SOUTHERN REGION

WEATHER RESILIENCE & CLIMATE CHANGE ADAPTATION PLAN 2024 – 2029

WORKING TO IMPROVE THE RESILIENCE OF ASSETS, NETWORKS AND SYSTEMS TO WITHSTAND CURRENT WEATHER EVENTS AND FUTURE EVENTS PROJECTED AS A RESULT OF CLIMATE CHANGE

Contents

Executive Summary

Climate change presents a significant risk to the safe, reliable running of our railway and we are increasingly experiencing severe weather events, with the region particularly affected by wind, rain, and heat, seeing over the last five years an increase in extreme storm events over winter months and record-breaking temperatures in summer.

Our CP6 route weather resilience and climate change adaption (WRCCA) plans included business as usual activities and standalone resilience workstreams, predominantly focussed on earthworks, drainage and off track (including vegetation), use of remote monitoring at priority locations and addressing risks associated with structures for scour, adverse rainfall and flooding.

Our focus in control period 7 (CP7) will be on mitigation and rapid recovery to minimise the impact of weather events on our network reflecting our asset management approach.

We will continue to develop our understanding of the vulnerability of our assets, building and adapting our infrastructure to improve the resilience of assets, networks and systems, to withstand current weather events and future events predicted as a result of climate change.

Our strategy for managing asset risk to achieve safety and performance outcomes is based on appropriately targeted maintenance activity. Renewals have been focussed on a market led and line-of-route criticality to give greatest passenger benefit within available funding, together with a degree of improved and future resilience as a result of changes to modern design standards and practices.

Our lineside strategy is an area where we are increasing investment compared to CP6. This increased investment in off track and drainage assets, partly to address Mair and Slingo's recommendations for the management of earthworks, but also to improve our vegetation management and lineside environment, will improve weather resilience through better water management and drainage across the network.

We will continue to work with our key stakeholders and look for opportunities to collaborate with our train operators and the Environment Agency on joint priorities.

Through CP7 we will create a regional approach aligned to the GBR Approach Checklists when it comes to Seasonal Preparedness, as well as undertaking research to review our weather readiness activities in respect of efficacy and value for money.

As we mature in our approach to weather resilience and climate change, we need to recognise where key interdependencies exist, and how we manage these alongside risks and opportunities to deliver our ultimate goal of a resilient railway.

This may include the need to overlay climate change projection data onto investment pipelines to support how we make considered investment decisions, as well as our approach to asset management, in that ultimately, we will use continued development of our asset policies and standards to integrate weather resilience and climate change adaptation decisions.

Our plan recognises the broader funding challenges and pressures within which we operate. We have had to make tough decisions and trade-offs to enable management of our CP7 spending in an efficient manner to deliver the best service we can for our customers, the taxpayer, and the communities we serve. Key to effective delivery is the success of our newly established Southern Renewals Enterprise (SRE) supported by a stable and integrated workbank. Our plans are built around a detailed bottom-up, five year workbank managed under a change control process, which will also enable more effective use of our access strategy.

In line with our market-led approach, investment is prioritised on the key routes into London, and critical junctions in the London area. Our plans will maintain a safe and operable railway although a deterioration of asset sustainability in some assets has been forecast, which will require greater investment in the future.

To support evolution of thinking and robust planning for CP8 and beyond, we will use adaptation pathway methodology to develop long term investment plans, which allows decision makers to plan for, prioritise and structure investment based on trigger points and thresholds.

We are committed to creating a long-term strategic approach to understanding and managing the impact of climate change and building a climate resilient railway for the long term. This plan will promote weather resilience and climate change adaptation as a priority, forming an integral part of asset management and operations across the region.

Chapter 1: Introduction

Weather conditions have always fluctuated around long-term averages, with occasional extreme weather events such as flooding, heat waves, droughts and storms. These events are so extreme, that they impact the operations of the railway and running of trains, for example, severe storm events or significant heatwaves. In the past these events have been relatively predictable and few and far between.

Climate change is causing these extreme weather events to occur more often, increasing the likelihood of critical coping thresholds being exceeded and therefore increasing the likely probability of operations and services being impacted.

Climate change is likely to have a variety of impacts on the rail network and our lineside neighbours, including:

- Rising sea levels/Coastal erosion – putting coastal railway locations at risk of flooding or damage
- Flood risk from inland watercourses – putting parts of the railway at risk of being flooded or damaged by subsequent landslides
- Impact of storms in terms of wind, lightening and rainfall – Which can cause damage to railway assets including track, signalling systems, Power supply and Telecoms systems
- Extreme temperatures both hot and cold – which can lead to a variety of impacts across the assets for example, Track buckling and adhesion issues.

Climate change will ultimately mean that many of the extreme weather conditions currently experienced, will become the 'new' normal. To enable us to manage this increased risk, it is vital that the railway is adapted to enable enhanced resilience, to provide a network that is able to operate in a safe and reliable way as often as possible, in light of changing climates.

Our WRCCA plan sets out our CP7 approach to:

1. Managing the short and medium-term impacts of today's weather events, through:

    - Improved reliability of assets and safe working of people during current and future weather events, measured by the reduction in delay minutes and significant events associated with severe weather, be that rain, wind, or temperature change
    - Improved understanding of areas at risk of long-term sea level rise and implications for long term planning and investment decisions
    - Improved understanding of assets requiring investment to respond to the short-term risk of asset failure as a result of today's severe weather events
    - Improved understanding of projects requiring investment for climate change adaption, responding specifically to a long-term climate risk outside of the control period

2. Creating a long-term strategic climate adaptation pathway

To support delivery of our plan in CP7, identified initiatives include:

1. Development of our climate adaptation pathway

2. Assessment of the impact of rising sea levels on the Southern region and identification of key risk coastal locations as part of strategic studies and the long-term planning process
3. Completion of vulnerability and criticality mapping to understand risk profile against all asset types
4. Continued partnership work with the Environment Agency to prioritise sites for investment based on our regional prioritisation matrix
5. Identification and development of pure resilience and adaptation projects
6. Delivery of the CP7 renewals workbank will replace assets with assets that meet modern standards around temperature and weather, providing increased resilience
7. Mair and Slingo recommendations reflected in our CP7 Operations, Maintenance & Renewals (OM&R) plan

We will also maintain engagement with our stakeholders, in particular our train operators (TOC) and freight operators (FOC), the Environment Agency, Local Authorities and other organisations such as Highways England, to support alignment with investment decisions and to embrace any potential collaborative opportunities.

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 such events 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 through the control period, which will be a significant factor in planning for future control periods.

Delivery in CP7 will build on activities from CP6, such as remote monitoring, reduction in CRT sites, and continued delivery of response to the recommendations from the Weather Risk Task Force. We will also seek to incorporate the GBR Approach Checklists to promote regional and national alignment in our response to weather preparedness.

This plan aligns to our regional Strategic Business Plan (SBP), Environmental & Sustainability Strategy and Strategic Asset Management Plan (SAMP) but does not repeat the detail.

Southern region

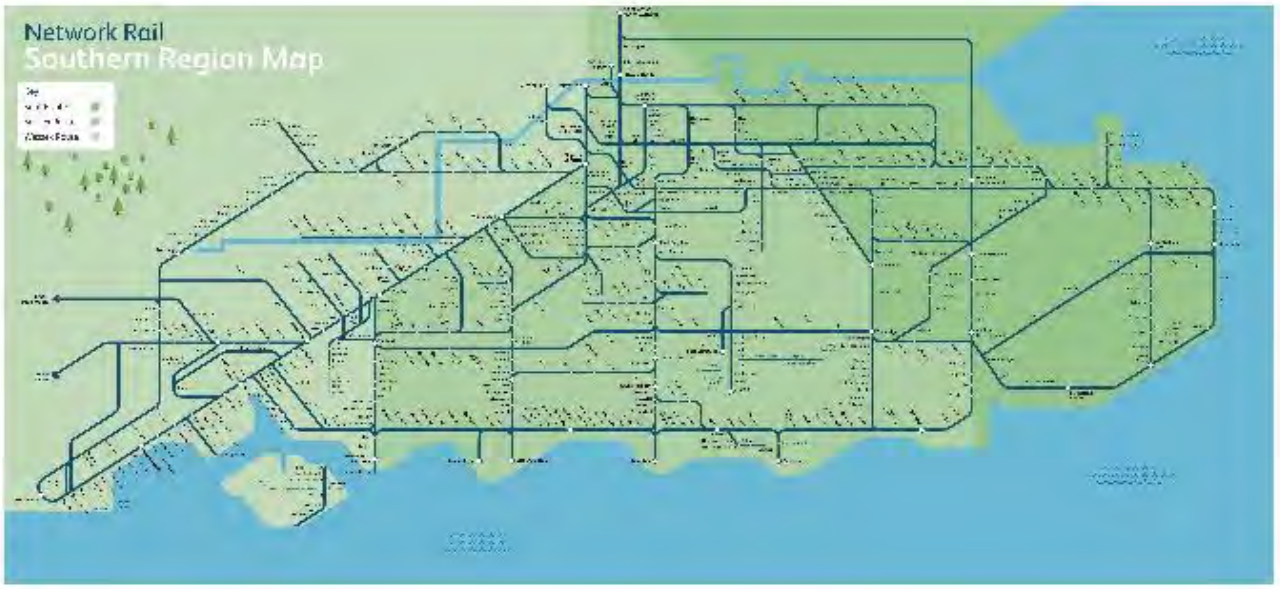
The Southern region comprises Wessex, Sussex, and Kent routes and includes Network Rail High Speed, but this is subject to a separate regulatory funding process. We link major towns and cities, including Bournemouth, Southampton, Portsmouth, Brighton, Canterbury, Ashford and Dover to each other and the capital.

We support key freight flows from the Channel Tunnel and Folkstone to, and through, London and from Southampton to the Midlands.

Stretching across the South and South-East of England the region has a number of coastal lines, passes through the undulating North and South Downs, the flood plains of the River Axe, and the unique challenge of the New Forest, which can often enjoy its own micro-climate from flooding to wild fires. This geology and topology lends the region to be vulnerable to sea level rises, coastal erosion, river flooding and the challenges of maintaining just under 900 miles of embankments, primarily clay, as well as rock (120 miles) and soil cuttings (650 miles), which are increasingly affected by storm events and hot weather.

We operate the busiest and most congested rail lines in the country. Our performance impacts the lives of millions of passengers, our lineside neighbours and the freight companies that depend upon us.

Figure 1: Southern region map



We are responsible for managing large London stations such as Waterloo, London Bridge and Victoria and every day carry large numbers of commuters to, and from, the capital as well as serving Gatwick and Southampton air and seaports.

Waterloo, London Bridge and Victoria are the three busiest stations in the UK; and Clapham Junction, London Bridge and Waterloo are the three busiest interchange stations; highlighting the need to recognise the welfare of our passengers during the changing seasons through simple things such as provision of water, shade, and shelter from the changing elements.

Weather in Southern

Every year the railway network is significantly affected by severe weather conditions including wind, snow, rain, lightning, heat and cold, all of which can cause significant disruption to our network, impacting our customers and passengers.

We monitor the impact of weather events on the performance of our network by using delay minutes and schedule 8 compensation costs. Incidents are recorded under nine categories as follows:

- Adhesion – line contamination leading to traction loss, e.g. leaf fall, moisture and oils
- Cold – e.g. 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 – e.g. rail buckles, temporary speed restrictions (TSR), overheated electrical components
- Lightning strikes – e.g. track circuit/signalling damage or power system failure
- Snow – e.g. blocked lines and points failures,
- Subsidence – the impact of landslips, rockfalls and sinkholes
- Wind – e.g. trees/ other items blown onto the track or TSRs

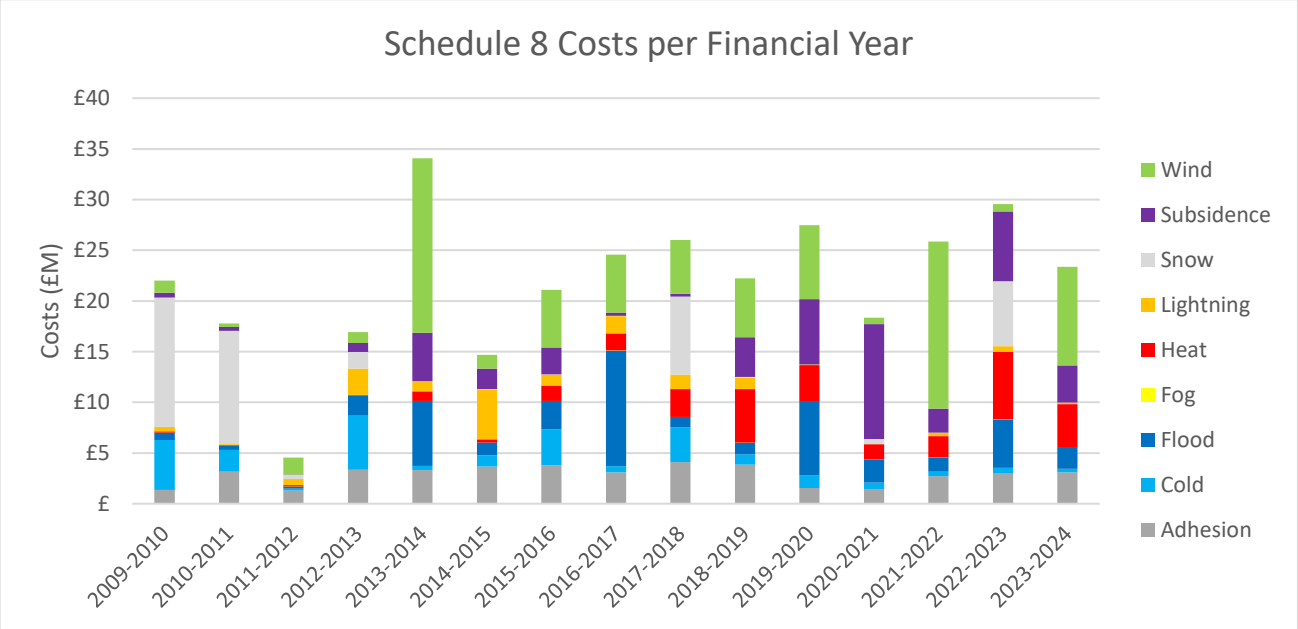
The impact of weather on the region's schedule 8 delay minutes across the 9 vulnerabilities is represented in the graph below (figure 2). Schedule 8 costs mostly mirror the impact, except for wind and subsidence events, which result in higher cost penalties versus minutes.

As can be seen from the data, 15 years ago our biggest impacting weather event was snow. In subsequent years, wind events have increased in impact (both cost and delay), with subsidence/earthwork

failures the second highest for schedule 8 cost. Less of an impact is fog, with the impact of lightning also seeing a decline in recent years; although this is most likely due to a lower frequency of such events.

Owing to the geographical makeup of the region, the primary challenges to the region into CP7 will continue to be from storm events (primarily the impact of vegetation management and earthwork failures), river flooding and heat (track resilience and soil moisture deficit).

Figure 2: Sch.8 Cost of Weather Impacts 2009-2024



Chapter 2: Managing WRCCA in Southern

Managing Weather

Day to day management of weather impacts is the responsibility of the three Routes who manage it through a combination of their operations, engineering and maintenance teams. It involves a combination of:

- Proactive works (based on the differing seasonal challenges),
- Preparation works e.g. rail head treatment, emergency plans
- Formation of Extreme Weather Action Teams (EWATS) when known weather events are forecasted
- Reactive works to deal with the impact of weather events e.g. clearing fallen trees
- Collaboration at the Seasonal Delivery Steering Group

Interaction with the TOCs and FOCs is also a critical part of weather management due to the need in some cases to operate TSRs or reduced timetables.

Post weather event reviews are also undertaken to help improve preparation for similar events in the future. Learning lessons and sharing best practice across the region and nationally, is essential for future proofing and improving response to an ever-increasing frequency of weather events. Using heat by way of an example, lessons learnt and acted on from the heat of July 2019, helped improve performance during the record temperatures of the summer months in 2022.

Our seasonal specialists in the routes are taking a much more strategic approach to weather management having season specific plans. They have also interacted and engaged with the weather risk task force (WRTF) and implemented use of tools such as the convective alert tool.

Weather Risk Taskforce

Following the incident at Carmont in August 2020, Network Rail received a series of recommendations from Lord Robert Mair and Dame Julia Slingo; these recommendations were assigned at various levels within Network Rail, to be led at either a national or regional level. To support cohesion, the WRTF was established and is collating plans to provide an overall integrated programme.

At a national level, the Mair and Slingo recommendations are being led by either the Technical Authority (TA), System Operator (SO) or Intelligent Infrastructure (II). Regionally, the asset management team have the lead, contributing and supporting as required and have a dedicated lead for this work. We will continue to improve our governance around weather resilience and climate change as we move towards CP7.

In respect of the WRTF recommendations, we have created an action plan; the Geotech, Drainage and Off-Track (GDOT) improvement plan, to deliver those actions identified to be led within the region.

Asset Resilience

During CP6 there has been a programme of asset renewals to replace old and failing infrastructure. Replacing old for new in this way has improved resilience through the nature of modern-day standards. Our engineering teams are actively engaged with the Standards update process and fully supportive of the nationally led programme.

We know though, that more needs to be done to make designs more 'climate ready' and our maturity in this area needs improving. Any drainage, earthworks or track renewals will be based on current best practice design standards, with an ambition to embed weather resilience and climate change into design thinking as we mature through CP7.

In CP7 WRTF schemes will provide some investment in pure resilience, but prioritisation of available funding means that such investment will be limited elsewhere. Renewal activity will be led as part of the newly formed Southern Renewals Enterprise (see Chapter 4), with reactive investment approached on a needs' basis, assessed by the risk and mitigations available.

Learning from CP6, planned earthworks interventions have been supplemented with an allowance for emergency reactive interventions based on historic failures trends. This approach has been taken because we know failures occur (there has been no year without failures) and to protect our planned interventions, up to a point. In CP6 this approach was not taken, and failure interventions had a huge impact on planned interventions, especially in years 1 and 2.

Our approach to risk reduction across our assets as well as how we intend to balance the need for reactive versus proactive measures is covered below within our Strategy & Investment into CP7 section.

Chapter 3: Our Climate Change Risk

This section provides an overview of the climate change risks to the region, but does not repeat the detail contained within the South East and Wessex Route CP6 plans.

The UK Climate Projections 2018 (UKCP18), which 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 as well as an increase in peak river flows. This means that Southern needs a detailed understanding of the vulnerability of our service, assets and activities to enable us to maintain a resilient railway.

Since the publication of our CP6 WRCCA Plans, Network Rail has increased the focus on understanding our weather and climate change risks. Over the last control period, we have continued to gather and analyse

data on our weather impacts, for example using our delay minutes as shown below, and as a region we continue to work closely with the WRTF.

As we evolve in our thinking and approach to weather resilience and climate change, we will look to move away from using schedule 8 delay categories as the primary indictor of impact of weather on the region, utilising the ARP3 assessment categories to facilitate not only an enhanced risk assessment approach, but also enable prioritisation of proactive targeted interventions.

Based on the projected changes to the climate and historic impact on performance (discussed further below); table 1 demonstrates prioritisation of weather-related impact on the region.

Impact	UKCP18 Projections	Prioritisation
Wind	Changes difficult to project, however generally expected to increase	High
Subsidence / Earthworks' Failures	Increases in mean daily rainfall across late Autumn, Winter and early Spring months, for example; 14.3 % in April and 53.2 % in January by the 2050s becoming 15.7 % in April and 85.3 % in February by the 2080s. Increased frequency and intensity of Winter and Summer storms. Decreases in mean daily rainfall for late Spring through to early Autumn, for example; 22.7 % in May and 51.7 % in August by the 2050s becoming 21.9 % in May and 60.6 % in August by the 2080s.	High
Heat	Increases in mean maximum daily temperatures range from 3.4°C to 3.9°C (Winter) and 4.8°C to 5.9°C (Summer) by the 2050s. In the 2080s this becomes 4.8°C to 5°C and 6.8°C to 8.3°C respectively.	High
Flooding	Increases in mean daily rainfall for late Autumn through to early Spring and increased intensity and frequency of Winter and Summer storms (see subsidence).	High
Snow	Changes difficult to project, but increases in Autumn, Winter and Spring minimum temperatures suggest reduced snow days.	Medium
Adhesion	Complex relationship between multiple causes and their climate projections.	Medium
Cold	Increases in mean minimum daily temperatures in Autumn, Winter and Spring ranging from 3.2°C in April to 4.5°C in January for the 2050s and 4.4°C in April to 6°C in January for the 2080s.	Medium
Fog	This is a complex picture with low confidence, however possible seasonal changes for the 2080s have been indicated as: Winter +7 %, Spring -42 %, Summer -70 % and Autumn -31 %.	Low
Lightening	Changes in storms difficult to project, however generally expected to increase.	Low

Table 1: Prioritisation based on UKCP18 Projections

ARP3 Risk Assessment

As part of Network Rail's Adaptation Reporting Power submission to UK Government in 2021, a detailed asset climate risk assessment was conducted by the Technical Authority using a template provided by DEFRA. The template was amended to incorporate a modified version of Network Rail's Corporate Risk Assessment Matrix scoring system. Over 600 risks were identified across a range of assets, with current risk scores provided, as well as possible levels of risk by the 2050's and 2080's. Full details of its development can be found in our Third adaptation report to Defra (ARP3) and a copy can be found here.

The national scoring within this integrated ARP3 Climate Risk assessment has been used as a baseline against which to assess the risk against each vulnerability for the region, with risk scores ranging from 1/minor to 25/severe. As part of the development of this plan, the risk assessment undertaken builds on the 2020 national Integrated Climate Change Risk Assessment carried out for ARP3; using the same method as the national assessment we have carried out a regional review of those risks with a current score of 9 or above, re-scoring to reflect the regional position, identifying any regional variations and their

levels of severity. Extracts of the ARP3 assessment are included within the relevant sections below, with the full assessment found here.

Completion of the risk assessment, together with a review of Schedule 8 impact over the last ten years, indicates that the region is generally aligned to the national position, both in respect of risk scoring, confidence levels, risk owner and discipline attribution. The primary difference in respect of risk scoring was found to be in respect of earthworks (for all weather variables), which scored higher, owing to the extent of earthworks across the region and the impact and interdependency of multiple asset disciplines. In addition, but to a lesser extent, the risk of wind and heat were also felt to be slightly higher in Southern compared to the national average. In contrast, the risk of sea level rise flooding, snow and adhesion has reduced as a result of proactive planning for extreme events, removal of all high risk scour sites in CP6 and enhanced management of adhesion.

Examples of risks rated higher	Desiccation of soil cuttings and shrinkage of clay embankments due to higher temperatures and associated SMD
	Earthwork failures due to prolonged saturation levels
	Long term degradation leading to earthwork failures with little or no advance warning
Examples of risks rated lower	Risk to tunnels across all weather variables were felt to be manageable via inspections and maintenance with risk primarily driven by asset condition
	Impact of sea level rise on coastal structures due to low level of structures
	Risk of scour was lower in the region due to level of works completed in CP6 (removal of all high risk sites)

Table 2: Risks different to National Scoring (ARP3)

Further detail on the effects of wind and storms, heat, cold, flooding and adhesion are discussed below. The actions we will take to manage and mitigate these risks through CP7 are discussed in Chapters 4 and 5, with specific actions detailed within Appendix 2.

Wind & Storms

The fact that Southern region is almost exclusively third rail traction current supply, could lead to an assumption that the region is not as vulnerable to winds as those reliant on overhead electrification. However, the last five years has seen wind events become our number one cause of delay; accounting for an average of just over 100k delay minutes at a cost of £7m per annum for the region.

High winds can lead to a range of different issues for the railway, usually caused by objects or lineside vegetation being blown on the infrastructure, either blocking trains from running or damaging the infrastructure. In addition, coastal lines are susceptible to increased risk of coastal erosion, sea spray and damage to flood defences during high winds. In December 2015, the coastal line between Dover and Folkestone was shut after being damaged by a violent storm that breached the sea wall causing 250 metres of track to collapse and closing the line to passenger services. The closure of the line impacted Southeastern and Southeastern HS1 services on this route with the line closed for 10 months whilst the line was repaired before it reopened in September 2016.

During periods of high winds, it is sometimes necessary to implement temporary speed restrictions, which can lead to cancellations and or delays to services. Speed restrictions are put in place to protect trains from wave impacts at coastal locations and hitting debris or trees fallen on the track. Line blockage from fallen trees and poor adhesion are the main issues to track, and where serious damage to rolling stock has required its removal from service for repair.

Where the infrastructure is designed without lineside vegetation and with suitable preventative infrastructure e.g., High fences, such as on HS1, trains are less likely to affected by high wind conditions.

The wind related Schedule 8 delay data shown below in figure 3 shows a slight increase through the years 2006/07-2021/22 in minutes and costs. The chart also depicts the unpredictability and inconsistency of measuring the impact of weather events on the railway. 2013/14, for example, experienced over 500,000 minutes of delay and over £17m in delay costs, whereas at its lowest, wind was responsible for just £0.3m of costs (2010/11) and 9000 minutes (2020/21) demonstrating the extent of variability in the weather system year to year.

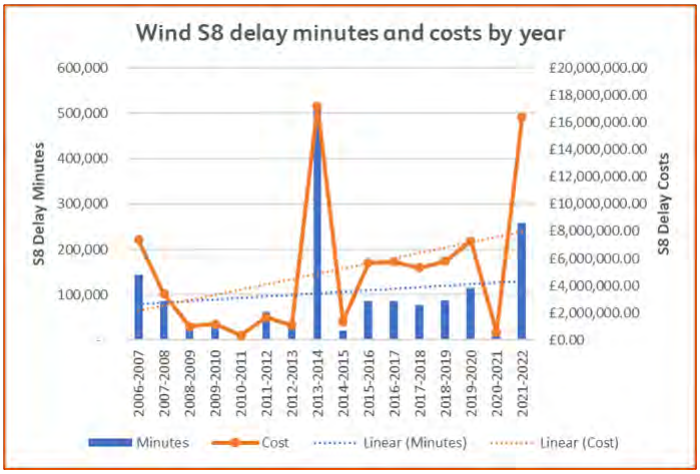


Figure 3: Sch 8 Wind

Our high risk asset scores reflecting the impact of wind and storms on the region are detailed in table 3 below:

Function	Asset	Risk Description	Current Risk Score	2050 Risk Score	2080 Risk Score	Comments
Level Crossing	Level crossing	Failure of barriers	9	10	10	
Signalling	Track circuit	Leaf fall - can provide an insulating layer between wheel and rail causing the track circuit to SCWO	12	9	1	
Vegetation	Rail vehicle - rolling stock	Vehicle derailment due to vegetation obstruction on the line	12	12	10	
Track	Track and S&C	Destabilised track and poor track quality causing speed restrictions or line closure	6	9	12	
Vegetation	Trees	High winds blow trees over causing risks to passengers and staff, blocking lines. Safety and performance risks and repair costs	9	10	10	
Structures	Coastal and estuarial protection	The risk of coastal erosion and sea defence overtopping as a result of high winds will have a serious impact on performance with safety speed restrictions imposed	6	6	6	Lower risk scoring based on interventions through CP6.

Table 3: ARP3 Moderate/Major Risks, Wind & Storms

Future Projections

There are no credible projections for future wind conditions, due to low levels of confidence in the modelling. See UKCP18 for further detail and a link to a fact sheet produced by the Met Office.

In recent years, notable storm events, for example Storm Arwen in 2021, followed in 2022 by Dudley, Eunice and Franklin, saw wind speeds ranging from 69mph to 122mph, with the resultant impact of trees and debris being blown onto the line. These events highlight vulnerable areas, but the inability to project changes, limits our ability to prepare in the long-term.

Subsidence/Earthworks' Failures

One of the most significant aspects of weather impact is the susceptibility of earthworks to adverse or extreme weather. The five key variables which determine the performance of our earthwork assets are type, geology, condition, moisture, and trees.

Over the course of the last five years, earthworks' failures as a specific cause of delay has averaged 58k minutes delay per annum across the region, with an average cost of £5m, making it our second largest risk, for both delay minutes and cost.

The specific impact of each weather variable on our earthworks is discussed within the relevant section below.

Heat

Heat is currently the third highest weather impacting event on the region. Extreme heat can cause a range of different effects on the operations of the railway. One of the main impacts is associated with track buckling, which prevents trains operating, with temporary line speeds needing to be implemented to prevent trains running over affected sections at line speed. In addition, extreme heat can lead to trackside equipment and systems overheating. Earthworks can also be affected by the ground being desiccated. Furthermore, high temperatures can increase the risk of trackside fires, particularly in areas of high vegetation. Finally, extreme temperatures can pose a risk to both the workforce and passengers, for example where appropriate working conditions cannot be provided or functioning air conditioning is not provided on trains.

In analysing the Schedule 8 data for heat related delay events (figure 4), it can be concluded that heat follows an opposite trendline to both cold and snow. Heat has typically become increasingly responsible for delay minutes and costs to the railway, with an initial seven-year period (06/07-12/13) showing lower levels of delay followed by a steady increase and peak of above £5m in delay costs for the year 2018-19. 2022/23 continued experiencing heat as a major impact, with 82k delay minutes at a cost of £6.6m, up to January 2023 (double the annual average of the previous five years).

Two notable instances of excessive heat in 2019 and 2022, seeing record temperatures, highlights heat as a realised risk and for short periods can severely affect the safe running of the railway.

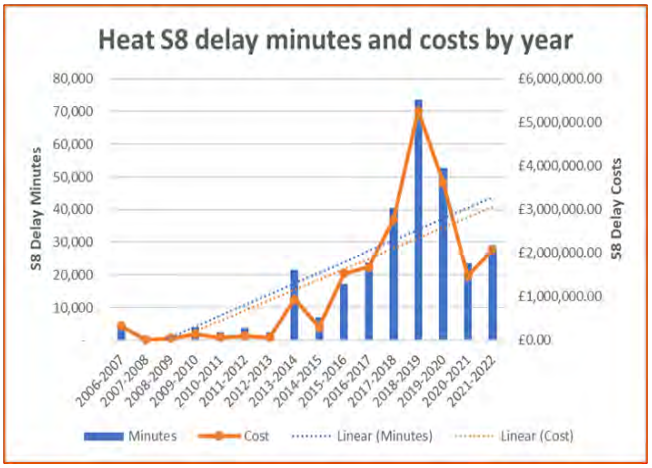


Figure 4: Sch 8 Heat

Our scoring as part of the ARP3 risk assessment recognises the changing impact of heat on our assets, as shown by table 4 below.

Function	Asset	Risk Description	Current Risk Score	2050 Risk Score	2080 Risk Score	Comments
Geotech	Rock cuttings, soil cuttings, embankments	Clay shrinkage of embankments will result in deterioration of track geometry and subsequently performance impacts	20	25	25	Higher risk scoring due to extent of asset across the region, historic failures and level of future investment.
Geotech	Rock cuttings, soil cuttings, embankments	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	20	25	25	
Signalling	Location case	Components housed within the location case can overheat	9	12	12	
Track	Mobile plant, rail vehicle - rolling stock	Derailment due to track buckle	6	9	9	Lower based on interventions through CP6, changes to process and better than expected performance in heatwave of 2022.
Track	Track and S&C (jointed)	Track buckles in jointed track (rail)	4	6	6	
Track	CWR	Track buckles in CWR (rail)	9	12	12	
Track	Track and S&C (low SMD)	Destabilised track and poor track quality causing speed restrictions or line closure	10	12	15	
Vegetation	Trees	Potential increase in invasive non native infestations that affects the mortality in trees	9	9	9	
Vegetation	Trees	Increase in tree mortality due to drought	9	10	10	

Table 4: ARP3 Moderate/Major Risks, Heat

Future Projections

Climate Change is predicted to bring much warmer conditions to the UK, with longer and hotter summer conditions predicted. The East of England and London will see the greatest projected increase in winter minimum temperatures. In Summer, London and South East England will see the largest projected changes. In January under a primary climate change scenario (UKCP18) it is forecasted mean daily minimum temperatures will have increased by 2.8 °C by 2050's and 4.0 °C by the 2070's across the South East.

Based on this, it can be expected that Southern region's railway will be much more susceptible to heat related delay events in the future in comparison to its Northern counterparts, owing to the warmer climate seen in Southern England. This has potential to lead to the Southern Region experiencing proportionally more delay costs and minutes due to heat. Where cold and snow related delays are forecast to potentially trend downwards, these issues could be replaced by increasing frequency and severity of heat-related delays.

Cold

Cold weather-related delay minutes and costs show both to be following a linear trendline of decreasing through the period of time in which data was recorded (figure 5). This encompasses a selection of two particularly bad years (09/10 and 12/13) followed by more consistently lower years with regards to both Schedule 8 delay minutes and costs which shows that cold delay events are susceptible to high levels of variability dependent on normal annual variation in temperatures. What is apparent, is that when these variations happen, and colder years occur, the railway can be significantly affected in both delay costs and delay minutes as seen by the extreme values below.

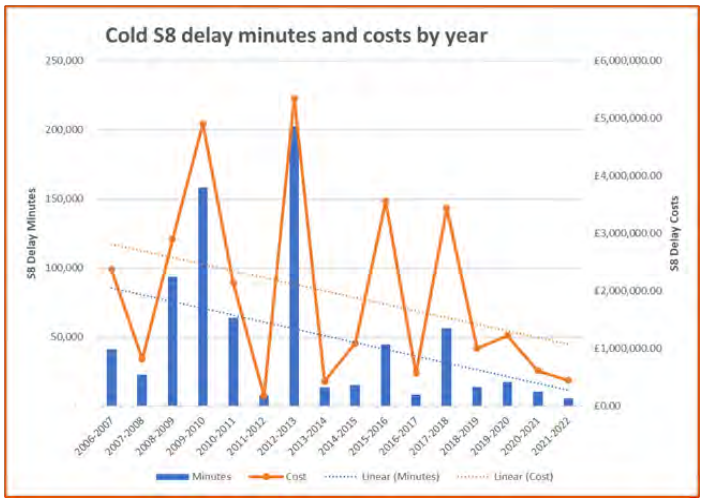


Figure 5: Sch 8 Cold

Cold temperatures in the UK are often combined with other weather hazards such as ice and snow, which compound impacts on the railway. Widespread and substantial snow events have occurred in 2009, 2010, 2013 and 2018, but their number and severity has generally declined since the 1960s.

Snow and ice pose a particular risk to the railway in relation to build around switches and point work, if these freeze up trains are unable to operate. In addition, snow can obscure signals sighting for drivers, meaning they are unable to see signals properly. Furthermore, ice can also build up on the third rail creating a gap between the electrical shoe gear on the train and the third rail, preventing clear contact between the rolling stock and the power supply.

High levels of precipitation in the winter months can lead to higher groundwater recharge, where surface water infiltrates the soil and becomes groundwater. This can lead to excessive ice formation in tunnels or structures, alongside causing frost damage. In addition, following considerable amounts of snow, melting can overwhelm drainage systems, if not appropriately designed. Finally, the combination of higher ground water levels and overwhelmed drainage systems, can lead to increased flooding or earthwork stability issues. Over the course of the last five years, subsidence as a specific cause of delay has averaged 58k minutes delay per annum across the region, with an average cost of £5m, making it our second largest risk, for both delay minutes and cost.

During the Beast from the East storm in March 2018, that bought blizzard like conditions to the UK and sub-zero temperatures, train services were severely disrupted. During the freezing weather a Southeastern Train service was stranded with passengers on board at Lewisham after ice and freezing rain impacted the third rail, leaving passengers stranded after a train failed nearby. Thick ice formed and made the train from London Bridge to Dartford via Bexleyheath break down. In total 9 trains were stranded in the Lewisham area with freezing rain being the contributing factor that exacerbated the problem. Our improved winter seasonal preparations, included railhead treatment and track circuit heating, have

reduced the risk of recurrence, but the possibility of a repeat incident remains, albeit at a much-reduced probability.

The table below shows our high-risk asset scoring for cold (snow and ice) following completion of the ARP3 risk assessment:

Function	Asset	Risk Description	Current Risk Score	2050 Risk Score	2080 Risk Score	Comments
Geotech	Rock cuttings, soil cuttings, embankments	Long term degradation due to age-driven/cyclical processes such as freeze thaw and snowmelt	9	12	15	
Structures	Bridges, culverts and retaining walls	Deterioration of condition of asset	6	6	6	
Structures	Tunnels	Ice formation within shafts leading to risk to both operational trains and the workforce of falling ice	5	5	5	Lower based on interventions through CP5/6, historic performance & low number of risk sites.
Structures	Tunnels	Ice formation within the bores leading to prevention of trains operating within the tunnel	6	6	6	
Welfare	Staff	Staff welfare. Staff can quickly become fatigued and loose concentration, in extreme cases hypothermia could develop. These can have severe health and safety implications	9	8	6	
Track	Track	Rails contract in cold temperatures increasing the risk of broken rails. On very tight radius curves the risk increases where contraction of the rails can cause the track to be pulled in towards the inside of the curve	9	8	7	

Table 5: ARP3 Moderate/Major Risks, Cold, Snow & Ice

Future Projections

Climate change is predicted to bring overall warmer temperatures to the UK, with shorter winter periods and less severe frost and snow conditions. However, extreme conditions will remain, meaning low temperatures will still be possible.

Winters are expected to experience much higher levels of rainfall with December predicted to be the wettest month of the year. The combination of higher rainfall and freeze and thaw is likely to remain a risk for the railway and its assets, particularly civils assets, earthworks and drainage.

Precipitation & Flooding

In the last 5 years (2017 – 2022) flood events have resulted in an annual average of 38k delay minutes, equating to schedule 8 costs of £2.2m; meaning flooding ranks as our fourth highest risk to the region (figure 6).

The primary driver of flooding in the Southern Region is drainage and topography. During periods of extreme rainfall drainage systems can become overwhelmed, which can lead to increased water onto the track beds, damaging assets and preventing services from running normally.

Electrical equipment can also become damaged, through water submersion, which can lead to power supply issues to electrical systems or signalling equipment. Flooding will continue to be a major issue for

the Southern Region, owing to the large amounts of DC third rail electrification, which is unreliable during flood events and poses additional safety risks, particularly to our people when responding to such events.

Another significant issue associated with increased rainfall includes the destabilisation of earthworks, which increases the risk of landslips. For example, a landslip at the entrance to Honiton Tunnel closed the West of England line in November 2022. The incident followed a prolonged period of heavy rain, at a site where we were already carrying out work on the slopes of a steep cutting with the aim of preventing further landslips.

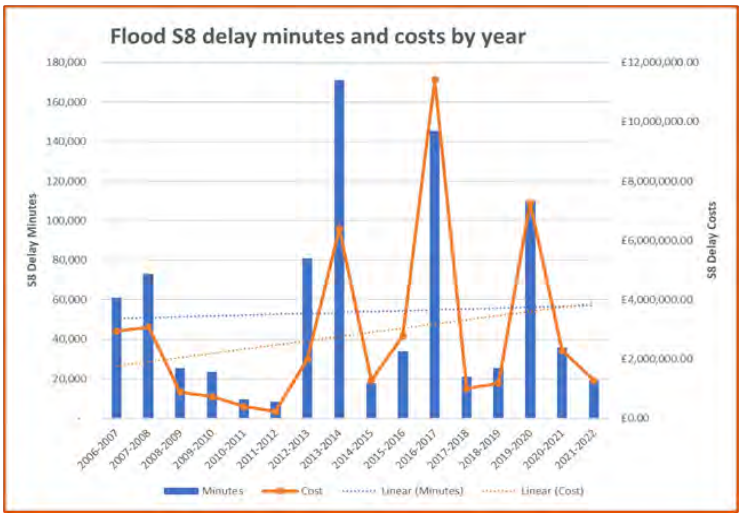


Figure 6: Sch 8 Flood

Increased rainfall also leads to increased peak river flows, which can lead to increased scour on bridges and piers. This is a particular issue for parts of the network which cross river courses multiple times.

Through August 2022, the UK received 54% of the average rainfall (51mm), making it one of the driest July's on record. During periods of little rainfall, the ground undergoes a process called desiccation which can be characterised by cracks in the ground. During this period, the ground is unable to soak up large amounts of water quickly, which leads to flash floods occurring during intense rainfall; often resulting in drainage systems becoming overwhelmed, where they haven't been designed to high enough thresholds or have been degraded due to increased periods of rainfall.

Clay is a continuing challenge for the region as it absorbs water and expands during the winter and then dries off and contracts as trees and vegetation soak up the water. This leads to poor track quality and landslips.

The discussion above is recognised in the table below, which outlines the key asset risks identified as part of the ARP3 risk assessment process (see also actions within Appendix 2):

Function	Asset	Risk Description	Current Risk Score	2050 Risk Score	2080 Risk Score	Comments
Drainage	Culvert	Design capacity of culvert exceeded and system surcharges with potential for resulting damage to surrounding earthwork and or flooding track	9	12	12	
Drainage	Pump	Pump failure due to work rate/failure to keep pace with rising water levels	12	12	14	

Drainage	Track/earthwork drainage	Design capacity of drainage network exceeded and system surcharges are potentially compromising parent assets	12	12	12	
Geotech	Rock cuttings, soil cuttings, embankments	Long-term degradation, adverse/extreme weather, 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	25	25	25	Higher risk scoring due to extent of asset across the region, historic failures and level of future investment.
Geotech	Rock cuttings, soil cuttings, embankments	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 >150 years old	25	25	25	
Structures	Bridges, culverts and retaining walls	Scour/undermining of structure due to erosion	8	8	8	
Track	Track and S&C	Destabilised track and poor track quality causing speed restrictions or line closure due to low SMD or erosion	10	12	15	Higher risk score due to challenges experienced in heat wave of 2022.
Geotech	Mobile plant, rail vehicle – rolling stock	Derailment due to landslip due to erosion	15	12	25	
Structures	Tunnels	Water ingress in tunnels leading to an increase in defects (e.g. open joints, spalling and missing bricks) as well as increase demand on track drainage	4	6	6	Lower risk score based on historic performance, level of intervention across asset base through CP5/6.
Vegetation	Trees	Washout resulting in loss of root anchorage	9	10	9	
Vegetation	Trees	Waterlogging resulting in loss of root anchorage	9	9	9	
Buildings	Station buildings	Building drainage overwhelmed	9	12	12	
E&P	Distribution network operator supplies	Flooding can affect power supplies	9	9	12	
Structures	Bridges, culverts and retaining walls	Scour	9	9	9	
Structures	Bridges, culverts and retaining walls	Hydrodynamic loading (including debris impact and buoyancy)	6	6	6	Lower due to number of assets.
Structures	Tunnels	Rising sea levels can lead to flooding to tunnels. These could result in scour to tunnels affecting their functionality	1	1	1	Lower due to removal of

Structures	Tunnels	Increased river flows can lead to potential flooding to tunnels. These could result in scour to tunnels affecting their functionality	1	1	1	high risk scour sites in CP6.
Buildings	Platforms	Flooding of platforms	7	12	12	Lower due to historic performance.
Buildings	Subways	Flooding of subways	9	12	12	
Drainage	Third party drainage systems	Flood risk for connected third party systems due to overwhelming of railway drainage systems/reduction in effectiveness of drainage systems	9	12	12	

Table 6: ARP3 Moderate/Major Risks, Precipitation & Flooding

Future Projections

Total precipitation (rainfall, sleet, hail and snow) is projected to increase in the late Autumn to early Spring months as a combination of increased average precipitation and increased severity and frequency of storms. In late Spring to early Autumn the frequency of extreme storms is projected to increase, but the total and average precipitation is projected to decline.

The reduction in summer rainfall and increases in winter rainfall are expected to balance each other out, leading to almost no change in overall yearly volume of rainfall.

During the Winter months it's more likely extreme rainfall periods will occur, contributing to drainage systems being overwhelmed, which can lead to increased water onto the track beds, damaging assets and preventing services from running normally. Whilst during the summer months, less rainfall will lead to higher levels of desiccation, increased risk of flash floods and drainage systems becoming overwhelmed.

Sea Level Rise

The Environment Agency forecast that across the southeast the cumulative impact of sea level rise will see 1.2 metres of sea level rise between 2000 – 2125. More localised data shows that by 2050 Margate and Portsmouth will see around 35cm of sea level rise, rising to 53cm by 2070.

The combination of sea level rise and projected increases in the frequency and severity of winter and summer storms will increase the risk and severity of coastal flooding and erosion events. This will pose a significant threat to the Southern Region, which has a number of coastal railway routes such as Folkstone to Dover, Holes Bay, or the Seaford to Newhaven Branch.

Rising river levels, whilst have been fairly consistent in impact over the last ten years, will increase in the future and will need to be managed carefully in partnership with adjoining landowners and various other bodies, such as the Environment Agency.

Recognition of the risk posed to our assets from sea and river level rises is reflected in the ARP3 scoring below:

Function	Asset	Risk Description	Current Risk Score	2050 Risk Score	2080 Risk Score	Comments
Drainage	Non-return valves/river outfalls	Wet winters increase river levels and flows in systems, resulting in flap valve levels becoming inappropriate, leading to flooding	12	16	16	

Drainage	Non-return valves/coastal outfalls	Rising sea levels resulting in flap valve levels becoming inappropriate, leading to flooding. (the combined effect of sea level rise and isostatic rebound are producing larger impacts in the Southern areas of England)	12	16	16	
Drainage	Flood defences/revetments	Increased river/estuarine flows resulting from longer wetter winters result in flood defences being challenged and overwhelmed with resulting flooding of the railway	12	16	16	
Drainage	Flood defences/revetments	Increased river/estuarine flows resulting from longer wetter winters result in flood defences being challenged and overwhelmed with resulting flooding of the railway	12	12	16	
Drainage	Coastal defences/ revetments	Sea level rise resulting from global sea level rise and isostatic rebound challenging flood defences with resulting flooding of the railway	12	12	16	
Structures	Coastal and estuarial protection	Adverse and extreme coastal events on structures	4	4	4	Lower risk score owing to number of structures and level of historic intervention. This may change into the future based on actual extreme weather events v projections.
Structures	Coastal and estuarial protection	Risk of coastal erosion and defence overtopping will increase with increased frequency and intensity of Atlantic storms, combined with sea level rise. Discharges to estuaries and the coast will become more difficult.	4	4	4	

Table 7: ARP3 Moderate/Major Risks, Sea & River Level Rises

Adhesion

Adhesion is historically categorised as a medium/low risk to the region, owing to it primarily being experienced during Autumn only, and is generally managed through national standards and practices.

Adhesion issues occur to the due to leaves on the track, creating moisture and oil contamination on the railhead, reducing the grip trains have. This leads to longer acceleration and deceleration. Adhesion issues are currently one of the most significant causes of delay across the network. Low adhesion between track and train was a major contributing factor to a train crash between 2 trains in the Salisbury Area in November 2021, where 2 trains collided at Salisbury Tunnel Junction.

Schedule 8 delay minutes and costs follow inverse trends with costs gradually rising and minutes slowing down. Despite this, figure 7 confirms that adhesion related issues are consistently responsible for large amounts of delay and significant costs year in year out.

The last 3 years have seen adhesion related Schedule 8 Delay minutes, below 40,000 each year and with Schedule 8 costs between £1,500,000 – 3,000,000 per year.

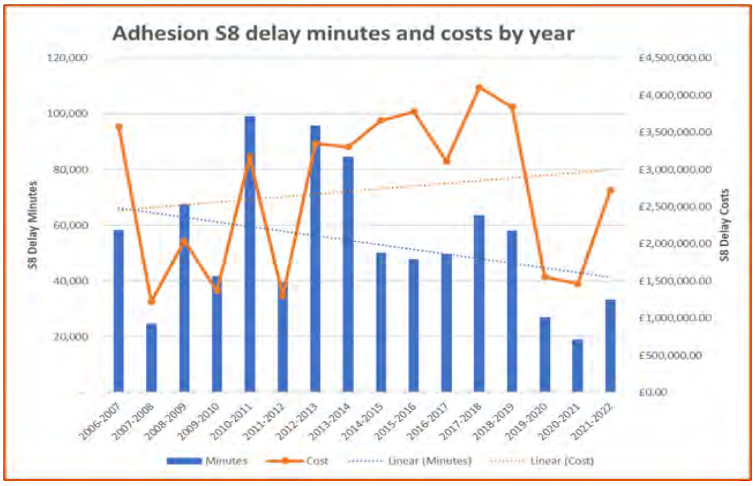


Figure 7: Sch 8 Adhesion

Future Projections

Higher temperatures and combined higher levels of rainfall predicted in the future will create the perfect environment for stronger vegetation growth and prolonged growing season than that of today. This will create higher overall levels of lineside vegetation. In the Autumn, during higher winds and storm events, leaf fall will therefore be higher, this will create significant adhesion issues, if not treated effectively.

Medium & Low Risk Impacts

In respect of our medium and low risk impacting weather categories (snow, fog and lightening), we will not be seeking to proactively mitigate over and above our response during CP6 and will continue to manage these events as part of our BAU operational approach.

Figure 8 shows how the regional risk will change across the vulnerabilities through to 2080. Table 8 outlines our headline approach to strategic risk management through CP7.

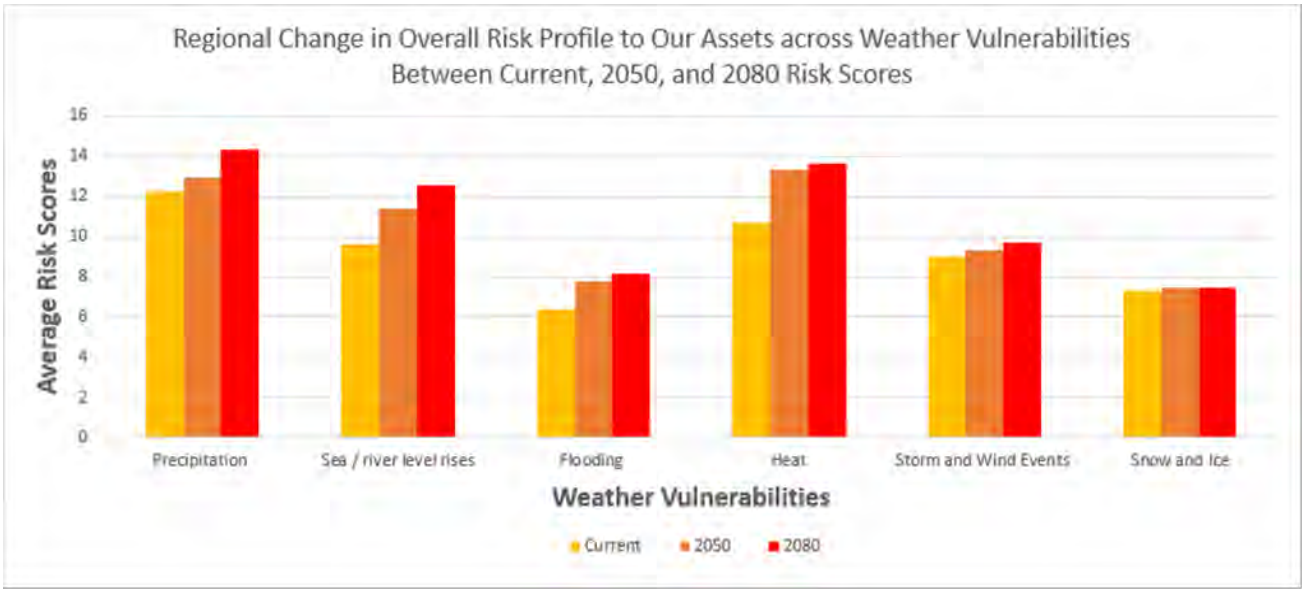


Figure 8: Regional Change in Risk Scores

Chapter 4: Strategy & Investment in CP7

We are committed to improving the resilience of our infrastructure to extreme weather and climate change.

The funding available will maintain a safe and operable railway but, a deterioration of asset sustainability has been forecast, which will require greater investment in the future. This may mean that some interventions may not represent optimal whole life cost over the long-term, but that CP7 will deliver the best outcomes for customers within the current economic climate. Greater investment will be required in later Control Periods such as CP8 and CP9, this will be factored into our adaptation pathways.

Where assets are being replaced or refurbished, we will utilise the opportunity to incorporate weather resilience within the design, but recognise that resilience will, in some cases, will be realised due to updated modern standards/design. We will work to update our processes and standards to embed weather resilience and climate change into BAU delivery and design.

We will continue to increase our understanding of vulnerable sites and plan for future control periods with a view to creating a robust foundation to aid long-term success using adaptation pathways.

Prioritisation of the available funding means that investment in standalone resilience schemes will be tailored to off track and drainage assets. This is partly to address the WRTF recommendations, but also to improve our vegetation management and lineside environment, where our funding allocation is higher than CP6 levels. The low level of Enhancement investment will also means reduce our opportunity to 'bolt on' resilience elements to large investment schemes.

Whilst there is no other funding for climate adaptation programmes or initiatives, requiring any such works to be part of our existing maintenance and renewals portfolio, a proportion of these planned works will contribute to improved resilience. We will continue to react and repair rather than proactively renew assets solely for the purposes of addressing extreme weather events throughout CP7, with maintenance budgets uplifted to reflect this across the control period.

Key actions that will continue into CP7 are:

- Installation of remote condition monitoring (RCM), supporting further reduction in weather patrols, optimising response, and increasing the efficacy of weather response
- Technology deployments for understanding risk and targeting intervention including: Hubble for vegetation detection, drone surveys for tree, wind and heat problem detection, train-borne CCTV, remote temperature monitoring, Use of Railhead Treatment Train (RTT), II for track circuits.

To support our whole system approach to improving resilience in CP7, going forward there has been greater integration between track drainage and track to allow more efficient delivery and better management of sites with poor formation and through centralisation of lineside assets, the delivery of vegetation, fencing and Off-Track drainage will be synergised to deliver efficiencies.

CP7 Risk Strategy

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.

The main weather risks felt by our assets continue to be rainfall and warmer temperatures through the 2050s and 2080s, both continuing to increase and risk levels moving from moderate to high as climate change makes events more frequent. Some of the increase is mitigated by our resilience mitigations and increasing knowledge in our asset base. There is also an offset from risks being removed through action and new risk emerging. For example, today some weather-related risks we suffer, such as issues with jointed track in hot weather, will not exist by 2080 as this asset type will be removed from our inventory by then.

Outlined below are the key elements of our response to wind, management of earthworks, heat, flooding and adhesion.

Table 8 provides our headline approach to strategic risk management by asset discipline.

Wind & Storms

As shown by Table 3 above, our top risks when it comes to storm and wind events centre primarily around objects on the line, and primarily vegetation; our headline strategy for addressing these risks into CP7 are based on a risk-based approach to undertake complete land management from a 'whole system' perspective, and includes:

- Removal of all vegetation from the immediate action zone
- Removal of all condition 3 and above, dead dying diseased trees (including Ash Die Back)
- Removal of all category 4 & 5 trees at leaf fall adhesion sites within standard timescales

Earthworks

Whilst it has always been known that earthworks are susceptible to a number of weather vulnerabilities and is the asset most affected by other asset failures, this was reaffirmed through completion of the ARP3 risk assessment as can be seen by the number of times earthworks are referenced within the table at Appendix 2.

To address and effectively manage the risk posed by earthworks, our headline strategy for CP7 is a combination of planned interventions to improve asset sustainability supplemented with an allowance for some reactive intervention for failures that history shows will happen. The planned interventions are more refurbishment activity focused (versus renewals) when compared to CP6.

Prioritisation of planned work will be done on a risk-based approach using a combination of condition information, local knowledge, RCM trend data and adverse weather sites. The CP7 plan provides for the same level of intervention on embankments, less intervention in soil cuttings and increased intervention in rock cuttings. The plan continues the work started in CP6 to further enhance the RCM regime to mitigate risk associated with failures. As failures occur there will be the need to reduce planned work to focus on reactive works.

Heat

As identified above, our top risks when it comes to heat primarily relate to track. Key elements of our approach to tackling heat in CP7 all focus on track and are linked to the work completed by the national Heat Taskforce in CP6, and include:

- Continued delivery of renewal plans; prioritising assets at higher risk (removal of full depth timber switches and crossings (S&C), jointed track and legacy track forms on high criticality routes)
- Reviewing from first principles and learning from research to re-write track engineering controls to more accurately reflect the track construction types and risk potential
- Working with Route Services to find a viable 3rd rail ballast regulator capability – allowing maintenance access to improved ballast management capability around 3rd rail
- Scenario planning to understand our preparation and response to 30, 35 and 40 degree air temperatures.

Precipitation & Flooding

Precipitation and flooding has an impact across all assets, but the primary risks, as identified within our ARP3 assessment, relate to drainage. During CP7 we have an ambition to better understand our drainage asset inventory and associated data, which will enable our flood risk to be much better understood and

the level of risk far more robustly quantified. This will include enhanced use of technology, such as the use of cameras in culverts to monitor water levels more accurately.

Our headline strategy for addressing the key risks posed by precipitation and flooding into CP7 is therefore focused on crest ditches of cuttings (highest risk) through to outfall in locations not covered through earthworks funded schemes and track drainage to reduce known flooding locations and sustain track formation integrity and will include over 1500 miles of new ditch/pipe drain and 4 miles of drainage renewed or refurbished.

These interventions are intended in part to address the WRTF requirements and where possible climate adaptation requirements (i.e. 1:25 year flood events + 20 % climate change uplift).

Adhesion

Following the incident at Salisbury in October 2021, where adhesion was found to be a causal factor, more needs to be done to understand the effectiveness of current processes and railhead treatment regimes. To support managing this risk in a cost-effective approach, research in this area is being undertaken, covered in more detail in Chapter 5 below, as well as trials of technology, such as forward and rear facing cameras and the development of AI to identify railhead contamination levels.

Managing Residual Risk

Our approach to asset resilience over the next five years has had to respond to the challenging financial climate in which we are operating. 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.

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

From a weather and climate resilience perspective, this means our plans focus more on where resilience can be accrued as a 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.

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 also 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).

In addition, a series of enabling activities are planned for CP7 (see non-asset led actions in Appendix 2) 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.

Nationally the TA are updating standards in respect of climate change, which is intended to facilitate resilient renewals through to 2050. This piece of work will support our regional approach, ensuring that long-term climate change is factored in as a matter of course across all renewals and refurbishment activities. Updates to standards will also allow us to recognise the changes in trends when it comes to the categorisation of 'extreme' weather events, moving to a new normal when considering any asset related works.

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

Our investment plan will improve resilience where a renewal, maintenance or monitoring technology is undertaken. When considering the range and extent of all assets in the region, the current CP7 investment will intervene at a small number of prioritised sites. Much of our resilience investment is through our core maintenance and renewals activity.

Asset Discipline	Strategic Approach to Risk Management
Off Track & Drainage	Targeted actions as a part of the WRTF and associated actions from the Mair & Slingo reports, RAIB recs and L3 investigation.
	Improving the quality of drainage inventory (commenced in CP6)
	Increased use of risk based inspections
	Proactive management of high risk/consequence/passenger impact locations, including reference within Key Route Strategies and Seasonal Working Arrangements at Route level
	Enhanced management of vegetation and leaf fall (adhesion impacting), as well as fire risk at known locations
	Consideration of lineside boundary measures, e.g. fencing type, recognising change in neighbouring land, imported risk to stability and objects on the line
Earthworks	Targeted actions as a part of the WRTF and associated actions from the Mair & Slingo reports, RAIB recs and L3 investigation.
	Implementation of the Soil Moisture Deficit strategy
	Improvements in responding to weather forecasts and engagement with operational response
	Use of Integrated Weather Management Plan
	Learnings from RCM over CP6 to be embedded, including live to control
	Continued integrated approach across earthworks, drainage and off-track for optimised pro-active management to prevent failures
	Use of R&D to minimise need for physical inspections
Track	Route led increased resilience through enhanced stressing and removal of vulnerable assets; replacing with modern robust equivalents
	Changes to standards; recognising changes to normalised temperatures and associated trigger thresholds
	Enhanced summer preparations, including reduction in unstressed track, low ballast and high risk track layout
Signalling	Route led enhanced maintenance and installation of robust modern equivalents
	Consideration of signalling environment e.g. requirement of cooling packs/reflective coatings
	Use of R&D to minimise need for physical inspections
Electrical & Plant	Route led enhanced maintenance and installation of robust modern equivalents
	Use of R&D to minimise need for physical inspections
Buildings	Impact of weather to be considered as part of maintenance, refurbishment and renewals on individual basis
	Heating and cooling systems to be reviewed and enhanced maintenance considered to support employee and passenger welfare
	Consideration of equipment housing to support resilient placement, installation of heating/cooling methods and/or reflective coatings
	Recognition of impact of weather on degradation levels of building fabric, particularly in respect of wind damage and flooding
Structures	Good understanding of structures' vulnerability to wind and snow; specific research into the effect of heat is required and is a proposed R&D workstream as part of the CP7 National Community Practice.
	Continued management of hidden shafts in respect of ice formation
	Continued reduction in scour sites (no high risk)
	Increased use of R&D/technology to simplify examinations' processes

Table 8: CP7 Risk Strategy

CP7 Action Planning

Our actions in CP7 will be split into two categories: asset-led, and non asset-led, with the former reflecting existing BAU workbanks (see Appendix 2). Whilst these BAU activities provide a mixture of primary and secondary resilience benefits, they should not be interpreted as a separate funding source for works outside of the current asset management allocations.

Progress against these actions will be reported through existing channels e.g., volumes. We will also utilise the SMART app to track progress against the relevant items in asset workbanks, which will be reviewed as part of the new governance framework as well feeding into the existing national channels and six-monthly reporting to the ORR.

We have included £148m within our Opex budget to support those actions as part of the WRTF, including better inspections and management of drainage performance to improve our operational planning, such as inclusions for operational management during hot weather and vegetation management. We will also continue our improving trend in seasonal failures by early deployment of our seasonal delivery strategies.

We will also look for opportunities to increase the use of nature-based solutions across the network, working with third parties and adjoining landowners to support activities outside of the railway boundary (e.g. catchment flood management schemes). Continuing into CP7 as part of the Adaptation Pathways trial in the region (see Chapter 7), a collaborative nature-based solution at Holes Bay (use of reeds as a natural defence, working closely with the Environment Agency and local councils) is being developed.

To further support increased awareness of weather resilience and climate change across the region we will utilise existing communications channels, hold workshops and introduce training modules.

Caring for our People

We must be mindful of the impact that extremes of weather can have on our people. Staff can quickly become fatigued and lose concentration, which is exacerbated by becoming too cold, too hot, or wet; this loss of concentration can lead to safety incidents.

As a minimum, our people need the right personal protective equipment (PPE) for the weather conditions. In CP6 different options for different seasons and weather conditions were sourced and made available; this will continue in CP7, and we will also embody one of our Southern region cultural principles “Listen, Learn, Improve”, using feedback from our teams to provide PPE which is fit for purpose.

In addressing wider workforce safety in the context of weather resilience and climate change, our initiatives will align to, and be governed by, our safety framework, which is based on the national safety framework and built from the results from our regional annual RM3 assessments; supporting delivery of safety improvements in a structured and effective way across the region.

Initiatives will include development of risk assessments for travelling to and working on site during extreme weather, increased use of technology and monitoring systems to remove the need for our people to go out reactively as well as enhanced monitoring and reporting for proactive management, proactive vegetation management, and testing operational response mechanisms for robustness.

Connecting with our Passengers

We remain committed to ensuring our passengers are connected to where they want to be, and in the context of weather resilience and climate change this encompasses two aspects: information during disruption and welfare.

Improving the provision of accurate and timely information to passengers during disruption is a key element of our CP7 Customer and Communities’ strategy, which includes innovative systems to provide our station staff with the tools and information to assist passengers with accurate information on

alternative routes during disruption, as well as continued engagement with the national 'smarter information for smarter journeys' programme.

We also recognise the need for simple jargon-free explanations when delays do occur. A huge success in CP6 has been the use of the route Twitter pages to share photos of incidents and video 'explainers', which not only serve as updates for planning future travel (during major and/or prolonged disruption) but also serve as a means of education. This approach will continue in CP7.

The welfare of customers is a basic principle that should be incorporated within station design, for example, the provision of toilet facilities, but it is unlikely that we have looked at customer welfare from a weather perspective. This could be as simple as ensuring a water fountain or the provision of bottled water is available during hot weather, to heated waiting rooms during winter or shelter during heavy rainfall. All station refurbishments in CP7 will include a review of passenger welfare facilities, and we will actively work with our TOCs to embed this approach in respect of our leased stations.

Lineside neighbours

With 3300km of track the Southern region has an impact on many lineside neighbours in many ways, with works causing noise and nuisance, lineside vegetation encroaching or damaging property and the potential for flooding.

Following storms over recent years we have seen an increase in contact from lineside neighbours in respect of fallen trees; we will mitigate this risk in CP7 through our lineside strategy, which embeds a vegetation management plan and sustainability strategy for the region.

We will also see a significant reduction in identified flooding sites by improving crest ditch maintenance, which will help us better manage third-party flooding and its impact on lineside neighbours. In support of this approach, we will also look to work with local planning departments and developers to consider the impact of water run-off from third-party developments on to our infrastructure with any necessary protection put in place.

Interdependencies

We cannot create a more resilient railway in isolation from the environment in which the railway operates. To effectively manage our risks and opportunities we will need to engage, and where possible, work in collaboration, with numerous stakeholders, organisations, and lineside neighbours – both old and new; if we do not take this whole system approach, we may not be able to implement aspects of our climate strategies and adaptation actions in the most efficient, appropriate or effective way.

We need to acknowledge there are multiple organisations who rely on us, who we rely on, and some where a 'co-dependency' exists in relation to our daily operations and our maintenance and asset management. For example, where railway system infrastructure is reliant on the infrastructure of other organisations, or other organisations are reliant on the railway infrastructure, resulting in a cascade effect when there is a failure within one of these inter-connected systems/organisations. A few examples of where asset independences are becoming apparent are:

- reliance of energy infrastructure, both on the railway and the risk of 'black-outs',
- the railway being impacted by the downstream flow of extreme rainfall through the South Downs and other Areas or Outstanding Natural Beauty leading to saturation of failure of earthworks,
- degradation of non-NR owned flood defence assets that protect the railway.

In some areas we already recognise these interdependencies (such as within our Environmental and Sustainability strategy and collaboration with the Environment Agency), but as a whole system in reacting to climate change there is a lot more to do to improve our understanding of the scale and nature of the interdependencies. Chapter 6 within our national ARP3 report sets out the start of our interdependencies' work and we recognise that we have a lot more to do to improve our understanding of the scale and

nature of the interdependencies across the whole business, to identify our priorities and what we need to do as a collective to address the risks.

Recognising that all organisations would benefit from a focused group to manage the interdependencies relating to Weather Resilience and Climate Change, we have created a working group with our TOC colleagues to create a cross-industry charter, which will include guiding principles and a framework for working together. The charter will:

- Define are our common principles including data for RCPs feeding our scenario planning
- Intentionally bring together sustainability, safety & performance
- Give a consistent, collaborative long-term message
- Create an industry understanding of financial impact including costs and savings
- Create clear business commitments, minimum requirements and a call for action
- Be clear on the business risks and opportunities
- Align to ORR requirements for CP7
- Align to the Sustainable Rail Blueprint
- Align to scenario planning and strategic approach in the national Network Rail WRCCA Strategy

This work will continue as a key workstream into CP7.

Asset Led Activities

In respect of Capex funding, we have a small number of pure weather resilience schemes within drainage. The majority of weather resilience benefit is as a result of works within the planned workbank that has been developed to support delivering a safe railway and minimising deterioration in performance when compared to CP6 and meeting the national CP7 prioritisation guiderails.

For Opex, we have increased intervention in drainage to meet the requirements as part of the WRTF. Non-maintenance vegetation expenditure has been allocated to land management within offtrack – Capex to address immediate action zone compliance, hazardous tree management (including Ash dieback) and category 4/5 leaf fall site compliance.

Following completion of a review of CP7 workbanks, these form the basis of our delivery plan with measurable targets, including volumes, budget, and timescales. Through CP7 these will be monitored and tracked through a new system called SMART (Southern Management of Asset Renewals Tool).

Using SMART will support deliverability and remove any risk of double counting or duplication of reporting, feeding into the governance workstream detailed in this plan.

KVL Analysis: Primary & Secondary Resilience

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 WRCCA Leads across regions, Network Technical Heads of asset engineering teams and national finance team, a review of the key volume lines (KVL) within the CP7 workbanks was undertaken to determine the 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:

Activities where weather resilience is a primary benefit of maintenance or renewals work:

- 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 weather resilience is a secondary benefit of maintenance or renewals work:

- 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).

The numbers presented here are based on plans submitted in the CP7 delivery plan. Volumes and budgets are reforecast through each financial year to reflect a range of circumstances. Progress on delivery will be reported against changes in forecasts during CP7. The method for this is still in development and will be agreed with ORR prior to delivery of the first report. For the purpose of this plan, only Primary resilience figures have been included.

Asset	CP7 £m Forecast	Primary Spend £m
Track	797	23
Off Track	108	38
Signalling	745	26
Structures	432	5
Earthworks	453	402
Drainage	139	125
Telecoms	106	1
E&P	538	7
Totals	***3,824***	***627***

Table 9: KVL Analysis. NB these numbers may change during CP7 owing to workbank flex, financial forecasting and development of the methodology used.

Whilst this analysis and the associated potential benefits to the weather resilience of Southern's railway is positive, keeping pace with the impact of extreme weather and climate change will be challenging. Our response to adverse and extreme weather events will therefore include a degree of targeted maintenance from forecast information, and before the adverse or extreme weather arrives to support vulnerable sites in preparation for the impending event, in line with a multi-discipline integrated weather management plan, including operational restrictions in extreme conditions to protect both our passengers, workforce and train operator colleagues alike. This work although reactive in nature, forms a key part of managing risk, and reducing asset failure.

The analysis shows that approximately 16 % of our investment in renewals will represent a primary form of resilience to weather through CP7, however we do expect our overall resilience spend to be higher than this following inclusion of activities that provide a secondary resilience benefit together with increased and targeted maintenance.

Renewals Delivery Model

In CP7, our approach to renewals delivery will be different from that in CP6 owing to the creation of the Southern Region Enterprise (SRE); comprising of three distinct entities: the Capable Owner, Southern Integrated Delivery (SID) and the Eco-System. Drawn from the ICE Project 13 principles, the model

replaces the traditional Route Asset Management and Capital Delivery operating structure, as explained below:

The delivery model splits the delivery of enhancements and renewals into two different approaches.

- Renewals delivery will shift from a traditional asset-siloed, project-by-project philosophy to one in which full integration and production management thinking drives efficient delivery.
- Enhancements delivery will be aligned to single project and programme business cases and resourced within their own right. The full spectrum of delivery methodologies from design & build to complete stand-alone programme enterprises will be utilised and selected on a best for programme basis.

Both renewals and enhancements delivery accountability will be held under the Capable Owner from within the Director of Engineering and Asset Management (DEAM) organisation.

Capable Owner

The Capable Owner will provide strategic direction and leadership and oversee the delivery of the entire enterprise. The focus will be on the delivery of outcomes, meaning a significant change in expressing what we wish to achieve, rather than how it should be done or how it should be delivered.

Southern Integrated Delivery (SID)

The SID will be a fully integrated team that will bring together the strengths, capabilities, and knowledge of the Supply Chain and Network Rail. It will own the renewals work bank, manage it at the portfolio level and drive transition to a production management ethos.

The SID will be commercially aligned and jointly incentivised - win together / lose together - to create a 'share in success' environment. Business partners within the SID will generate profit through performance against the final determination rather than work completed and turnover.

Eco-system

The Eco-system will consist of both strategic and tactical suppliers, to be split depending on the level of influence they may have on final outcomes. Recognising that the key to unlocking efficiencies lies with the small and medium enterprise communities, strategic members will be incentivised along similar lines as the SID.

Initially, the Eco-system will be formed of Network Rail and Supplier Frameworks. However, as the Enterprise matures, we intend for the SID to collectively develop a new set of contracting arrangements that will complement the capabilities held within the SID.

11 Levers

As we develop our understanding and use of the 11 levers, we will use them to shape our response procedures to incidents, aligning them to any new risk assessment process as well as using them to create a framework for lessons learnt reviews. Development of this approach across all asset types has already begun, noting it is a key enabler to mature our thinking and approach to weather resilience as we commence CP7. In addition to the items included within our CP7 Workbank and Action Plan at Appendix 2, a number of initiatives are also underway which will support the regional response to weather and climate change and have been categorised against the 11 levers approach proposed by the ORR below.

These initiatives began in CP6 and will continue into CP7 as part of BAU workstreams and budgets across the business.

Lever	Weather Category	Discipline	Initiative	Benefit
Neighbours & Catchment	Precipitation	Various	Flood management schemes delivered in partnership with the Environment Agency as per agreed funding schemes in CP7.	Collaborative working, enhanced/efficient delivery with wider reaching impact for optimal solutions
		Drainage	Research & partnership working with third party landowners in Sway in respect of crest drainage and flood water behaviours	Improved understanding of asset risk with third party landowners
Whole Systems	Precipitation	Drainage & Off Track	Data Improvement: Improved understanding of drainage and off track assets through asset inventory data completeness, consistency and maintenance (Ellipse)	Increased knowledge base, data availability & reliability
	Various	Various	Land Management Strategy	Collated & collaborative asset management strategy for drainage and off-track
	Heat	Various	SMD Improvement Projects: - Trial of Van Elle piled foundation technique between Tisbury & Gillingham - Pollarding of trees - Better management of track foundation	Resilience to extremes of weather by more effective management of SMD related movement to track
Monitoring	Various	Earthworks	Installation of RCM on soil cuttings (high risk complete)	Improved risk management of soil cuttings to ALARP
	Precipitation & Heat	Earthworks	Earthworks RCM to be linked live to Control	Integrated alarms to Control 24/7 to enable efficient decision making and management of real time risk and incidents
	Precipitation	Earthworks	Installation of RCM at high risk rock cuttings	Improved risk management of rock cuttings & brings risk level to ALARP (in line with soil earthworks)
	All	Vegetation	Integration of the digital lineside inspection technology in to monitoring programmes and undertaking hyperspectral surveys to update data to move to more risk based vegetation clearance (II Programme)	Increased asset information leading to more informed asset investment decisions
	Wind & Storms		Completion of vegetation asset management surveys twice per control period	Increased asset information leading to more informed asset investment decisions
			Hazardous tree surveys completed & managed as part of risk-based regime	Increased asset information leading to more informed asset investment decisions
			Use of MPV trainbourne cameras to enable real time review of railhead contamination	Increased understanding of management & treatment of adhesion
Forecasting	All	All	Continued input and use of forecasting tools from the weather risk taskforce	Increased understanding of asset risk & behaviours, enabling improved & quicker decision making
	Precipitation	Earthworks	Tonbridge to Hastings Undrained Earthwork & Modernisation Programme & Engineering Research (THUMPER) - trial on Bluebell Railway	Better able to predict failures and target works on TTH line of route and apply learnings across the region

Design Redundancy / Resistance	All	All	Modern standards & design use in planning	Enhanced resilience of assets
			Build climate change in to design/planning processes	Enhanced resilience of assets
Design Reliability	Heat	Track	Renewal of timber S&C layouts	Enhanced resilience of assets
	Precipitation	Drainage	Increased drainage capacity (20 % of new build/renewals)	Enhanced resilience of assets
Intervention Extents	All	Various	Track renewals and drainage schemes delivered together to aid efficiencies	Efficient delivery of works & enhanced resilience of assets
Asset Knowledge	All	Various	Implementation of Land Management Strategy	Whole system approach
		Drainage	Data Improvement	Increased knowledge base, data availability & reliability
Funding & Risk	All	Drainage	Develop & implement a robust assurance & risk management process to enable robust risk-based decision making	Effective risk & incident management
	All	Earthworks	Outside Party Slope Hazard Assessments: Assessment of D & E CHOPS sites: 1939 sites across the region	Better management of OP risk sites
	All	Earthworks	Scheduled Evaluations & Work Intervention assessments: review out of date scheduled evaluations & locations where work interventions have been recorded but not accepted	Improvements in data quality, reduction in risk at scheduled evaluations, reduction in sites to be examined
Awareness & Implementation	All	Drainage & Off Track	Right size organisation for drainage & lineside, and develop competency framework (Mair & Slingo)	Enable efficient management of assets

Table 10: Responding to ORR 11 Levers

Chapter 5: Adaptation Actions & CP6 Progress

Our CP7 plan will build on the CP6 route plans but will take a regional approach to promote consistency and efficiency of delivery.

CP6 Delivery

During CP6, the region has managed the impact of weather through the implementation of the South East and Wessex route WRCCA plans, which included work items that improve resilience to assets at risk of weather related failures. For context, the CP6 WRCCA plans, valid to March 2024, refer to the South East route, which was the combination of Kent and Sussex prior to devolution under Putting Passengers First (PPF) in 2019.

The workstreams included different asset types across the various engineering disciplines, and the progress of work items has been reported bi-annually. The CP6 WRCCA plans included business as usual activities and stand-alone resilience work streams to promote focus on items associated with weather resilience. Work items within the plan were predominantly on geotech, lineside and drainage, as well as vegetation, remote monitoring and structures associated with flooding, adverse rainfall, and scour. Key deliverables in CP6 were:

- Remote condition monitoring (RCM) installation at all high risk sites (62 in Kent, 90 in Sussex and 108 sites in Wessex)
- Removal of all high risk scour sites in Wessex
- 40 % reduction in critical rail temperature (CRT) risk sites

Further detail on CP6 delivery is covered in Appendix 1. To note, of the 15 actions; 5 were completed early, 2 were delivered later than planned (due to Covid and Industrial Action), with the remaining 8 delivered on time.

In addition to those actions included within the CP6 route plans, a number of unplanned works were also completed, providing resilience to a range of assets and improving our response to extreme weather events. Examples of such works include:

- Conversion of over 100 track circuits to axle counters, resulting in removal of significant on-track hardware which is susceptible to temperature failures leading to improved track signalling performance.
- Water ingress/depth sensors installed at 150 lift shafts, allowing proactive removal of water from lift pits to prevent failures and entrapment.
- Installation of humidity sensors at 500 HV sites, improving safety to our staff by allowing advance warning of water ingress and high humidity levels which could lead to electrical flashovers.

CP7 Approach

To support continued development in our maturity and approach to preparing for climate change a number of 'non-asset' activities will take place through CP7. These are detailed in Appendix 2, but primarily centre around risk management, learning and awareness, research and change.

These activities will form part of our BAU change delivery across the business, maximising opportunities for utilising national funding, particularly in respect of research, and engagement with nationally led projects, offering possibilities for trials and testing wherever possible across the region. These will be driven and managed by the newly appointed weather SPOC and supporting team, being tracked and assured through the newly proposed governance structure (discussed in more detail in Chapter 6 below).

To support improved resilience and response through CP7, we will need to respond to weather events and complete seasonal delivery preparedness plans and practices in the most cost-efficient way, offering value for money across the business and reliability to give customers and passengers confidence in our plans and when travelling across the network. Undertaking research is key to understanding and enabling efficient delivery and the ability to make evidence-based decisions. Through CP6, and continuing into CP7, several research projects are in flight, namely:

1. Improving lineside asset performance in extreme weather, which looked at identifying correlations between faults in various lineside assets and weather hazards to enable a better understanding of associated risks.
2. Optimising Rail Adhesion Management (efficiency of treatment, use of technology and environmentally friendly solutions).
3. Efficiency & Optimising Points & Conductor Rail Heating – including consideration of carbon impact.
4. Adaptation Pathways Pilot.

The outputs from research projects will inform our BAU seasonal preparedness, influence how we plan and respond to weather events and will be incorporated into future strategy planning.

We recognise that to embed climate change into how we manage our assets is a national challenge and will be fully engaged with the national programme to drive forward changes to standards and processes to embed climate change at the outset of projects, including renewals and refurbishments. We will work with the asset teams across the region to embed changes within the region as appropriate and drive continuous improvement in this space.

Chapter 6: Resources & Implementation into CP7

Governance

Weather resilience and climate change is currently managed through various forums within the regional governance framework; both from a strategic perspective as well as BAU.

At a national level, the environment and sustainability team own the environmental sustainability strategy and corporate risk register for managing weather and climate change risk, with its weather resilience and climate change adaptation team leading collaboration with teams across the organisation.

The national weather resilience and climate change adaptation team also defines the company vision, strategy, and policy for the management of weather and climate change resilience within Network Rail.

Our Southern regional strategy and governance are aligned to the national governance structure.

A revised national WRCCA strategy is in development. Once finalised, our strategy will be reviewed accordingly, with any amendments made to promote alignment.

We continue to actively participate in the periodic weather resilience and climate change collaboration forum as well as bi-monthly reporting to the Office of Rail Regulation (ORR) on progress.

As we move towards CP7 the intention is to create a clear line of sight between the WRTF, weather resilience, climate change and sustainability within the region and up to national levels. This is covered in more detail below.

Business as Usual

BAU management sits across the three routes, as well as within the Director of Engineering and Asset Management (DEAM) function and is reviewed at route periodic business reviews and DEAM periodic meetings. This includes overseeing the implementation of, and updates to, the seasonal delivery plans. These ultimately feed into the regional executive level periodic business review and quarterly business review with the Chief Executive.

Operational preparation for adverse weather is managed through the nationally agreed EWAT and SWC structure, with lessons learnt reviews undertaken and best practice shared between the three routes. This will continue, but on an enhanced basis, into CP7. As a consequence of the extreme heat experienced in the summer of 2022, particular focus was placed on our seasonal preparedness for summer 2023, at both a national and regional level. To assure ourselves of the proposed levels of service and our readiness to respond to the heat a question set was developed, and workshops were held with each route, enabling a regional readiness output to be shared. This process is being repeated in advance of summer 2024 and will be replicated for both autumn and winter as we approach CP7.

We will continue to develop this new process utilising our regional principle of Listen, Learn, Improve to embed within the seasonal preparedness plans of each route, including asset management, to not only support a regional, whole system approach but to allow for benchmarking across the routes.

Strategic

For the majority of CP6, weather resilience was reviewed at our regional Infrastructure Board and Environment & Sustainability Board; both of which have executive level attendance and both route and function representatives. However, this approach changed through Yr5, recognising that a single point of focus was needed to enable an aligned regional approach – see below under CP7.

Ongoing through CP6, and continuing into CP7, is the GDOT Improvement Plan Group and the Autumn Strategy Management Group.

In respect of national forums and the WRTF recommendations specifically, the following meetings are attended to support a fully integrated approach:

- Mair and Slingo recommendations working group - a two weekly group led by the TA with representation from all regions and other action plan owners.
- Weather Management Steering Group - a periodic group focussing on ensuring progress is being made against the actions.
- Slope Safety Review Group - a periodic regional meeting set up as part of the recommendations, now being used to share best practice, peer review and focus on progress against remaining actions.

As part of the regional GDOT improvement plan, a periodic update is completed and shared both nationally and within the region.

CP7

As we move towards CP7 a new governance structure has been introduced with the creation of a regional Weather Risk & Climate Change Programme Board, which will continue to evolve through CP7. This new structure effectively manages weather resilience and climate change within the region, providing a clear line of sight between the Weather Risk Task Force, weather resilience, climate change and sustainability. Key items include management and assurance of WRTF actions, WRCCA progress, enabling an enhanced focus on delivery and embedding practices within BAU processes, progress and sharing of best practice from trials within our routes and our GDOT Improvement Plan. The output from this Board is used to update the regional executive as well as national teams and routes and functions.

This new structure is supported by the dedicated role recruited within the region to act as a single point of contact, providing clear line of sight, leadership and consistency for all weather-related matters, both at a regional and national level.

Throughout CP7, there will be resource to undertake WRCCA reporting and development as well as drive the completion of actions, which will sit within the DEAM function.

Our three routes have appropriately resourced seasonal management teams who will support the increasing demand to understand the impact of weather on our train performance and recognise the developing risk of adverse and extreme weather events and allow the team to develop systems to deliver robust and consistent responses and learn from these events.

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.

Progress on delivery will be reported bi-annually (April – September and October – March each financial year) through the national Technical Authority to the Climate Change Adaptation Steering Group and the ORR.

Chapter 7: CP8 & Beyond

Our regional CP7 SBP and our delivery plans have been drafted based on a market-led approach; and we continue to develop our thinking in this space when it comes to weather resilience and climate change.

Throughout CP7, and in preparation for CP8 and beyond business planning, weather resilience and climate change will need to be considered through this lens and will ultimately build on learnings from the overarching approach during CP7. We will also need to consider ‘line of sight’ from asset management to revenue and passenger demand.

An example of such thinking is to challenge investment in areas which, based on current projections, will be flooded by the 2050s or 2080s, or recognising the change in passenger behaviour, allow failures at identified locations, with thinking either based on revenue or short-term operational resilience versus long term adaption.

We should also challenge ourselves when considering the efficiency of asset maintenance, when over a long-term approach, it may be more cost effective to allow the asset to degrade enabling a full renewal. In these scenarios we would instead mitigate the risk in the best way possible, either by enhanced monitoring or increased data analysis.

Lastly, is specification standards; are like-for-like renewals cost effective in the long term, if weather resilience and climate change have not been considered within the assessment of the standard; therefore, setting up our infrastructure to degrade at a faster rate in the medium to long-term. This thinking will be enabled by adaptation pathways.

Adaptation Pathways

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. During CP7 we will use the adaptation pathways methodology to develop long-term investment plans, aiming to embed this work as part of our BAU asset management processes.

The approach allows decision-makers to plan for, prioritise and structure investment in adaptation options with trigger points and thresholds, helping to identify when to revisit decisions or actions.

This approach enables us to take actions at the right time, avoiding the cost of acting too early or too late. The underlying concept is straight forward and based around two questions:

1. Are there climate change impacts that render current assets or services inefficient, ineffective, or redundant?
2. At these thresholds, what are the best options for enabling the region to continue to meet its objectives?

By repeating these questions at different levels of climate impact, you can construct sequences of actions, or “pathways” to enable delivery of objectives through to 2100.

A trial is currently underway in Southern, testing the approach, which will look to identify and define the wider impacts of climate change on the railway when considered against how the railway is expected to change over a 30+ year planning horizon, as per the Network Rail long term planning process.

The study will:

- Be a proof of concept and highlight future decision points that may be required
- Be strategic and consider wider than just assets
- Act as a pilot study, focusing on 8 case studies
- Support a learning process and provide a framework for other regions to follow.

Progress of this trial will influence future planning and will be reported through the national strategic studies programme. 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 our asset teams 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 do 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.

The output will facilitate the discussion around long-term asset management strategies with climate change in mind, supporting a more strategic and proactive approach to long-term adaptation and will guide decision-making regarding intervention and investment across Opex and Capex activities through CP7, into CP8 and beyond.

Conclusion

We have more to do in Southern to deliver weather resilience and climate change adaptation; both in terms of physical delivery and strategic thinking.

We will continue to learn from the national extreme weather taskforce and where appropriate feed findings and recommendations into our plan to provide a fully aligned approach to weather resilience.

The activities outlined within this plan will enable us to take a holistic approach to the management of weather. We will continue to challenge ourselves to do things differently, utilising a market-led approach to drive value for money and efficiency of delivery when it comes to addressing not only seasonal preparedness, but pro-active management and mitigation of extreme weather events and ultimately climate change in the longer term.

Appendix 1 – CP6 Delivery

During CP6, the region has managed the impact of weather through the implementation of the South East and Wessex route WRCCA plans, which included work items that improve resilience to assets at risk of weather related failures. The CP6 WRCCA plans included business as usual activities and stand-alone resilience work streams to support items associated with weather resilience were focused upon. Work items within the plan were predominantly on geotech, lineside and drainage, as well as vegetation, remote monitoring and structures associated with flooding, adverse rainfall, and scour.

Those actions identified within the Route WRCCA plans are detailed below – together with the benefits realised as a consequence:

Vulnerability	Action	Resilience Benefit
Rainfall and landslip	Deliver Geotechnical Renewal and Refurbishment programme	Landslip risk reduced at 25 % of highest risk geotechnical assets Resilience and passenger safety improved at intervention sites Mix of intervention has changed with a focus to renewal which has increased effective volume but also budget required. Recent works has taken place at Fareham and Honiton in blockades
Rainfall and flooding	Deliver Drainage Renewal and Refurbishment programme	Track flooding, wet formation and landslip reduced at highest risk drainage locations
Flooding and scour at structures	Renewal of river level monitoring installations at 6 high risk locations and review processes and procedures.	Improved detection of flooding and flood damage to structures, reduced risk of delay due to over cautious processes Reduction in safety risk to passengers
Scour at structures	Scour risk reduction at 4No. high risk locations in Wessex	Reduced risk of structure collapses due to scour
Rainfall and landslip	Renewal of RCM at high risk earthworks, expansion of monitoring network and review procedures and procedures to 22 miles of earthwork across the region.	Reduced risk of train striking landslip. These will also be linked to Control not to RAM Team providing 24/7 coverage Capability to mitigate risk of train derailment in event of early detection of earthslip
Flooding/ hydraulic conveyance	Remediation including relining to 30 poor condition culverts to maintain support to track and hydraulic conveyance.	Reduced risk of culvert collapse or blockage
Adhesion and Wind	Wessex Route wide tree survey to inform future management plans	Better tree risk management including reduced tree strike during windy weather and reduced adhesion delay Tree and leaf enable priority works to remove risk and improve safety. Changes to reporting to give and understanding of Ash Die Back on the route

Adhesion and Wind	Wessex Route wide vegetation management in line with CP6 plans	Route wide vegetation management in line with CP6 plans
Rainfall and landslips	Partnership with Southampton University to provide PhD and MSc topics with industry placements for investigations into earthwork stability Clay embankment/underbridge interface risk, Wanborough and The Street (Guildford) sites (Wessex), Southampton Uni	Better modelling of and understanding and management of weather impacts on earthwork assets in CP7 and beyond R&D will lead to identifying RCM systems that can be affordably scaled up over CP7 to monitor geotechnical asset performance, allowing long term investment efficiencies and improved service performance through better targeting of operational mitigations and engineering preventative works
Rain	Earthworks Remote Condition Monitoring installed at 62 sites in Kent and 90 sites in Sussex	Reduction in risk & delay minutes (not quantified) associated with earthslip. Capability to mitigate risk of train derailment in event of early detection of earthslip.
Wind	Vegetation Inspections completed for Hazardous Trees along 160 miles in Kent and 104 miles in Sussex.	Reduction in risk and delay minutes (not quantified) associated with trees on the line. Reduce delay minutes during extreme weather from fallen trees Identification of dead, diseased or dying trees before they fall
Wind	Vegetation Removal to support a compliant lineside, resulting in a clearance programme of 350 miles in Kent and 150 miles in Sussex.	Reduction in risk and delay minutes (not quantified) associated with trees on the line. Improvement in % compliance with in CP6 Kent move from 15 % to 51 % Sussex move from 35 % to 56.3 %
Rain	Reduction in number of Adverse and Extreme Weather sites as part of earthworks' improvements.	Additional resilience to weather events
Staff	Improvements to reduce risk to staff from extreme weather conditions through review of organisational structures and availability of staff for reactive response.	Reduction in absence due to sickness and non-lost time and lost time injuries. During an extreme event there is adequate capability to provide robust reactive response and client repair work
Rain	Earthworks Remote Condition Monitoring along 48x5ch sections in Kent and 81x5ch sections in Sussex.	Reduction in risk and delay minutes (not quantified) associated with earthslip. Capability to mitigate risk of train derailment in event of early detection of earthslip

Appendix 2: CP7 Workbank & Action Plan

The figures included within the table below under Asset Led Activities represent those deemed to provide Primary resilience only. All activities included below will be undertaken across the region.

Asset Information		Action Information	Climate Adaptation / Resilience			Linked ORR 11 Levers
Asset Class	Asset Type	Description	Cost (£m)	Benefit	Risks Addressed	
Asset Led Activities						
Drainage	New build drainage - track, earthworks	Renewal - New build drainage	125	Increased capacity to deal with rainfall events	Flooding/earthworks failure	Whole System, Design redundancy/resistance, design reliability
Off track	Land management / Vegetation Control	Vegetation – leaf fall areas, profile compliance, hazardous trees	38	Management of vegetation risk while meeting biodiversity requirements	Leaf fall risk, high risk hazardous trees, vegetation profile compliance	Whole System, Design redundancy/resistance, design reliability
Track	S&C renewals	Track renewals & S&C renewal with concrete bearer layouts	23	Increased CRT associated with concrete bearer layouts higher than wooden bearer layout	CRT speed restrictions	Whole System, Design redundancy/resistance, design reliability
Earthworks	Embankments /cutting renewals	Earthworks embankment and cutting renewals	402	Reduction of high risk earthworks locations reducing performance impacts and improving asset safety profile.	Earthworks incidents/failures	Whole System, Design redundancy/resistance, design reliability
Structures	Structures refurbishments	Improvements to coastal and estuarine defences	5	Coastal & Estuarine defence works for structures and scour protection works provides increased resilience. Southern have no high risk scour sites.	Improved resilience, safety and performance at coastal and estuarine locations.	Whole System, Design redundancy/resistance, design reliability
Signalling	Signalling renewals	External equipment - “design for resilience” specifies greater tolerance in terms of temperature ranges,, positioning of trackside	26	Great tolerance for temperatures, smarter positioning away from flood areas, & improved design for lightening strikes.	Failure fo equipment during high temperatures, failure of equipment during flood events & failure following lightening strikes.	Whole System, Design redundancy/resistance, design reliability

E&P	E&P renewals	equipment to take out of flooding zones, design resilience into systems to allow for losses eg due to lightning.	7	Improved resilience & performance of assets	Safety and performance impact on E&P asset base leading to improved resilience	Whole System, Design redundancy/resistance, design reliability
Telecoms	Telecoms renewals		1	Improved resilience & performance of assets	Safety and performance impact to telecoms asset base leading to improved resilience	Whole System, Design redundancy/resistance, design reliability
Non-Asset Led Activities (Funded as BAU)						
Long term strategic thinking & business planning	Adaptation Pathways	Undertake adaptation pathways project, developing adaptation plans for high risk locations and develop framework for roll out.	Adaptation Pathway model integrated into business planning for CP8 and beyond.		Improved long-term strategic thinking and planning across the region.	Whole System, funding & risk, asset knowledge, forecasting, interdependencies
Awareness, knowledge & competence	Regional WRCCA Sharepoint	Develop regional sharepoint site for weather resilience and climate change; providing a single source for documents, guidance, reports, governance.	Creation of a resource for building and sharing knowledge of the impact of weather resilience and climate change		Improved understanding & knowledge of climate change and all ongoing activities	Forecasting, awareness & implementation, funding & risk, interdependencies, whole system
Awareness, knowledge & competence	Climate Change eLearning	Embed climate change learning and training modules across the region	Improved understanding of climate change and the impact the region		Improved understanding & knowledge of climate change	Forecasting, awareness & implementation, funding & risk
Risk Management	Risk Assessments	Undertake climate risk assessments of infrastructure assets (down to asset specific scale where possible), to include expansion of scope to include risks to our people and operations.	Improved climate risk assessment of infrastructure assets to influence investment and business planning		Improved recognition of climate change risk across all assets	Asset knowledge, forecasting, awareness & implementation, funding & risk, design reliability
Risk Management	Asset Resilience	Integrate climate change resilience into the assessment and maintenance management of built asset	Embed climate change into built asset processes		Improved recognition of climate change risk across all assets	Asset knowledge, forecasting, awareness & implementation, funding & risk, design reliability

Assurance & Capability	Maturity Assurance	Development and delivery of an annual assurance plan assessing maturity of use of climate change impact assessments during design.	Enhanced assurance to track recognition and compliance	Improved knowledge of climate change and impact	Funding & risk, awareness & implementation, asset knowledge, whole system
Assurance & Capability	Capacity Assurance	Undertake a review of our capacity and ability to adapt to impacts of climate change	Understanding of Adaptation Maturity / Capability Assessment across region	Improved maturity, understanding and recognition on effects of climate change	Funding & risk, awareness & implementation, whole system & design reliability
Interdependencies	Collaborative Workshops	Undertake workshops across the region to identify cross-asset/route risks and opportunities to develop plans to improve delivery in recognition of climate change	Develop interdependency thinking across the region in readiness for CP8 business planning	Improved maturity, understanding and recognition on effects of climate change	Awareness & implementation, whole system, funding & risk, interdependencies
Weather Risk Taskforce (WRTF)	WRTF	Provide resource and input to national activities, with a view to bringing together all elements of weather task forces, weather resilience, climate change and environment and sustainability	Integration and alignment within region to enable maturity in approach to weather and climate change	Enhanced national collaboration & alignment	Whole System, Awareness & Implementation
Intelligent Infrastructure (II)	II	Use technology to assist with the management of weather resilience and climate change	Embed II technology within the region	Improved monitoring systems	Monitoring,

NB: The figures included above represent those activities deemed to provide Primary resilience to weather only. These numbers may evolve through CP7 in line with financial reforecasting and improved methodology used in analysis. Numbers may also flex due to currently unknown financial pressures.