership with train and freight operating companies to make safe train service plans during periods of extreme and adverse weather.

2.3 Regional Sustainability Strategy

The Regional Sustainability Strategy currently delivers the CP6 WRCCA action plan. It is aligned to the National Environmental Sustainability Strategy. We will update this strategy when the National Strategy is next reviewed during CP7. We will carry forward the relevant elements of the current sustainability strategy into any CP7 update. Specifically:

1. Agree levels of service during periods of extreme weather with Government and Regulators by 2027
2. Develop long term pathways and identify investment for different climate scenarios by 2029.
3. In addition, we expect to deliver the WRCCA program for CP7.

Through CP7 we will develop our understanding of future asset vulnerabilities through modelling future climate scenarios based on best available science. Our approach will mirror industry best practice around the use of adaptive pathways to flex our investment plans in future control periods. We will also consult with other strategic partners in this topic area, such as the Environment Agency, to ensure our plans are aligned.

As discussed above, our goal in CP7 is to minimise and mitigate the impact of extreme weather events. We have adopted good practice asset management, in line with ISO Standards, which brings a 'line of sight' from the following aims to delivery 'on the ground': -

- Improve weather resilience of our infrastructure.

- Implement flood site management plans and targeted investment.
- Develop multi-asset seasonal resilience plans.
- Use alert and alarm equipment to target appropriate responses.
- Use RCM on drainage assets to provide proactive intervention to prevent / reduce delay.

In summary we will manage 'known knowns' that are already impacting service through our CP7 investment programme, prioritised on risk within the available funding. We will also prepare for the 'known unknowns' by developing our understanding of future weather patterns and the impact on our asset base.

2.4 Eastern Strategic Principles

The goal for CP7 is to focus on building intelligence of our asset base and its vulnerability to weather, and to target investment in work that increases our resilience to the current impacts of rainfall, flooding, heat, and high wind speeds. Recognising the broader funding context and pressures, we have had to make some tough choices and trade-offs about how we balance our spending in CP7 to provide the most value to our customers and the taxpayer. Therefore, in CP7 we will undertake an increase in refurbishment activities and maintenance rather than renewals or standalone resilience schemes. Any new assets will incorporate weather resilience in the design. The resilience schemes will predominantly focus on drainage and managing flooding.

Moving from renewals to refurbishment will not increase resilience across all our assets, but we aim to maximise resilience within the funding available. However, we will consider how to deliver mitigation and make recovery as easy as possible as part of all designs in vulnerable areas. Our approach is to retain and protect £5m for modelling to build intelligence of vulnerable sites and grow our capabilities for managing weather risk. Our hierarchy of design is to consider in the following order:

1. Remove the event.
2. Reduce the risk.
3. Mitigate the impact.
4. Recover from the risk.

We will actively engage with third- parties to identify opportunities to work together to achieve better outcomes. We have already established a working arrangement with the Environment Agency and will continue to review their list of issues alongside ours to identify opportunities for joint solutions.

2.5 Weather Risk Task Force actions, including those from Lord Mair and Dame Slingo

A national Weather Risk Task Force (WRTF) has been established by Network Rail in recognition of the risk to the railway from current and future weather patterns following the tragic derailment at Carmont in 2020. This is an important step in recognising the impact of weather on the railway system and to make decisions and develop industry tools to support better managing the risks and hazards extreme weather presents. A number of recommendations from the Lord Robert Mair report, the Dame Sligo review and RAIB/L3

recommendations from the Carmont accident investigations are under the supervision of this task force. Specific actions are owned by different teams within the business covering tools/systems, process, people, competency, training and culture.

We are committed to adopting these new tools, techniques, processes and improving the management of the railway system. This will require changes to the way our operations team receive and manage weather forecasts, our confidence in asset condition and our ability to target critical systems (e.g., drainage) with interventions that deliver a meaningful change to their performance during weather extremes.

The management of risk is essential for a positive step-change, and a fundamental to this capability is that we have the information, tools, processes, and also sufficient resources (i.e., drainage inspectors and maintenance teams) to drive changes throughout the region.

These actions centre primarily on the management arrangements of geotechnical and drainage assets, and while not centred on learning from the 2020 train accident at Carmont, they were created with the open mindset of 'what can we do better'. The numerous recommendations and action plans comprising this work are best seen through the lens of 'risk'.

Prior to an event we can improve our control measures to limit the likelihood of a 'risk' occurring. These include:

- Improved weather projections.
- Improved asset knowledge.
- Improved knowledge of flood risk and impact.
- Risk focused proactive interventions (maintenance of drainage assets in preparation for and during winter, and management of track assets in preparation for and during summer).
- Establishing stronger relationships between weather projections and asset performance
- Proactive work prior to seasons/or individual events.
- Alert and Alarm systems (a subset of remote condition monitoring).
- Tools that enable weather and asset information to be used to reduce risk in the form of operational restrictions.

Control measures to limit the consequences of an event include:

- Application of targeted operational restrictions (e.g., slower speeds lessen the consequences of a defective asset).
- Ability to recover (e.g. through quick assessment of damage and ready deployment of people and response equipment).

The Weather Resilience Task Force hold the business masterplan for implementation, with Eastern Region contributing to product and process development. In addition, Eastern Region have locally led actions that include:

1. Improved quality drainage asset inventory
2. Improved, risk prioritised, drainage maintenance
3. Better geotechnical asset knowledge, including through technical assessment
4. Creation of integrated management plans for geotechnical, drainage and vegetation assets

5. Increased use of monitoring instrumentation arrays (to understand asset behaviour) for geotechnical assets, and 'Alert & Alarm' systems (linked to operational control) for geotechnical and drainage assets.

For 1 and 2, additional funding of £30m has been incorporated in our maintenance plan. An expenditure of circa £70m is proposed for items 3, 4 and 5 using both capital and operational budgets. We recognise the need to introduce new processes and associated standards along with necessary training and monitoring. For this we shall bring a new accountability within the Eastern team to own this 'change management' process.

2.6 Scale of Earthworks and Drainage challenge

Route and Region summaries often contain reference to the numbers of bridges, tunnels and track miles. The geotechnical infrastructure that the routes manage, such as embankments, soil and rock cuttings and associated drainage features are less commonly referenced and yet the scale of these are remarkable; Eastern Region has 58,800 earthworks; if they were to be placed end to end, they would extend a distance in the order of >3,000 miles (>4,800km). Drainage asset data is currently being improved to further understand the scale of assets we manage. All of these assets need to be managed in the context of the environment and landscape in which they have been constructed. Our earthworks are a complex mix of engineered and natural slopes, and our drainage assets receive water from neighbouring land, from groundwater and from rainfall landing on our estate, and drain into a mix of third party ditches, sewers and natural watercourse.

2.7 Hot weather report

In July 2022, the UK experienced an extreme heat event accompanied by a prolonged period of severe drought which affected Network Rail infrastructure, including track, OLE and earthworks, leading to a significant degradation to performance in our Region. Network Rail commissioned taskforces to investigate the circumstances surrounding the responses to the heatwave. Network Rail's Chief Executive, Andrew Haines commissioned, at a national level, an Extreme Heat Taskforce Engineering report and an Extreme Heat Taskforce Operation report, whilst the Region carried out a review of the extreme heat event led by Regional Engineering.

The first two reviews are works in progress, with draft interim reports produced. The regional review has been completed, which highlighted:

- Track and OLE assets had the biggest impact on performance and for track, specifically, full-depth timber S&C assets.
- The management of higher risk assets was inadequate; the sites where 7 of the 8 track buckles were recorded were not in the risk register.
- The assessment and mitigation required for vulnerable assets was lacking guidance.
- A few clauses in the standard for the managing of track in hot weather drove the most performance restrictive mitigations.
- The imposition of speed restrictions or closing lines by conflating risks such as track, OLE, passenger safety on trapped trains, staff safety working in the heat, are no longer acceptable mitigations.

- The reliance on deploying Watchpersons for the track asset as the primary mitigation no longer fits in our operating context.
- The strategy for monitoring air or rail temperatures across the Routes was inconsistent, which resulted in inconsistent decisions.

As a result of this regional review, action plans have been developed to better to prepare for next summer. These include making changes to key standards to remove conservativism, implementing a more detailed summer preparation regime to improve asset resilience and adopting more technology to replace manual surveys during the heat. Plans have been developed on a route basis as for example risks on our East Coast route differ from the risks associated with the Anglia route.

In addition to improving the management of individual assets in the heat, we are also working at managing the railway as a system. For example, we have established a process for managing track on earthworks that suffer from desiccation after our experience with a very dry 2022 summer. This consists of: -

- Management plans developed for high-risk sites, jointly owned by the Earthworks Manager and Track Maintenance Engineer, which includes,
    - data analysis to develop triggers for proactive management.
    - targeted vegetation management.
    - proactive stone drops and tamping.
    - development of long-term plans to identify track formations and earthworks requiring stabilising works.
- Triggers based on Soil Moisture Deficit (SMD.)
- Processes for deploying tampers to correct track geometry when the SMD is high.
- A process to review risk sites and triggers on an annual basis.

Some changes to the initial CP7 track renewal plans were also made, with the focus now being on providing weather resilience. For example, East Coast Route is targeting the renewal of timber S&C assets on higher speed lines as their key route strategy. Jointed track sections, which are high maintenance and are vulnerable to heat are also targeted.

2.8 Accountabilities

Eastern is a devolved structure and so the accountabilities with delivering and reporting on the WRCCA plan lie in the Routes. The Route Infrastructure teams hold the accountability for the delivery of the plans, with Route Infrastructure Engineering being responsible.

Weather resilience is managed across the operational and maintenance teams and climate change adaptation is the responsibility of the Route Engineering teams of each asset discipline.

The CP7 plan will be delivered by the Routes and tracked through reporting in each of their Route organisations.

The DEAM organisation is a support function providing subject matter expertise, collation of Route information for reporting and assurance. The DEAM team will assure the progress of the WRCCA plans on a six-monthly basis and this will form part of the reporting to National. The DEAM team will also provide resources to develop and implement the approach to adaptation pathways for CP7.

2.9 Governance

Effective governance of the wider WRCCA programme including route WRCCA Plans is embedded within the Eastern governance structure.

Delivery of asset volumes will be tracked through a report of authorised investment of activities providing resilience benefit. Individual projects will not be reported in favour of an overarching view of activity within different asset functions. This process will also enable us to demonstrate where asset volumes are providing secondary resilience benefit and it is expected that cumulative investment in resilience during CP7 will be higher than what is forecast in this plan.

Based on existing structures, the following high-level management, review and reporting is undertaken:

- Routes provide updates on implementation of their WRCCA Plans to the regional WRCCA lead for cascade to the central WRCCA Team and ORR in line with an agreed reporting timetable,
- A report combining progress from all regions is presented to the National Asset Management Review Group and Quality, Health, Safety and Environment Integration Group (or future equivalents) twice a year,
- Progress in achieving milestones is included in regular WRCCA reviews by the Network Rail Executive Leadership Team and the National Safety, Health and Environment Periodic Report (or future equivalent),
- Route WRCCA plans form a key risk control in managing Network Rail's Enterprise Risk relating to weather related impacts on the railway, which is managed through route and national level Business Assurance Committees (or future equivalent),
- The WRCCA Working Group will review progress and identify any improvements which would be approved by the National Asset Management Review Group and Quality, Health, Safety and Environment Integration Group (or future equivalents) or Executive Leadership Team as appropriate, and
- The central WRCCA Team will use the information in the route reports to inform the next National Climate Change Risk Assessment being compiled by the Committee on Climate Change and as part of its Adaptation Report under the Climate Change Act. We will also look to engage with the wider rail industry, specifically Train and Freight Operating Companies, to discuss the route WRCCA actions to identify opportunities for collaboration to facilitate effective increase of rail system resilience.

Progress on delivery of this action plan will be reported every six months (April - September and October - March each financial year). Each Route will report progress and the information will be collated at regional level and sent through the Technical Authority to the Climate Change Adaptation Steering Group and to ORR.

Within Eastern there is also a periodic Sustainable Development Steering Group where WRCCA progress is reported and monitored. This group comprises representatives from Routes and Regions and tracks improvement activities as well as progress.

Further scrutiny will be provided by Slope Review Group (SLG) on WRCCA actions targeted at Earthwork and Drainage management.

2.10 Reactive work

It is recognised that a proactive approach to asset maintenance and renewal is beneficial for railway safety and performance. It brings economic benefit also, in allowing work to be planned in an integrated way, designed appropriately (recognising whole life management, environment and carbon consumption) and delivered efficiently. It may be argued that this is one of the biggest challenges to the modern-day railway, and in enabling a true integrated approach we will release many benefits.

Recent control periods have seen efforts across all assets in increasing work-bank stability, and contracts placed that reward Network Rail for stability in planning. In parallel, we have increasingly sought to limit the spend on reactive activities.

Assets most vulnerable to large costs due to adverse and extreme weather are typically identified as soil and rock slopes that form embankments and cutting. We know that proactive management of drainage, (and to a lesser degree vegetation), is a key enabler for asset integrity in weather event.

3. Our Climate Change Risk

3.1 The Current Climate in Eastern

Our weather patterns are changing and have shown some dramatic shifts over the last ten years.
Information from the State of the UK Climate 2022 published 27 July 2023 showed that 2022 was a year of extremes. Highlights of the report include:

- The UK climate continues to change, but UK temperature extremes are changing much faster than the average (based on 1960 to 2022 UK daily average maximum and minimum temperature)
- Last year was the first ever to record an annual mean temperature above 10°C and Eastern recorded 40°C for the first time in the July heatwave
- In 2022, the UK received 6 % below average rainfall (1991 – 2020), but there has been a slight increase in heavy rainfall in recent decades.
- Sea level around the UK has risen by 18.5cm since the 1900's, but the rate is increasing with over 60 % of this (11.4cm) occurring over the past 30 years
- Overall, 2022 leaf-on season was 7 to 16 days longer than average due to extended spring and autumn seasons.
- The winter of 2023/24 has so far proven the wettest (for Eastern Region) for 30 years.

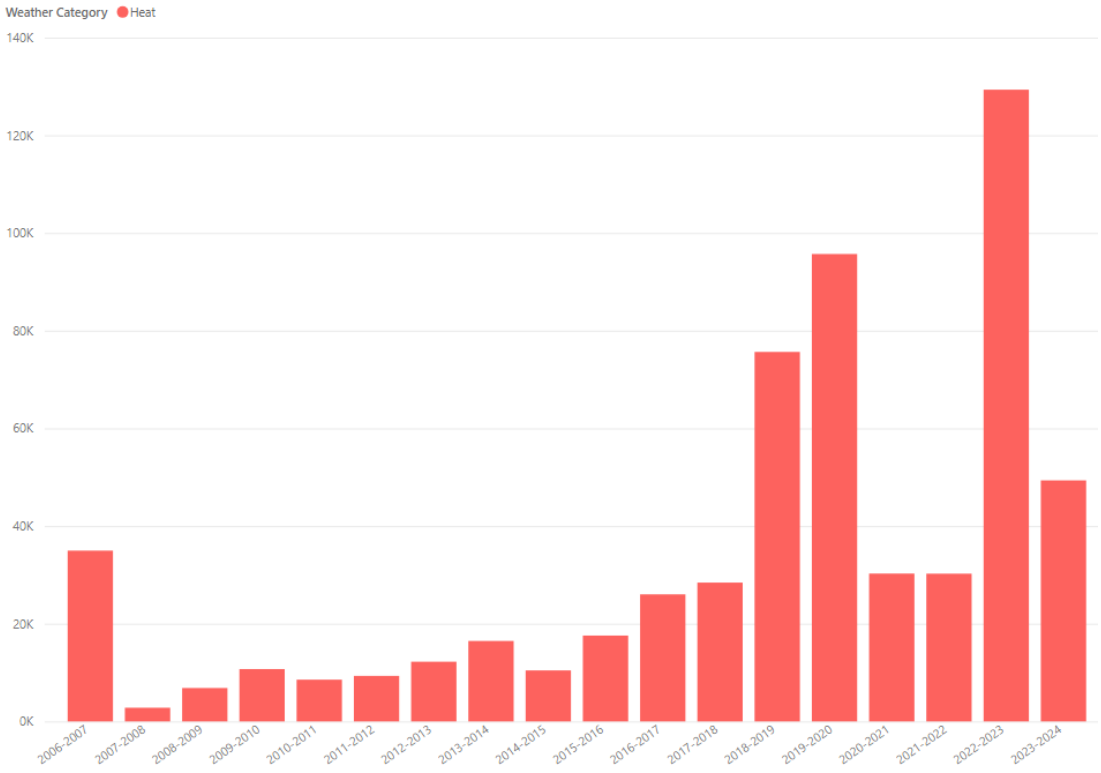
As temperatures are getting warmer there is expected to be less impact from snow, and this is reflected in reducing impacts so we have discounted activities to improve snow resilience from our CP7 plans and this will be reviewed in the following planning window. Lightning is also not a major disrupter to the running of our railway and much has already been done to provide protection, so it is not a driver for investment in the near future.

Projections show that the recent changes observed in UK climate are set to increase. The graphs below show how these trends are impacting the operation of Eastern's railway in terms of delay minutes we experience from severe weather events:

- A sharp increase in heat delays over the last five years
- A step change in the impact from wind in the last 10 years
- Peak years for flooding impact every 4-6 years
- Adhesion impacts vary over time, dependant on the growing season.

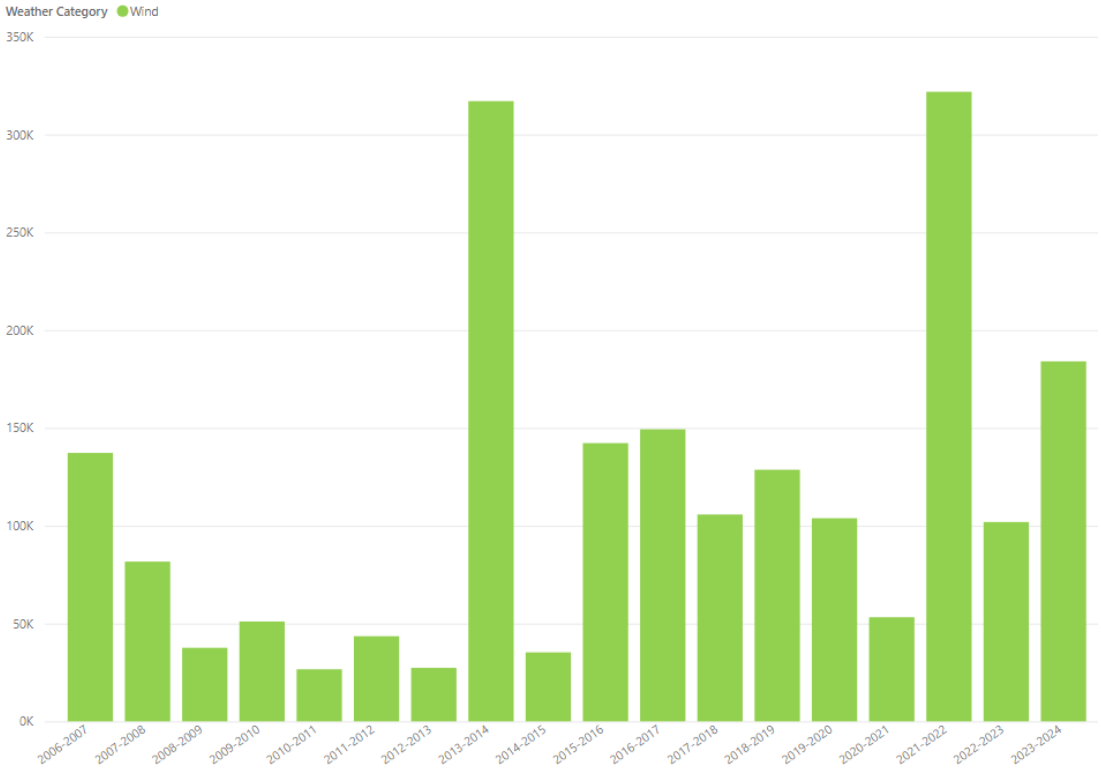
Heat

S8 Minutes by Year and Weather Category

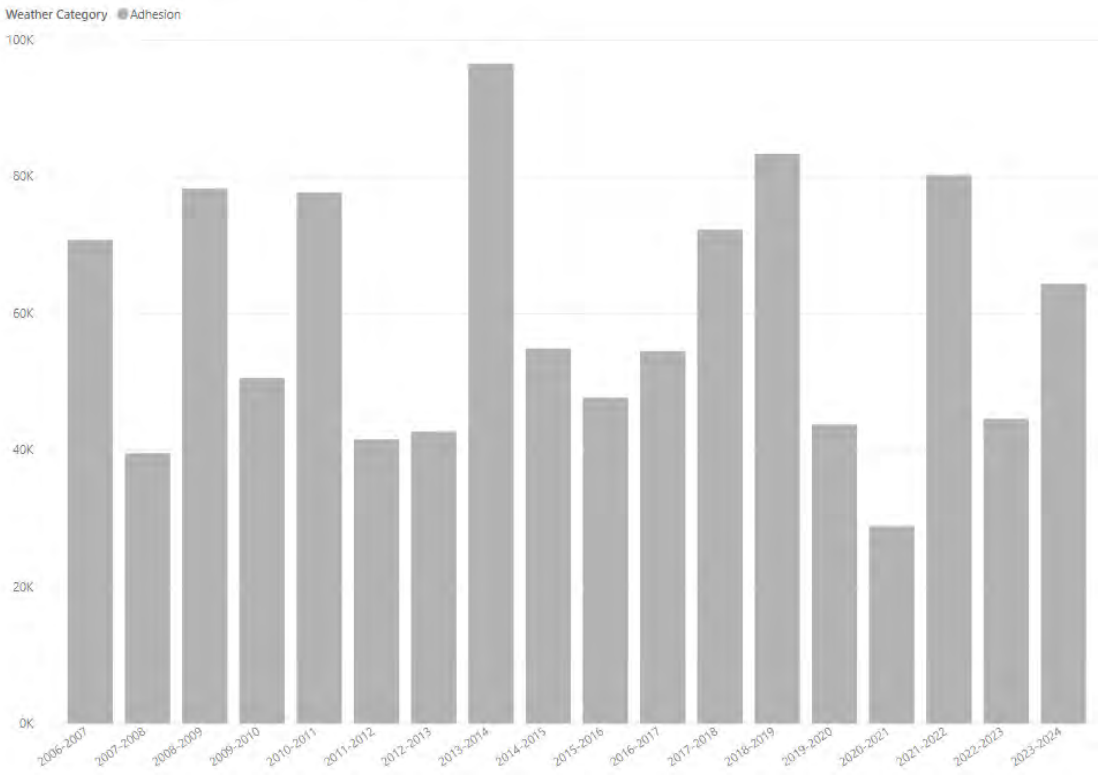


Wind

S8 Minutes by Year and Weather Category



Adhesion



Flood

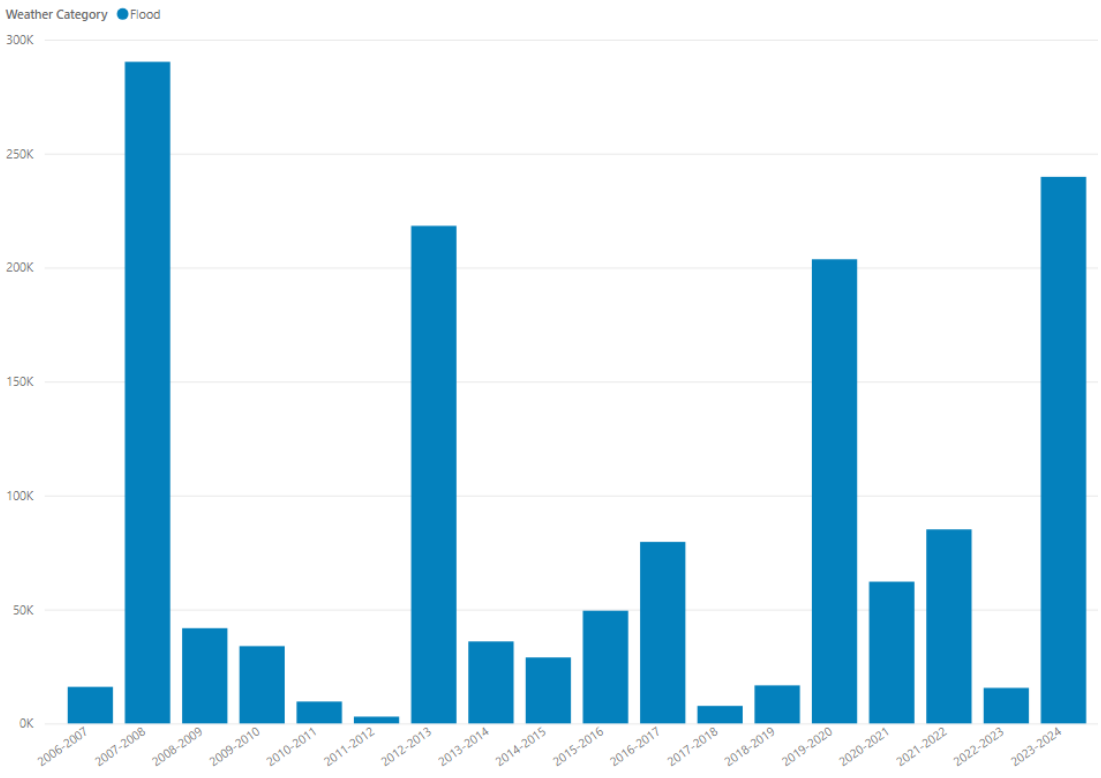


Figure 7: Weather trends for heat, wind, adhesion and flood 2006-2023

3.2 Climate Change Projections

Figure 8 shows the overview of our climate challenges for the future. And further detail on each will be explored below.

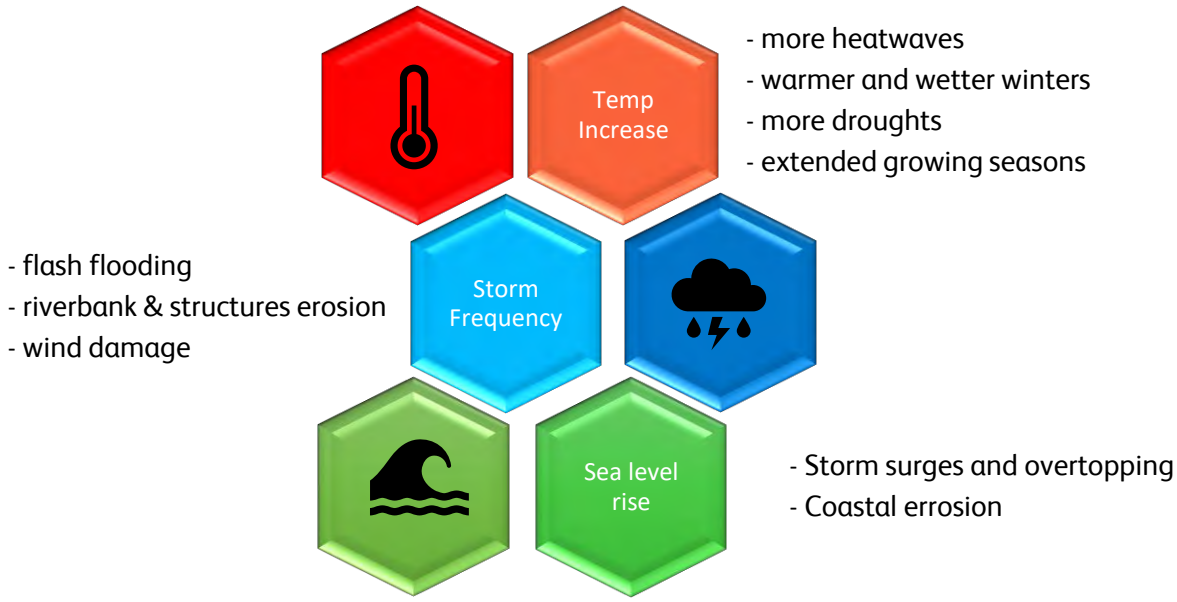


Figure 8: Overview of future weather/climate risks

The climate change scenario considered is outlined in the Climate Change Projections Guidance Note based on projection data from UKCP18. The UKCP18 projects an overall shift towards warmer climates with drier summers and wetter winters for the whole of the UK, with regional differences. The frequency of and intensity of winter and summer storms will increase, and summer storm rainfall will be more severe than in winter. Intense summer rainfall after droughts/dry periods will increase the surface/flash flood risk and peak river flows will increase.

The table below details the two climate scenarios deemed most appropriate for planning for a safety critical and future reliable railway.

Scenario name	UK Climate Projections 2009 (UKCP09)	UK Climate Projections 2018 (UKCP18)
Primary	Medium emmisions scenario 90% probability	RCP* 6.0 90th percentile**
Higher	High emmisions scenario 90% probability	RCP* 8.5 90th percentile**

* Representative Concentration Pathway
** 90th percentile is used for the majority of UKCP18 climate data in this guidance (exceptions are noted in the relevant sections)

Figure 9: Climate scenarios for a safe and reliable railway

In CP7 we focus on the greatest impacts and risks, concentrating on hot weather and precipitation projections. We will work to understand and quantify our vulnerabilities to build plans for CP8 and beyond, particularly for areas such as rising sea level.

3.2.1 Temperature

The maximum, average and minimum temperatures are projected to rise in all months of the year across the UK. This will lead to more frequent and severe heatwaves in the summer months, and fewer snow and frost days in the winter months. Although current extremes of winter weather will be less frequent, they will still be possible.

- Every year we will experience at least one heatwave for around a week, temp > 29°C.
- From 2029 to2034 we could experience two extreme heat events per control period - 1 x 38°C, 1 x 40°C
- Beyond 2034 we could experience four extreme heat events per control period - 2 x 38°C, 2 x >40°C

Summer temperature change, mean daily maximum temperature change for July (UKCP18):

		Baseline	2020	2050	2080
North East England	Primary	18.7	1.7	2.4	3.7
	Higher		2.0	3.1	5.0
East Midlands	Primary	21.3	2.4	3.4	5.0
	Higher		2.8	4.5	6.8
East of England	Primary	22.1	2.7	3.7	5.1
	Higher		3.1	4.8	7.0
London	Primary	22.9	2.9	3.9	5.5
	Higher		3.2	5.1	7.5

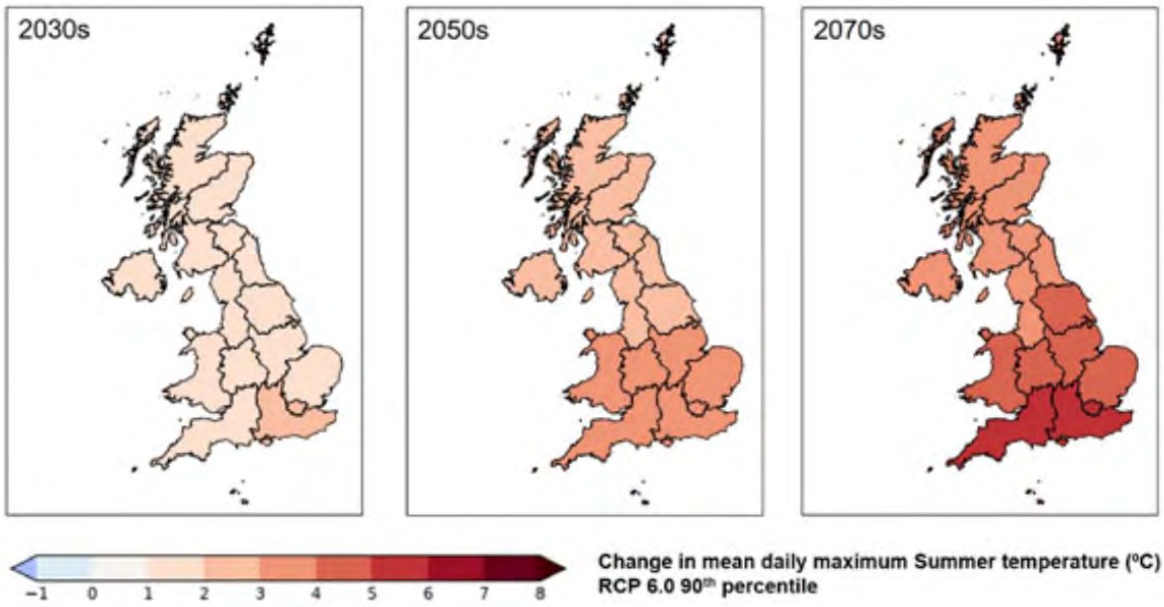


Figure 10: Summer change temperature forecast

Precipitation Total rainfall from extremely wet days (days exceeding the 99th percentile of the 1961-1990 rainfall) has increased by around 17 % in the most recent decade (2008-2017), for the UK. However, changes are largest for Scotland and not significant for most of southern and eastern England.

The wettest February on record for the UK (2020) showed that extreme rainfall could become nine times more likely by the end of the century than in pre-industrial times.[2]

Over the past 50 years, more winter rainfall has fallen in heavy events while summer rainfall, which varies greatly, appears to have decreased. Annual average rainfall may not change much over the 21st century but the trend of more rainfall falling in heavy, more intense events is expected to continue, the table below showing the number of events per year. Bigger, more frequent floods are expected over the 21st century, particularly during winter, along with increased river flows. Summer flooding may become more common and rising sea levels will increase the risk of damage from storm surges.[3]

Applies across all England	2020s (2015-2039)	2050s (2040-2069)	2080s (2070-2115)
Central	5	10	20
Upper end	10	20	40

Upper end = High emissions scenario 90 % - equivalent to our Higher scenario
Central = Medium emissions scenario 70 % - use as our Primary scenario
Baseline 1961-1990

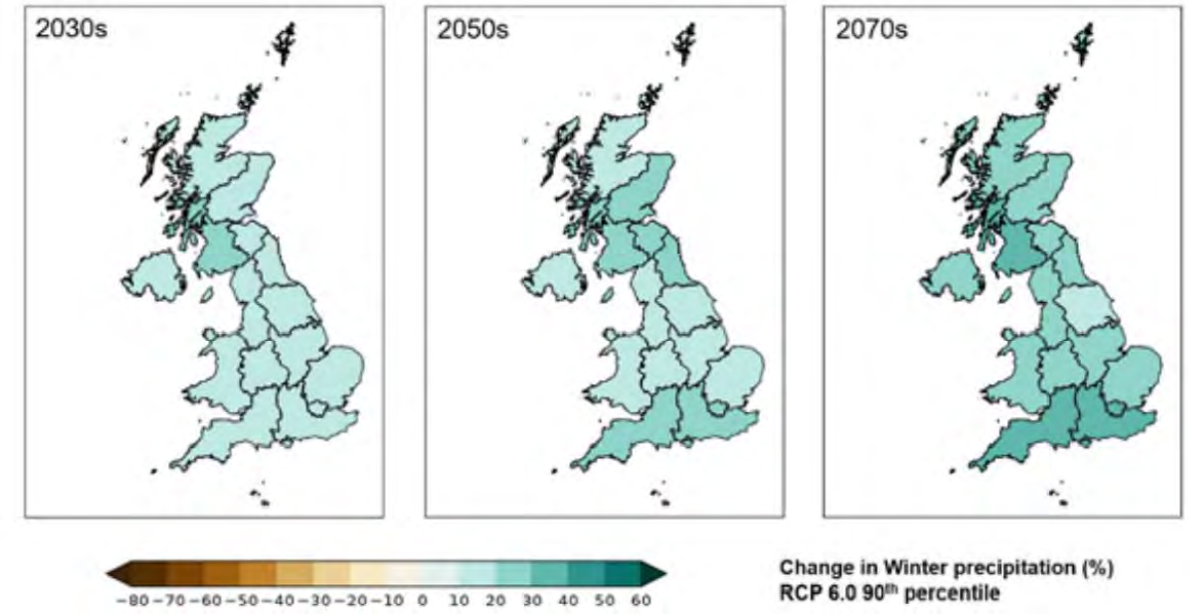


Figure 11: Winter Rainfall Change Forecast

3.2.2 Sea Level Rise and Coastal Erosion

The projections in this table are averages for their respective geographic regions, so local effects may need to be considered depending on the sensitivity of the asset and the accuracy

[2] Met Office UKCP18 National Climate Projections presentation UKCP18-overview-slidepack-notes.FF.pptx (metoffice.gov.uk)
[3] EA – Climate change impacts and adaptation Nov 2018 Climate change impacts and adaptation report (publishing.service.gov.uk)

of the assessment that is required. For example, shoreline features, defences, seabed changes, asset characteristics, location within the region, etc.

Area of England	Allowance	2000-2035 (cm/yr)	2036-2065 (cm/yr)	2066-2095 (cm/yr)	2096-2125 (cm/yr)	Cululative rise 2000-2125 (cm)
Anglian	Higher central	0.58	0.87	1.16	1.30	120
	Upper end	0.70	1.13	1.58	1.81	160
Northumbria	Higher central	0.46	0.75	1.01	1.12	103
	Upper end	0.58	1.00	1.43	1.65	143
Humber	Higher central	0.55	0.84	1.11	1.24	115
	Upper end	0.67	1.10	1.53	1.76	155

Figure 12: EA guidance on sea level rise allowance (cm/year) by river basin (UKCP18)

3.2.3 Storms/Wind

In 2021, Storm Arwen brought winds up to 98mph across our region with the main impact being trees and debris falling on our lines. This exceptional event identified vulnerable areas of our network. The UK modelling of future wind speeds to achieve robust outputs is challenging for a variety of reasons. In November 2010, to address the absence of quantitative data, the Met Office produced a fact sheet on wind speed that has been updated for UKCP18. This concludes that:

- There are no compelling trends in maximum gust speeds from the UK wind network over the last four decades,
- Global projections over the UK show increases in near surface wind speeds in the second half of the 21st century,
- For the winter season, when more significant impacts of wind are experienced, this is accompanied by an increase in frequency of winter storms over the UK, but;
- That the increase in wind speeds is modest compared to interannual variability.

Wind speed projections are not available for the probabilistic projections due to low levels of confidence.

3.3 Our approach to assessing climate change risks

Our approach has been to understand the asset base and its existing vulnerabilities, building on our experience in recent years. This identified specific risks that we must address. We have considered the impact of weather on reliability alongside the risk of asset condition in our CP7 plan. Recognising the broader funding context, in developing our CP7 plan, we have attempted to strike the right balance of risk for the coming five years to manage safety and performance. We have made trade-offs and choices on all areas of our plan, including schemes specifically identified for climate change and longer-term weather resilience. However, we do gain benefit from any full renewals where newer standards demand assets with better weather resilience.

To understand risk. we used the Network Rail Integrated ARP3 Climate Risk Assessment of the likelihood of different weather impacts across our asset base both currently and in the future. This risk assessment uses a modified version of the Corporate Risk Assessment Matrices (CRAM) to score the likelihood and impacts of weather and climate change on our assets. Please see Appendix B for more information. The assessment was prepared for the government as part of its Adaptation Reporting Power and we held workshops to determine where our asset landscape, geology or past experience identified any regional differences as demonstrated in Figure 13 below.

Examples of risks that were higher	Examples of risks seen to be lower
Desiccation of soil cuttings across Eastern due to high temperatures and experience from 2022.	Asset deterioration creating spalling of structures due to ice was seen to be lower and manageable.
Wire tensioning in OLE during hot weather with a risk of dewirements (experience in 2022)	Risk to tunnels were felt to be more related to asset condition than weather and should be manageable with inspections and maintenance.
Staff and passenger discomfort during extreme heat.	Risk from non-return valves on coastal areas was felt to be lower due to the number of locations.

Figure 13 – Examples of Eastern Regional differences to NR National risk methodology

The table below summarises the impact weather has on each of the asset types that make up the railway system.

	Precipitation	Heat	Storms/Wind	Adhesion
Track	• Localised flooding and track failure	• Ballast management • Track buckles or breaks • High risk with jointed track • Temporary speed restrictions		• Track circuits reliability • Reduced traction
Drainage & Off-track	• Blockage and overflows leading to localised flooding • Vegetation washout	• Increase in vegetation mortality or growth • Lineside fires	• Vegetation and trees on track	
Signalling, LX & Telecoms	• Flooded equipment	• Equipment overheating • Lineside S&T equipment rooms struggling to provide a workable environment for Supply batteries failure • Sun-glare on signals	• LX barrier failures	• Disruption to signalling
E&P	• Electrical faults from water ingress	• OLE sags and dewirements	• Overhead line damage • Lightning strikes on power distribution	
Buildings	• Drainage blockages and subterranean flooding • Flooding • Electrical hazard from water ingress	• AC failures in op buildings and offices affecting • Uplift of platform surfaces	• Damage to roofs - glazed roofs, listed canopies • Damage to decorative panels (footbridges)	
Structures	• Highway flooding at under bridges and saturated formation on underbridges. • Bridge scour	• Swing bridge expansion causing them to become stuck • Risk of metal buckling • Tunnel humidity impacting masonry	• Damage from overtopping	
Earthworks	• Cutting washout or failure • Scour damage to embankment toes • Groundwater leading to cutting failures • Softening and failure of clay embankments	• Clay bank desiccation		

Figure 14: Weather impact on Railway asset types

The weather variables considered are included in the table below.

Season	Weather shock	Weather stressor
Spring		• Long wet winter/spring
Summer	• Heatwave • Changes in soil moisture (intense rainfall/ drier summers)	• Drier summers • Long hot, dry summer
Autumn	• Adhesion • Storms	
Winter	• Heavy snow • Ice/hail • Snow/ice • Snow/ice/rainfall • Extreme cold temperatures	• Long wet winter/spring
Any season - Shocks	• Heavy rain/cloudburst • Intense rainfall / Flooding • High winds • High average rainfall over several days • Large diurnal temperature range • Lightning • Low soil moisture • Sun glare	• Erosion • Extended growth season (combination of weather parameters) • High average rainfall over seasons • High average temperatures • High soil moisture • Low average rainfall • Sea level rise • Sea level rise/storms

Figure 15 Weather shocks and stressors

The risk assessment methodology developed at national level is shown below, in figure 16. More detail can be found in the ARP3 report. [The full risk assessment can be found here.]

Figure 16: Our risk assessment methodology

We reviewed and assessed the top three levels of risk from moderate to very high risks identified at national level and made regional adjustments where risks differed. There are over 400 risks in the national risk assessment, so we focused on evaluating the top 100 risks spread across all asset and weather types. We cross checked where we may have different levels of risk to the national analysis. Figure 17 shows that currently the greatest risk areas for us are Flooding, Heavy Rail/Cloudburst, Extreme Hot Temperatures, Long, Hot, Dry Summer, Heat Waves, Snow/Ice, Storms and High Winds.

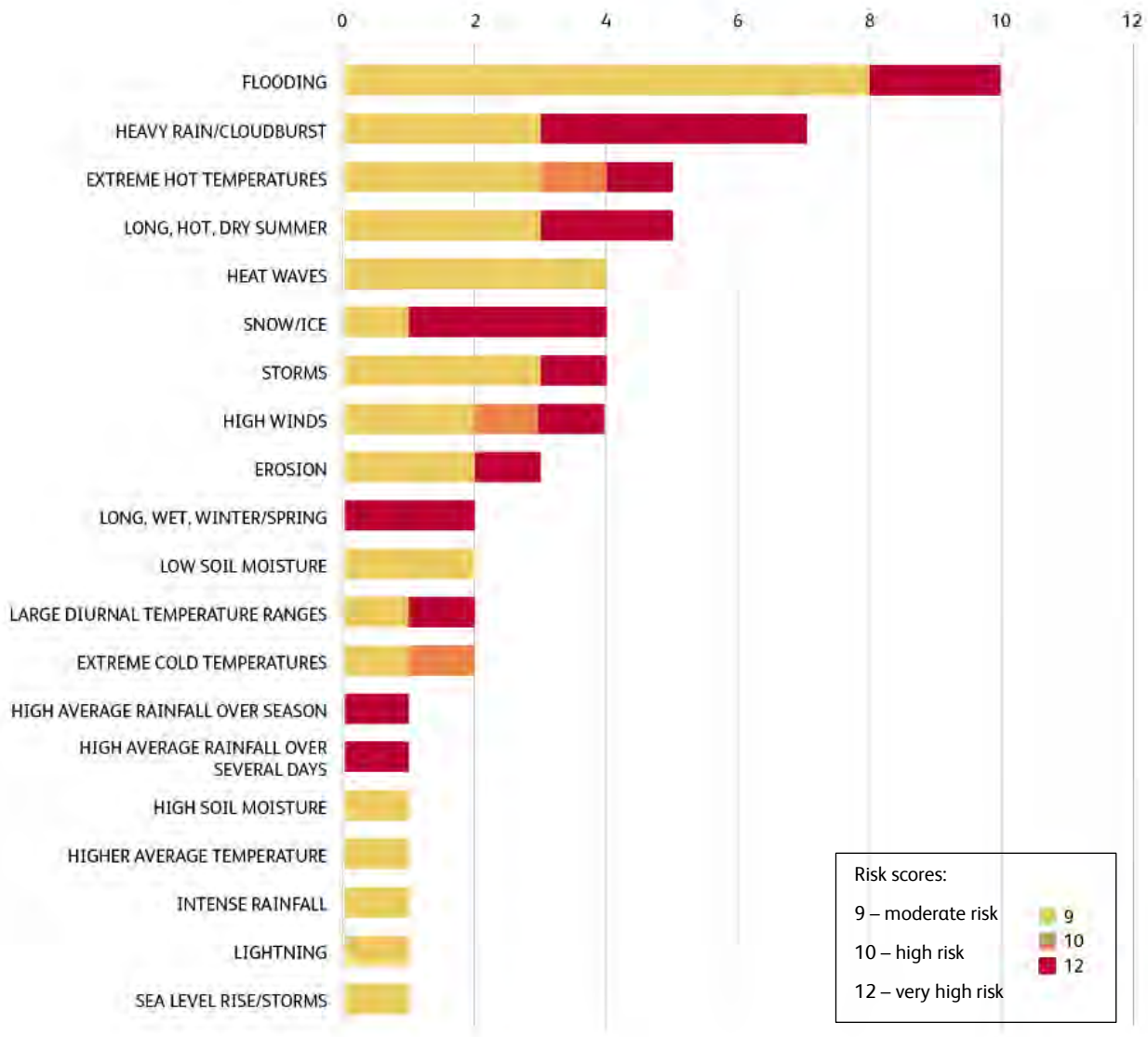


Figure 17: Current Moderate to very high-risk weather variables impacting Eastern assets.

The asset bases that carry the highest risk over all the weather types are track and drainage. However, the interdependencies of our assets mean that weather impacts on one can transfer onto others. For example, earthworks failures affect drainage or electrification systems, vegetation management and bank stability.

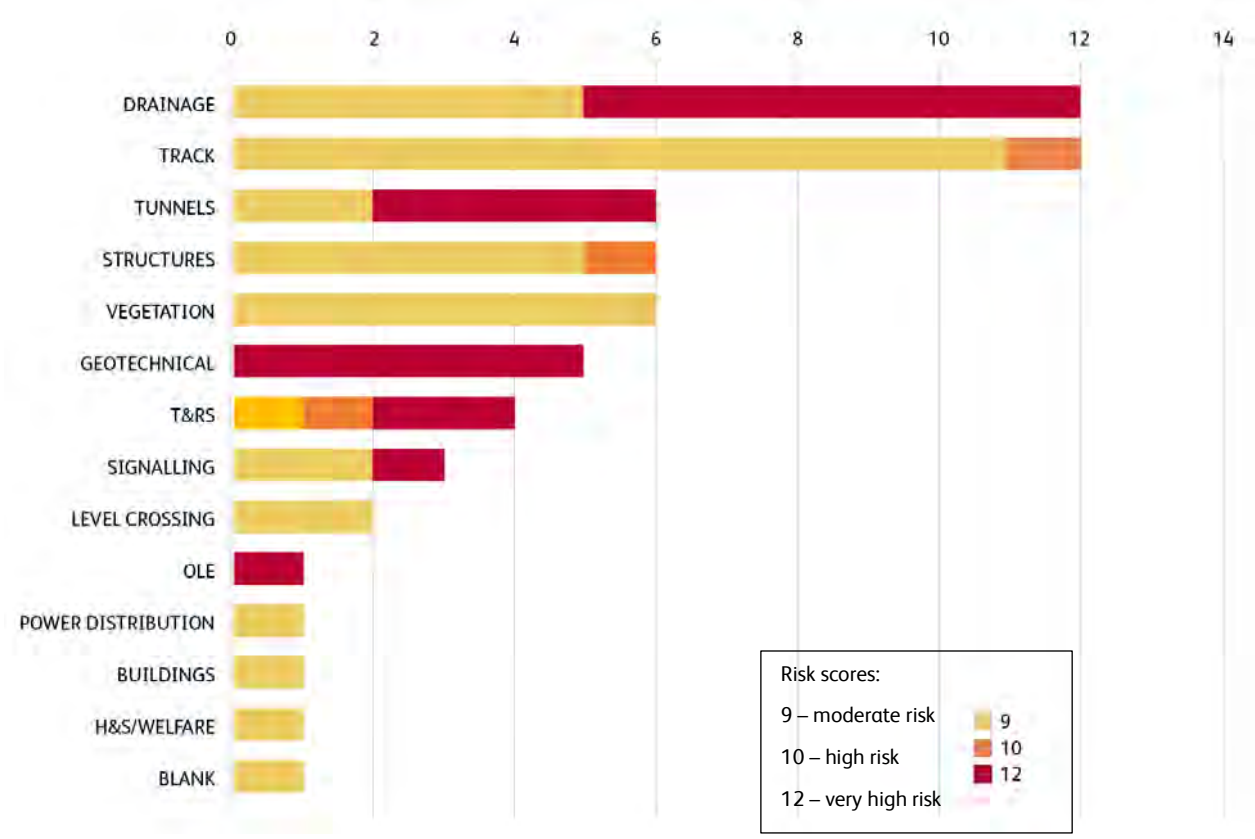


Figure 18: moderate and high-risk asset types in Eastern region

The risk analysis considered those risks we are facing today and looked at how this will change over time, considering 2050 and 2080 as the time horizons. Forecasting how our risk will change over this time frame is very difficult but we have considered both the changing weather impact and the changing asset base.

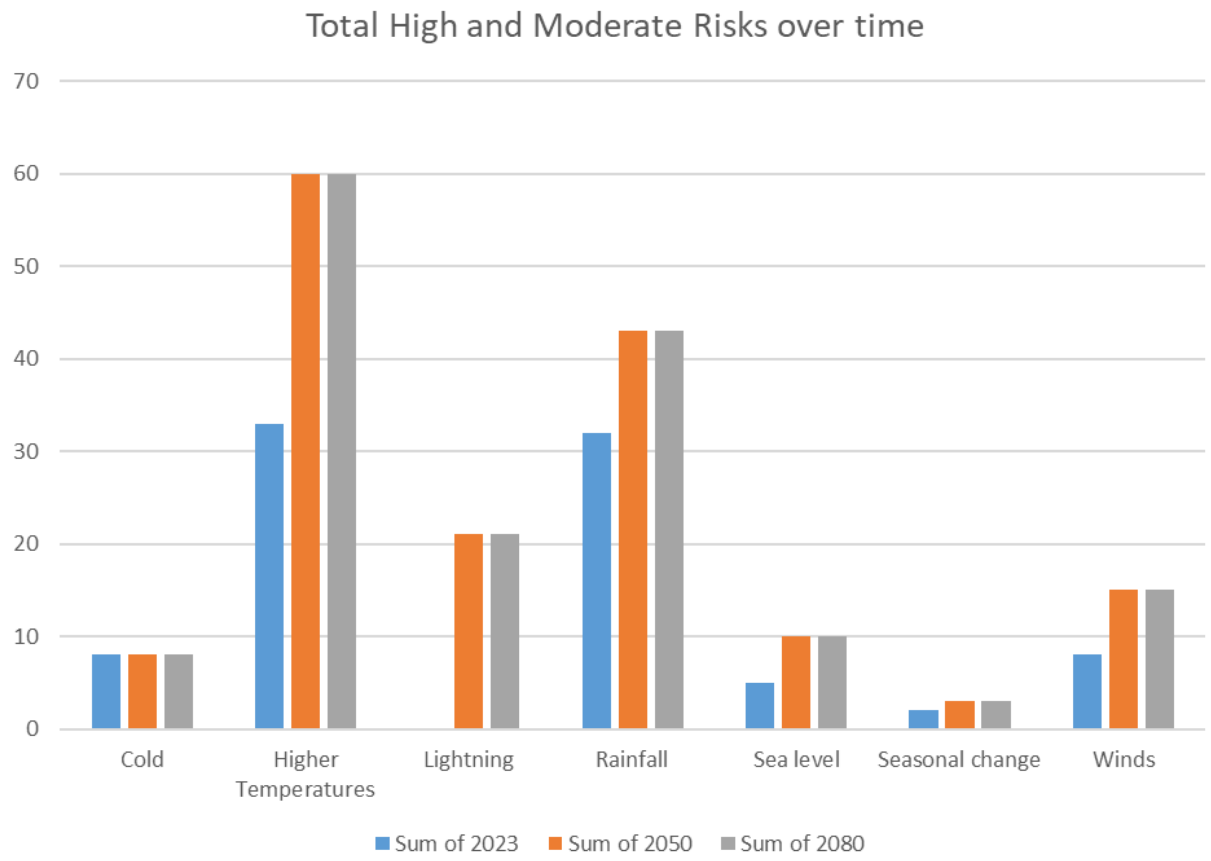


Figure 19: Total High and Moderate Risks over time

The main weather risks felt by our assets continue to be rainfall and warmer temperatures through the timesteps. Both continue to increase with risk levels moving from moderate to high as climate change makes events more frequent. Some of the increasing risk is controlled by resilience activity such as better focused interventions and increasing knowledge in the vulnerabilities of our asset base and how to recover from events. There is also an offset from risks being removed through action. For example, today some weather-related risks we suffer such as failures due to jointed track susceptibility in hot weather will not exist by 2080 as this asset type will be removed from our inventory by then. However, high temperatures will increase the risk to our buildings and electrical equipment over time. Some additional risks were identified relating to heat waves following our experience in the summer of 2022, for example the need for speed restrictions across timber S&C when temperatures are greater than 51 degC. The graph below shows the movement in risk by 2050. The green box shows where risk levels stay the same or improve, yellow shows substantial movement in risk and red is where there is significant increase in risk levels. Examples in the red area cover issues such as:

- significant risk of earthworks failure from continued desiccation
- Risk to earthworks due to saturation (wetter winters)
- impacts on electrical equipment operating at prolonged higher temperatures.
- buildings not being able to cope with more frequent high wind speeds
- track long term sustainability in higher temperatures leading to safety risk from track buckles.

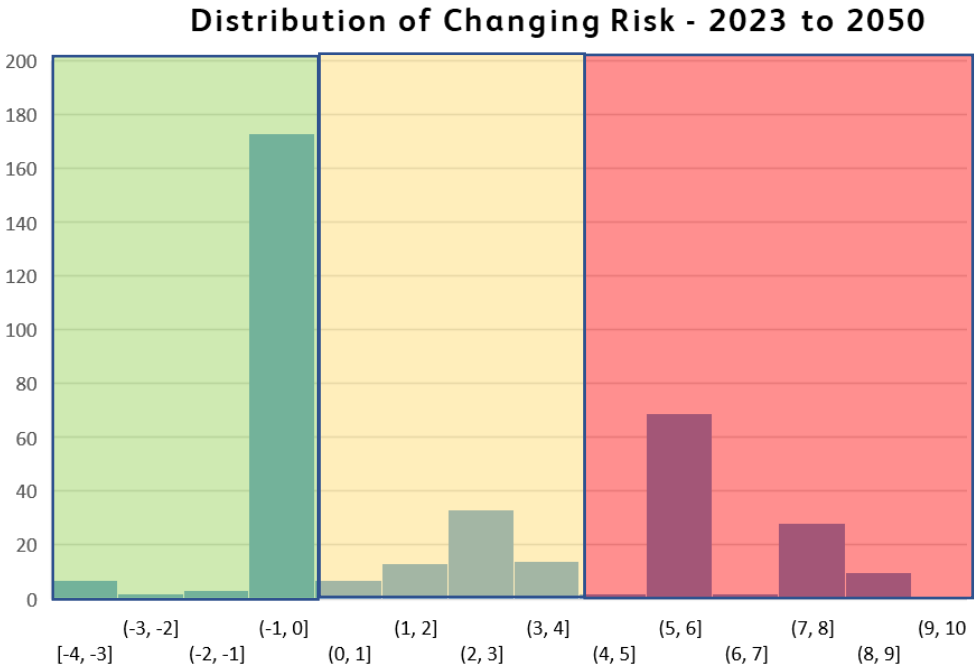


Figure 20: Risk movement over time

3.4 Management of Enterprise Risk from Weather

We capture regional risk in our Enterprise Risk Register. We use the bow-tie methodology to evaluate and describe the risk, its causes and consequences and the controls we put in place to manage it. The effectiveness of the controls and the management of the risk is evaluated regularly, and action take if any activities are found to not be in control.

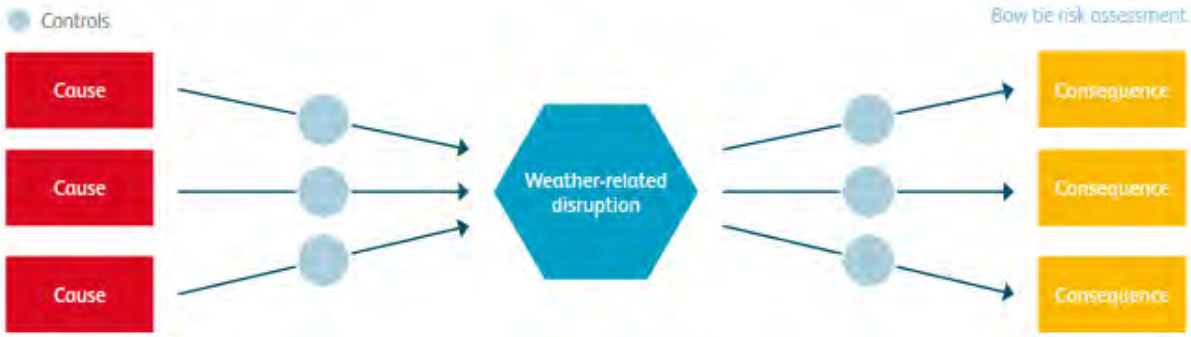


Figure 21: The bow-tie methodology for risk

The actions required to maintain risk control are captured below, by asset type.

Asset	Overarching Risk Management Strategy
Track	• Increase asset resilience to extreme weather by strategically removing vulnerable assets such as timber bearer switch and crossing layouts, 113lb/yard smaller section rails than currently used, jointed track and 'double lengths' • Replace with more robust modern equivalents that are designed to accommodate a broader range of temperature variations/stressing conditions • In parallel, changes to numerous clauses in the track standard, such as the critical rail temperature "action trigger threshold" • Improve summer preparedness by reducing volume of unstressed track, deficient ballast and high-risk track arrangements
Drainage & Off-track	• Improving the quality of our drainage inventory in CP6 • A step change in the management of drainage - Risk based inspection frequencies - Proactive maintenance for high risk, high consequence locations • Leaf fall (poor railhead adhesion) and falling trees risk will continue to be managed • Vegetation to be managed to minimise fire risk in the future, including maintaining fire breaks around critical lineside buildings • Longer term, consideration may need to be given to fencing selection if different weather patterns lead to changes in agricultural land use
Earthworks	• Targeted actions associated with the Lord Mair and Dame Slingo recommendations recorded elsewhere in this document • Improvements to (wet) weather forecasting, and our operational response • Creation of agreed integrated management plans for earthworks, drainage and vegetation, recorded in the integrated weather management plan • Shift asset management approach to move from a reliance on visual indicators to one where selectively assets are subject to fact-finding investigation and interpretative assessment - Including monitoring to understand behaviour and/or act as alarm systems • In CP6 geotechnical and track teams have started to explore how we can better predict and manage future temperature and drought events, with these anticipated to increase in frequency and severity - Embankments may rely on tree root suction for stability in prolonged wet periods, so any vegetation management needs to consider this - For embankments at risk of desiccation, vegetation can contribute significantly to the risk, and problem 'thirsty trees' need to be managed
Signalling	• The control of risk in CP7 should focus on the environment of signalling equipment • It is expected that routes will take a lead in this, considering where appropriate, the provision and/or enhanced maintenance of: - surge arrestors for lightning strikes - passive air flow measures for location cases - reflective coatings and air-conditioning units in equipment enclosures to counteract the effects of heat • Similarly, tactical steps can be taken with reviewing alarm trigger thresholds with respect to equipment design specifications • Upgrade to higher rated battery backup systems and chargers

Buildings	• Changes in weather patterns are likely to impact primarily on asset degradation rates, and increased risk of wind damage and localised flooding • Consideration on an individual basis will be required to consider appropriate maintenance, refurbishment and renewal actions in the short term • Regional and National direction (via design code changes) will be considered, with these most likely being through changed performance criteria (e.g. for asphalt roofing systems) • Building heating and cooling systems may need to be upgraded to maintain a comfortable environment for staff, passengers and other building users, and to maintain design working temperature for equipment housed in buildings as temperatures change
Structures	• Typical assets within the portfolio have a significant thermal mass. Their behaviour is influenced by average and duration rather than maximum temperatures. The impact of extensive periods of warmer climate is not fully understood - Initiate a suite of work in CP7 to establish the level of exposure as a discipline imperative - This is captured as part of R&D work streams suggested as part of our National Community of Practice for CP7 • Continue to manage risks related to hidden shafts and icicle formation - Funding to reduce risks to acceptable levels have been allocated for CP7 • There is good understanding of the vulnerability of assets to extreme wind and snow loading • Immediate Regional effort in CP7 is to maintain a programme of sustained decline in the number of high-risk scour sites - This will be supported by our proactive underwater examination regime and scour assessments - There is a pipeline of work targeted at the responsiveness of our scour management standards and asset management protocols by leveraging on industry expertise
Electrical & Plant	• Two studies have been commissioned to understand how overhead line equipment behaves above the current temperature threshold of 38 degrees and, from a forecasting perspective, how we relate ground temperatures to current carrying metallic components elevated above ground level • Wind also impacts on overhead line performance, with new systems installed better able to perform - There are no current plans to modify the existing systems for wind resilience; this would require a step change in approach and funding and shall be considered in future WRCCA plans • Other plant and componentry is relatively agnostic of temperature and is shown to operate in mainland Europe and other locations around the world • Winter preparation to continue to include points heating maintenance, and fitment of RCM to monitor the performance of points heating equipment

Figure 22: Overarching risk management strategy by asset

For CP7, we will review the effectiveness of our existing risk management processes and controls for weather resilience and climate change adaptation. This will include how these risk assessments are applied to our assets to understand controls and operational responses needed (bowties) and will determine the appropriate balance of interventions needed to improve weather resilience and adaptation.

3.5 The Eastern Region Routes and their risks

In addition to the risks described above there are some common risks that affect the Eastern region as a whole and some risks that are particular to individual routes. These are described below.

Eastern Region Common Vulnerabilities

- Groundwater flooding, particularly in tunnels and cuttings.
- The impact of third-party water management, where floodwaters drain onto railway land. This situation adds complexity to the management of flood risks and demands collaboration with external stakeholders.
- Vegetation management is a shared concern due to longer growing seasons and the presence of trees near the tracks, resulting in leaf fall issues that impact track safety and train operations.
- The reliance on manual inspection, particularly in tasks like ballast management, is another shared risk. Transitioning to advanced technologies, such as laser scanners and 3D technology, represents a common goal within the Eastern Region to enhance precision and efficiency in maintenance practices.

The risks particular to each route are described below.

3.5.1 Anglia Route and Climate Change Risks

1. **Low-lying Coastal Vulnerabilities**: The Anglia route faces significant vulnerabilities due to its low-lying coastal areas, such as the Norfolk Broads, Lowestoft, and estuary regions, which are susceptible to flooding from sea-level rises, storm surges, and tidal action.
2. **London Clay Geology**: Many lines on the Anglia route are built on or from London Clay, which is sensitive to moisture content, making them susceptible to failures from saturation and desiccation. This issue is particularly acute between West Horndon and Lower Dunton in Essex.
3. Peat areas like the Cambridgeshire Fens experience summer shrinkage.

3.5.2 East Coast Route and Climate Change Risks

1. **Geological Variability:** As the route moves north from London, it passes through various geological areas, including coal measures, cohesive and granular tills, peat, and alluvium. This diverse geology can make earthwork assets vulnerable to various types of failures.
2. **Regional Weather Patterns:** Cold in the North promotes freeze-thaw processes increasing risk to earthwork failures.

3.5.3 East Midlands and Climate Change Risks

1. **Geological and Topographical Variability:** North from London the topography becomes more variable as does the geology (cohesive and granular tills, coal measures, peat and alluvium) and the earthwork assets are vulnerable to various types of failures.

3.5.4 North & East and Climate Change Risks

1. **Geological Variability:** The North & East route's vulnerabilities are influenced by its geological and topographical diversity. It encompasses low-lying and gently undulating land in the east and higher ground in the west and north, including areas with coal measures.
2. **Regional Weather Patterns:** Cold in the North promotes freeze-thaw processes in rock fractures causing increased weathering and rock falls.
3. **Tidal Surge Risk:** The route is exposed to tidal surge risk at the Humber and Tees estuaries.

Summary of Key Weather and Climate Risks

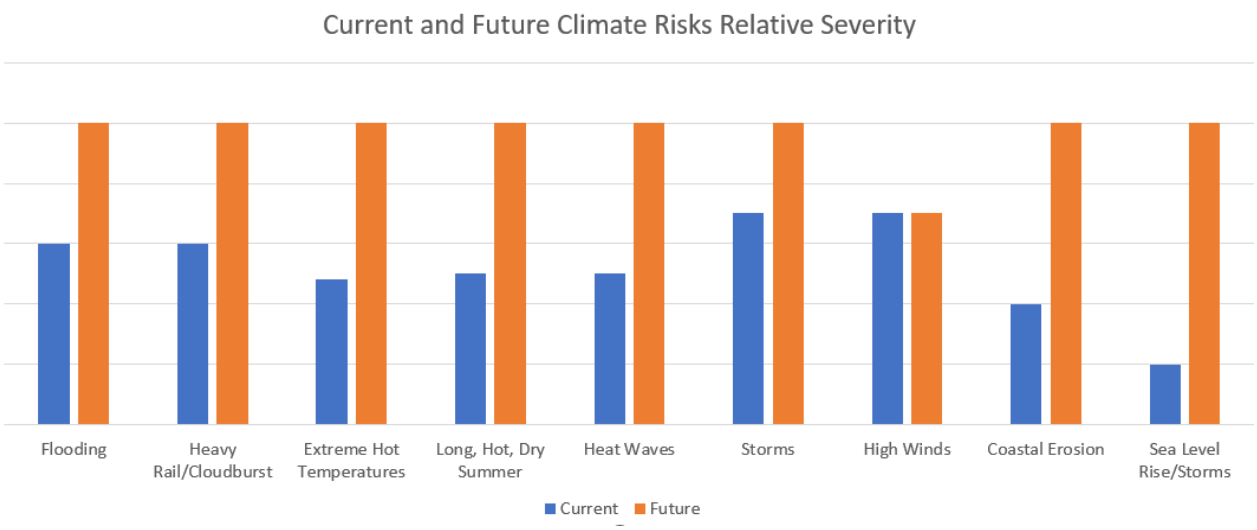


Figure 23 Current and Future Risks Relative Severity

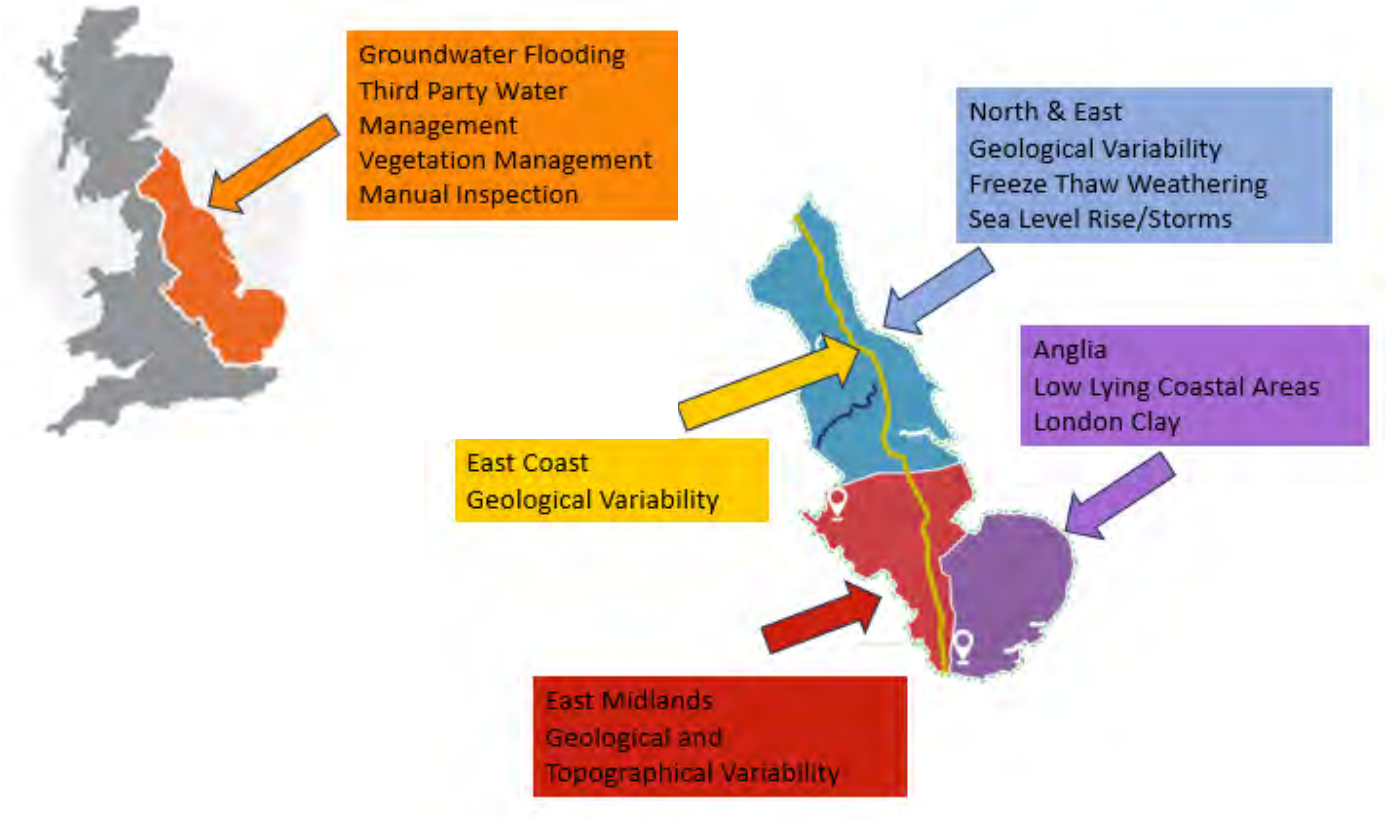


Figure 24 Eastern Regional and Route Risks

3.6 Managing residual risk

As in other industries with large asset bases and long operational lives, the investment profile for asset renewals is not always smooth. In making trade-offs across our asset base, renewals investment has been targeted to the most vulnerable assets, with workbanks transitioning from full renewals to a blend of full renewals and life extending interventions.

Across all Regions, there will be a lower volume of asset renewals and a greater proportion of refurbishment and maintenance volumes to mitigate decline in asset condition. This will result in more reactive and unplanned interventions on existing assets.

From a weather and climate resilience perspective, our plans include where resilience can be accrued as a secondary benefit when intervening on assets, as well as a few specific pure resilience schemes driven by known weather and climate-related challenges e.g., scour protection on our bridges at risk from high river flows. We expect it to become increasingly challenging to keep pace with the frequency and intensity of extreme weather events which will be a significant factor in future control period planning.

Residual risk associated with this approach will be mitigated by applying more targeted refurbishment and maintenance interventions, with activities focussed on maintaining levels of safety and reliability. We'll expand the use of remote monitoring (e.g., tilt meters and water telemetry), surveying techniques (e.g., helicopter, lidar and train-borne CCTV) and we'll improve our forecasting capabilities to manage residual weather and climate-related risks (e.g., development of the new national forecasting platform – ROWS).

Enabling activities are planned for CP7 that will help us better understand and measure the risks associated with climate change on our infrastructure, for example, improvements to how we undertake climate risk assessments and development of longer-term adaptation pathways for the locations where a more transformational approach to managing climate-related risks will be likely required.

Combined, these approaches will allow us, in time, to better quantify levels of climate-related risk across our railway, and to better articulate the impact of our weather and climate-related resilience interventions on addressing those risks.

3.7 Interdependencies and their impact

The Network Rail Eastern Region WRCCA (Weather Resilience and Climate Change Adaptation) plan is a multifaceted strategy that extends its influence and interdependencies to various interfaces within the railway network. These interdependencies are integral to ensuring the smooth operation of the railway system, minimising disruptions, and enhancing the overall resilience and reliability of services.

Figure 25 shows the interdependencies graphically mapped that was produced for the Network Rail 3rd Adaptation Report.

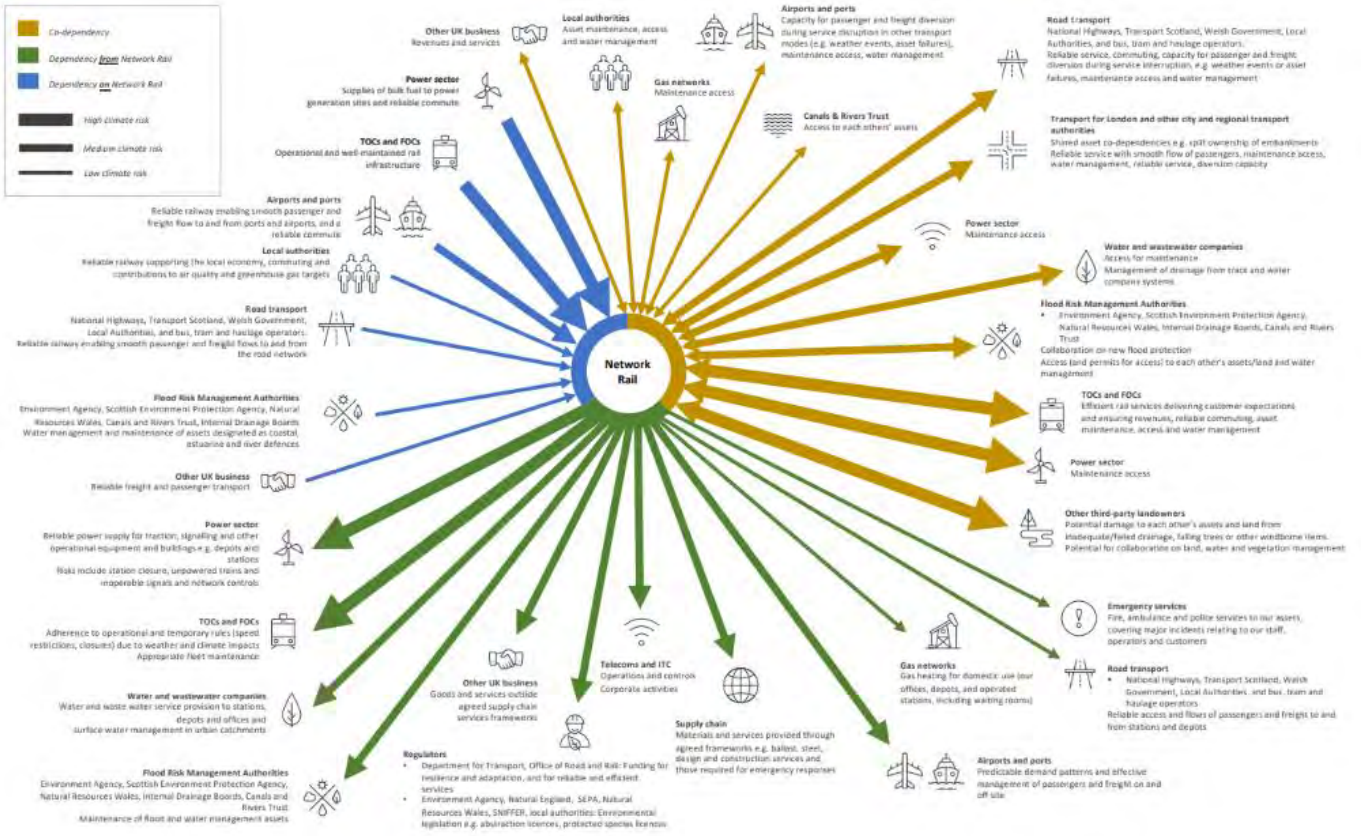


Figure 25: Interdependencies Map

The Eastern Region CP7 WRCCA plan will have an impact on various interdependencies, these include but are not limited to train paths cross from other Regions into Eastern and within Eastern between its four Routes:

- Anglia carries freight flows to and from three major UK ports, Tilbury, Felixstowe and Harwich, cross through the Route to and from other destinations in the country. Passengers to and from Stanstead and Southend airports are served by Anglia. The Route brings commuters into London's Fenchurch Station and Liverpool Street Station. There is an interface with London Underground and the Elizabeth Line which connects passengers to East London, Canary Wharf, Heathrow and west to Reading.
- East Coast is an intensively used, mixed purpose Route that provides freight, commuter, regional and long-distance high-speed connectivity along the East Coast between London and Edinburgh. It includes the East Coast Mainline, which bisects the East Midlands and North and East routes, connecting key cities in the Midlands and North with the capitals of England and Scotland. The Route includes rail hubs such as Peterborough, Doncaster, York, Darlington and Newcastle. There is an interface with London Underground at Kings Cross Station.
- East Midlands brings commuters into London and contains the major economic hubs of Derby, Nottingham and Leicester. Its key route is the Midland Mainline which connects London St Pancras with Nottingham and Sheffield. It serves North London

with a high frequency metro style service. Through East Midlands Parkway it provides links to the region's airport.

- North and East serves key Northern destinations including Sheffield, Leeds, Hull and Bradford. It provides vital inter-city connectivity across the Pennines and to the North East of England. It's path also provides links to the west and the major airport at Manchester.

Our passengers and freight operators rely on a reliable and uninterrupted service between the various service providers and, therefore, our response to weather events and plans for a resilient railway network must align.

Third party assets may also be directly impacted by the resilience of the railway infrastructure. Drainage infrastructure which is either in poor condition or not of insufficient capacity can lead to flooding issues for Network Rail and its neighbours. In addition, where third party flood protection and drainage systems are not maintained that can impact our network. Some recent earthwork failures have been the result of drainage on neighbouring land not working effectively.

There are numerous examples of where asset independences have become apparent in CP6. For example, at Haddiscoe, in our Anglia Route, the track bed was seriously affected when flood waters overcame EA flood defences, recently at Baildon, drainage on a neighbouring property caused an earthwork to fail closing the line.

Many utilities have assets adjacent to our network and working together is essential to ensure all are protected in extreme weather conditions. Close relationships with power companies are critical when power supplies may be affected by weather so we can manage disruption and keep our passengers informed.

On the rail network, track and earthworks rely heavily on drainage assets and signalling and electrification and plant assets rely on the buildings team to keep their assets dry and protected. Resilience needs to be considered and applied with the railway system in mind to ensure fixing one issue in isolation doesn't create another.

4. CP7 WRCCA Strategy and Investment Plan

4.1 Approach to Climate Resilience

4.1.1 Eastern Overview

Background

As discussed above CP7 will have a greater balance of refurbishment activities over renewals, so we are investing less in standalone resilience schemes.

For assets being replaced or refurbished, weather resilience will be incorporated in the design. The focus on refurbishment will not increase resilience across all our assets, but we aim to maximise resilience within affordability bounds.

General Approach

Our hierarchy of design is to consider in the following order:
1. Remove the event
2. Reduce the risk
3. Mitigate the impact
4. Recover from the risk

Where it is not cost beneficial to remove the event or substantially reduce risk, we will incorporate mitigation and recovery to minimise impacts, rather than full scale prevention.

System Thinking

We are taking a strategic management approach and moving to whole system thinking in CP7, and processes and strategies to support this initiative are in development. We will look at how our assets interact with others and how system solutions can support our goals.

We are developing integrated management plans that consider the needs of multiple asset groups, and that are prioritised to support our safety and operational objectives. For high-risk earthwork sites such as at tunnel portal cutting slopes, we will develop integrated asset management plans, agreed by asset managers in Drainage, Track, Geotech and (where required) Structures to agree the frequency and scope of pro-active drainage inspection and maintenance. Later in CP7 we will further enhance these maintenance plans to include vegetation maintenance and the medium-and long-term Cap-Ex interventions required to manage safety and performance on these sites.
For lower risk earthwork sites, a more generic approach will be developed, based on an agreed matrix, and supplemented by find and fix drainage management, and standard vegetation management practice.

Adaptation Pathways

During CP7, we will use adaptation pathway methodology to develop long term adaptation pathway investment plans, initially to sites subject to tidal flooding or coastal processes. This planning method allows the uncertainty and challenges of climate change to be covered in our decision-making by considering multiple possible futures. We can use it to build solutions today that will not inhibit future needs and allow us to understand the required timelines for

when we need to act, particularly useful for bigger issues that may appear a long way into the future, or where we rely on flood or coastal erosion protection from the Environment Agency, Local Authorities, Internal Drainage Boards or other third parties.

We are including £1m per annum for modelling and adaptation pathways planning, to continue building intelligence of vulnerable sites and grow our capabilities for managing and responding to weather events.

Seasonal Preparedness

We will continue our improving trend in reducing seasonal failures by early deployment of our seasonal delivery strategies, supported by integrated management plans.

Lord Mair and Dame Slingo

We have included £94m operational expenditure to support actions recommended in the Lord Robert Mair report, including better inspections and management of drainage performance, to improve our operational planning such as inclusions for operational management during hot weather and for vegetation management.
Our region has made progress in response to the Lord Mair and Dame Slingo findings. We will continue to implement and track progress against those recommendations through the Weather Risk Taskforce.

Following the learning from the tragic derailment at Carmont in 2020, Eastern Region have established an engineering focused 'improvement' team to lead regional and route response to the actions.

Central to this team's activity will be driving regional action plans and the management and closure of recommendations following assurance. These recommendations cut across engineering, health and safety, operations and our delivery functions (work delivery, capital delivery and direct delivery). Areas of particular focus will be;

- the development of a risk-based drainage inspection and maintenance regime based on the requirements of Drainage, Geotech, Track & Structures
- the closure of projects, ensuring Health and Safety files are collated for all completed works, and that assets are appropriately managed and maintained after being constructed.

The team will be the primary point of contact with the Weather Resilience Task Force and includes hot weather actions across all asset types.

Knowledge

In CP7 Eastern will focus on building intelligence of our asset base and its vulnerability to weather. Further work will be delivered in CP7 to better understand flood and sea level rise risk, through analysis of a nationally developed catchment mapping project, and flood risk mapping data which will be available late in CP6. These data will form a foundation upon which we can develop operational plans to improve safety in the short term, and to begin to develop adaptation pathways.

Technology

Key technology deployments for understanding risk and targeting intervention, deployed in CP6, will continue into CP7 including:

- Hubble for vegetation incursion detection [to be replaced by DLI when developed and deployed, expected late CP6].
- Drone surveys for tree, and for detecting hot electrical assets, a precursor to failure.
- The use of train-borne CCTV to replace on foot inspections, and to feed Hubble/DLI.
- Remote temperature monitoring for rail temperature measurement.
- Use of Railhead Treatment Train for managing adhesion from autumnal leaf fall.
- Intelligent Infrastructure for monitoring track circuits and other electronic systems.

Metrics

We will continue to develop leading metrics and regional wide tracking of action and outcomes.

Our approach to managing the various types of climate risks is shown in the table below.

Climate Risk	Approach
Flooding	We are actively engaging with third parties to deliver collaborative opportunities; working together to achieve better outcomes.
	We have an established working group with the Environment Agency and will continue to jointly review both our lists of issues to identify opportunities for combined joint solutions.
	Working with neighbours and local stakeholders, we will mitigate impacts such as encroaching trees and third-party drainage issues.
	Full and partial resignalling is designed to increase resilience to flooding.
Heavy Rain/Cloudburst	Much of the drainage workbank is for drainage pipe renewals and refurbishment, providing around 200 km of improved drainage pipes across the region. This will significantly improve drainage performance to reduce flood risk to track.
	We have deployed CAT to mitigate the risk of convective rainfall on the operational route sections considered to be at highest risk during this type of weather event.
	We are investing to protect bridge structures from scour.
	In late CP6 we launched risk-based inspection and maintenance of drainage assets, with proactive maintenance, and enhanced inspection undertaken on higher risk sites, this focuses on the safe management of crest drains and other drainage features with the potential to lead to safety incidents. This will be refined in early CP7 as our asset knowledge improves.

Extreme Hot Temperatures	Track renewals will improve our resilience to Extreme Hot Temperatures
	Plain Line track renewals and switch and crossing renewals will provide increased resistance to Extreme Hot Temperatures.
	Full and partial resignalling is designed to increase resilience to heat.
	We will be better prepared for high summer temperatures through more pro-active maintenance work to ensure the track asset is free of defects that increase the risk of track buckles before summer arrives.
Long, Hot, Dry Summer Heat Waves	All earthworks investment provides increased resilience to earth movement caused by varying moisture content and temperature impacts. Where possible, we will aim for full length earthworks renewals, rather than targeted to a specific area.
	We are developing operational plans to manage the impact of desiccation on clay and peat embankments more effectively. We are developing This includes triggers that link Soil Moisture Deficit (SMD) to the onset of track geometry problems, therefore allowing us to intervene before we impact customers.
Storms	Our management plans will link to operational plans, supported by the new weather management tools. These operational plans will, allow us to deploy staff to site in receipt of weather forecast information to proactively inspect and clear drainage systems so they are ready for the arrival of adverse or severe weather, and during weather events if known pinch points need attention.
	These pinch points will be monitored with RCM equipment capable of detecting and reporting water levels, and with CCTV so that blockages can be identified remotely, and staff deployed to clear.
High Winds	Allowances are included in contact systems for OLE upgrades in areas susceptible to wind.
Snow/Ice	We are not focus on specific activities associated with fog and snow as they have lower impacts on the operation of the railway.
	Allowances are included in contact systems for OLE upgrades in areas within tunnels susceptible to ice.
	In distribution and plant there are provisions for work to install point heating and to protect switchgear.
Coastal Erosion Sea Level Rise/Storms	Use adaptation pathway methodology to develop long term adaptation pathway investment plans, initially to sites subject to tidal flooding or coastal processes.

Figure 26: Weather risk management approach

To conclude, Eastern region will develop more effective approaches to manage weather and climate-related risks to the railway as a whole system, supporting colleagues across track, signalling and geotechnical asset management teams, and operations teams, with data, tools and analytics to consider an integrated risk approach.

The following table summarises the principles we will follow to achieve our outcomes.

CP7 Outcomes					
Principle	**Safety**	**Sustainability**	**Performance**	**Innovation**	**Efficiency**
Whole life cost	Where affordable, interventions should consider full asset life cost with optimum split between OPEX and CAPEX.				
Risk management	Risks to the business from vulnerable assets will be quantified and understood, particular focus on flooding.				
Resilience and adaptation	Works carried in CP7 consider the impact of future weather data and risk to our railway by changes in climate.				
Sustainability, energy & carbon	Use less energy in CP7 and produce less CO_2 working towards our long-term net zero ambition.				
Mitigation	Where interventions for resilience are not possible consider additional requirements for speedy recovery.				
High integrity asset information	Simplified and accurate source of data to manage our asset.				
Efficient inspection & maintenance plans	Ensure our assets are maintained in the best state of preparation for forecast weather events.				
Innovation	Embrace new ways of working to achieve a greater value from modelling and asset interventions.				
People & culture	Everyone understands they have a role to play in delivering resilient assets. Collaboration is key to delivering success.				
OPEX vs CAPEX	Maximising third-party collaborating opportunity IE EA on flooding hotspots.				
Accountability	The Region plays a coordination and support role for the routes and the routes have full autonmoy on their plans and activities.				

Figure 27: CP7 Planning Principles for Weather Resilience

4.1.2 Weather Resilience & Levers

Our weather resilience activity has been mapped against the 11 weather resilience levers for earthworks and drainage that came from Earthworks and Drainage Weather Resilience Targeted Assurance Review 25 May 2021.

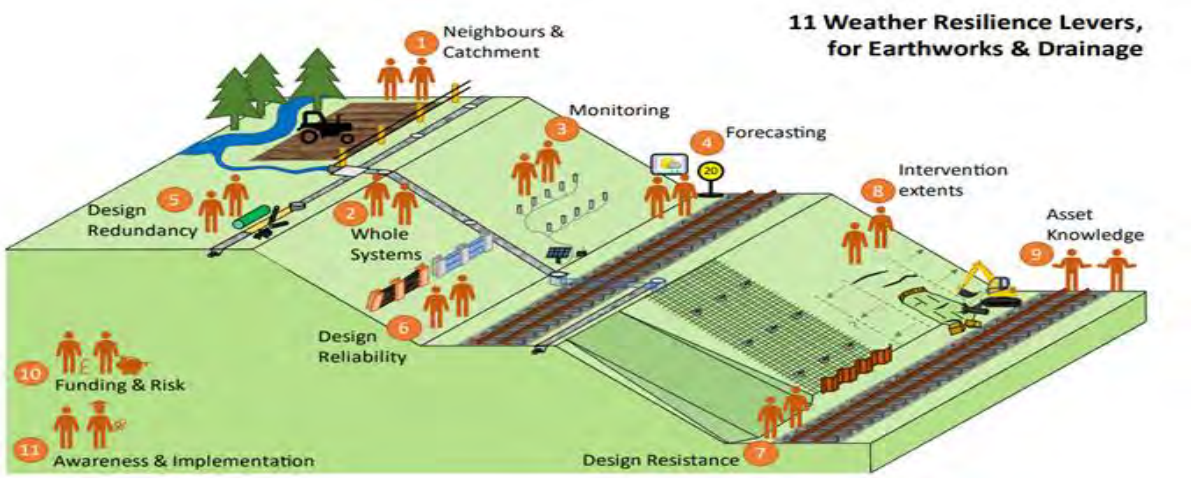


Figure 28: Weather resilience levers for earthworks and drainage

The table below summarises the resilience that has been provided during CP6 across the four routes, full details can be found in Appendix C:

Weather Resilience Levers	Regional overview of Route Activity
Neighbours and Catchments	• Management of vegetation • Working with third parties on flood management
Monitoring	• Geotechnic Alert & Alarm systems e.g., tiltmeters and inclinometers • Real-time/remote monitoring of water levels including CCTV • Train-borne systems e.g., Digital Lineside Inspection, Hubble • RCM for signal cabling • Anemometers to understand wind speed patterns
Asset Knowledge	• Improved drainage knowledge - survey, inspection & analysis • Earthwork management plans developed where necessary. • Identified earthworks at risk of desiccation
Awareness & Implementation	• Improved first responder flood guidance/training • Improved reporting & management of track assets during hot weather • Better and more accessible drainage system information • More site-specific flood management plans & standard operating procedures • Desktop flood incident/risk reviews • Development of a strategy for use of remote monitoring • Best practice sharing across the organisation.

	• Relocation of critical equipment • Closer working between operational control & maintenance teams
Asset Reliability & Resistance Improvements	• Flooding protection & resilience works • Vegetation removal to reduce desiccation • Crest drain refurbishing • Rock netting installation • Scour protection • Landslip mitigation works • Removal of jointed track & timber layouts, & high-speed timber S&C • OLE Resilience refurbishments • Overheating protection measures for electronic cabling & equipment • Heating to negate cold weather impact points

Figure 29: CP6 activity against weather resilience levers

4.1.3 Adaptation Pathways planning

Even when assets are in good condition, expert experience in the UK and abroad indicates that it is not necessarily an indication of future resilience. Adaptation Pathways planning is global best practice as it supports strategic, flexible and structured decision-making.

Adaptation pathways planning is an approach that will help Eastern plan, prioritise and phase investment over the longer term to provide resilience to climate change. It considers adaptation options with trigger points and thresholds which can be used to identify when decisions need to be made and actions taken, helping to develop long term, time bound, adaptable investment plans. An allocation of £1m per annum has been identified to commence the application of this approach to our vulnerable high-risk locations. The outputs of this work will build our long-term resilience plans for CP8 and beyond.

Adaptation pathways are a sequence of adaptation investments or policy actions that work coherently to achieve resilience efficiently and affordably over time. The pathways approach supports strategic, flexible, and structured decision-making. It allows decision makers to plan for, prioritise and stagger investment in adaptation options with trigger points and thresholds helping to identify when to revisit decisions or actions.

The methodology for undertaking the adaptation pathways work in Network Rail is in development building on the lessons learned during the pilot project undertaken in Southern in 2023. A multicriteria screening will be undertaken of all operational route sections of the rail network to identify those at highest risk from extreme weather and climate change. The outputs of this prioritisation work will be reviewed by asset managers and combined with their understanding of where the highest risk lies prior to shortlisting locations to go through a rapid adaptation pathways assessment. This will be a high-level review of the key risks and adaptation options for a particular location. Those areas deemed to be highest priority from a risk/criticality perspective will be put forward for a detailed adaptation pathways assessment with modelling of adaptation solutions.

This approach enables Eastern to take adaptation actions at the right time, minimising the risk of acting too early, investing in resilience measures before they are required, or too late, resulting in costly delays and works to recover damaged assets, before upgrade or abandonment.
The output of the adaptation pathways work will be detailed understanding of where and when investment will be required in the railway setting out the pathways for achieving the strategic objective.

The approach asks-two questions:

1. Are there climate change impacts that render current assets or services inefficient, ineffective, unsafe, or redundant (i.e. the climate change relevant thresholds beyond which things to do not work)?
2. At these thresholds, what are the best options for enabling the Region to continue to meet its objectives?

By repeatedly-answering these questions at different levels of climate impact, sequences of actions or "pathways" can be constructed that will keep Eastern on track to deliver their objectives through the long-term within the available funding.

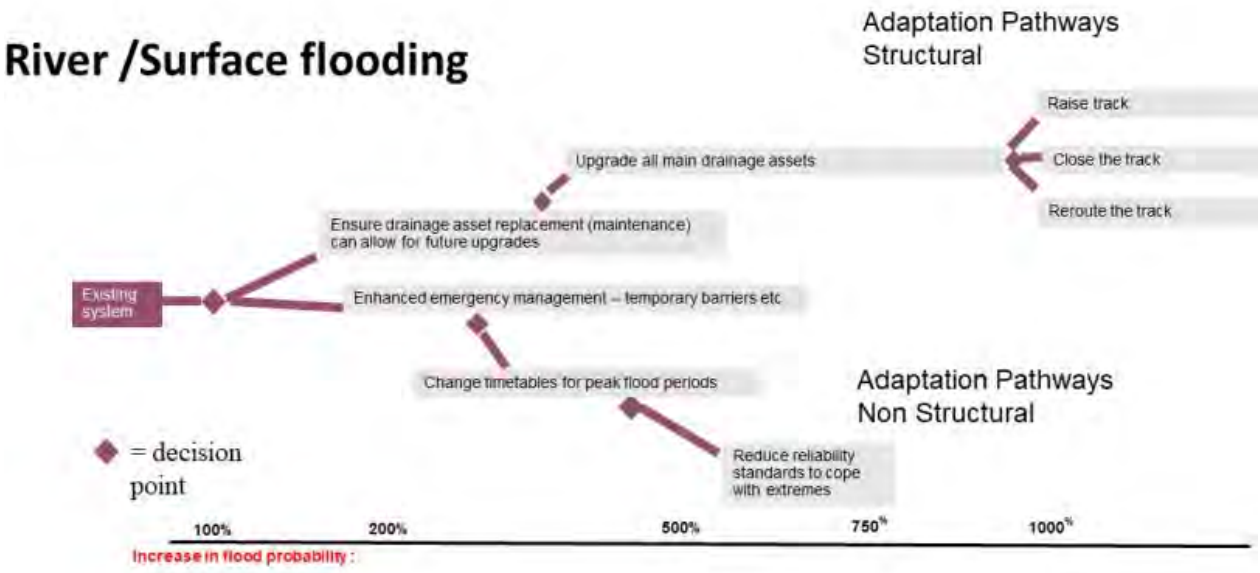


Figure 30: Example of Adaptation Pathways

Alongside this work we will continue to collaborate with neighbours and stakeholders to look at how we tie in the broader system perspective and how we can work together to build resilience across organisations, communities, and industries. We are already exploring with the Environment Agency common risks and opportunities and have started conversations with National Highways to consider risks to structures from flooding. In the future we will engage with regional development agencies and administrations and Government Departments.

To support this work. we will procure new datasets and the support of consultants to help quantify current and future climate risk to set timescales for decision making. Pathway development and implementation progress will be measured and reported at regular intervals.

4.2 - Financial Investment Plans

4.2.1 Accounting for Benefits

The Technical Authority has led a piece of work to better understand the resilience benefit of business-as-usual investment in asset management. Working with experts across regions, Technical Heads of asset engineering teams and the Cost and Volumes team in Finance, a review of the key volume lines (KVL) within the CP7 workbanks was undertaken to determine the investment giving resilience benefit of each activity within our workbanks. This analysis includes activities where weather resilience is a primary or secondary benefit of the maintenance or renewals defined as follows:

Primary benefit	Secondary benefit
• Pure resilience schemes - these are activities that are being undertaken solely for the purpose of improving our network's resilience to extreme weather. • Business as usual asset schemes with resilience - these are activities which are driven by poor asset condition as well as weather condition challenges so undertaking this work delivers an improvement in asset condition and a clear improvement in weather resilience (i.e. a primary benefit of the work is improved resilience to extreme weather).	• Activities where there may be a secondary weather resilience benefit but this has yet to be determined (i.e. design work for this project has not been undertaken but it could be the case that when we undertake further design of the project, we include some changes to the asset which improve its resilience to extreme weather). Activities where just by the nature of doing a renewal, makes the asset more resilient (e.g. modern standards are more resilient than asset is designed to).

4.2.2 Investment Plan

An overview of the total investment for CP7 can be seen in Figure 31. This shows that in total, 35 % of the investment in renewals will give some form of resilience to weather giving us a more reliable railway under varying weather conditions. The proportions vary across the routes with East Coast showing higher proportions due to the additional resilience benefits of moving to a digital signalling system.

£m	Total Renewals Investment in CP7	Primary Benefit	Secondary Benefit	Weather Resilience investment	No benefit to Weather	% WR investment of total plan
Anglia	1,099	104	272	376	723	34 %
East Coast	1,288	102	380	482	806	37 %
East Midlands	779	107	159	266	513	34 %
North and East	950	92	204	296	654	31 %
Regional	5	5	0	5	0	
Total	4,121	410	1,015	1,425	2,696	34 %

Figure 31: Table showing investment proportions for 2024 – 2029 by route

This is further broken down below, in tables summarising by asset type the spending predicted in CP7 on asset renewals and refurbishments, which will contribute to and improve the Weather and Climate Resilience of the Network Rail Eastern Region Asset Base. For each Asset Category, we have focused on the 'Big Ticket' items and combined the smaller work items into a miscellaneous category.

The investment focuses on essential components and maintenance to ensure the reliability and robustness of the railway network in the face of adverse weather conditions.

In addition to the Financial Investment Plans, that purely detail the spend planned for each work type, we have also included the CP7 Action Tracker in Appendix E. This details for each Asset Class:

- Actions Information
- Action Target
- Delivery Years
- Climate Adaptation
- Resilience resultant from the action
- Risks addressed
- Monitoring regime
- Linked Levers.

This should aid in the reasoning behind spend items and provide greater context around the targets set for CP7. As opposed to just money spent, it helps us to understand what work is being done, with targets set for work units.

The first table shows the amount of funding planned for CP7 to improve weather and climate resilience across the various work types. Total spend across all work types amounted to £410m when considering the primary driver only. Due to the needs and nature of the various work types, there was a significant range in spend planned across the Eastern Region, with Earthworks giving the highest primary benefit at £179m and Telecoms the lowest at £3m.

Work Type	Sum of Primary benefit £m	Sum of Secondary benefit £m	Total Weather Resilience benefit £m	Spend Rank
Track	£14m	£872m	£886m	1
Earthworks	£179m	£12m	£191m	2
Contact Systems	£88m	£45m	£133m	3
Drainage	£87m	£34m	£121m	4
Signalling & LX	£23m	£58m	£81m	5
Structures	£9m	£6m	£15m	6
Distribution & Plant	£4m	£1m	£5m	7
Lineside	£3m	£1m	£4m	8
Telecoms	£2m	£1m	£3m	8
Buildings	tbc	tbc	tbc	
Total Spend	£409m	£10230m	£1,439m	

Figure 32: CP7 Expenditure delivering weather resilience benefit across work types

Track

Our risk assessment highlighted that track assets are particularly vulnerable to temperature. The impact of extreme high temperatures causes track buckles and requires speed restrictions to be applied to manage the risk. Track buckles have been assessed as a moderate risk now moving to a severe risk by the 2080s. In combination with moisture levels a further impact can be earth movements around the track such as desiccation which can destabilise the track resulting in poor track quality. This risk rises from the current Moderate to Major by the 2080s. Both of these risks require speed restrictions to be applied to manage the risk. This risk will reduce across some of our assets as it is planned that we will have removed jointed track by this time which has low resilience to temperature above 38 degrees.

Where assets are renewed the design standards will give some improved resilience for weather and for heat.

£28m of investment will be spent renewing 20km of waybeam and longitudinal timber bearer which are particularly sensitive to movement in hot weather conditions so improving resilience in heatwaves.

Secondary benefit from improved standards will be gained from plain line track renewal and refurbishment activities over 600km of track which covers 3 % of the overall network in Eastern. A further £334m will be invested in refurbishing or renewing switch and crossings across the network. Both of these give improved resilience in hot weather.

Track	Sum of Primary cost	Sum of Secondary cost	Total
Plain line interventions		£524m	£524m
Switch and Crossings renewal and refurbishment		£334m	£334m
Longitudinal timbers replacement	£14m-	£14m	£28m
	£14m	£872m	£886m

Figure 33: Track CP7 expenditure delivering weather resilience benefit

Earthworks

Earthworks spend provides the second greatest contribution, in the Eastern Region for weather and climate resilience and provides the largest primary benefit.

Extreme heat causes clay shrinkage of embankments resulting in deterioration of track geometry and subsequently performance impacts. Repeated periods of hot dry weather lead to drying of soils and shrinkage as part of cyclical processes such as seasonal shrink/swell in tandem with seasonal wetting. This can cause degradation and failures with other age driven processes. This risk is currently classed as major and is expected to move to severe by 2080.

Increasing storm frequency and heavy rainfall leads to long-term degradation as surface water, scour and groundwater lead to asset failure with little or no precursor to the failure. These events can cause serious safety concerns and significant performance impacts.

Prolonged periods of wet weather increase the likelihood of asset failure as the ground becomes saturated. Every asset will have a limit of resistance to saturation as most are greater than 150 years old which leaves a significant residual risk that needs to be managed through monitoring and response processes.

To manage the residual risk, we have an earthwork evaluation programme which is the business process during which threats and consequences are considered holistically and management strategies including interventions and mitigations determined and implemented.

The work, at 4820 locations, is due to take place over CP7 and will involve Maintenance, Refurbishment, Renewal and Monitoring of Embankments and Rock and Soil cuttings. In addition to these physical works, and as part of the miscellaneous spend, there will be increased assessment activity that will see benefits going forward in how best to mitigate the effects of weather and climate.

The earthworks interventions provide resilience during high rainfall or flooding events and for against desiccation due to hot weather. In addition, it will, address the risks of earthwork failures, improving both safety and performance through preventing landslips obstructing the line or leading to loss of support, and reducing the requirement for increased track maintenance and speed restrictions.

Earthworks	Sum of Primary cost	Sum of Secondary cost	Total
EW-Embankments	£114m	£7m-	£121m
EW-Soil Cuttings	£38m	£4m-	£42m
EW-Rock Cuttings)	£26m	£1m	£27m
TOTAL SUM	£179m	£12m	£191m

Figure 34: Earthworks CP7 expenditure delivering weather resilience benefit

Contact Systems

Contact systems will make up a large part of the CP7 spend for the Eastern Region (ranked 4th). Assets such as overhead lines are especially vulnerable to changes in climate both in temperature and wind. There is a major risk of losing tension on overhead wires as they start to sag above 38 degrees, and tensioning weights have no further downward movement capacity. This risk is expected to remain a major risk over the next 20 years and work will continue to monitor balance weights and find additional solutions. The mitigation action to manage the residual risk across the network is to apply speed restrictions to manage the risk under days of extreme heat.

Both renewal and refurbishment to lines will be carried out to ensure safety of passengers and compliance with regulations. Additionally, these mid-life refurbishment activities will extend the asset life for greater long-term reliability in high temperatures, despite changes in weather and climate.

We see a moderate risk to overhead line from storms and high winds and expect storms to become more severe and frequent. Although the amount of OLE equipment will rise, we expect that modern designs will be more resilient and counteract any increase in this risk. The

refurbishment planned will reduced the risk of train disruption due to OLE failures in storm conditions and reducing risk to public safety from dewirements in station areas. The work is due to take place over the duration of CP7. Work is to be carried out at 766 locations.

Contact Systems	Sum of Primary cost	Sum of Secondary cost	Total
Overhead line Refurbishment	£32m	£32m	£64m
Headspans Resilience	£31m	£6m	£37m
OLE-Structure Renewal (E)	£24m	£8m	£32m
Tensioning Equipment	£2m		£2m
TOTAL SUM	£89m	£46m	£135m

Figure 35: Contact Systems CP7 expenditure delivering weather resilience benefit

Drainage

The major risk to drainage is from heavy rain and cloudbursts and with the frequency of storms increasing due to climate change the future risk is expected to rise by 2080. Current design capacities will be exceeded faster than we can upgrade the capacity across the entire network of drainage assets.

Drainage and water management are essential to the safe and economic management of railway infrastructure across the Eastern Region and has an increasingly important role to play in helping deliver the timetable for our customers. Effective management of water reduces risk to trains and people, makes the timetable more resilient to adverse and extreme weather, helps extend the life of parent assets (track, earthworks, structures and signalling equipment) and makes us a better neighbour.

Our programme of work for CP7 features a wide range of interventions across the Region such as major collaborative flood alleviation schemes, renewals and refurbishments of existing drainage systems (to restore and improve capacity) and capacity enhancement schemes to address emerging risks.

There is a residual risk that we are still understanding the assets we own, their condition, criticality and interdependencies with other flood defences. Asset investigations will grow our knowledge in the assets and their future risk and working alongside third parties such as the Environment Agency and Local Authorities will help find collaborative and integrated solutions.

Drainage	Sum of Primary cost	Sum of Secondary cost	Total
Renew \ Refurbish Track Drainage	£61m	£23m	£84m
Renew \ Refurbish Earthworks Drainage:	£2m	£1m	£3m

Drainage Resilience	£23m	£10m	£33m
TOTAL SUM	£86m	£34m	£120m

Figure 36: Drainage CP7 expenditure delivering weather resilience benefit

Signalling

One of our most significant risks to signalling is extreme temperatures which causes components housed within the location cases to overheat This is something that already can cause significant delay minutes and is expected to move from moderate to major by 2080. Impacts from sun glare impacting visibility of signals will reduce significantly with the installation of digital signalling which will replace current physical signals through the delivery of the long-term deployment plan.

Eastern is investing in Digital signalling in CP7, which by removing the need for lineside signalling, eradicates a significant amount of risk from wind, heat and floods, hence enhancing the resilience to climate change. We will be installing digital signalling on the East Coast Mainline. Schemes in East Midlands and Anglia will be delivered in the following control period 2029 – 2034. There will be residual risk in our signalling assets until the network is fully moved over to digital signalling.

In addition, components associated with signalling have a higher likelihood of being affected by adverse climate events, such as flooding and drainage issues due to their electronic nature.

Risks that will be reduced through this work include prevention of accidents and delays due to signals from visibility and reliability issues, including risk of obscuration from vegetation growth, risk of overheating assets in high temperatures and risk of failure from assets flooding.

The work is due to take place over the last 2 years of CP7. Work carried out is to include 194 SEUs (Signalling Equivalent Units). This includes the East Coast Digital Signalling Programme, including design, new control systems and recovery of lineside signals upgrades.

Figure 37: Signalling CP7 expenditure delivering weather resilience benefit

Signalling	Sum of Primary cost	Sum of Secondary cost	Total
Digital Signalling	£9m	£24m	£33m
Refurbishment	£11m	£25m	£36m
TOTAL SUM	£20m	£29m	£69m

Structures

The most significant weather risk to structures is due to scour effects undermining the foundations during severe flood events. Good progress was made during CP6 to physical mitigate the high-risk assets through installation of physical protection measures. Flood events are increasing in frequency and severity and continuation of this resilience workstream is key to ensuring the ongoing management of this risk. Risk of coastal erosion and defence overtopping will increase with increased frequency and intensity of Atlantic storms, combined with sea level rise this risk is seen to move from moderate to severe by 2080.

Structures as they age become increasingly more vulnerable to the impacts of weather. £9m of the investment is being spent on structures from scour due to rivers being at higher flows

in storm conditions. The rest of the investment is in strengthening structures to be more resilient and reliable.

CP7 will be used to increase understanding of risk that flood events present to retaining wall assets to support prioritisation and formation of future investment plans.

Structures	Sum of Primary cost	Sum of Secondary cost	Total
Culverts	£5m	£1m	£6m
Tunnels	£2m	£1m	£3m
Underbridge	£2m	£4m	£6m
Total	£9m	£6m	£15m

Figure 38: Structures Predicted CP7 expenditure delivering weather resilience benefit

Lineside

Eastern Region routes take a proactive approach to the management of hazardous trees, those afflicted by diseased, dying, dead or otherwise damaged. Tree risk is heightened during high winds, when even healthy trees can topple or become damaged, causing risks to passengers, third parties and railway staff. Trees can block lines and strike OLE and other railway equipment, causing significant damage. Safety and performance risks and repair costs to both railway infrastructure and to trains are the main consequence.

Risk is managed by the current vegetation management programmes, targeted at the high-risk trees, and vegetation profile, however the Varley review has highlighted improvements that form part of the Sustainable Land Use Programme. This risk is forecast to move from moderate to major by 2050 as storm intensity and frequency increases, as tree diseases progress and as the proportion of routes requiring significant vegetation management is held steady at best. Lineside management plays a critical role in the management of water flows through our drainage systems and is the major contribution to our habitat management obligations.

Lineside makes up the 4th smallest expenditure for the Eastern Region. Depending on individual locations and schemes some land management nature-based solutions will be 100% primary resilience but others may be more secondary. The development of our Integrated Vegetation and Habitat Management Plans will help to guide works to improve the biodiversity, simplify remitting for vegetation management, and provide sustainable solutions for weather resilience.

Most of the lineside risk mitigation is in vegetation management which is operational expenditure. £5.3m will be invested every year managing vegetation on the lineside.

Lineside	Sum of Primary cost	Sum of Secondary cost	Total
Land Management (L)	£3m	£1m	£4m
TOTAL SUM	£3m	£1,m	£4m

Figure 39: Lineside CP7 expenditure delivering weather resilience benefit

Distribution and Plant

There is a moderate impact from extreme heat affecting electrical equipment and degrading batteries this is expected to become a major risk by 2080 as we experience more days at higher temperatures. Lightning does have a devastating impact on electrical distribution systems but as this has a very low likelihood this is not seen as a risk that needs major investment within the available funding.

Flooding is not seen as a high risk as current typical flood levels are known and accounted for however this could rise in the future, but it is expected that drainage strategies will mitigate this.

The investment for weather resilience in Distribution and Plant is for Point heaters installation to protect from freezing and Uninterruptable Power Supplies protect against damage to the power distribution system from multiple causes and particularly heat.

Electrification	Sum of Primary cost	Sum of Secondary cost	Total
FP-Points Heaters (E)	£3m	-	£3m
UPS (Full Renewal) (E)	£1m	-	£1m
Miscellaneous	-	-	-
TOTAL SUM	£4m	£0	£4m

Figure 40 Electrification CP7 expenditure delivering weather resilience benefit

Buildings

Buildings are susceptible to a wide range of weather impacts. They are under a moderate risk from extreme heat impacting welfare and comfort of Network Rail staff and passengers in station buildings that will become a major risk over time that will need to be managed. Heat can also cause expansion on flat roofs which can cause further damage and deterioration, this risk is controlled and well managed through building assessment and management practices. Snow and ice can cause slippery conditions, and this is managed operationally with extensive gritting of platforms and walkways as needed.

There is a moderate risk that building drainage will become overwhelmed under intense rainfall leading to damage due to water entering the properties. This applies to stations and lineside buildings and experiences of flash flooding have occurred in recent years so there is a strong expectation that this will become a major risk as storm intensity increases.

Detailed contributions against buildings can only be undertaken at scheme-by-scheme level so for now the contribution is understated until more information on scheme content is available.

It is expected that for any new or modified buildings they will be built to cope with higher impacts from extreme heat and have appropriately resilient drainage systems. Platform canopies will be constructed to be more resilient to wind and snow loading, platforms to be less susceptible to impacts from temperature variations.

Currently around £3m has been clearly identified as contributing towards weather resilient but in a workbank of over £350m much more resilience contribution is expected once further analysis is undertaken as schemes are developed through the control period.

Telecommunications

Telecommunication assets suffer similar issues to electrical equipment under Distribution and Plant. Heat is the major risk factor with the impact on battery life and power supplies affected by extreme temperatures. Telecoms is to be the most minor expenditure area for the Eastern Region in CP7. Work involves the replacement of short asset-life items such as batteries and power supplies to maintain reliable communications throughout the Eastern Region.

Telecoms	Sum of Primary cost	Sum of Secondary cost	Total
Batteries (Te)	£3m	-	£3m
Miscellaneous	-	£1m	-
	£3m	£1m	£4m

Figure 41: Telecoms Predicted CP7 expenditure delivering weather resilience benefit

5. Adaption Actions and Progress

5.1 Eastern Region Progress on CP6 Actions

The Eastern Region has embarked on a journey to bolster its weather resilience and effectively adapt to the changing climate in the UK. This encompasses the Anglia, East Coast, East Midlands, and North & East railway routes, each of which has developed and implemented tailored Weather Resilience and Climate Change Adaptation Plans for Control Period 6 (CP6).

Progress has been made in the following (but not limited to) areas in the wider Eastern Region. Individual Routes are looked at in more detail separately - see Appendix F.

5.1.1 Collaborative Partnerships:

Engaging with Stakeholders*:* The Eastern Region has proactively established collaborative relationships with local stakeholders, neighbours, and third-party organisations such as the Environment Agency. For instance, the collaboration with lineside neighbours on drainage provisions, as highlighted in the case of Clayton and Rotherham station, has contributed to the reduction of flooding risks.

Water Management: Recognising the links between the railway infrastructure and the surrounding environment, the Region has adopted a holistic approach to water management. It has not only collaborated with external partners like Leeds City Council to protect railway assets, as seen in Kirkstall, but also initiated works on leaky dams and the dredging of holding ponds, as illustrated at Corby Pen Green.

5.1.2 Advanced Monitoring Systems:

Real-time Monitoring: The Eastern Region has invested in real-time monitoring systems to gain insights into how its infrastructure responds to various weather events. It has deployed an extensive network of fixed CCTV cameras to enhance its preparation and response to intense rainfall events.

Remote Condition Monitoring: The Region is embracing technology, including tiltmeters, inclinometers, and the Hubble system, to assess the condition of railway cuttings, unstable embankments, and signal sighting. These measures have provided early warning indicators and in instances where applicable will also incorporate alert and alarm systems (automated fault detection) for a more proactive response.

5.1.3 Enhanced Asset Knowledge:

Drainage Improvements: The Eastern Region has launched a targeted drainage inspection programme, leading to a more comprehensive understanding of its drainage assets. This knowledge has resulted in more effective maintenance schedules and the development of earthworks management plans, crucial for managing the railway's sustainability and resilience.

5.1.4 Operational Procedures:

Standard Operating Procedures: To mitigate the impact of weather events, the Region has established standard operating procedures for critical flood risk sites, such as Rotherham and Kirkstall. These procedures encompass proactive and reactive responses, which are efficiently managed with clear responsibilities and close collaboration between operational control and maintenance teams.

Proactive Drainage Management: A proactive campaign for drainage management near tunnel portals, set to be completed by 2024, further showcases the Region's commitment to ensuring railway resilience in the face of adverse weather conditions.

5.1.5 Infrastructure Upgrades:

Flood Risk Mitigation: The Eastern Region has addressed flood risk at numerous sites, providing local flooding resilience at locations like Garforth, Rotherham, Morley Tunnel, and Harper's Bridge. Additionally, the Region has undertaken an £8 million scheme at Hessel Foreshore to protect against landslips, a vulnerability during adverse weather.

Track and Signalling Resilience: To address issues related to heat and other weather conditions, the Region has adopted measures such as upgrading jointed track to concrete systems, replacing weather-vulnerable components, and implementing advanced signalling power cable renewal programmes.

The Eastern Region's Weather Resilience and Climate Change Adaptation Plans have demonstrated a proactive commitment to enhancing the resilience and adaptability of its railway network. By forging strong collaborative partnerships, adopting advanced monitoring technologies, improving asset knowledge, refining operational procedures, and investing in infrastructure upgrades, the Region has begun to provide a safer, more reliable, and robust railway service for both passengers and the communities it serves.

Figure 42: Progress on CP6 actions

Lever	Weather Category	Discipline	Initiative	Benefit
Neighbours & Catchment	Wind / Storms	Various	-Three yearly tree survey -Clearance and maintenance of lineside vegetation	-Improves the network's resilience to high winds and disruption from vegetation debris on the line
	Precipitation	Drainage	- Collaboration with EA and other stakeholders to find holistic water management solutions	-Solution proposed to be a cascade upgrade and a track drainage enhancement.
	Precipitation	Earthworks	-Risk based proactive management of drainage adjacent to tunnel portals	-Prevention of flooding incidents around tunnel portals
	Heat	Track	-To improve track system resilience against the impact of hot weather events, East Midlands develop and	-Increased reliability of track during warm weather conditions

Lever	Weather Category	Discipline	Initiative	Benefit
			implement a rolling 5-year plan for ballast drops at strategically key sites across the route.	
Monitoring	Various	Earthworks	Alert and Alarm systems (a form of remote condition monitoring) using tiltmeters are used to monitor the condition of railway cuttings at various sites	Increased asset information leading to more informed investment decisions
	Precipitation	Drainage	Real-time monitoring of water levels in the drainage assets helps us understand how our systems react in rainfall and when we need to intervene	Increased asset information leading to more informed investment decisions
	Precipitation	Earthworks	To monitor unstable embankments and to provide early warnings inclinometers have been installed at vulnerable locations.	Increased asset information leading to more informed investment decisions
	All	Various	The route has also explored the use of drones for remote condition monitoring, which can be particularly useful in assessing hard-to-reach or critical areas.	Increased asset information leading to more informed investment decisions
Forecasting	Precipitation	All	Remote water level monitoring equipment has been installed to improve preparation and reaction to intense rainfall events.	Remote monitoring of early weather events increase the ability to predict failures / flooding.
Design Redundancy / Resistance	Heat	Signalling	- Battery upgrades have been made to those where batteries failed during higher temperatures. - Across track assets the removal of high-speed timber switch and crossings at high speeds (75mph+) is a key to making the rail more resilient to heat.	Enhanced Resilience of Assets
Design Reliability	Heat	Various	-Temporary air-conditioning units have been installed in equipment buildings that were not resilient to higher temperatures. -Heat reflective paint has been used on assets that failed due to heat expansion.	Enhanced Resilience of Assets

Lever	Weather Category	Discipline	Initiative	Benefit
	Precipitation	Drainage	During CP6 some R&D funding was invested to review options to limit the impacts on the railways of ground water changes in underlying peat	Enhanced Resilience of Assets
	Precipitation	Earthworks	-Rock netting has been installed on chalk slopes to prevent spalling impacting railway operations.	Enhanced Resilience of Assets
Intervention Extents	All	Various	Track renewals and drainage schemes delivered together to enhance efficiency	Efficient delivery of works and enhanced resilience of assets
Asset Knowledge	Precipitation	Drainage	-Desktop studies, and comprehensive surveys have significantly improved knowledge of drainage assets, facilitating optimised maintenance schedules -There has been an extensive programme of drainage inspection and maintenance, which has identified local resilience improvements through a structured flood resilience review	This has improved the asset registers, and levels of information and data we hold on drainage asset (an ongoing data capture task that will be substantially complete in CP6).
Funding & Risk	Precipitation	Drainage	In total 25 high risk flood sites have been addressed delivering less delays to trains on the railway with a dedicated annual budget of £3.7m allocated for drainage and flood risk management	Effective Risk & incident management
	Heat and Storms	All	Known vulnerabilities and location susceptible to weather impact identified and addressed	Effective Risk & incident management
Awareness & Implementation	All	Drainage	N&E: To mitigate flood risk and reduce the severity of impacts on service, a drainage renewal programme was delivered across 25 locations with previous history. The top ten locations addressed, accumulated 79 weather related incidents between 2009 and 2022.	Enhanced Resilience of Assets

5.2 Summary of measurable, funded actions for CP7

5.2.1 Eastern Region Overview

The Network Rail Eastern Region is committed to addressing the challenges posed by extreme weather events and climate change to ensure the continued safe and reliable operation of the entire railway network within the region in CP7. By strategically investing in infrastructure upgrades, deploying monitoring technologies, and collaborating with local authorities, the CP7 plan ensures that the railway network will remain resilient in the face of extreme weather events and ongoing climate change.

Details of the plans for each of the routes can be found in Appendix G.

5.2.2 Weather Resilience Strategies

As detailed in Figure 32 in section 4.2.2 above, investments totalling £409 million will be allocated to renewals that specifically enhance weather resilience. These investments will focus on improving the region's ability to withstand various weather-related challenges.

High-risk locations will be identified and prioritised for these investments. Monitoring equipment and state-of-the-art technologies will play a crucial role in identifying and managing these high-risk areas. These technologies will provide real-time data, enabling proactive responses to weather-related threats.

Considerable secondary benefit will be gained from investment directed towards improving asset condition across a wide range of the network, including buildings and track,. Although the investment is not primarily for weather the upgrading of the assets will be critical in fortifying the entire network against adverse weather conditions.

The Network Rail Eastern Region is particularly mindful of the vulnerability of coastal lines to sea-level rise. Collaborative efforts with local authorities and adaptation pathways planning will play a significant role in preparing for long-term climate resilience in the longer term.

We will look to increase the use of nature-based solutions when undertaking resilience improvements and will collaborate with third parties to support activities undertaken outside the railway boundary (e.g., catchment-based flood management schemes). Full details from each of the routes on their individual strategic approach can be found in Appendix D – Strategy on a Page.

Enhancing Rainfall Resilience:

A substantial portion of the investment will target drainage and earthwork assets. These investments aim to mitigate flood risks and maintain the structural integrity of the railway network during heavy rainfall and poor water management.

Proactive and post-storm inspections of vegetation will continue to be a priority, particularly in areas with steep cutting slopes. Utilising specialist technology with aerial and infrared photography will identify and remove dangerous trees in a timely manner to reduce the risk of obstructions and damage during storm events.

Improving Heat Resilience:

Investments will be focused on enhancing the network's heat resilience. Strategies will include track renewals, improved signalling, and equipment cooling to withstand the challenges posed by hot weather conditions.

Addressing Cold Weather Challenges:

In preparation for cold weather challenges, a comprehensive programme will remove older rail sections susceptible to rail breaks, especially in areas with greater tonnage and known defects. Additionally, refurbishment of contact systems in tunnels will address issues caused by ice and cold weather, minimising disruptions to services.

Enhancing Wind Resilience:

Investments will be made to improve the resilience of overhead lines at critical locations. Partial refurbishments will also be carried out at hundreds of locations to mitigate wind impacts.

To further address wind-related threats, proactive and post-storm inspections of vegetation will be conducted in critical locations, especially those with steep and high cutting slopes. Specialist technology employing aerial and infrared photography will be used to identify dangerous trees, allowing for their timely removal.

Eastern Region CP7 Plans

Lever	Weather Category	Discipline	Initiative	Benefit
Neighbours & Catchment	Wind / Storms	Various	Flood management schemes delivered in partnership with the Environment Agency as per agreed funding schemes in CP7	Improves the network's resilience to heavy rainfall and storms.
	Precipitation	Drainage	-Research & partnership working with third party landowners in respect of Crest drainage and flood water behaviours	Solution proposed to be a cascade upgrade and a track drainage enhancement.
Whole Systems	Wind	Track	Improving resilience of the overhead lines through 17 stations and partial refurbishments at a further 400 locations will also give some protection against wind impacts.	Improves the network's resilience to high winds and disruption from vegetation debris on the line
	Precipitation	Earthworks	Across earthworks, £2m has been allocated on continuing to build our asset knowledge and assessment of high-risk areas	Prevention of flooding incidents around tunnel portals

Lever	Weather Category	Discipline	Initiative	Benefit
Monitoring	Wind / Storms	Vegetation	-Specialist technology which uses aerial and infrared photography is used to identify dangerous trees allowing timely removal in preparation for stronger wind.	Increased asset information leading to more informed investment decisions
			Completion of vegetation asset management surveys twice per control period	Increased asset information leading to more informed investment decisions
			Hazardous tree survey completed & managed as part of risk-based regime.	Increased asset information leading to more informed investment decisions
	Precipitation	Earthworks	Earthworks RCM to be linked to live control	Increased asset information leading to more informed investment decisions
	Heat	Earthworks	This is usually not a highly monitored risk, however given the unexpected high temperatures in 2022, desiccation going forward will be a much more prevalent risk as further drought like conditions are likely to be experienced from 2023 onwards.	Increased asset information leading to more informed investment decisions
Forecasting	Various	All	investment in monitoring equipment, growing asset intelligence, and growing knowledge of long-term vulnerabilities across the Anglia route.	Remote monitoring of early weather events increases the ability to predict failures / long term vulnerabilities
Design Redundancy / Resistance	All	All	Ensure modern standards & design use in planning	Enhanced Resilience of Assets
			There is a further £1bn of secondary benefits and together with the primary drivers over 30 % of the 2024 – 2029 plan will provide risk mitigation to weather events. Resilience to heat, cold and wind will be maintained at current levels with some marginal improvements for hot	Enhanced resilience of Assets

Lever	Weather Category	Discipline	Initiative	Benefit
			weather due to track investment.	
			Build climate change into design / planning processes	Enhanced Resilience of Assets
Design Reliability	Heat	Various	Renewal of timber S&C layouts, as well as track, to accommodate rising temperatures.	Enhanced Resilience of Assets
	Precipitation	Drainage	Earthworks and drainage provide resilience against rainfall events and action will be targeted at those which have the highest risk.	Enhanced Resilience of Assets
	Various	Earthworks	Earthwork improvements will be provided at 75 sites with resilience improved at 59 embankments, 2 rock cuttings and 14 soil cuttings.	Enhanced Resilience of Assets
Intervention Extents	All	Various	Track renewals and drainage schemes delivered together to aid in efficiencies.	Efficient delivery of works and enhanced resilience of assets
Asset Knowledge	Precipitation	Drainage	Modelling and level monitoring in drainage assets	Remote monitoring of early weather events increases the ability to predict failures / long term vulnerabilities
	All	All	Currently, at the level of investment in standalone climate improvements it is unlikely our resilience will keep pace with climate change, leading to more reliance on operational restrictions.	No Benefit
	Sea Level	Various	Currently there is no investment in standalone climate improvements for sea level rise and it is unlikely our resilience will keep pace with climate change which may result in more reliance on operational restrictions.	No Benefit
Awareness & Implementation	All	Drainage & Off track	Right Size Organisation for drainage & lineside, and develop competency framework	Enable efficient management of assets

Figure 43: Summary of CP7 actions

6. Resources and implementation

6.1 Assurance

We will track delivery of Weather Resilience and Climate Change plans in four areas:

- Delivery of multi-discipline integrated weather management plans for known vulnerable sites, here plans will detail weather or RCM triggers, and the actions to be taken by Operations, Asset Management and Maintenance functions.
- Delivery of seasonal preparedness including
    - Track asset preparation for summer.
    - Track asset preparation at desiccation risk sites.
    - Tamper allocation for desiccation risk sites.
    - Drainage Management Plans issued.
    - Vegetation & Railhead Treatment plan for autumn and winter.
- Delivery of agreed capital schemes to improve asset resilience, such as bridge scour schemes, specific drainage schemes and specific earthwork schemes.
- Delivery of workstreams to quantify known unknowns, such as network level flood risk assessment.

Each of these activities will be delivered to a timetable agreed by the appropriate regional asset discipline lead, and progress tracked through Route & Region PBR process, overseen by Regional Engineering, and reported to route and regional exec.

Performance indicators are already in place to measure train punctuality on adverse and extreme weather days. There is a recognition of the need to introduce a more strategic, leading metric and target to be able to demonstrate overall progress towards a more resilient railway. Development of outcome focused metrics will continue, and these will be in place for the start of CP7 to allow the effectiveness of plans on delivering weather resilience improvements to be made. Tracking of delay minutes associated with weather will also continue into CP7 and targets set to achieve less disruption to passengers and freight from weather events.

Unlike previous years, it is not proposed that the action plan is tracked against a defined list that details individual on the ground projects but rather considers volumes of work directly linked to asset management plans. These volumes will be linked to deliver resilience benefits and will be defined and confirmed in time for the start of CP7.

6.2 Resources

The project element of the CP7 project will be delivered as part of business-as-usual activities with the routes. For CP7 new supplier frameworks are being established as part of the Eastern Route Partnership. A full deliverability assessment has been undertaken across the whole of the CP7 renewals programme and suitable supplier frameworks established, Governance has been set up to manage the deliverability of the renewals programme throughout the next five years.

Extra resources are being requested specifically to support the sustainability strategy including weather resilience. Initially we are seeking to expand resources to support the development of business cases and assurance across all themes of the sustainability strategy. This would include ensuring WRCCA is considered in the business case stage of project

development. These roles are critical in supporting project sponsors and Route engineering teams. They would also have a role to assure outcomes as projects progress.

Early in CP7 we anticipate additional WRRCA capability is required to deliver the modelling and development of adaptive pathways for our asset base. This is separate from resources identified to deliver Mair and Slingo workstreams as it is focused on developing future climate scenarios that will inform both asset management and these specific workstreams. The outputs of this modelling would inform those other workstreams.

We will continue to encourage dialogue and sharing of best practice with third parties such as the Environment Agency. This will identify where we can work together on schemes or R&D where there is a clear benefit to both parties.

Regional Governance of these issues is picked up through the Sustainable Development Steering Group. This includes six weekly reviews of our plan on a page for WRCCA as well as periodic deep dives into specific topic areas.

Appendix A
Abbreviations and Glossary of terms

Abbreviation	Meaning
AC	Air conditioning
Capex	Capital investment
CCRA3	Third round of climate change risk assessment as carried out by the UK Committee on Climate Change
CERD	Coastal, estuarine and river defences
CP	Control Period – a five-year regulatory control period, used to decide priorities for investment.
CP6	Control Period 6 –2019 to 2024
CP7	Control Period 7 –2024 to 2029
CRT	Critical rail temperature – relevant to managing track buckle risk
DfT	Department for Transport
DLI	Digital lineside inspection
EA	Environment Agency
ELR	Engineer's line reference – a short, multi digit code for a significant portion of a railway route, e.g., ECML1 is the southern part of the East Coast Main Line
ERR	Enterprise Risk Review – A spreadsheet-based process developed by Network Rail to capture the detail required for conducting robust risk assessments, including both threats and opportunities.
EWAT	Extreme Weather Action Teleconference
FOC	Freight train operating company
FTE	Full time equivalent as related to staff time
KONUX	Technology system
LOC	Lineside equipment cabinet
LX	Level crossing
NR	Network Rail
OLE	Overhead line equipment – the wires and supports that carry the electric traction current for train
Opex	Operational expenditure
ORR	Office of Rail and Road
R&D	Research and development

RCM	Remote condition monitoring
RCP	Representative concentration pathway – a climate-related term referring to concentrations of greenhouse gasses in the atmosphere
RHTT	Rail head treatment train
S&T	Signalling and telecommunications
SuDS	Sustainable drainage systems
SWiX	Technology system for asset monitoring
T1009 TRaCCA	Tomorrow's railway and climate change adaptation – a pan-rail industry project that ran from 2012 until 2016
TARR	Train Accident Risk Reduction
TOC	Passenger train operating company
TSR	Temporary speed restriction
UKCP18	UK Climate Projections published by the UK Climate Impacts Programme
WRCCA	Weather resilience and climate change adaptation
WRTF	A national, business wide Weather Risk Task Force

Glossary of terms

Adaptation pathways	Series of adaptation choices involving trade-offs between short-term and long-term goals and values NOTE: These are processes of deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid potential maladaptation.
Adhesion	Term used to describe the friction grip of rail vehicle wheels to rails
Bow-tie methodology	A risk-assessment concept depicting causes and consequences of risks in a graphic that looks like a bow-tie shape
Climate projections	Simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models
Climate scenarios	Plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change
Desiccation	The drying out of soil in an earthwork during a long period of drought that leads to deformation of the track and structures built on the earthwork

Digital signalling	A concept that makes use of transmission-based signals that inform train drivers (or autonomous systems) of the 'authority' to move. Digital signalling at its most sophisticated removes the need for lineside fixed signals and its associated equipment, including cabling.
Hazard	A potential source of harm
Hubble	A commercial product that enables analysis of forward-facing camera footage to identify violations to the Network Rail vegetation management standard
Multi-disciplinary	Across many different actors – in a railway sense it can include those individual engineering disciplines such as civil engineering alongside track, signalling, electrical etc. and operations teams
Point ends/ Switches	A junction of two railway lines that can be set to guide a train onto one of two alternative routes, or allow two lines to merge into one
Railhead Treatment	Physical intervention at the running surface of a rail to condition it in a way that reduces the slipping of rail vehicle wheels and improves adhesion
Risk	Effect of uncertainty
Sustainable Development	Development that meets the environmental, social and economic needs of the present without compromising the ability of future generations to meet their own needs
Systems, systems thinking	Systems thinking is about understanding the complex, nonlinear and interconnected system in which an organization operates. From ISO 14090:2019
Vulnerability	Propensity or predisposition to be adversely affected

Appendix B
Risk Scoring Matrices and link to Integrated Climate Change Risk Assessment

Link to National Risk Register: National Integrated Climate Change Risk Assessment

Link to Risk Register : Eastern Integrated Climate Change Risk Assessment

		1 - Minimal	2 - Minor	3 - Moderate	4 - Major	5 - Catastrophic
Impact	Safety/ Environment	Minor Safety event with the potential to cause up to 20 minor injuries or a single major injury and with environmental incidents that can be addressed using existing control measures	Significant Safety event with the potential of a single major injury to five major injuries with adverse environmental impact within a Control Period that can be mitigated using existing control measures	Significant safety event with the potential of between five major injuries and two fatalities, with significant environmental impact that results in Regulatory intervention and it exceeds existing control measures	Catastrophic Safety event with the potential of between two and 10 fatalities, with major environmental impact resulting in Regulatory fines and current control measures are not suitable	Catastrophic Safety event with the potential of over 10 fatalities, with catastrophic long term environmental damage
	Performance	Planned disruption for up to a day on any one route	Unplanned disruption for up to a day on any one route	Unplanned disruption (for up to a week) on any one route or multiple routes	Unplanned disruption for over a week on multiple routes	Prolonged and unplanned severe disruption to key routes resulting in adverse media attention and protests/lobbying resulting in a review of Network licence condition
	Finance	Costs to resolve issue - up to £2m per annum	Costs to resolve issue - £2m to £25m per annum	Costs to resolve issue - £25m - £75m per annum	Costs to resolve issue - £75m to £250m per annum	Costs to resolve issue in excess of £250m per annum
		1 - Highly Unlikely	2 - Unlikely	3 - Possible	4 - Likely	5 - Almost certain
Likelihood	Criteria	No known event or if known extremely rare	Low likelihood the risk will occur and current mitigations provide effective risk control	Medium likelihood with risks resolved using current controls. Further control improvements underway or actively being developed to mitigate	High likelihood the risk will occur with current controls ineffective leaving problem unresolved for a long period. No effective mitigations currently identified and control weakness known and unmanaged	Very High likelihood the risk will occur and there are no effective controls or mitigations to prevent the event

Appendix C - CP6 Regional Action Plans

Anglia

Vulnerability	Location	Action to be taken	Cost of action	Breakdown of workbank cost and volumes	Expected benefit	Target completion date	Resilience	National Adaptation Programme action reference
Flooding	Various	Drainage inspection and maintenance	Various		Flood risk/severity reduction	End of CP6	Local resilience improvement at selected flood risk sites, through improvement of existing asset condition by maintenance (does not extend to physical enhancements to adapt to climate change)	NRNAP3
Flooding	Various (e.g. Brentwood, Gidea Park, West Ham)	Drainage renewals	Various		Flood risk/severity reduction	End of CP6	Local resilience improvement at selected flood risk sites, generally through improvement of existing asset condition. Climate change allowance included as per NR/L2/CIV/005 where full system renewal is being designed	NRNAP3
Flooding	Various (typically not site specific)	Flood risk and impact reduction through drainage asset management continuous improvement initiatives	Variable		Flood risk/severity reduction through initiatives such as improved first responder flood guidance/training, better and more accessible drainage system information, more site-specific flood management plans and other improvements identified through flood incident reviews, desktop flood risk reviews, strategy for use of remote monitoring and best practice sharing with other asset/ risk managers	End of CP6	Increased resilience and/or impact mitigation, or improved risk awareness/ assessment	NRNAP3
Deep seated embankment slope stability	Notable sites are Wrabness Chitts Hill West Horndon to Dunton Maldon Road Jimmys Lane Wilkinsons Brook Wash Road	Typically soil nailing, slope regrade and toe weighting or, sheet piling	Variable		Safety and performance improvements by renewal of assets, savings from reduction in OTM interventions and Temporary Speeds	End of CP6	Resilience Increased	NRNAP5
Cuttings instability during adverse weather – Programmed business plan earthworks renewal	Ipswich Tunnel Portals	Drainage improvements and local soil nailing	Variable		Reduction in risk of soil cutting failure during adverse weather, safety and performance improvement	End of CP6	Resilience Increased	NRNAP5
Cuttings instability during adverse weather - Programmed business plan earthworks refurbishment and maintenance interventions	Numerous sites including local sites on LTN1 between 60miles and 111miles	Counterfort drains in slopes and crest drain refurbishment	Variable		Reduction in risk of soil cutting failure during adverse weather, safety and performance improvement	End of CP6	Resilience Increased	NRNAP5
Peat Wastage	Prickwillow West River Queen Adelaide Ely North Junction Lakenheath Manea West	Cess support and/or ballast lowering	Variable		Safety and performance improvement, savings from less OTM interventions and Temporary Speeds	End of CP6	Resilience Increased	NRNAP5
Clay desiccation	Numerous – FSS2, LTN1 and TLL desiccation sites	Increased levels of large tree removal	Variable		Safety and performance improvement, savings from less OTM interventions and temporary speeds	End of CP6	Resilience Increased	NRNAP5
Ash degradation	Hill Farm River Tas Muntons Stowmarket	Cess support	Variable		Safety and performance improvement, savings from less OTM interventions and temporary speeds	End of CP6	Resilience Increased	NRNAP5
Scour	BGK 1438 TLL 166 BDM 1	Rock armour, toe gabion baskets or Reno Mattress	Variable	Underbridge preventative KVL: 180m2 £173k 50m2 £77k 272m2 £191k	Will remediate the risk of scour to high risk scour sites. Safety risk improvement	End of CP6 Year 2	Resilience Increased	NRNAP5
Chalk slope toppling and spalling	Purfleet	Rock netting	Variable		Significant safety risk improvement	End of CP6	Resilience Increased	NRNAP5
Early and continuous warning of unstable embankments	Various sites including Stourview and West Horndon to Dunton	Remote condition monitoring inclinometers	Variable		Risk reduction	Ongoing	No Change (Monitoring Only)	NRNAP4
Remote condition monitoring cuttings	Various sites including Ipswich Tunnel Portal and Brantham High Cutting	Remote condition monitoring tiltmeters	Variable		Risk reduction	Ongoing	No Change (Monitoring Only)	NRNAP4

East Coast

Vulnerability	Location	Action to be taken	Weather factor	Cost of action	Spend to year 3	Breakdown of workbank cost and volumes	Expected benefit	Target completion date	National Adaptation Programme action reference	Resilience
Falling trees in high winds	Route wide	Programme of clearance and maintenance of lineside vegetation targeted at highest risk safety and performance sites. Includes programme to remove dead, diseased and dying trees	Wind	£37	£13	£12.9m has been invested in the first three years of CP6	Train accident risk reduction through reduced likelihood of train striking a tree. Reduction in number of incidents will also drive train performance benefit and reduction in overhead line damage	2019-2024	-	Increase in resilience t high winds
Flooding & Landslip Mitigation	Route wide	Programme of drainage resilience renewal schemes	Flooding	£15	£7	£7m has been invested in the first three years of CP6	Reduction in likelihood of flooding and/or earthslip at sites with most significant failure history. Reduction in associated service affecting delays	2019-2024	NRNAP5	Increased resilience to intensive rainfall events
Flooding & Landslip Mitigation	Route wide	Programme of drainage jetting	Flooding	£15	£9	£9.3m has been invested in the first three years of CP6	Drainage systems are fully functional and able to run at full capacity providing improved resilience reducing service affecting delays. Improved long term sustainability of track ballast	2019-2024	-	Increased resilience to flooding and ballast degradation
Landslip mitigation	Route wide	Earthworks Management Plans in place for all earthworks assets	Flooding	£6		N/A	Management Plans in place for all earthworks assets, providing improved asset sustainability. Reduce likelihood of failures and associated safety and performance impacts	2019-2024	NRNAP4	Increased resilience of earthworks
Landslip mitigation	Browney Curve	Geotech support works	Flooding	£26	£8	£8m spent at Hessel Foreshore	Improved performance of the two geotech assets and support for track assets	2020-2024	-	Increased resilience of earthworks
Bridge Scour	Route wide	Mitigation of all Level 1 sites with risk score ≥16, including emerging sites. Currently there are 75 active schemes	Flooding	£20	£6	Yr1 & 2 delivery: Physical works at 27 site, 23 of which Policy L1 (£6.3m) Further investigation increasing asset intelligence reducing risk on: 4 Policy L1 and 28 L2 sites	Train accident risk reduction through reduced likelihood of asset failure in storm flows	2019-2024	-	Increased resilience to scour
Heat related track buckling	Route wide	Programme of upgrading Jointed track to CWR, 34km planned	Heat	£26	£27	LNE 18km for £23.9m EM 3.63km for £2.666m	CWR is far more resilient to hot weather and track buckle	2019-2024	-	Increased track resilience to heat
Heat related track buckling	Route wide	Programme of upgrading timber S&C layouts to Concrete, 265 units planned	Heat	£235	£56	LNE 52 converted unit rate cost of £36.5m EM 26 Units for £19.85m	Concrete S&C layouts are far more resilient to hot weather and track buckle	2019-2024	-	Increased track resilience to heat
Mitigate heat and lightning risk	Route wide	Various recontrol schemes	Heat	£57			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	Route wide	Various signalling renewal schemes	Heat	£125			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience

***Please note all spend is in £m unless specified otherwise.**

East Midlands

Vulnerability	Location	Action to be taken	Weather factor	Cost of action	Spend to year 3	Breakdown of workbank cost and volumes	Expected benefit	Target completion date	National Adaptation Programme action reference	Resilience
Falling trees in high winds	Route wide	Programme of clearance and maintenance of lineside vegetation targeted at highest risk safety and performance sites. Includes programme to remove dead, diseased and dying trees	Wind	£37	£13	£12.9m has been invested in the first three years of CP6	Train accident risk reduction through reduced likelihood of train striking a tree. Reduction in number of incidents will also drive train performance benefit and reduction in overhead line damage	2019-2024	-	Increase in resilience to high winds
Flooding & Landslip Mitigation	Route wide	Programme of drainage resilience renewal schemes	Flooding	£15	£7	£7m has been invested in the first three years of CP6	Reduction in likelihood of flooding and/or earthslip at sites with most significant failure history. Reduction in associated service affecting delays	2019-2024	NRNAP5	Increased resilience to intensive rainfall events
Flooding & Landslip Mitigation	Route wide	Programme of drainage jetting	Flooding	£15	£9	£9.3m has been invested in the first three years of CP6	Drainage systems are fully functional and able to run at full capacity providing improved resilience reducing service affecting delays. Improved long term sustainability of track ballast	2019-2024	-	Increased resilience to flooding and ballast degradation
Landslip mitigation	Route wide	Earthworks Management Plans in place for all earthworks assets	Flooding	£6		N/A	Management Plans in place for all earthworks assets, providing improved asset sustainability. Reduce likelihood of failures and associated safety and performance impacts	2019-2024	NRNAP4	Increased resilience of earthworks
Bridge Scour	Route wide	Mitigation of all Level 1 sites with risk score ≥16, including emerging sites. Currently there are 75 active schemes	Flooding	£20	£6	Yr1 & 2 delivery: Physical works at 27 site, 23 of which Policy L1 (£6.3m) Further investigation increasing asset intelligence reducing risk on: 4 Policy L1 and 28 L2 sites	Train accident risk reduction through reduced likelihood of asset failure in storm flows	2019-2024	-	Increased resilience to scour
Heat related track buckling	Route wide	Programme of upgrading Jointed track to CWR, 34km planned	Heat	£26	£27	LNE 18km for £23.9m EM 3.63km for £2.666m	CWR is far more resilient to hot weather and track buckle	2019-2024	-	Increased track resilience to heat
Heat related track buckling	Route wide	Programme of upgrading timber S&C layouts to Concrete, 265 units planned	Heat	£235	£56	LNE 52 converted unit rate cost of £36.5m EM 26 Units for £19.85m	Concrete S&C layouts are far more resilient to hot weather and track buckle	2019-2024	-	Increased track resilience to heat
Mitigate heat and lightning risk	Route wide	Various recontrol schemes	Heat	£57			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	Route wide	Various signalling renewal schemes	Heat	£125			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	East Midlands	Various other life extension work	Heat	£10			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
OLE resilience in hot weather	East Midlands	Refurbishment of 88 wire runs resetting balance weights and pulley wheels	Heat	£5			Improved performance of OLE and balance weights	2020-2024	-	Increased resilience to longer, hotter Summers
OLE resilience in hot weather	Nottingham PSP	Renewal of the Forced Air Cooling System with Air Conditioning	Heat	TBC			Improved performance of power supply in hot weather	2021 – 2023	-	Increased resilience to longer, hotter Summers
Points performance in cold weather	Alrewas	Installation of point heating at a site with historic issue of frozen points	Cold	£0			Improved performance of points	2020 – 2021	-	Increased resilience in cold weather
Points performance in cold weather	Corby	Installation of point heating at a site with historic issue of frozen points	Cold	£0			Improved performance of points	2021 – 2023	-	Increased resilience in cold weather
OLE Development work for CP7 schemes	East Midlands	Various schemes including: • OLE balance weight conversion to Tensorex C+ • OLE head span conversion to Mechanised Independent Registration (MIR) • Fixed tension wire run conversion to auto-tension	Wind				Improved performance of OLE	2019-2024	-	Increased resilience to hot weather
D&P Development work for CP7 schemes	East Midlands	Various schemes including: • Flood risk mitigation for lineside D&P assets • Kings Cross renewal of pumping system	Flooding				Improved performance of D&P equipment	2019-2024	-	Increased resilience to heavier and more frequent rainfall

***Please note all spend is in £m unless specified otherwise.**

North and East

Vulnerability	Location	Action to be taken	Weather factor	Cost of action	Spend to year 3	Breakdown of workbank cost and volumes	Expected benefit	Target completion date	National Adaptation Programme action reference	Resilience
Falling trees in high winds	Route wide	Programme of clearance and maintenance of lineside vegetation targeted at highest risk safety and performance sites. Includes programme to remove dead, diseased and dying trees	Wind	£37	£13	£12.9m has been invested in the first three years of CP6	Train accident risk reduction through reduced likelihood of train striking a tree. Reduction in number of incidents will also drive train performance benefit and reduction in overhead line damage	2019-2024	-	Increase in resilience to high winds
Flooding & Landslip Mitigation	Route wide	Programme of drainage resilience renewal schemes	Flooding	£15	£7	£7m has been invested in the first three years of CP6	Reduction in likelihood of flooding and/or earthslip at sites with most significant failure history. Reduction in associated service affecting delays	2019-2024	NRNAP5	Increased resilience to intensive rainfall events
Flooding & Landslip Mitigation	Route wide	Programme of drainage jetting	Flooding	£15	£9	£9.3m has been invested in the first three years of CP6	Drainage systems are fully functional and able to run at full capacity providing improved resilience reducing service affecting delays. Improved long term sustainability of track ballast	2019-2024	-	Increased resilience to flooding and ballast degradation
Landslip mitigation	Route wide	Earthworks Management Plans in place for all earthworks assets	Flooding	£6		N/A	Management Plans in place for all earthworks assets, providing improved asset sustainability. Reduce likelihood of failures and associated safety and performance impacts	2019-2024	NRNAP4	Increased resilience of earthworks
Landslip mitigation	Hessel Foreshore	Geotech support works	Flooding	£26	£8	£8m spent at Hessel Foreshore	Improved performance of the two geotech assets and support for track assets	2020-2024	-	Increased resilience of earthworks
Bridge Scour	Route wide	Mitigation of all Level 1 sites with risk score ≥16, including emerging sites. Currently there are 75 active schemes	Flooding	£20	£6	Yr1 & 2 delivery: Physical works at 27 site, 23 of which Policy L1 (£6.3m) Further investigation increasing asset intelligence reducing risk on: 4 Policy L1 and 28 L2 sites	Train accident risk reduction through reduced likelihood of asset failure in storm flows	2019-2024	-	Increased resilience to scour
Heat related track buckling	Route wide	Programme of upgrading Jointed track to CWR, 34km planned	Heat	£26	£27	LNE 18km for £23.9m EM 3.63km for £2.666m	CWR is far more resilient to hot weather and track buckle	2019-2024	-	Increased track resilience to heat
Heat related track buckling	Route wide	Programme of upgrading timber S&C layouts to Concrete, 265 units planned	Heat	£235	£56	LNE 52 converted unit rate cost of £36.5m EM 26 Units for £19.85m	Concrete S&C layouts are far more resilient to hot weather and track buckle	2019-2024	-	Increased track resilience to heat
Mitigate heat and lightning risk	Durham Coast	Resignalling scheme	Heat	£45	£45	£45m	Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	Ferrybridge – Goole	Resignalling scheme	Heat	£44			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	Middlesbrough/ Whitehouse	Resignalling scheme	Heat	£45			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	South Kirby	Resignalling scheme	Heat	£24			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	Route wide	Various recontrol schemes	Heat	£57			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Mitigate heat and lightning risk	Route wide	Various signalling renewal schemes	Heat	£125			Improved performance of the signalling asset	2019-2024	-	Increased signalling resilience
Points performance in cold weather	LNE	Installation of point heating at five sites with historic issue of frozen points	Cold	£0			Improved performance of points	2019 – 2021	-	Increased resilience in cold weather

***Please note all spend is in £m unless specified otherwise.**

Appendix D
Route Plans on a page

Strategy on a page | Weather Resilience

Anglia Route

Regional outcomes	Route objectives	Stakeholder priorities and how they are addressed	Assumptions & key dependencies	Govt. objectives served	Impact against CP6
A reliable railway that is resilient to climate change	a. Improving the resilience of Track, OLE & buildings infrastructure against hot weather to reduce disruption b. Working collaborative as an industry to reduce the impact of flood and earth works events c. Harnessing technology & infrastructure innovation to improve resilience to changes in weather (using II, snow drifts vegetation mitigation) to reduce disruption	Our stakeholders expect us to deliver a safe and reliable service, throughout weather events, to enable communities and customers to thrive. This is a journey for us with the challenge increasing over time. Collaborative approach to seasonal change will ensure stakeholder needs are met or understood. Including decision making to the response of weather events, to safeguard against safety and reliability of service. This approach also enables stakeholders to be informed well ahead of an extreme weather event. Key focus and understanding is required for our line side neighbours, as our need to maintain our infrastructure to mitigate weather events, can mean we are at odds with their requirements (i.e. tree felling), so an intelligent and empathetic approach is required, in some areas as well as the continued adoption of new technology and improvements in our risk and mitigation understanding.	Adequate funding and access to undertake lineside preparation is key. Anglia is at the forefront of increases in Freight and customers returning to our trains, in addition to the Elizabeth Line opening. Getting the balance right is key to enable a safe and reliable service. Key technology deployment for understanding risk and targeting intervention is to be maintained: - Hubble - Drone surveys - Train CCTV Use of RHTT, SandRover, II for track circuits & current expected funding for Ash die back and drainage		 **KPIs & targets** <53° CRT on mainline Balance weights to 38°C Year on year reduction in 'at risk' trees (drone) Reduction in high risk sites 0 'at risk' sites un-actioned No unforeseen tidal events

Strategic narrative (Where are we now, where do we want to be?)

Anglia has made progress in responding to the Mair & Slingo findings, key challenges remain in urban environments for rain-water run-off and flood events in costal and estuary areas of our infrastructure, which will take sustain focus on seeing improvements from Control Period to Control Period.

We continue to improve our resilience & ability to manage weather events. We are at the early stages of harnessing technology, monitoring system, as we move into CP7, the capability and utilisation of these aspect will be driven to become core to our operation as well as our understanding of where our risks are, that could impact the operation of the railway. This will enable a greater level of targeted intervention to provide a safe and reliable service for our customers.

Whole industry & market-led considerations

Planning further out for intervention is an absolute requirement, to maximise access to the infrastructure. We have started on the journey of utilising Passenger trains for greater and more frequent understanding of our infrastructure. When this is matured, this may lead to industry savings (i.e. our yellow fleet).

Delivery of our transformation programme will be fully in place prior to CP7 as well as sustaining our approach to eliminating red zone working.

Both elements are key industry drivers, mandating changes in our approach to access and how we understand risk.

Enablers/ Value levers	Wind	Heat	Water	Other
OMR activities	• Implementing additional tree management for KRS performance	• Continuing to deliver the Mair report findings • Long term asset deficiencies removed • Lumar skin kits implemented with Cambridge works	• Continuing to deliver the Mair report findings • Embedding new Org design and approach to remedial works for drainage assets	• Utilisation of II for winter and autumn
Industry collaboration	• CCTV (front facing, static) for real time risk mitigation	• Access approach for CRT works • Feasibility to use onboard technology to understand ride quality (TOCs)	• Ride through standing water on multiple fleets, to reduce impact of flood events • Collaboration with the EA on tidal plains, asset condition from both NR and EA	• Brake application intelligence for autumn
Technology implementation/ change & data; RD&I	• Hubble used across the route (auto CCTV upload to system) • Tree drone survey across the route • II for structures and earthworks	• Drone surveys, to identify risk and readiness • Heat mapping data gathering systems • Remote telematic information for equipment locations	• Mapping of flood locations with response plans • Embedding use of data systems for risk and targeted investment modelling	• Establishing secondary systems for resilience when moving to new technologies for rail adhesion etc
Process improvement/ change	• With the advent on new II on structure, ability to use this with EWAT process (especially on exposed areas of the route) • Drone survey data	• Embedding clear remit for stressing, managing a good state of readiness as part of the workload for track works	• Sustaining new process and procedures from tidal risk, to mitigate and prevent issues	• Seasonal readiness via the assets management system
People (Capability/ workforce planning)	• Developed and capable team, able to understand risk and targeted intervention requirements from new technologies and ways of working	• Consistent and clear understanding of heat and action needed to prevent incidents, across our disciplines, from the data sources and inputs to the in the field actions	• Increased development and understanding of drainage systems, to enable assets deficiency markers to be identified and action prior to incident	• Developed team in understanding assets plan implementation on autumn risk and the linkages
Contracting/ procurement strategy	• Move to a more intelligent supply chain who can undertake the work and the line side neighbour relationship to enable works	• Increasing the volume of competence in the supply chain to undertake verse testing and stressing services in additional to capability to ramp supply up at peak times	• Introduction of framework for drainage packages of works, to enable remedial works to be actions from increases in inspection and asset understanding	• Adoption of laser or dry ice innovation for autumn prep

Strategy on a page | Weather Resilience

East Coast Route

Regional outcomes	Route objectives	Stakeholder priorities and how they are addressed	Assumptions & key dependencies	Govt. objectives served	Impact against CP6
A reliable railway that is resilient to climate change	a. Targeted interventions at high-risk soil cuttings. b. Targeted drainage maintenance strategy (inc. remote monitoring plus capacity increases.) c. OLE wire run re-design at most vulnerable sites (Wind). d. Scour resilience at 8 critical sites (TARR).	Stakeholder priorities have been identified through engagement workshops with all Train Operators and a range of external stakeholder groups and relevant industry partners to develop this strategy and to align key priorities and outcomes. Outcomes relating to weather resilience include: • Improve OLE performance through continued campaign of resilience work throughout the Route. • Managed and maintained drainage assets • Targeted track refurbishment and renewal to reduce likelihood of TSRs and SAFs. • Build on current local community and biodiversity relationships.	All disciplines will recognise the need to make the asset more resilient to weather events. The following are key dependencies: • Access requirements • Contracting strategy and supply chain capacity • Integration with other major works It is essential that adequate funding is available to handle the high-risk interventions included in the plan. Monitoring and technology deployment for understanding risk and targeting intervention is to be maintained:	 Meeting customer needs Delivering financial sustainability Contributing to long term economic growth Levelling up and connectivity Delivering environmental sustainability	 **KPIs & targets** Reduction in the impact that the different events have on our asset from falling trees, flooding events to hot weather speeds.

Strategic narrative (Where are we now, where do we want to be?)

In the current cash constrained environment, the drainage budget in East Coast has been reduced in line with other discipline reductions with key areas identified through risk prioritisation.

Resilience to heat, cold and wind maintained at current levels. Slight improvement in track hot weather resilience due to timber S&C upgrades. Whole system drainage approach will improve resilience to convective rainstorms and flooding which will drive reduced risk of cutting slope failure.

Action plans and progress has been made against Mair & Slingo findings, key challenges remain in urban environments for rain-water run-off and flood events in costal and estuary areas of our infrastructure, which will take sustain focus on seeing improvements from Control Period to Control Period.

Whole industry & market-led considerations

Considerations being progressed include:

- Access Strategy being developed collaboratively with Train Operators considering changes in passenger markets and potential for more mid week engineering access.
- Supply Chain engagement events ongoing to drive process improvement and align objectives.
- Procurement Category Strategies in place for each discipline

Enablers/ Value levers	Wind	Heat	Water	Other
OMR activities	• Continued vegetation management • Investment in overhead line and contact system assets.	• Slight improvement in track hot weather resilience due to timber S&C upgrades.	• Storm resilience maintained in earthworks and drainage	• Utilisation of II for winter and autumn
Industry collaboration	• CCTV (Front facing, static) for real time risk mitigation	• Access approach for CRT works • Feasibility to use onboard technology to understand ride quality (TOCs)	• Ride through standing water on multiple fleets, to reduce impact of flood events • Collaboration with the EA on tidal plains, asset condition from both NR and EA	• Brake application intelligence for autumn
Technology implementation/ change & data; RD&I	• Hubble used across the route (auto CCTV upload to system) • Tree drone survey across the route • II for structures and earthworks	• Drone surveys, to identify risk and readiness • Heat mapping data gathering systems • Remote telematic information for equipment locations	• Mapping of flood locations with response plans • Embedding use of data systems for risk and targeted investment modelling	• Establishing secondary systems for resilience when moving to new technologies for rail adhesion etc
Process improvement/ change	• With the advent on new II on structure, ability to use this with EWAT process (especially on exposed areas of the route) • Drone survey data utilisation for wind events	• Embedding clear remit for stressing, managing a good state of readiness as part of the workload for track works	• Sustaining new process and procedures from tidal risk, to mitigate and prevent issues	• Seasonal readiness via the assets management system
People (Capability/ workforce planning)	• Developed and capable team, able to understand risk and targeted intervention requirements from new technologies and ways of working	• Consistent and clear understanding of heat and action needed to prevent incidents, across our disciplines, from the data sources and inputs to the in the field actions	• Increased development and understanding of drainage systems, to enable assets deficiency markers to be identified and action prior to incident	• Developed team in understanding assets plan implementation on autumn risk and the linkages
Contracting/ procurement strategy	• Move to a more intelligent supply chain who can undertake the work and the line side neighbour relationship to enable works	• Increasing the volume of competence in the supply chain to undertake verse testing and stressing services in additional to capability to ramp supply up at peak times	• Introduction of framework for drainage packages of works, to enable remedial works to be actions from increases in inspection and asset understanding	• Adoption of laser or dry ice innovation for autumn prep

Strategy on a page | Weather Resilience

East Midlands

Regional outcomes	Route objectives	Stakeholder priorities and how they are addressed	Assumptions & key dependencies	Govt. objectives served	Impact against CP6
A reliable railway that is resilient to climate change	a. We will manage extreme weather risk better b. We will become more resilient to the changes in weather	Stakeholder priorities have been identified through engagement workshops with all Train Operators and a range of external stakeholder groups and relevant industry partners to outcomes: • Proactive maintenance of drainage assets and investment in high flood risk sites, minimising risk of earthworks failures • Ring-fenced budget to support flood and heat resilience projects, and regional modelling • Increased intelligence on vulnerable assets • Funding constraints and reduced levels of renewals mean we cannot deliver a fully seasonally agnostic railway so weather resilience initiatives can only focus on mitigation and quick recovery	Integration workstreams with MML3 The following are key dependencies: • Access requirements • Contracting strategy and supply chain capacity • Integration with other major works It is essential that adequate funding is available to handle the high-risk interventions included in the plan. Monitoring and technology deployment for understanding risk and targeting intervention is to be maintained.	Meeting customer needs Delivering financial sustainability Contributing to long term economic growth Levelling up and connectivity Delivering environmental sustainability	 **KPIs & targets** 80% of risks with defined mitigation plans 80% risks reviewed on a quarterly basis

Strategic narrative (Where are we now, where do we want to be?)

Have a populated risk register of known risk locations
Have short-, medium- and long-term action plans for known risk sites
Enhance our drainage strategy after review of asset condition
Have increased people capability and competence
Embrace and embed new technology e.g. remote condition monitoring of assets
Identify and embrace new materials and methodologies for application on the route

Whole industry & market-led considerations

Considerations being progressed include:

- Access Strategy being developed collaboratively with Train Operators considering changes in passenger markets and potential for more mid-week engineering access.
- Supply Chain engagement events ongoing to drive process improvement and align objectives.
- Procurement Category Strategies in place for each discipline

Enablers/ Value levers	Wind	Heat	Water	Other
OMR activities	• Continued vegetation management • Investment in overhead line and contact system assets.	• Slight improvement in track hot weather resilience due to timber S&C upgrades.	• Storm resilience maintained in earthworks and drainage	• Utilisation of II for winter and autumn
Industry collaboration	• CCTV (Front facing, static) for real time risk mitigation	• Access approach for CRT works • Feasibility to use onboard technology to understand ride quality (TOCs)	• Ride through standing water on multiple fleets, to reduce impact of flood events • Collaboration with the EA on tidal plains, asset condition from both NR and EA	• Brake application intelligence for autumn
Technology implementation/ change & data; RD&I	• Hubble used across the route (auto CCTV upload to system) • Tree drone survey across the route • II for structures and earthworks	• Drone surveys, to identify risk and readiness • Heat mapping data gathering systems • Remote telematic information for equipment locations	• Mapping of flood locations with response plans • Embedding use of data systems for risk and targeted investment modelling	• Establishing secondary systems for resilience when moving to new technologies for rail adhesion etc
Process improvement/ change	• With the advent on new II on structures, ability to use this with EWAT process (especially on exposed areas of the route) • Drone survey data utilisation for wind events • Continuous development of people, processes, technology, and standards to enable predictive asset management, an increase in risk identification and understanding failure root causes	• Embedding clear remit for stressing, managing a good state of readiness as part of the workload for track works	• Sustaining new process and procedures from tidal risk, to mitigate and prevent issues	• Seasonal readiness via the assets management system
People (Capability/ workforce planning)	• Developed and capable team, able to understand risk and targeted intervention requirements from new technologies and ways of working	• Consistent and clear understanding of heat and action needed to prevent incidents, across our disciplines, from the data sources and inputs to the in the field actions	• Increased development and understanding of drainage systems, to enable assets deficiency markers to be identified and action prior to incident	• Developed team in understanding assets plan implementation on autumn risk and the linkages
Contracting/ procurement strategy	• Move to a more intelligent supply chain who can undertake the work and the line side neighbour relationship to enable works	• Increasing the volume of competence in the supply chain to undertake verse testing and stressing services in additional to capability to ramp supply up at peak times	• Introduction of framework for drainage packages of works, to enable remedial works to be actions from increases in inspection and asset understanding	• Adoption of laser or dry ice innovation for autumn prep

Strategy on a page | Weather Resilience

North & East Route

Regional outcomes	Route objectives	Stakeholder priorities and how they are addressed	Assumptions & key dependencies	Govt. objectives served	Impact against CP6
A reliable railway that is resilient to climate change	We will deliver a line of route asset strategy, which supports the resilience of the timetable. We will reduce the likelihood of seasonal asset performance incidents.	**Linespeed should be an area of focus for CP7** We've been given a list of TfN line speed priorities and will continue to work closely with our partners to undertake line speed improvements. TRU delivers performance, capacity, environmental and journey time benefits with a line speed increase for large proportions of the corridor between Manchester and York. These elements are being delivered through the delivery of electrification, but also wider enhancement works. **How will we increase network resilience?** There will be improved resilience to extreme weather events and climate change through (for example) early deployment of our seasonal delivery strategies, improving waterflow through drainage strategy to reduce the impact of flooding and actively manage water from third party assets through attenuation systems. **Improve efficiency of rolling stock** We plan on using technology to measure, baseline and improve key asset operating threshold.	Workbanks have been developed with a view that TRU will be delivered in full. Plans would need revisiting should TRU face scope changes, or not be delivered in full. Integrating new assets into our workbanks following major enhancements presents a challenge, as we must ensure we have the resources and capabilities to maintain new assets.		 KPIs & targets

Strategic narrative (Where are we now, where do we want to be?)

Our strategy is to focus on higher volume, lower complexity works, given the current economic environment, enabling us to directly improve larger proportions of our asset base over a shorter period.

We will use technology to reduce reliance of conventional techniques to asset condition and we will identify key initiatives to drive improved on-time performance. Our strategy is to focus on higher volume, lower complexity works, enabling us to access larger proportions of our asset base over a shorter time period.

In the current cash constrained environment, we are protecting our drainage budget and propose to invest in railway corridor landscape management works (compliant vegetation, enhanced biodiversity, habitat, drainage, boundary and litter/debris management).

Whole industry & market-led considerations

Supporting colleagues in track, signalling and geotechnical asset management to manage weather and climate-related risks to the overall railway system and utilising tools such as RAMP to look for alignment opportunities. Planning further out for intervention is an absolute requirement, to maximise access to the infrastructure. Utilising Passenger trains for greater and more frequent understanding of infrastructure.

Enablers/ Value levers	Wind	Heat	Water	Other
OMR activities	• Improve the resilience of our overhead line system in high winds, including head-span to portal conversions • Vegetation • Proactive pre- and post-storm inspections of vegetation at critical locations (steep and high cutting slopes) • Analysis of historical storm impacts in terms of wind direction and alignment of railway • Ongoing programme of work to minimise risk of vegetation falling on or near the line during storm events. • Establish a sustainable lineside environment which minimises performance and safety risk and maintenance intervention by removal of problem vegetation and dangerous trees utilizing specialist inspection and aerial and infrared photography captured by the RINM project	• Track impacts (jointed track etc.) • Upgrade jointed track and timber S&C layouts to increase temperature resilience • Improve the resilience of our track assets to high temperatures through continued upgrade of track components, • Signalling and telecoms: - improve performance of building and equipment cooling • Operational property forced air cooling system design	• Embedding new Org design and approach to remedial works for Drainage assets • Risk ranking for optimal inspection and maintenance schedules. • Lines vulnerable to pluvial and fluvial flood risk in the northern Pennines, South and West Yorkshire – are drained by numerous steeply-inclined watercourses and main rivers (the Aire, the Calder and the Don,) that are subject to rapid and extreme fluctuations in level during significant storm events – monitored to enable prompt delviery of mitigation	• Utilisation of II for winter and autumn
Industry collaboration	• CCTV (Front facing, static) for real time risk mitigation • Work with lineside neighbours to establish an environment beyond the boundary that does not negatively affect safety of the line or performance, including more effective management of trees and surface water run-off	• Access approach for CRT works • Feasibility to use onboard technology to understand ride quality (TOCs)	• Ride through standing water on multiple fleets, to reduce impact of flood events • Collaboration with the EA and Local Authorities on common flooding locations • Full collaboration with CD track (PL and S&C) renewals teams to ensure functional drainage ahead of core renewals • Where it is neither viable, affordable or practicable to mitigate flood risk alone, we will reach out to neighbours and stakeholders to develop jointly funded major projects	• Closer working with universities and professional institutions to better understand risk and mitigation • Working with the EA and University of Hull to understand risks associated with storm surges and sea level rise between Barton and New Holland on the South Bank of the Humber
Technology implementation/ change & data; RD&I	• Hubble used across the route (auto CCTV upload to system) • II for structures and Earth works • Utilising specialist inspection and aerial and infrared photography captured by the RINM project for vegetation management	• Drone surveys, to identify risk and readiness • Heat mapping data gathering systems • Remote telematic information for equipment locations	• Mapping of flood locations with response plans • Embedding use of data systems for risk and targeted investment modelling • Installation of drainage remote condition monitoring and CCTV	• Establishing secondary systems for resilience when moving to new technologies for rail adhesion, etc
Process improvement/ change	• With the advent on new II on structure, ability to use this with EWAT process (especially on exposed areas of the route) • Drone survey data utilisation for wind events	• Embedding clear remit for stressing, managing a good state of readiness as part of the workload for track works	• Dedicated annual budget line for reactive drainage and flood risk mitigation work • Catchment study and hydrological modelling to understand the capacity and capability of our network of drainage systems and – crucially – whether they are fit for purpose considering current and future changes in climate	• Embedding seasonal readiness via the assets management system
People (Capability/ workforce planning)	• Developed and capable team, able to understand risk and targeted intervention requirements from new technologies and ways of working	• Consistent and clear understanding of heat and action needed to prevent incidents, across our disciplines, from the data sources and inputs to the in the field actions	• -Increased development and understanding of drainage systems, to enable assets deficiency markers to be identified and action prior to incident	• Developed team in understanding assets plan implementation on autumn risk and the linkages
Contracting/ procurement strategy	• Move to a more intelligent supply chain who can undertake the work and the line side neighbour relationship to enable works	• Increasing the volume of competence in the supply chain to undertake verse testing and stressing services in additional to capability to ramp supply up at peak times	• Introduction of framework for drainage packages of works, to enable remedial works to be actions from increases in inspection and asset understanding	• Adoption of laser or dry ice innovation for autumn prep

Appendix E
CP7 Action Tracker (Cost base is cash post-efficient)

Asset Information		Action Information					Climate Adaptation / Resilience		Monitoring	
Asset Class / Lead Team	Sub-Asset Class	Category	Name	Location	Description	Cost (£m)	Benefit	Risks Addressed	Monitoring Regime	Linked 11 levers
Contact system	Overhead line electrification	Refurbishment	Various	Eastern	Partial and full life refurbishment including wiring and component parts	32	Reduced risk of train disruption due to OLE failures in storm conditions.	Risk of failure due to wind	Volume delivery through RF reporting	Design Reliability
Contact system	Overhead line electrification structures	Refurbishment & Renewal	Various	Eastern	Complete renewal or refurbishment of OLE structures and foundation (portal, mast/cantilever). Full renewal includes the new structure, civil works, OLE alterations and removal of original structure.	24	Reduced risk of train disruption due to OLE failures in storm conditions.	Risk of failure due to wind	Volume delivery through RF reporting	Design Resistance
Contact system	Overhead line electrification	Re-wire	Various	Anglia & East Mids	Replacement of overhead wiring	1	Reduced risk of train disruption due to OLE failures in storm conditions.	Risk of failure due to wind	Volume delivery through RF reporting	Design Reliability
Contact system	Overhead line electrification	Headspan Resilience	Various	East Midlands	Resilience of headspan through replacement of insulators and span wire renewals	23	Reduced risk of train disruption due to OLE failures in storm conditions.	Risk of failure due to wind	Volume delivery through RF reporting	Design Resistance
Contact system	Overhead line electrification	Headspan conversion	Various	East Coast & North & East	Conversion of Headspans to have Mechanical independence in Station Areas	8	Reduced risk to public safety from dewirement in station areas.	Risk of failure due to wind	Volume delivery through RF reporting	Design Resistance
Drainage	Pipe, Ditch & Channels	Refurbishment	Various	Eastern	Refurbish and restoring the performance of the assets through major repair, local replacement or re-profiling	34	Improved management of flood waters through refurbished assets that are profiled to create capacity for rainwater and to act effectively in storm conditions.	Reduced flood risk	Length delivered tracked through RF reporting	Design Reliability
Drainage	Pipe, Ditch & Channels	Renewal	Various	Eastern	Renew and upgrade the performance of the assets	46	Improved management of flood waters through renewed and upgraded assets that are profiled to create capacity for rainwater and to act effectively in storm conditions.	Reduced flood risk	Length delivered tracked through RF reporting	Design Resistance
Drainage	Pipe, Ditch & Channels	New Build	Various	Eastern	Contributions to flooding schemes and construction of new assets	6	Improved management of flood waters through new assets to protect the railway effectively in storm conditions.	Reduced flood risk	Length delivered tracked through RF reporting	Design Resistance
Earthworks	Embankments	Renewal	Various	Eastern	Renewal of Embankments	76	Slope stability for embankment on EC main line, reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Embankments	Renewal	Browney Curve	East Coast	Renewal - completion of Browney Curve	18	Slope stability for embankment on EC main line, reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Embankments	Renewal	Frodingham Ap	North & East	Renewal - embankment regrade or Piling	5	Slope stability for embankment , reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Embankments	Refurbishment	Various	Eastern	Refurbish and restoring the performance of the assets through major repair, local replacement or re-profiling	10	Slope stability for embankment , reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Embankments	Maintain	Various	Eastern	Maintenance of earthwork embankments	6	Slope stability for embankment , reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Embankments & Cuttings	Monitoring, Alert and Alarms	Various	Eastern	Monitoring equipment and investigations	20	Asset intelligence and improved speed of response		Volume delivery through RF reporting	Monitoring
Earthworks	Rock and soil cuttings	Renewal	Various	Eastern	Renewal of soil and rock cuttings	38	Slope stability for embankment , reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Rock and soil cuttings	Refurbishment	Various	Eastern	Regrading of soil cutting in places, scaling and netting of rock cutting in places	23	Slope stability for embankment , reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks	Rock and soil cuttings	Maintain	Various	Eastern	Maintenance of rockand soil cuttings	6	Slope stability for embankment , reduced costs from enhanced maintenance and removal of speed restrictions. Resilience for moisture content changes due to weather.	Risk of earthwork failure	Volume delivery through RF reporting	Intervention extents
Earthworks Opex	All	Evaluations	Various	Eastern	**Opex** - Easthwork evaluations	34	Opex - Lord Robert Mair recommendations - Assessments and evaluations to quantufy condition of earthworks assets.	Risk of earthwork failure	Progress against milestone plan	Asset Knowledge
Signalling	Signalling	New Build	Kings Cross - Peterbrough	East Coast	Work type 20 - 40 % contribution from East Coast Digital Signalling Programme, including design, new control systems and interlocking and recovery of lineside signals upgrades.	56	Prevention of accidents and delays due to signals from visibility and reliability issues	Risk of obscuration from vegetation growth, Risk of overheating assets in high temperatures, Risk of failure from assets flooding	Volume delivery through RF reporting	Design Resistance
Structures	Culverts	Replacement	Various	Eastern	Structural relining, infilling, replacement etc.	5	Provision of reliabile drainage assets.	Reduced flood risk	Area delivery through RF reporting	Design Reliability
Structures	Underbridge	Scour protection	Various	Eastern	Provision of scour protection to bridge structures so damage from high and fast flowing rivers is reduced.	4	Reliability of bridge structures improved and less susceptible to damage from high river levels during heavy rainfall.	Risk of bridge failure	Area delivery through RF reporting	Design Resistance
Structures	Underbridge	Strengthening	Various	Eastern	10 % contribution of structural strenghtening of bridge assets contributing to weather resilience	15	Reliability of bridge structures - resistance to weather related damage, prevention of speed restictions.	Risk of bridge failure	Volume delivery through RF reporting	Design Reliability
Track	Longitudinal timbers	Renewal	Various	Eastern	Waybeam and longitudinal timber bearer renewals	14	Reduced risk from movement under extreme temperatures causing damage to the track.	Risk of track buckles and breaks	Length delivered tracked through RF reporting	Design Reliability
All	Non-asset	Modelling	Various	Eastern	Adaptation Pathways: Modelling and analysis to support Adaptation Pathways approach	5	Agile approach to future planning scenarios and risk management	Climate change risk on vulnerable assets	Progress against milestone plan	Design Resistance
Drainage, track and Earthworks	Non-asset	Planning	Various	Eastern	Integrated Management Plans: Development of integrated plans that consider multiple asset groups that are realted such as track, drainage and earthworks.	-	Plans that integrate management and intervention approaches acroos connected assets where strong dependencies exist on failure modes: track, earthworks and drainage.	Risk of earthworks, drainage and track failure	Progress against milestone plan	Design Reliability
All	Non-asset specific	Event response	Various	Eastern	**Opex** - Weather ~control command structure strengthening	5	Opex - Improved practices for managing extreme weather events and clear accountabilities for action.	Risk of impact on train performance due top slow recovery from extreme events	tbc	Awaremess and Implementation
All	Non-asset specific	Event response	Various	Eastern	Table-top weather scenario exercises		Improved practices for managing extreme weather events and approaches to achieve speedy response and recovery	Risk of impact on train performance due top slow recovery from extreme events	tbc	Awaremess and Implementation
Drainage	Non-asset specific	Capability	Routes	Eastern	**Opex** - Resources and capability for inspection, management and technical leadership for drainage management	55	Increased resources, competence and capability to manage drainage assets so they are more resilient under extreme weather	Risk of drainage, earthworks and track assets failure and flooding resilience	Roles recruited	Awaremess and Implementation
Earthworks	All	Investigations	Various	Eastern	Investigations into high risk hillside failures adjacent to our earthworks assets.		Understand implications and risk from 3rd party assets adjacent to our track.	Risk of earthworks failure	tbc	Neighbours and Catchment
Lineside	lineside	Planning	Various	Eastern	Habitats Management Plans	5	Improved biodiversity and sustainable solutions for weather resilience.	Risk of flooding and vegetation on the track during storms.	Nr	Neighbours and Catchment

Unless stated the above costs are Capex, all are post-efficient and cash

Appendix F
Route Progress on CP6 Actions

Factor	Anglia	East Coast	East Midlands	North & East
Neighbours and Catchment	All hazardous trees identified in the most recent three yearly survey are on target to be removed before 2023.	A programme of clearance and maintenance of lineside vegetation has targeted the highest risk sites, removing dead, diseased and dying trees. This improves the network's resilience to high winds and disruption from vegetation debris on the line.	East Midlands collaborate with third parties and key stakeholders, such as the Environment Agency (EA) and lead Local Flood Authorities (LFA), as an efficient means of finding sustainable and holistic water management solutions. The route also wishes to do more to improve resilience, with a likely solution proposed to be a cascade upgrade and a track drainage enhancement.	A programme of clearance and maintenance of lineside vegetation has targeted the highest risk sites, removing dead, diseased and dying trees. This improves the networks resilience to high winds and disruption from vegetation debris on the line.
Monitoring	Alert and Alarm systems utilising tiltmeters to monitor the condition of railway cuttings have been installed at various sites, including Ipswich Tunnel Portal and Brantham High Cutting. Inclinometers have been installed at locations including Stourview and West Horndon to Dunton	Alert and Alarm systems (a form of remote condition monitoring) using tiltmeters are used to monitor the condition of railway cuttings at various sites. To monitor unstable embankments and to provide early warnings inclinometers have been installed at vulnerable locations. An extensive and growing network of fixed CCTV cameras (23 sites so far) and	To respond to weather-related challenges, the East Midlands Route has invested in innovative monitoring and inspection tools. The **Digital Lineside Inspection (DLI) Tool** aids in real-time condition monitoring, helping identify faults and issues promptly. The route has also explored the use of drones for remote condition monitoring, which can be	Real-time monitoring of water levels in the drainage assets helps us understand how our systems react in rainfall and when we need to intervene. An extensive and growing network of fixed CCTV cameras (23 sites to date) and remote water level monitoring equipment has been installed to improve preparation and reaction to intense rainfall events.

Factor	Anglia	East Coast	East Midlands	North & East
		remote water level monitoring equipment has been installed to improve preparation and reaction to intense rainfall events.	particularly useful in assessing hard-to-reach or critical areas.	
Asset Knowledge	There has been an extensive programme of drainage inspection and maintenance, which has identified local resilience improvements through a structured flood resilience review. This has improved the asset registers, and levels of information and data we hold on drainage asset (an ongoing data capture task that will be substantially complete in CP6).	To support flood risk management a programme of targeted drainage jetting has been developed and delivered, which has improved service and protected ballast from further degradation and wet beds. Using current knowledge, a comprehensive risk ranking exercise was undertaken across the drainage asset base to understand likelihood and impact of water management failures on assets and their performance	Drainage inspections, desktop studies, and comprehensive surveys have significantly improved knowledge of drainage assets, facilitating optimised maintenance schedules. Earthworks management plans are under development to address weather vulnerabilities. In CP6 East Midlands has worked towards a greater understanding of how drainage infrastructure is mapped and verified.	Drainage inspections are being delivered on a risk-based programme which is improving the knowledge of the drainage assets. Over 90 % of the route had been surveyed by the end of 2022 and 20 % of the route has comprehensive desk top studies to support optimal maintenance plans to manage risk.
Awareness and Implementation	To mitigate flood risk and reduce the severity of impacts on service: • Better and more accessible drainage system information • Improved first responder flood guidance/training	In total 25 high risk flood sites have been addressed delivering less delays to trains on the railway with a dedicated annual budget of £3.7m allocated for drainage and flood risk management. A proactive campaign of drainage management near	In CP6 East Midlands has worked towards a greater understanding of how drainage infrastructure is mapped and verified. At Belize Tunnel, a drainage survey identified that 90 % of the catchpits were not functional and the culvert	To mitigate flood risk and reduce the severity of impacts on service, a drainage renewal programme was delivered across 25 locations with previous history. The top ten locations addressed, accumulated 79 weather

Factor	Anglia	East Coast	East Midlands	North & East
	• More site-specific flood management plans • Delivery of small-scale improvements identified through flood incident reviews. • Desktop flood risk reviews	tunnel portals will be completed by 2024.	system was not functioning as a connected system. Jetting works, catchpit refurbishment and culvert renewals have been carried out to rectify with further drainage upgrades planned into CP7.	related incidents between 2009 and 2022.
Asset Reliability and Resistance Improvements	To protect against soil cutting failure, a programme has improved counterfort drains in slopes and refurbished crest drains. Alongside this, there has been a programme to remove selected large trees to reduce clay desiccation. Rock netting has been installed on chalk slopes to prevent spalling impacting railway operations. During CP6 some R&D funding was invested to review options to limit the impacts on the railways of ground water changes in underlying peat.	East Coast has established collaboration between the track delivery teams and drainage to make sure that drainage is functional in advance of work being undertaken on the track. Flood risk has been mitigated at 25 sites and local flooding resilience has been provided. Across track assets the removal of high-speed timber switch and crossings at high speeds (75mph+) is a key to making the rail more resilient to heat.	A major issue mitigated in CP6 is overheating in buildings and lineside equipment cases due to adverse high temperatures. Temporary air-conditioning units have been installed in equipment buildings that were not resilient to higher temperatures. Heat reflective paint has been used on assets that failed due to heat expansion. Battery upgrades have been made to those where batteries failed during higher temperatures.	Where track interventions are delivered, the delivery teams have included activity to make sure that drainage is functional in advance of work being undertaken on the track. Flood risk has been mitigated at 25 sites and local flooding resilience has been provided at sites including Garforth, Rotherham, Morley Tunnel and Harper's bridge. An £8m scheme has been completed at Hessel Foreshore to provide geotechnical support and protect against landslip which is vulnerable to weather events.
Strategic Responses		Strategic actions: • embedding the EWAT process and have a strong representation for Route	To improve track system resilience against the impact of hot weather events, East Midlands develop and implement a rolling 5-year	Development of standard operating procedures for critical flood risk site at Rotherham and Kirkstall

Factor	Anglia	East Coast	East Midlands	North & East
		Engineers and support from Works Delivery • development of a standard operating procedures for critical flood risk site at Kirk Sandall • raising of critical signalling and telecoms equipment so they are above flood levels in areas at risk	plan for ballast drops at strategically key sites across the route. Development of standard operating procedures for critical flood risk site at Corby, Pen Green, Draycott.	Raising critical signalling and telecoms equipment so they are above flood levels in areas at risk (Rotherham, Kirkstall and Healey Mills) Risk based proactive management of drainage adjacent to tunnel portals.

Appendix G

Eastern Region Route CP7 Plans

Factor	Anglia	East Coast	East Midlands	North & East
Renewals & Improvements	In total, £376m renewals investment will deliver improved weather resilience in the next control period which is 34 % of the overall budget for the route. Further investment will be made in monitoring equipment, growing asset intelligence and growing knowledge of long-term vulnerabilities across the Anglia route. In CP7, within the available funding, the route plan is focused on delivering £77m improvement to around 30km of drainage assets to manage flood risk from poor water management. Embankment and cutting renewals which are in poor condition and vulnerable will also be remedied.	Improving resilience of the overhead lines through 10 stations and partial refurbishments at around 400 locations will also give protection against wind. Earthwork improvements will be provided at around 70 sites with resilience improved at 50+ embankments, rock cuttings and soil cuttings. An extensive programme to remove over 1700km of rail more susceptible to rail breaks includes older rail sections. Refurbishment of the contact system through tunnels will address corrosion from water ingress and risk from ice in tunnels causing failures and delays to service. Whole system drainage approach will improve resilience to convective rainstorms and flooding which will drive reduced risk of cutting slope failure.	Just over £100m will be invested in providing weather resilience as a primary driver. Across earthworks, £2m has been allocated on continuing to build our asset knowledge and assessment of high-risk areas. £7m will be invested on creating resilience and removing temporary speed restrictions, providing solutions at 15 embankments and 3 rock cuttings. Over 90 locations will have renewed drainage pipes and a further 100 will have refurbishment. Where possible the integration between track, earthworks and drainage activity will be aligned and treated as a system. Earthworks and drainage provide resilience against rainfall events and action will be targeted at those	The earthworks investment includes embankments refurbishment at 9 locations, including £5m at Frodingham and addresses issues at 12 soil cuttings and 7 rock cuttings. The drainage submission includes a £3m contribution towards flooding protection for Rotherham, renewals at approximately 30 locations and refurbishment schemes at over 200 high risk locations. covering drainage pipes, ditches and channels. The structures investment addresses scour risk and a major underbridge repair costing £18m at Conisbrough on the River Don.

Factor	Anglia	East Coast	East Midlands	North & East
			which have the highest risk.	
Risk and Monitoring	All effort is focussed on high-risk locations. Maximising the use of monitoring equipment and new technologies to identify and make sure that the highest risk locations are managed, so new technology will play a key part in this strategy.	Specialist technology which uses aerial and infrared photography is used to identify dangerous trees allowing timely removal in preparation for stronger wind.	There are few locations on the East Midlands that are at risk of desiccation occurring, but it is still a potential risk that needs to be prepared for. Given the unexpected high temperatures in 2022, desiccation going forward will be a much more prevalent risk as further drought like conditions are likely to be experienced from 2023 onwards.	Continued deployment of remote monitoring technologies particularly at high-risk sites. Investing in new technology and analytical capabilities to increase understanding and mitigation of risks.
Secondary Benefits	A further £272m of improved resilience will be provided as a secondary benefit across buildings, track and electrification assets. Substantial secondary benefit can be gained from the investment in buildings, particularly where roofs and buildings are receiving major investment; solutions will be designed to improve resilience.	There is a further £380m of secondary benefits and together with the primary drivers nearly 40 % of the 2024 – 2029 plan will provide risk mitigation to weather events. Resilience to heat, cold and wind will be maintained at current levels with some marginal improvements for hot weather due to track investment. Secondary benefits from track renewals improves heat resilience by up to 4C	Over 30 % of the renewal's investment in CP7 will give some form of resilience to weather, although the majority of it is around secondary benefits derived for improved renewals particularly track.	Secondary benefits are delivered from nearly £300m of investment, predominantly from track including greater heat resilience through upgrades to jointed track and timber switch and crossing layouts. Signalling and telecoms equipment have also suffered in the recent hot summer so improvement to building and equipment cooling are included in the plan.

Factor	Anglia	East Coast	East Midlands	North & East
		by increasing the numbers of sleepers per length and using heavier rail sections		
Trade-offs and choices	Currently, at the level of investment in standalone climate improvements it is unlikely our resilience will keep pace with climate change, which may result in more reliance on operational restriction.	In the current funding environment, the renewals drainage budget in East Coast has been managed in line with other discipline reductions with key areas identified through risk prioritisation, it still represents an increase from CP6 funding.	It should be noted that the introduction of new electrification assets brings an infrastructure reliability disbenefit as they will inherently become susceptible to wind, lightning, and hot weather. Across the MML there will be additional electrification installed.	There is minimal investment in standalone climate improvements and increasing risk will be managed through maintenance and operational interventions.