SCOTLAND'S RAILWAY
GREENER IN THE MAKING

# Climate Ready Plan

## 2024 - 2029

**Version:**

This is Version 1.0 of our Climate Ready Plan published in April 2024. Any amended versions will be available and free to download on the Scotland's Railway website at www.scotlandsrailway.com.

**Context:**

This Climate Ready Plan has been published as part of Network Rail Scotland's Control Period 7 (CP7) plan. The Climate Ready Plan should be read in conjunction with the CP7 Delivery Plan (available on Network Rail's website) in order to understand the wider context.

**Lead author:**

David Harkin, Network Rail (Scotland)

Weather Resilience and Climate Change Adaptation Strategy Manager

**Imagery:**

All images unless otherwise stated are © Scotland's Railway.

**The warming stripes:**

A visualisation of our planets warming climate. Each stripe represents the average temperature recorded each year since 1850 (left) to 2022 (right) globally. Warmer colours indicate years with above average temperatures, cooler colours indicate years with below average temperatures. Recent decades have been dominated by warmer than average years.





# Purpose and Scope

**Scotland's climate is changing. It is warmer than it once was, rainfall patterns are more unpredictable and certain weather extremes are becoming more severe and occurring more frequently. This introduces climate-related impacts to our railway that require action so that we can continue to provide a safe and reliable service for our passengers.**

This Climate Ready Plan for Scotland's Railway (2024-2029) sets out the actions we will take over the next five years to improve the resilience of our railway against these physical changes in climate. This includes direct intervention on our infrastructure assets, as well as introducing additional climate science and adaptation capabilities to underpin and strengthen our decision-making processes.

Our plan merges the legacy ScotRail Trains Ltd Climate Change Adaptation Plan with Network Rail's previous Weather Resilience and Climate Change Adaptation Plans – creating an inclusive approach to addressing the impacts of our changing climate across all of Scotland's Railway. Our plan lays the groundwork for development of a longer-term adaptation strategy for managing the risks and impacts associated with changes in Scotland's climate.


Glasgow Central Station

# Plan Summary

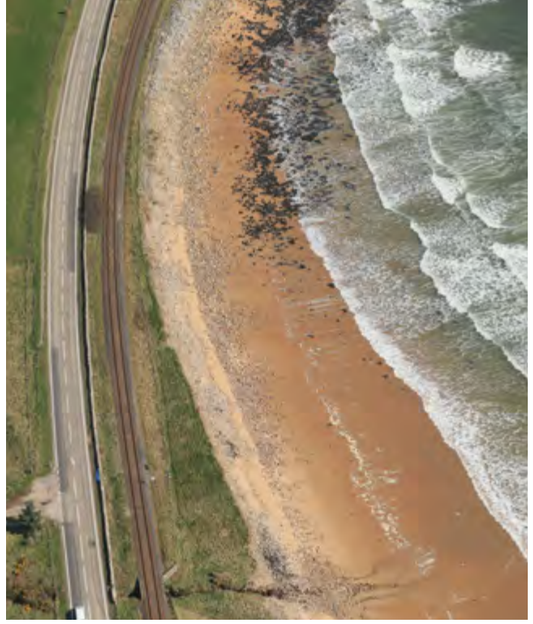
**Our railway in Scotland connects communities and businesses across the country, navigating challenging terrains and environments that place it on the frontline of Scotland's often harsh climate.**

The weather conditions we expect to see, and plan for, in Scotland are changing. There has been a sustained and notable shift in our climate in recent decades. It's warmer than it once was, rainfall patterns have changed, and certain weather extremes are occurring more frequently and are often more severe.

In response to the changes in climate we have already experienced, and the changes we are likely to see in the decades ahead, we are working hard to make Scotland's railway 'climate ready'. This plan sets out the actions we will take to do this and includes both Network Rail Scotland and ScotRail actions.

Over the next five-years we have set ourselves the challenge of achieving four key outcomes in this space:

1. Ensuring the decisions we make are based on a maturing understanding of climate-related risk.
2. Developing a long-term climate adaptation and resilience strategy to increasingly guide our investment decisions.
3. Delivering a programme of asset refurbishments and renewals that deliver resilience to acute weather events, as well as preparing for longer term changes in climate.
4. Delivering new and improved risk, assurance, competence, and data processes to underpin our climate ready journey.



Wick line

We have outlined a detailed series of actions that will help us deliver these outcomes. This includes work planned directly on our railway infrastructure to increase its resilience against adverse and extreme weather and changes in climate.

It also involves actions to deliver a series of knowledge and capability enhancing projects. For example, improvements to our climate risk assessment processes, delivery of a flagship adaptation pathways project and development of a longer-term climate change adaptation strategy.

Our existing governance structure will help us deliver these actions. Our Sustainability Steering Group and Sustainability Board will continue to oversee delivery of this plan. We'll also establish a robust monitoring framework, where we look to integrate observed weather data with how our assets and organisation are responding.

Successful delivery of this plan will allow Scotland's Railway to contribute positively to national objectives in this space, such as Scotland's National Adaptation Programme, while delivering benefits for the passengers and customers that we serve.

An overview of the key priorities, levers, and enablers that will help drive forward progress and monitoring of this plan, can be found on the next page





**Objective: Increase our adaptation capability maturity score from 2.5 to 4 as measured by the Rail Safety and Standards Board rail sector adaptation capacity assessment**

**OUTCOMES**

| The decisions we make are based on a maturing understanding of climate-related risk | A long-term climate adaptation and resilience strategy increasingly guides investment | Our assets are made increasingly resilient to acute weather events, as well as longer-term, more chronic changes in climate | Our 'climate ready journey' is underpinned by a maturing foundation of risk, assurance, competence and data insignts |
|---|---|---|---|

**ENABLERS**

| Data and Monitoring | Funding/Investment | Governance |
|---|---|---|
| Improved monitoring of weather related disruption on our railway (milestone 8)<br><br>Weather and climate impact assessment tool – use in major projects assurance (Milestone 6)<br><br>Delivery of asset volumes tracked through a report of authorised investment of activities providing resilience benefit<br><br>Climate risk assessment improvements (milestones I & 2) | Funds have been allocated as required to actions in our plan and are derived from Network Rail Scotland's Control Period 7 settlement from Transport Scotland<br><br>Approx. £400m has been allocated to asset refurbishment and renewals where weather or climate resilience benefits can be achieved (outcome 3)<br><br>Approx. £3.7m has been allocated to climate science and adaptation enabling activities (outcomes 1 & 2) | Our Climate Ready activities from one of five key themes that make up Scotland's Railway Climate Action Plan (2024 to 2029)<br><br>Scotland's Railway Sustainability Steering Group drives forward continual development, and tracks progress of, delivery plan implementation for all priority areas of our overarching Climate Action Plan<br><br>Scotland's Railway Sustainability Board, chaired by our Managing Director, provides strategic direction and advises on and supports the delivery of our wider climate action objectives |

**LEVERS**

| Standards | Risk and Assurance | Reporting |
|---|---|---|
| Updating of standards relevant to improving the resilience of Network Rail infrastructure assets is the responsibility off Network Rail's Technical Authority<br><br>**Internal Strategy**<br><br>Long-term climate change adaptation strategy to guide investment (milestones 3 & 4) | Climate change risk assessment-physical risk (milestone 1), transtion and interdependencies (milestone 2)<br><br>Integration of climate risks into corporate risk registers (milestone 6) | Quarterly progress reports on delivery of actions set out in this plan will be provided to Scotland's Railway Steering Group. Six-monthly progress reports on delivery of actions set out in this plan will be provided to Network Rail's Technical Authority for reporting to Office of Rail and Road. And, annual progress reports will be provided by ScotRail Trains Ltd to Scottish Rail Holdings |

**NATIONAL PRIORITIES**

| Government Priorities | Funder Priorities |
|---|---|
| **Scotland's National Adaptation Plan (2024 to 2029) outcome:**<br><br>The transport system is prepared for current and future impacts of climate change and is safe for all users, reliable for everyday journeys and resilient to weather-related disruption | **Transport Scotland's Approach to Climate Change Adaptation and Resilience:**<br><br>Vision: A transport system which is well adapted and prepared for current and future impacts of climate change. It is safe for all users, reliable for everyday journeys and resilient to weather related disruption<br><br>Sub-Outcome: The High Level Output Specification for Control Period 7 contains up-to-date requirements relating to climate change, including adaptation and resilience<br><br>Sub-Outcome: We are engaged and supportive of the development of future specifications and policies relating to climate change adaptation and resilience across the Scottish rail network |

**CONTEXTUAL FACTORS**

| Climate Hazards | Climate Vulnerability and Exposure |
|---|---|
| **Observed and projected changes in:**<br>• Rainfall (chronic) and rainfall extremes (acute)<br>• Temperature (chronic) and emperature extremes (acute)<br>• Other associated meteorological hazards e.g., growing season length and species distribution<br>• Sea-level and associated coastal hazards | Infrastructure asset condition and levels of investment<br><br>Location of infrastructure assets<br><br>Criticality of routes<br><br>Maintenance regime<br><br>Asset knowledge (related to climate change) |

# Contents

# Network Rail Scotland Foreword

**We know that our climate is changing at an unprecedented rate, and that this is having an impact on Scotland's Railway. In our current climate – which is already warmer and wetter – we know that adverse and extreme weather events can impact our railway in a way that causes disruption for our passengers and freight customers.**

But, beyond the way our weather and railway currently interact, are the increasingly concerning future impacts of our changing climate. Without intervention we know that our railway infrastructure will be more vulnerable to flooding, landslips and other weather and climate-related impacts. For example, more frequent disruption because of extreme heat in the summer months which can cause rails to buckle, or greater rates of erosion of our coastline which can damage our coastal defences.

In Scotland, our changing climate and its impacts are further heightened by the landscape in which we operate. We work hard to run a railway that must navigate very challenging and often remote terrains and environments. To add to that, much of our railway was designed and constructed over 100 years ago and without knowledge that we'd go on to experience such huge shifts in our climate.

Across Scotland's Railway we're working to prepare for these future changes in climate and our Climate Ready Plan sets out the actions we'll take over the next five-years to help us do this.

For example, over the next five-years we'll spend approximately £400m renewing and refurbishing parts of our infrastructure in a way that provides resilience against adverse and extreme weather events.

Our plan will also look at how we can implement new and improved climate science and adaptation capabilities that will strengthen our decision-making processes. For example, improvements to how we assess future climate risk on our infrastructure, operations, and people. In fact, our plan details the actions we will take to identify the parts of our railway that we believe will be most vulnerable to future changes in climate and outlines the approach we'll take take to develop long-term adaptation plans for those locations.

There's still lots to do to meet the challenge of our changing climate, but I'm confident that our joint Climate Ready Plan sets out a clear approach to understanding the transformational adaptation that will be required in the years and decades ahead.

**Alan Ross**
Director of Engineering and Asset Management





# ScotRail Foreword

**ScotRail's vision is to deliver a safe, sustainable, inclusive, and accessible railway for Scotland**

The impacts of climate change are affecting Scotland's Railway. For example, heavy rainfall events and associated flooding are becoming more frequent. We're also seeing new challenges introduced, like the record-breaking heat we experienced in 2022 – part of a longer-term trend in warming temperatures for Scotland.

Climate resilience is a strategic priority identified in the sustainability strategy for Scotland's Railway, with the goal of ensuring Scotland has a sustainable, more resilient railway that is adapting to climate change, and is more robust to the impacts of climate change.

ScotRail is a key stakeholder and contributor to this Climate Ready Plan. The joint plan will ensure track and train continue to work together to ensure Scotland's Railway is adapting to the impacts of climate change on operational activities, while targeting actions that enable the continued safe operation of the railway and a reduction in the disruption climate change can cause.

**David Lister**
Safety, Engineering & Sustainability Director

> The joint plan will ensure track and train continue to work together to ensure Scotland's Railway is adapting to the impacts of climate change

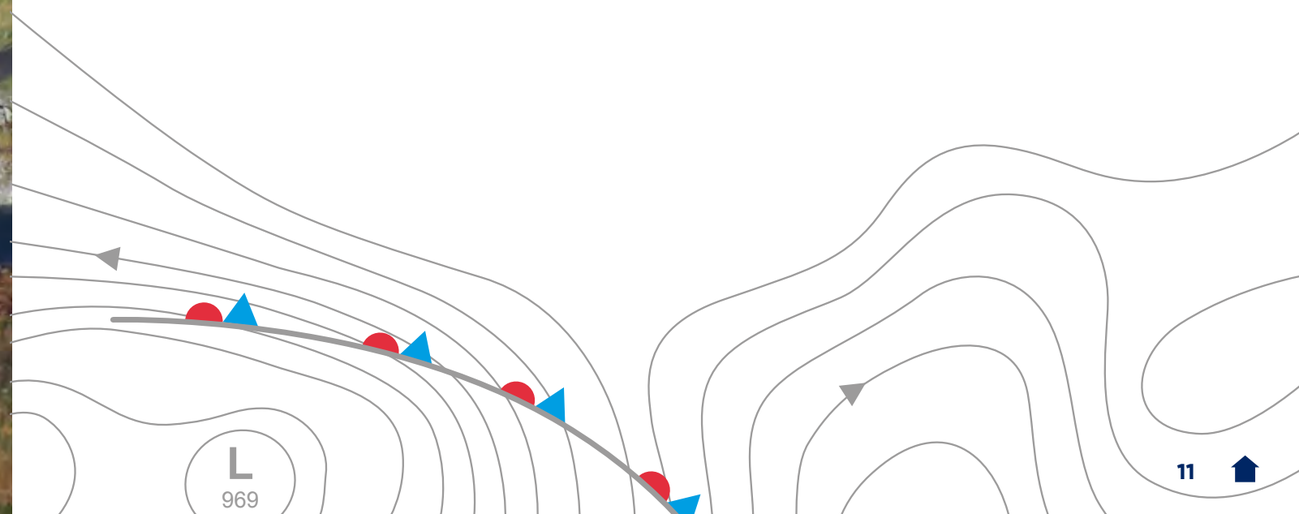
Section 01

# Introduction

## Summary:

- Scotland's Railway is an essential part of our country's social and economic infrastructure.
- Our railway connects communities and businesses across the country, navigating challenging terrains and environments, placing it on the frontline of Scotland's often harsh climate.
- Adverse and extreme weather can impact our railway infrastructure, leading to disruption, safety, and performance challenges. Weather-related disruption is already a key factor impacting performance and reliability targets.
- The weather conditions we expect to see, and plan for in Scoland, are changing. In fact, there has been a sustained and notable shift in our climate in recent decades.
- It's warmer than it once was, rainfall patterns have changed, and certain extreme weather events are occurring more frequently and are more severe.
- This change in climate will continue. We know that summers in Scotland will become hotter and drier, and that winters will become milder and wetter.
- We also know that we will experience more frequent weather extremes – some we are used to dealing with, others that we will have never experienced before.
- To better prepare our railway for future changes in climate, we are working hard to make Scotland's railway 'climate ready'.

Loch nan Uamh Viaduct



# Introduction

## Our Railway and our Climate

**Scotland's railway is a vital part of our social and economic infrastructure – supporting communities and businesses across Scotland. In 2021/22[1]:**

- **52.5 million** passenger journeys were made on our railway.
- **4.2 million** tonnes of goods were transported by our freight customers.

At over 1700 miles in length, and with 360 stations, our railway covers a large geographical area, operating in a diverse range of landscapes.

We connect communities and businesses across Scotland with a railway that navigates challenging terrains and environments. This places our railway on the frontline of Scotland's often harsh and increasingly unpredictable climate.

The weather conditions we expect to see in Scotland are changing. In fact, there has been a sustained and notable shift in our climate in recent decades. It is warmer than it once was, rainfall patterns are more unpredictable and certain weather extremes are becoming more severe and occurring more frequently.

This change in our climate is having an effect on our railway. It shows itself through impacts like more frequent disruption because of heavy rainfall and flooding. Or through disruption linked to record-breaking weather events, like the heat experienced in July 2022.

We know that Scotland can be disproportionately impacted by many of these weather-related challenges.

For example, we know that the North West Highlands is already the wettest region of the British Isles. We also know that these challenges can be further intensified by Scotland's varied topography.

A rich and diverse geological past has shaped the distinct and varied landscapes we are famed for. From the mountainous highlands to the hilly lowlands and our intricate coastline – our railway must operate in a range of often challenging environmental conditions.

Oban line and A85, near Cruachan Dam

Saltcoats

Outside of the more urban Central Belt, our railway tends to follow the coast, or contour through steep-sided glens. As a result, it must regularly crossover watercourses. Many of the structures that do this can be prone to flash flooding and subject to seasonal snowmelt. We also have a high proportion of railway constructed along steep valley-sides where drainage is essential in preventing potentially disruptive washaways.

In addition, we know that we have an ageing infrastructure, with much of it constructed over 100 years ago, and without knowledge of the fact we'd go on to experience human-caused changes in climate. These varied challenges will be compounded by future changes in our climate.

We can see the impacts of our weather and climate on our railway already. Two measures that help us demonstrate this are Schedule Eight compensation payments and the Public Performance Measure.

## Public Performance Measure

**The Scotland Public Performance Measure (PPM) is our standard measure for train service performance and has two elements – punctuality and reliability.**

- **Punctuality** – the percentage of trains that arrive at their destination within five minutes of the advertised time. When a specially advertised revised timetable is in operation, at times of engineering work for example, we are measured against the revised times.
- **Reliability** – the percentage of our advertised train services that operate.

Our target for Scotland's Railway in Control Period 7 (CP7) is for 92.5% of services to arrive at their destination within five minutes of the advertised time unless impacted by speed restrictions during severe weather or connections to other services or ferries (this will be known as the Scottish Train Performance Measure).

This whole industry target is extremely challenging to achieve, with factors like extreme weather playing a large factor.

In fact, since 2012, extreme and adverse weather has accounted for 8% of ScotRail trains that miss the PPM target. This total is based on figures where adverse or extreme 'weather' has been noted as the leading cause of disruption. 'Weather' will also be a key but secondary factor in other disruption metrics, for example delays caused by damaged infrastructure assets.

PPM data (Figure 1) can also be used to give an indication of the times of year when we tend to experience the most weather-related disruption. The Autumn into Winter months tend to see the most weather-related disruption. Since 2012, 16% of all missed reliability and punctuality targets associated with weather have occurred in December, 12% in January and 16% in February.

April and May, which happen to be two of the driest months on average in Scotland, both see the lowest percentages.

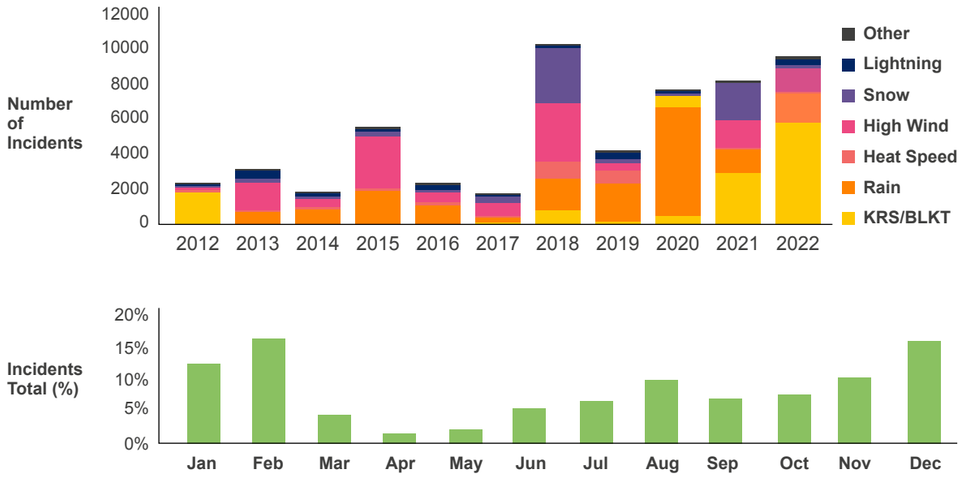



**Figure 1:** Top: A breakdown of the number of missed punctuality and reliability targets since 2012, by casual type. KRS/BLk refers to speed restrictions applied during periods of adverse and extreme weather. Bottom: A breakdown by month of when missed punctuality and reliability targets associated with weather have occurred – a proxy for when we experience the most disruptive weather events

## Schedule Eight

**Another measure we use to monitor the impact of weather on our performance is the financial cost of delays we cause to train operators during disruption on our infrastructure (we call this Schedule 8). We record incidents associated with:**

- Adhesion caused by leaf-fall which can cause track contamination leading to traction loss.
- Cold weather events which can lead to ice accumulations on points and in tunnels.
- Flooding which can cause standing or flowing water leading to asset damage or preventing trains from accessing the track.
- Fog which can lead to reduced visibility and obscuring of signals.
- Heat which can result in rail buckles, Temporary Speed Restrictions (TSRs) being put in place and overheated electrical components.
- Lightning strikes which can lead to track circuit and signalling damage or power system failure.
- Snow, which can block lines and cause points failures.
- Subsidence caused by the impacts of landslips, rockfalls and sinkholes.
- Wind, which can cause trees and other items to be blown onto the track and into the overhead line equipment.

Since 2006/07, over £145m has been paid out in Schedule Eight costs by Network Rail, in Scotland (Figure 2). Disruption linked to high winds and flooding account for the greatest proportion of these payments (£46m and £41m respectively), snow (£22m) and adhesion (£15m). Disruption linked to subsidence, heat, lightning, cold and fog are also tracked.

Recent years have seen above average payments, driven by some particularly disruptive weather events such as Storm Arwen in November 2021, widespread flooding in August 2020 and 'Beast from the East' in February and March 2018.

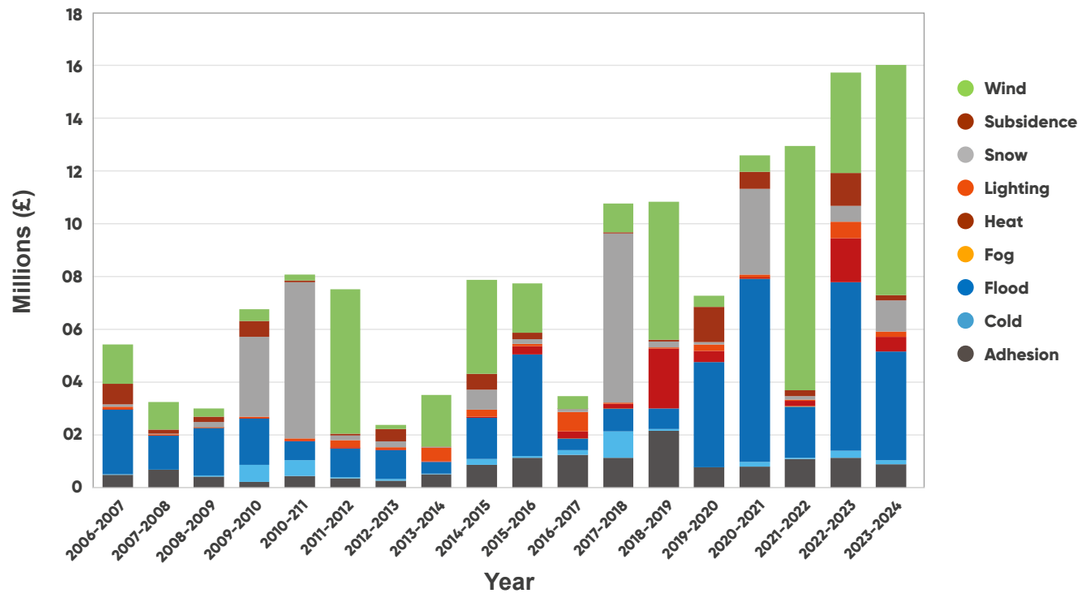



**Figure 2:** A breakdown of Schedule Eight costs by weather type since 2006-2007.

# Scotland's Changing Climate

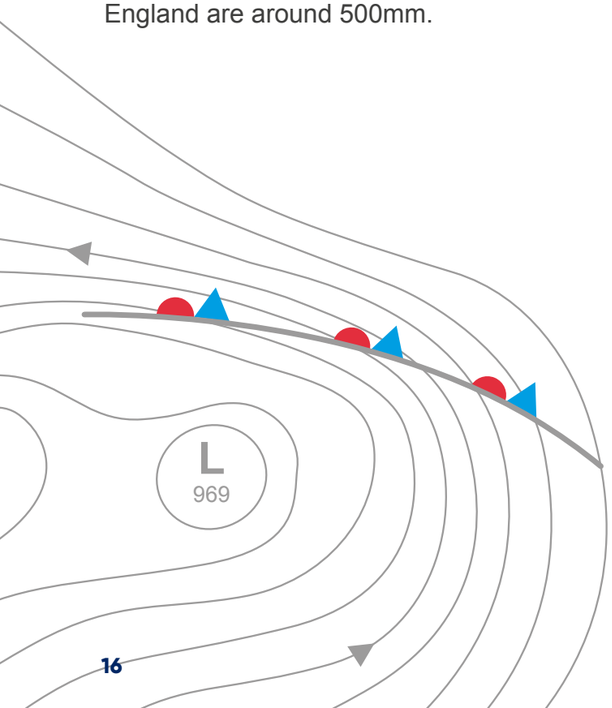
**Scotland's climate is changing. It's getting warmer (Figure 3), rainfall patterns are changing, and weather extremes are becoming more frequent and often more severe.**

## Scotland's Current Climate

Scotland has a temperate maritime climate, characterised by relatively mild temperatures and frequent rainfall throughout the year, though typically cooler and wetter than the rest of Great Britain.

The West of Scotland tends to be milder and wetter than the east due to the direction of prevailing weather systems and shelter provided by the mountainous terrain in the west.

Parts of the North West Highlands record around 3500mm of rainfall on average each year. The wettest locations on average (North West of Fort William) record over 4000mm. The driest areas of Scotland, in the East, record around 700mm of rainfall in a typical year[2]. For context, the typical annual totals in the driest parts of Eastern England are around 500mm.




## Scotland's Climate is Changing

In recent decades there has been a notable shift in Scotland's climate, evidenced through an extensive collection of scientific observations.

According to the latest State of the UK Climate Report from the Met Office, when compared to earlier in the 20th Century[3]:

- The average annual temperature recorded in Scotland has increased by around 0.8°C.
- Average rainfall totals recorded in Scotland have increased by over 100mm a year.

Additional observations from the Met Office tell us that:

- The 10 warmest years recorded in Scotland since records began have all occurred since 1997[4].
- 2022 was Scotland's warmest year on record and recorded the highest daily maximum air temperature of 34.8°C at Charterhall in the Borders on the 19th of July.

**According to data issued by Dynamic Coasts[5]:**

- Scottish tidal records show that over the past 20 years, relative sea-levels around Scotland have been increasing on average by 3 mm/yr.
- 'Rates of erosion on our soft coastline (dunes / beaches / soft sediment) have nearly doubled since the 1970's to 1m/yr.

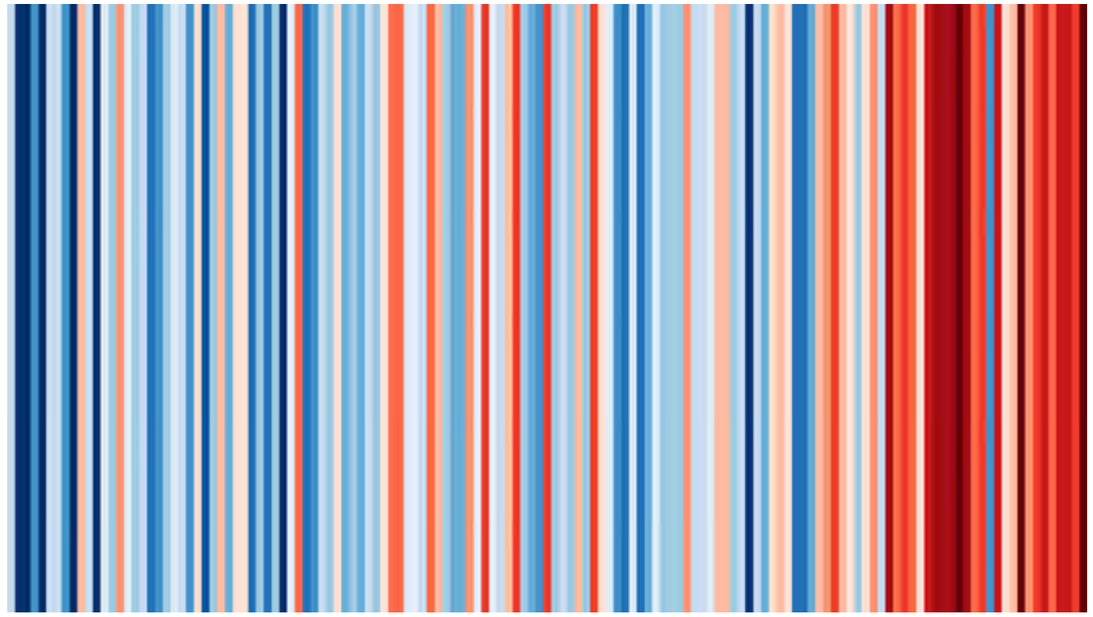


**Figure 3:** The warming stripes – a visualisation of Scotland's warming climate. Each stripe represents the average temperature recorded each year since 1884 (left) to 2022 (right) in Scotland. Warmer colours indicate years with above average temperatures, cooler colours indicate years with below average temperatures. Recent decades have been dominated by warmer than average years

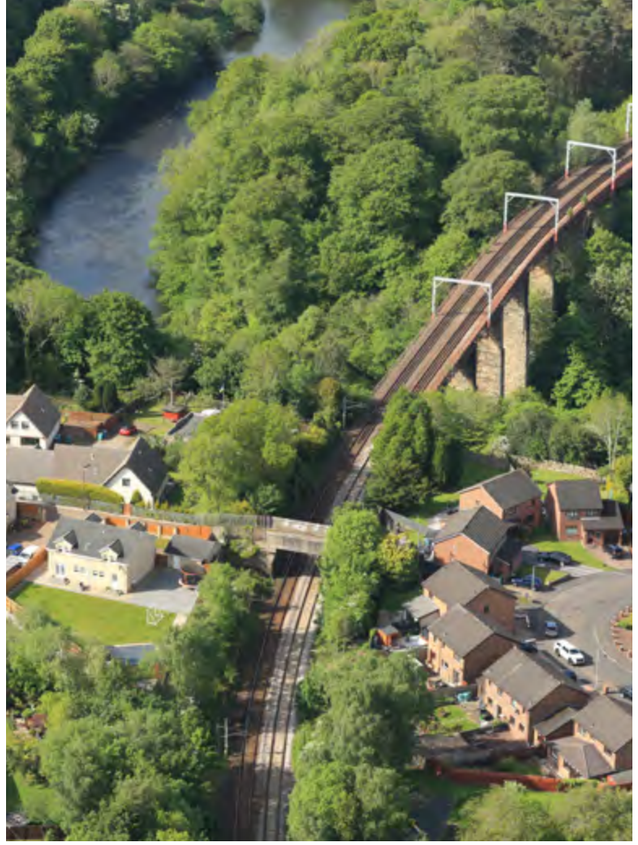
Wick line

## Scotland's Future Climate

The changes we have already observed in Scotland's climate are projected to continue, and in some cases intensify.

In 2021, Adaptation Scotland published a Scotland specific analysis of the Met Office UK Climate Projections[6]. This guide summarised the key changes we expect to see in Scotland's climate across all future climate scenarios – the key messages are:

- Average temperatures will increase across all seasons. This would likely result in a further extended vegetation growing season, which could lead to heightened risks associated with invasive and non-native species.
- Summers will become increasingly warmer and likely drier. This would likely result in more frequent disruption associated with, for example, hot-weather days, and the safety measures implemented during such conditions.
- Winters will become increasingly warmer and wetter. This would likely result in more frequent disruption caused by heavy and prolonged rainfall, and associated flooding, though changes in intensity of rainfall could have more significant impacts.
- An increase in heavy, convective type rainfall across all seasons. Even though a typical summer's rainfall is projected to decrease, extreme downpours when they do occur will likely be heavier and more intense despite the overall drying trend. This could lead to, for example, an increase occurrence of washout events on railway infrastructure.
- Sea-levels will continue to rise. This will lead to an increase in disruption to our railway associated with storm surges, wave-overtopping, sea-spray, and coastal erosion.



Camps Viaduct

- Cold weather hazards (frost / snow) will likely reduce in frequency. Despite a general decline in frequency, these events will still occur, with potential to cause disruption.
- Our weather will remain variable and may become more variable. Alongside the key changes listed already, there are others we may need to anticipate, for example a possible extension of the core convective rainfall season (during the summer) into the autumn months, and potential changes to the leaf-fall season. Extending the period over which disruption may be likely.

In 2018, Network Rail commissioned a review to select two future climate scenarios most appropriate for use in planning for the future resilience of our railway. A detailed extract of the UK Climate Projections[7] was produced as part of this work.





# Our Plan

**Our Climate Ready Plan sets out our response to these changes in climate that we are experiencing – and is structured around delivery of four key outcomes (below). It covers both Network Rail Scotland and ScotRail, with timescales aligned to Network Rail's control period cycle – the five-year planning timeframes over which Network Rail receives its funding.**

It details the actions that both organisations, under the umbrella of Scotland's Railway, will take to improve the resilience of our railway to adverse and extreme weather. It also lays the groundwork for action required to address more significant, longer-term risks associated with physical changes in our climate and the transition to a low-carbon economy.

1

**The decisions we make are based on a maturing understanding of climate-related risk.**

This includes actions to enhance our approach to undertaking climate risk assessment, and better integrating climate and natural hazard data into our decision-making processes.

2

**A long-term climate adaptation and resilience strategy increasingly guides investment.**

This includes actions to develop adaptation pathways which will help us better understand the long-term climate adaptation and resilience investment needs of our railway.

3

**Our assets are made increasingly resilient to acute weather events, as well as longer-term, more chronic changes in climate.**

This includes actions to improve the resilience of our infrastructure assets against adverse and extreme weather events, as well as longer-term changes in climate.

4

**Our 'climate ready journey' is underpinned by a maturing level of risk, assurance, competence, and data insights.**

This includes actions to better integrate considerations of longer-term climate risk into our corporate risk management processes and creating new training resources and opportunities for our people.

Section 02

# Strategic context

Edinburgh Waverley





## Summary:

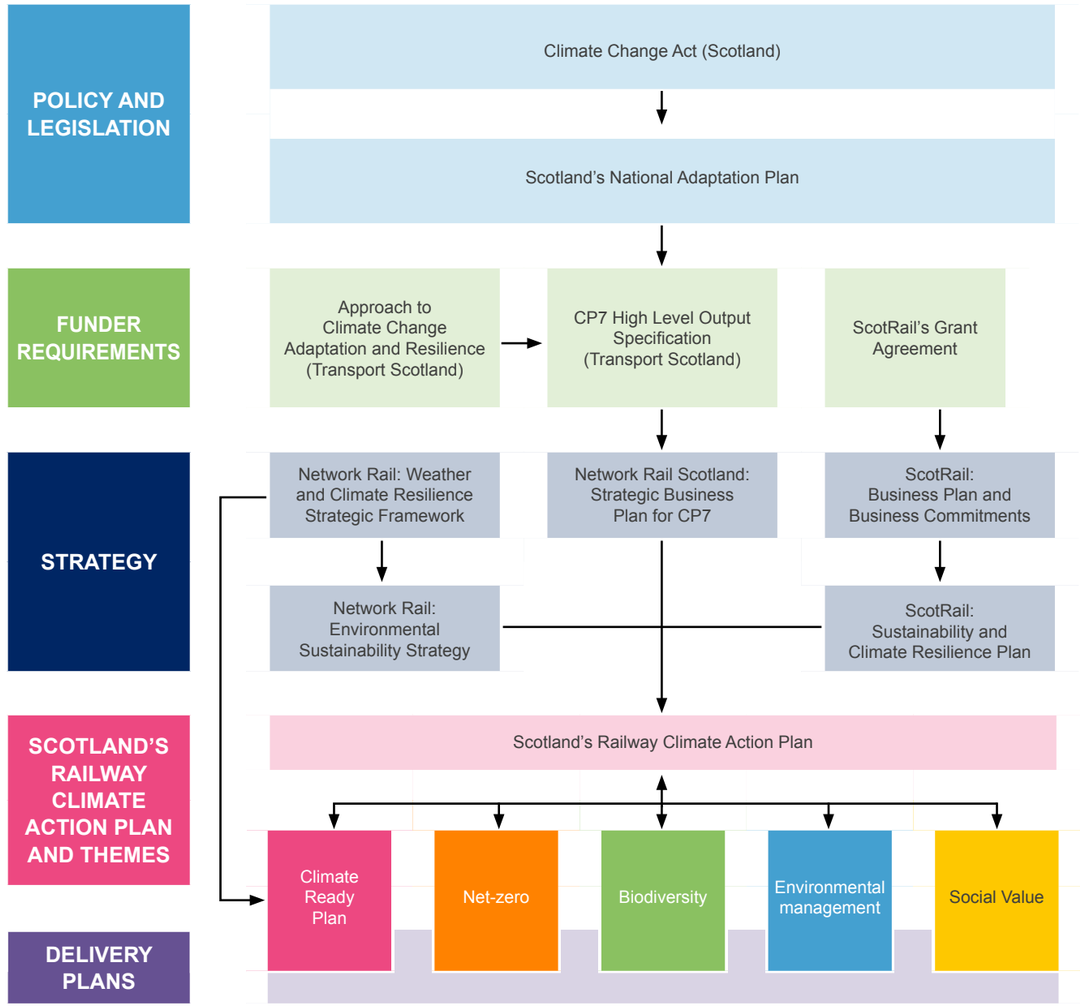



**Figure 4:** Overview of the relationship between key national legislative and policy drivers and requirements, and internal strategy with our Climate Ready Plan.

# Strategic Context

## Funder Oversight

### Network Rail Scotland

**Through the Railways Act 2005, Scottish Ministers have the power to take long-term, strategic decisions about future investment on our railway. They also hold the power to fund and specify where resources are targeted by Network Rail on track maintenance and investment in Scotland.**

Each five-year Control Period (Network Rail's funding cycle), the Scottish Ministers outline their key priorities for our sector.

Based on this commitment, Transport Scotland, in partnership with Scotland's Railway and ORR, develop a 'High Level Output Specification' (HLOS) for each five-year Control Period. The HLOS outlines what Scottish Ministers require the rail industry in Scotland to achieve during that Control Period.

West Highland line

The HLOS for Control Period 7 (2024 to 2029)[8] has placed climate change adaptation and resilience requirements on Network Rail Scotland to:

- Maximise the benefit of planned asset renewals so that they improve resilience. This is to be achieved through targeted physical climate change adaptation works on assets.
- Evolve its Weather Resilience and Climate Change Adaptation (WRCCA) strategy to set out the main threats and proposed mitigations associated with changes in weather patterns.
- Make continual improvements to climate risk assessment processes.
- Develop a longer-term adaptation strategy.
- Work in partnership with Scottish Rail Holdings, ScotRail Trains Ltd., and other external stakeholders to deliver its climate change adaptation objectives while contributing to related Scottish Government objectives included in the National Transport Strategy.

Our Climate Ready Plan has been developed aligned to these HLOS requirements.

### ScotRail Trains Ltd

The transfer of the ScotRail franchise into the public sector as ScotRail Trains Limited took place on Friday 1 April 2022.

Scottish Rail Holdings is a Non-Departmental Public Body controlled by Scottish Ministers and was set up with the express purpose of overseeing the governance of train operating companies under Section 30 of the Railways Act 1993 – including the new publicly owned ScotRail Trains Limited, in line with the Scottish government policy.

ScotRail Trains Ltd is a publicly owned company that operates rail services in Scotland under the ScotRail Grant Agreement, which is an agreement between Scottish Ministers, Scottish Rail Holdings Ltd and ScotRail Trains Ltd.

Schedule 13.2, clause 2 "Business Plans" of the Grant Agreement sets the requirements for the content of the ScotRail Business Plan. The business plan has associated commitments that are agreed with Scottish Rail Holdings Ltd setting out the annual actions that ScotRail will take. Progress towards the agreed commitments is reported by ScotRail on a four-weekly basis with associated performance review.

Then on an annual basis prior to start of the Operator Year a full business plan review is complete with performance reviewed and the next series of business commitments agreed with Scottish Rail Holdings.

This governance process enables annual operational financial performance to be assessed in line with business commitment progress and enables any required short-, medium- or long-term financial investment to be established, assessed, and planned accordingly.

## Scotland's Railway Climate Action Plan

A **Climate Action Plan for Scotland's Railway** has been developed that outlines the activities we will take to play our part in addressing the climate crisis. This includes the actions we will deliver to make Scotland's railway climate ready.

The plan covers both Network Rail Scotland and ScotRail activity. The first iteration of this plan was published in 2021 and has now been updated to cover the period 2024 to 2029.

The revised plan sets out a series of actions that we will take under five themes. The five themes are:

1. Climate Ready: The document you are reading now is the more detailed delivery plan for this theme.
2. Net-zero: This sets out the actions we will take to ensure Scotland's Railway remains on track to achieve net-zero emissions by 2045.
3. Biodiversity: This sets out the actions we will take to better support and promote biodiversity across Scotland's Railway.
4. Environmental Management: This sets out the actions we will take to be an environmentally responsible organisation.
5. Social value: This sets out the actions we will take to realise and deliver positive societal impact through our activities on Scotland's Railway.

See the Climate Action Plan document for more information.

# Network Rail Strategy

The first Network Rail Weather Resilience and Climate Change Adaptation (WRCCA) strategy was published in 2017 and in 2020 its principles and aims were incorporated into the Network Rail Environmental Sustainability Strategy (2020 to 2050)[9]. As of March 2024, it is under review and a revised Weather and Climate Resilience Strategic Framework is being developed.

It outlines a series of high-level outcomes that Network Rail's weather resilience and climate change adaptation activities are working towards, those are:

- Infrastructure able to withstand the impact of future weather conditions.
- Rapid recovery from the impacts of adverse and extreme weather.
- Improved performance and safety during adverse and extreme weather conditions.
- Financial savings through reduced compensation payments and repair costs.

In addition, Network Rail's National Environmental Sustainability Strategy (2020-2050) has set a series of milestones that our Climate Ready Plan is aligned to. This includes Scotland and the England and Wales regions developing a longer-term climate change adaptation strategy by 2029 – informed by an 'adaptation pathways' approach.

There are also a series of milestones due in advance of our Climate Ready Plan commencing. These are primarily national led activities including a review, and updating of, relevant asset policies and standards to reflect longer term changes in climate, and delivery of a criticality and vulnerability mapping project that covers all Network Rail assets.







Departing ScotRail passenger service

# ScotRail Strategy

Schedule 13.2, clause 2 "Business Plans" of the Grant Agreement with ScotRail Holdings sets the requirements for the content of the ScotRail Trains Ltd business plan which includes the need for sustainability and climate resilience to be addressed.

The ScotRail Trains Ltd business plan also sets out how they will deliver the vision of providing a safe, sustainable, inclusive, and accessible railway for Scotland.

The following measures of success identified:

- Increase the number of people travelling by rail by 40% within five years.
- Deliver passenger satisfaction of at least 90% every year.
- Contribute to Scotland's net zero targets by significantly reducing carbon emission; and
- Delivering the contracted services within the agreed subsidy.

The plan explains how ScotRail Train Ltd.'s actions contribute to Scotland's Railway overarching Sustainability Strategy and its strategic priority areas.

Scotland's Railway's sustainability priority areas are aligned to the UN's Sustainable Development Goals meaning ScotRail Train's actions contribute to the overall national progress made to the Scottish Government's commitments to the UN's Sustainable Development Goals.

The delivery plan enables ScotRail Trains Ltd to contribute to the delivery of the Scottish Government's plans for sustainable inclusive growth and the delivery of net zero emissions by 2045 as well as the goals of Transport Scotland's Mission Zero.

The delivery plan also sets out the Key Performance Indicators used to track the overall progress of the actions against key environmental impacts as well as actions to establish measures of the social impact.

Progress is tracked to ensure we take and invest in actions over the next three years to be as energy and resource efficient as possible as well as identifying ways to eliminate fossil fuel consumption and to become climate resilient.

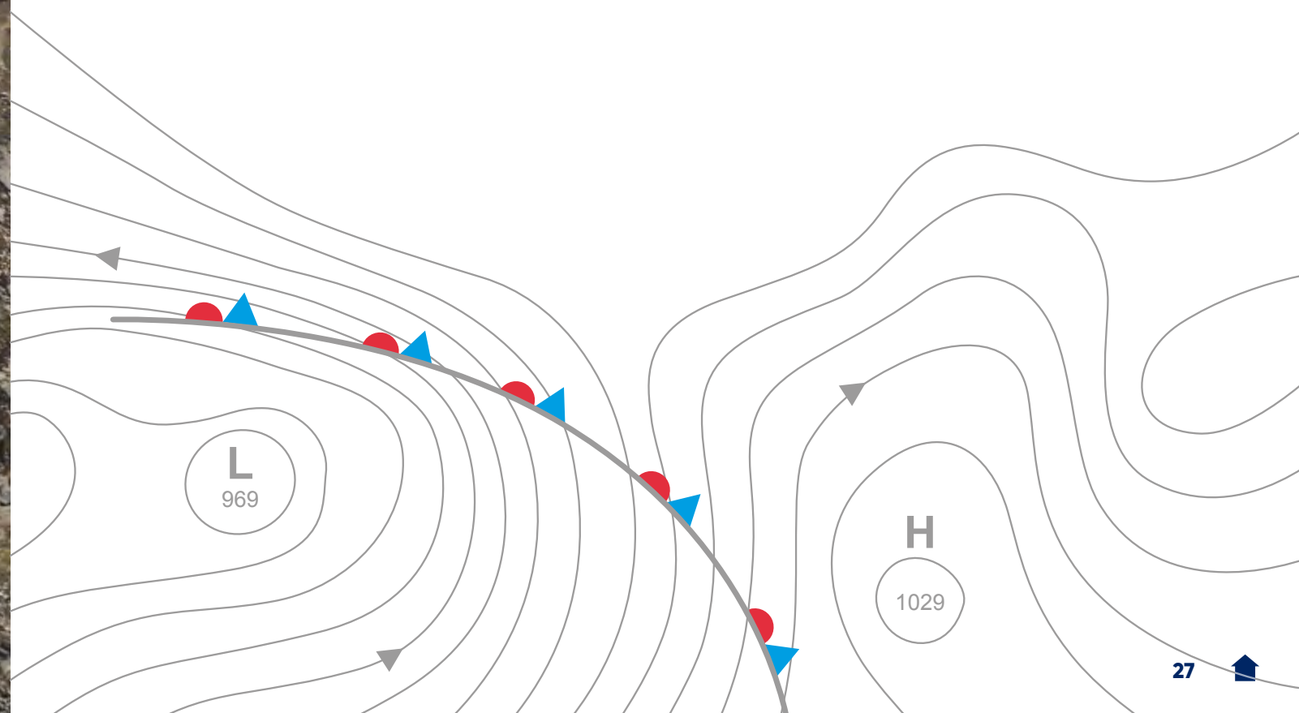
Section 03

# Climate change risk assessment

## Summary:


- To evaluate what key future climate-related risks we should be responding to, a series of climate risk assessments have been undertaken over recent years, continually improving our understanding of how climate change may impact our assets.
- The most recent assessment has identified approximately 700 climate-related interactions between our assets and our climate – this includes, for example, the impact of extreme rainfall on our earthworks, buildings, and structures.
- When we analyse how climate change may alter the future climate-related risk profile of our assets, we see a likely increase in impacts because of more heavy and intense rainfall events, more frequent spells of hot weather and combination impacts where multiple weather events coincide.
- Further analysis, and refinements to the risk assessment process are needed to draw firm conclusions on the changing risk profiles of our assets, including alignment with an updated national climate risk assessment due later in 2024. This includes expanding assessments to better consider how changes in climate might impact our people, operations, and interdependencies with other critical national infrastructure operators.


Wick line



# Climate Change Risk Assessment

## Climate Risk

**In recent years, we have undertaken a range of activities to help better understand the physical climate risks our railway is exposed and/or vulnerable to because of changes in our climate. To date, this has focussed primarily on the climate risks to our railway infrastructure.**

### What Are Physical Climate Risks?

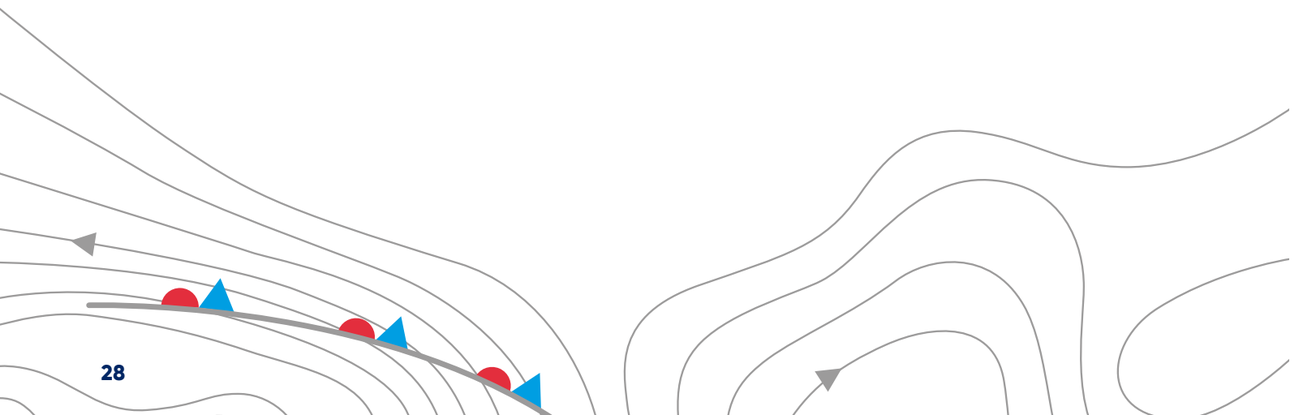
Physical climate risks are those directly linked to our weather and climate. This includes day-to-day risks associated with adverse and extreme weather events that have potential to negatively impact our railway and operations. It also includes risks that are emerging because of longer-term changes in our climate.

Physical climate risks can be described as:

- Acute: these are risks that are event-driven, including increased frequency, intensity, and severity of extreme weather events, e.g., an intense rainfall event, a flood, storm, wildfire, or heatwaves.
- Chronic: these are risks that occur due to longer-term changes and shifts in our climate, e.g., gradual changes in temperature, changes in rainfall patterns, sea-level rise, changes in growing seasons and the spread of pests and disease.

The extent to which climate risks result in damage or disruption of our assets or operations is strongly controlled by additional factors – mainly the varying levels of exposure and vulnerability of our assets and operations. For example, the age and current condition of an asset will play a role in determining the extent to which physical climate risk impacts that asset.

To methodically identify the key physical climate risks that have the potential to negatively impact our railway, we have undertaken various iterations of climate vulnerability, impact, and risk assessments. Further improvements to our climate risk assessment processes are planned and outlined in Section 5.





## Previous Assessments

**There are various climate risk and vulnerability assessments which have been produced over recent years. These include:**

### Control Period 6 Climate Vulnerability Assessment

A climate vulnerability assessment was produced as part of the Network Rail Weather Resilience and Climate Change Adaptation plan for Scotland covering Control Period 6 (2019 to 2024). This assessment sought to identify the key high-level climate variables with the greatest impact to different types of assets. It also included a review of the latest climate projections for Scotland.

### Schedule 8 Climate Impact Assessment

In addition to the vulnerability assessment, an impact assessment was produced. This focussed on the Schedule 8 compensation payment costs for a variety of climate variables – see Section 1 for an updated assessment of these costs.

### ScotRail Climate Change Adaptation Plan

A high-level climate risk assessment was also produced as part of ScotRail's 2021 Climate Change Adaptation Plan. Risks identified were primarily linked to railway infrastructure with actions to address these risks covered by previous Network Rail Scotland's Weather Resilience and Climate Change Adaptation Plans.

### Network Rail Adaptation Reporting Power

As part of Network Rail's Adaptation Reporting Power (ARP) submission to UK Government in 2021, a more detailed asset climate risk assessment was undertaken.

The risk assessment from the ARP was conducted by the Network Rail Technical Authority Chief Engineers – adopting an approach used by the Department for Environment, Food & Rural Affairs. The template was amended to incorporate a modified version of Network Rail's Corporate Risk Assessment Matrix scoring system.

Over 600 climate-related 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.

For more information on the methodology used see the Adaptation Reporting Power publication[10] and the accompanying risk assessment results worksheet.

Combined, these previous assessments have provided a baseline understanding of the key climate risks our railway is exposed and/or vulnerable to.

# Updated Climate Risk Assessment

As part of the process for developing this Climate Ready Plan for Scotland's Railway, an assessment of climate risk on our rail infrastructure assets was updated. The assessment was designed to provide a standardised list of climate-related drivers and hazards that can impact the different asset types that make up our railway in Scotland.

The intention of producing an updated climate risk assessment in Scotland was to provide a more accurate assessment of climate risk for Scotland, considering variations in climate and geology that likely drive the different climate risk profile to other parts of Great Britain.

The national level risk assessment, developed in support of the Adaptation Reporting Power, was used as a springboard for the development of the assessment. In line with the national level risk assessment our climate risk assessment considers the possible levels of present and future (2050's and 2080's) risk to each asset type because of changes in weather and climatic conditions.

Likewise, the climate risk assessment was not carried out at the asset specific level, rather it was at the asset type classification (e.g., a risk assessment of bridges, rather than a risk assessment of a specific bridge at a specific location).

We used the process of updating the climate risk assessment for Scotland to trial slight amendments to the methodology used to that of the national assessment.

This was to see if we could further refine the results. Amendments included:

- Asset hierarchies specific to Network Rail Scotland's operations were created for our assessment to ensure an appropriate level of detail was captured by asset teams.
- Telecoms assets were not included in the national assessment but were added into our assessment for Scotland.
- The national level risk assessment identified risk based on the climate variable alone. A climate hazard hierarchy was developed for our assessment to ensure teams were considering a range of climate-related risks, not just those already familiar to the asset teams. This means our climate risk categories are not directly comparable to the national level assessment.
- Our assessment identifies multi-factor and combination events but does not differentiate between direct and indirect impacts.

Our assessment does not look at trigger points for when action is required – this will be achieved in greater detail by actions in this plan to improve our climate risk assessment processes and development of a longer-term adaptation strategy.

Further analysis of our results, combined with deliverables from Network Rail's national Climate Change Adaptation Team will allow us to draw firmer conclusions on how our climate risk profile differs from other Network Rail Regions.

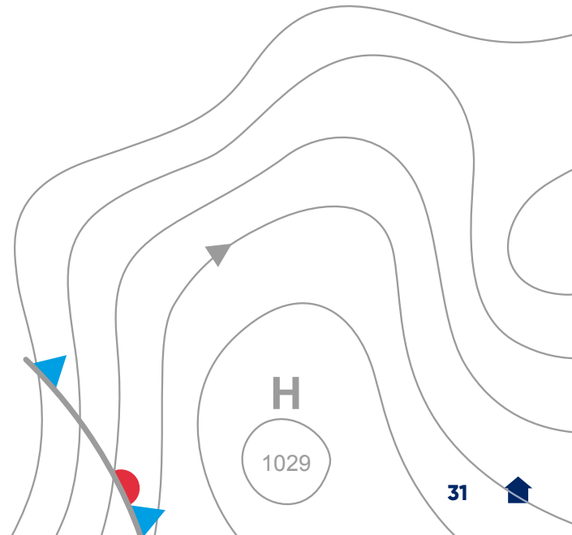
In addition, the national climate risk assessment for Network Rail is to be revised and updated based on learnings from the revisions made to our assessment. This is due to be published alongside the next Adaptation Reporting Power report.

## Methodology

To develop a more specific climate risk assessment for Scotland, we worked collaboratively with asset teams and other stakeholders across our network. Each of our eight asset teams followed the same process to identify a series of key climate-related physical risks. The approach used to undertake the assessment is shown in Figure 5.

Each of our asset teams followed the following steps:


**Figure 5:** Approach taken in the Climate Change Risk Assessment



## Step one

### Asset Hierarchy:

Each asset team was asked to produce an 'asset hierarchy.' The purpose of this was to identify the key asset groups that would be assessed, and to ensure each asset team was undertaking the assessment to a broadly similar level of detail.

## Step two

### Hazard Screening and hierarchy:

Each of the identified asset types were then screened against a standardised list of climate-related hazards.

The purpose of this exercise was to identify the key climate hazards of concern for each asset type, which in turn would help prompt the types of risks identified in the final risk register. We also wanted to ensure that a full-range of climate-related hazards were being assessed, and not just those already familiar to the asset teams.

Our hazard hierarchy (Figure 6) makes a distinction between the weather drivers and natural hazards. Characterised by the **hazard classes** of:

- Meteorological
- Geophysical
- Environmental
- Hydrological
- Climatological

These hazard classes are then sub-divided into the below **climate variables:**

- Precipitation
- Temperature
- Other meteorological drivers
- Sea-level
- Solid-mass related
- Vegetation related
- Combination events

These climate variables were split out to combine both weather drivers and associated hazards. The weather drivers and natural hazards are outlined in Figure 8. With the weather drivers relating particularly to those identified under meteorological, climatological, and hydrological processes, and the natural hazards being driven by environmental and geophysical processes.

Hazards are assessed for both direct and indirect impact. For example, a climate-related risk could be driven purely by extreme rainfall e.g., saturation of masonry driven by heavy rainfall. However, a climate-related risk could materialise in association with heavy rainfall. For example, inundation of a structure due to surface water flooding. In this example, precipitation is still the variable in question as it led to surface-water flooding.

Traditionally, risk assessment methods typically only consider one driver and/or hazard at a time, potentially leading to an underestimation of risk. The climate variable 'combination events' has been used to encompass the wider array of risks which are a result of multiple weather drivers acting together to generate the risk.

For instance, heavy rainfall and high winds in combination can lead to damage to buildings. Damage then being cause by both exposure of roof elements to high winds and water ingress into buildings during heavy rainfall leading to further damage to buildings.

In addition, some weather drivers also contribute to a natural hazard. High winds and rainfall, for example, are contributing factors to tree fall, as they destabilise tree roots, resulting in a risk of damage to buildings, tracks, or rail users. These risks are captured under the climate variable 'combination.'

**Figure 6:** Climate Hazard Hierarchy. The inner circles represent the hazard classifications, the second layer represent the climate variables and the outer circles represent the weather drivers and natural hazards (indicated by *)

## Step three

**Climate Risk Descriptions:**

With an indication of what climate hazards are of concern for a range of asset types, each team then wrote a series of risk descriptions, explaining how a climate-related hazard could interact with that asset type.

The purpose of this exercise was to get our engineers to match up their in-depth knowledge of their assets with how they interact with our weather and climate. Risk descriptions generally followed the same formula, describing what the potential risk was, what could cause it and what the possible consequence could be.

These risks were validated against the national level risk assessment to ensure that any omissions were accounted for.

## Step four

**Risk Scoring:**

Information was provided on how each hazard might change because of our changing climate. The method for scoring was the same as that developed for the national level risk assessment produced as part of Adaptation Reporting Power. To demonstrate how changes in our climate might change the risk profile, indicative climate risk scores were provided for three time periods – current, 2050's and 2080's.

We worked with each asset team to develop the score for likelihood and impact. This was an assessment based on the expert judgement of the engineers undertaking the climate assessment.

Scores were also provided assuming no intervention on the assets beyond mitigating measures already in place.

Edinburgh to Glasgow Mainline, August 2020

# Results

Through the assessment process, 698 risks were identified across the nine asset classes. These risks were identified from the asset hierarchy, hazard screening exercises with engineers and the National Climate Change Risk Assessment.

The breakdown of the risks across the hazard hierarchy are shown in Figure 7, depicting the number of risks associated with each weather driver or hazard, and their associated climate variable and risk category.

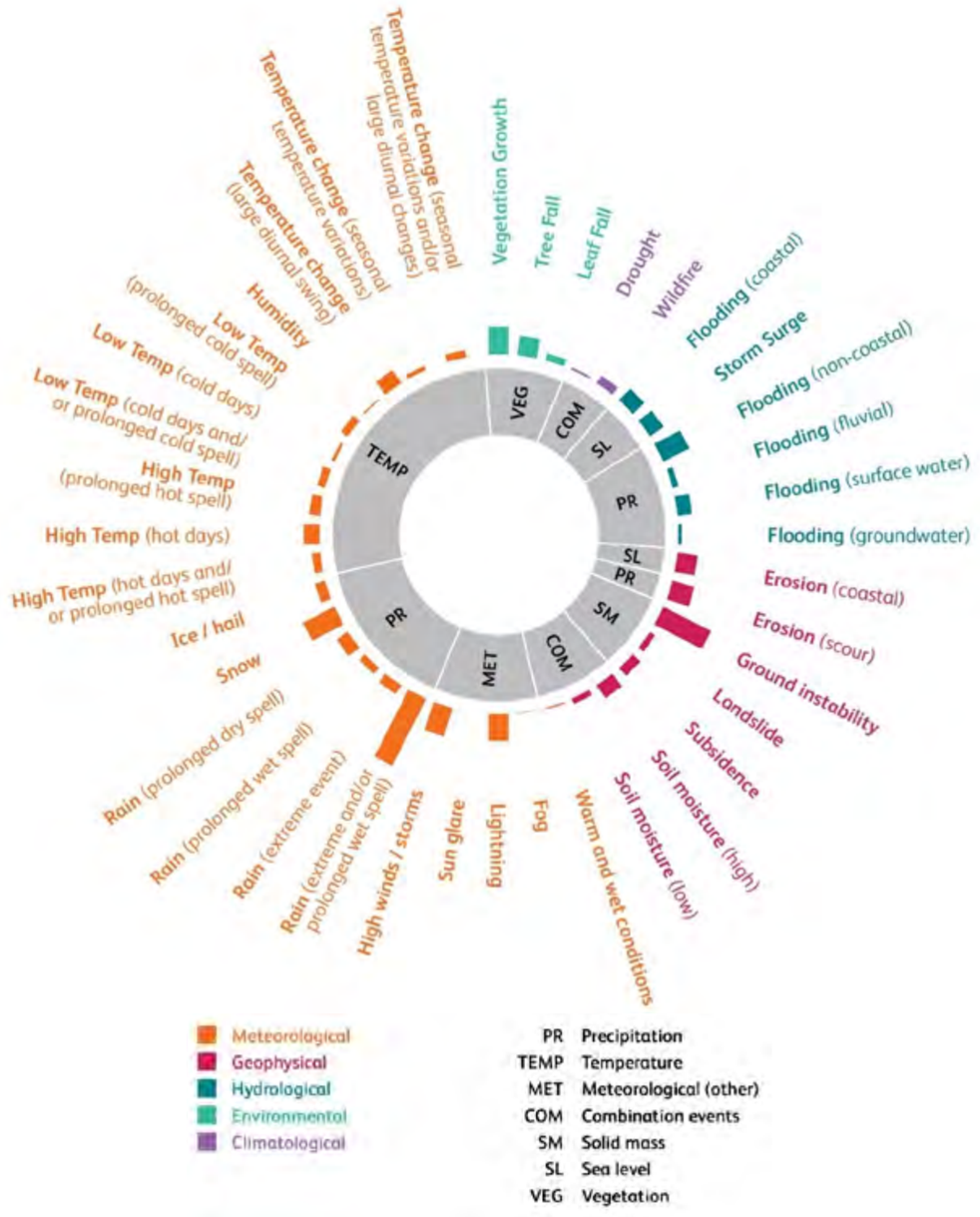



**Figure 7:** The breakdown of the number of risks across the hazard hierarchy

Most of the risks are found to be associated with meteorological events. Almost half of the meteorological risks are related to precipitation, notably extreme and/or prolonged rainfall, with one third of this category relating to temperature. Meteorological (other) accounts for almost one-fifth of this category, including lightning and high winds/storms.

Geophysical is the second most prevalent category, half of which is comprised of solid-mass related hazards such as ground instability. Hydrological is the third most common category, accounted for by almost all flood-related hazards from sea-level and precipitation. Following this is the environmental category, with half of these risks relating to vegetation growth. The category with the fewest risks is climatological, largely accounted for by drought hazards.

Around 22% of the total risks identified result from combined events, meaning that they are caused by interactions between various weather drivers and natural hazards. For example, ground instability results from multiple different weather drivers including precipitation, temperature, and humidity; flooding is influenced by various precipitation events, high winds / storms, and wet and humid conditions; and vegetation growth and tree fall are associated with precipitation events, temperature events, lightning and high winds / storms.

The average score recorded for each of the five climate risk categories and the seven climate variables across the three time periods (current, 2050's and 2080's) are shown in Figure 8 and Figure 9, respectively. Both figures show an increase in the average risk score with time. Larger changes are anticipated to be seen in the Hydrological and Geophysical risk category and for the sea-level (Hydrological) and solid-mass (Geophysical) climate variables.

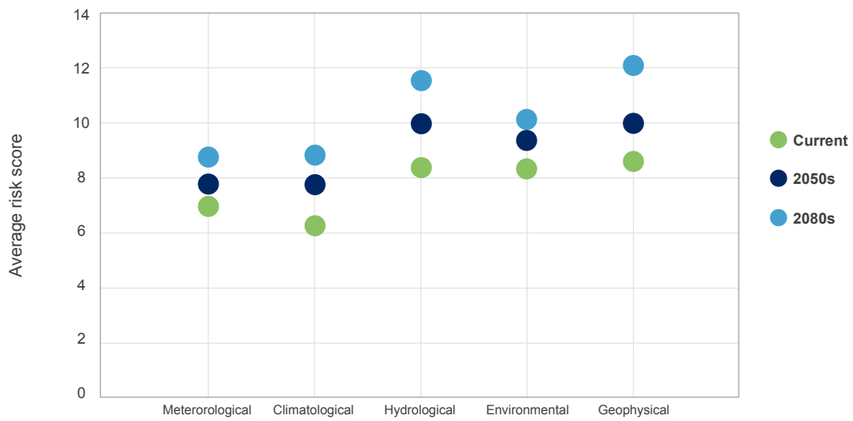



**Figure 8:** The changing average risk score for each risk category across the three time periods assessed.

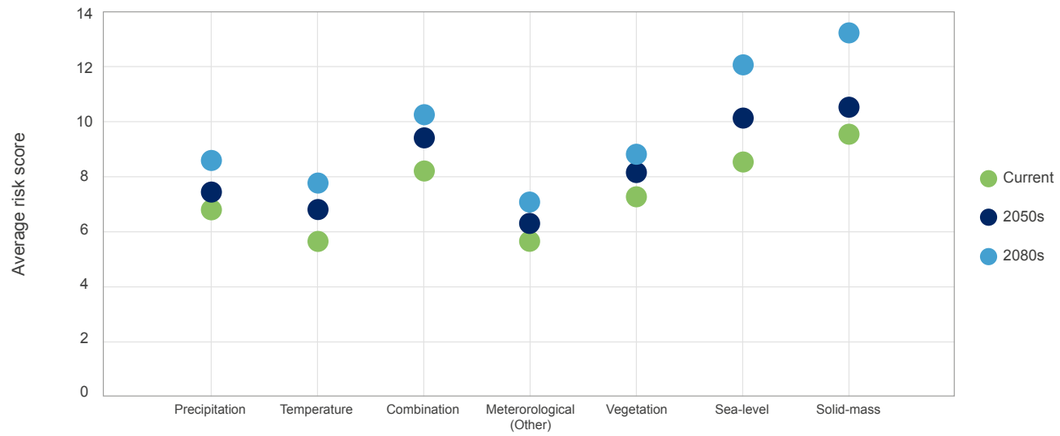



**Figure 9:** The changing average risk score for each climate variable across the three time periods assessed.

From these figures it is possible to build a picture of what the key impacts of climate could be on our railway infrastructure assets. In summary we can say that without any direct intervention on our infrastructure assets in the decades ahead, we would expect:

- Increased impacts associated with high temperatures (both prolonged hot spells and hot days).
- Lower levels of impact associated with cold temperatures (both prolonged cold spells and very cold days), and consequently impacts associated with snow and ice.
- Increased impacts associated with rainfall (both prolonged wet spells and extreme convective type rainfall), and consequently impacts associated with terrestrial flooding (fluvial and surface water) and river scour.
- No significant change in impacts associated with high winds.

However, we expect that other impacts, such as prolonged saturation of the ground, may increase the effectiveness of wind in, for example, toppling trees. More research is required here, including monitoring of the climate science data on wind.

- Increased impacts in the coastal zone from sea-level rise and increased rates of erosion, both of which have implications for impacts associated with storm surges, sea spray and coastal flooding.
- Increased impacts associated with ground instability / mass movement (e.g., landslides), driven primarily, we expect, by wider changes in rainfall and temperature patterns.
- Increased impacts from the more complex, multi-hazard climate risks, for example those associated with prolonged hot and dry spells.

Using the results of this assessment, it has been possible to identify the key climate-related impacts of concern for each asset type.

Each asset class is impacted by various different climate hazards and therefore impacted to varying degrees with time. Figure 10 details the changing average risk score for each asset class across the three time periods assessed, illustrating an increase in risk with time across all asset classes.

There is a greater distinction between the average risk from current levels to future levels (2050's and 2080's) for Drainage, Earthworks, Track and Structures.

For the 2050's, the average score is highest for Earthworks (10.8), Track (10.7) and Structures (10.6) followed by Drainage (9.1) and Signalling (9.0).

For the 2080's the average score is highest for Earthworks (12.7), Track (12.0), Structures (11.4) followed by Drainage (11.2) and Signalling (10.6).

Figure 11 provides a breakdown of the risks to each asset class by the climate variables.

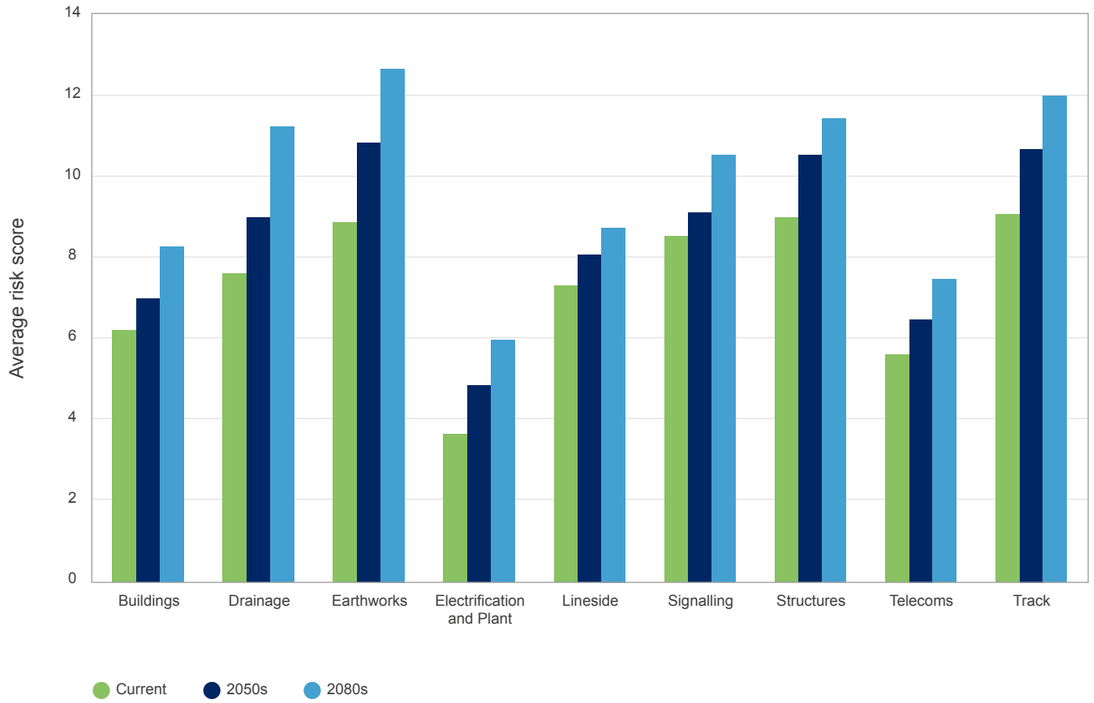



**Figure 10:** The changing average risk score for each asset class over the three time periods assessed in our Climate Risk Assessment.

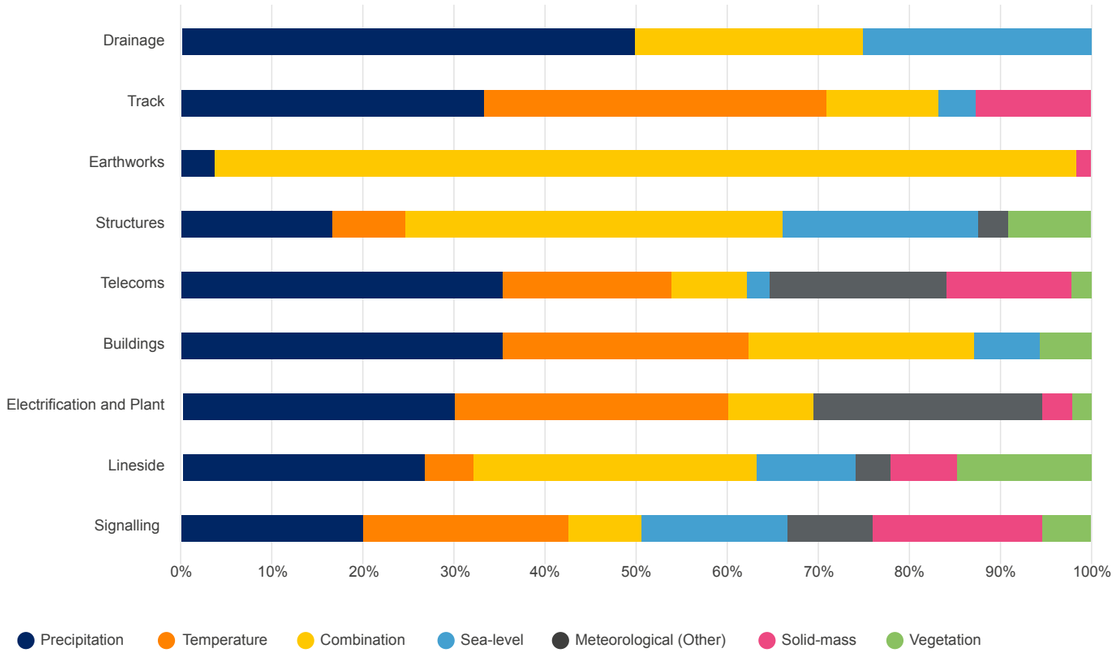
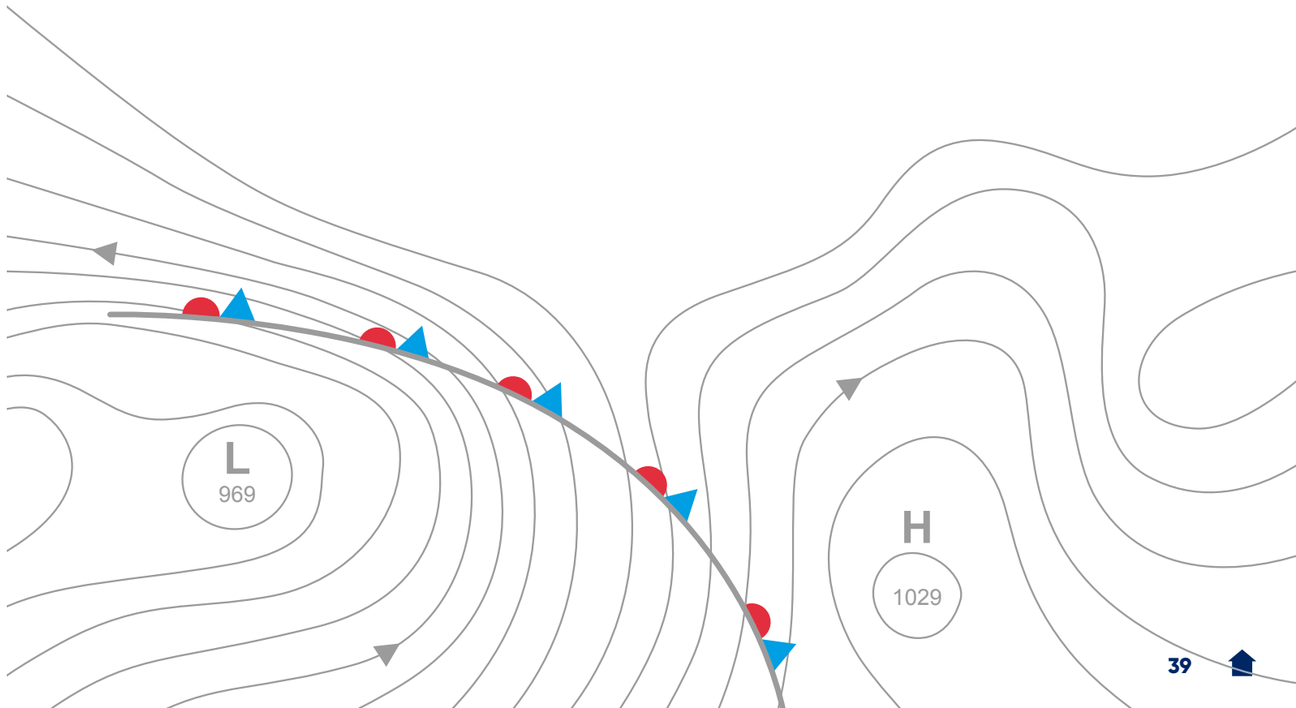



**Figure 11:** Overview of percentage of risks by climate variable and asset class.



# Results by asset class

## Drainage:

**The highest percentage of potential climate-related risks are associated with precipitation, combination hazards, and sea-level. For example:**

- Extreme rainfall events could overwhelm the drainage system and culverts, resulting in asset failure and further flooding.
- Increased leaf-fall and vegetation growth may cause blockages in the drainage system, leading to system failure and flooding. This climate-related risk is also possible because of blockages from mass movement.
- Sea-level rise may result in coastal erosion and defence overtopping, causing difficulties in discharging to estuaries and the coast. Drainage systems may also become tide locked or surcharged. Tidal outfall additionally poses a risk of backflow through the drainage system, leading to flooding.

Track flooding

## Signalling:

**The highest percentage of climate-related risks are associated with precipitation and temperature. For example:**

- Higher temperatures could lead to overheating of electrical components and control equipment, expansion in switches and crossings, rails and signal wire runs, and crushing of insulations.
- Extreme and/or prolonged rainfall could lead to water ingress and shorting of track circuits due to flooding, a rapid change of ballast conditions due to flooding can also lead to circuit failures. Mechanical components could also lose lubrication due to flooding which can lead to rusting/seizure.
- Landslides could cause damage to or displace cable routes and equipment, leading to circuit failures.
- Sea-level rise may result in coastal erosion, causing damage to cables and resulting in circuit failure. Coastal erosion could also lead to damaged equipment, inadequate protection of vehicles, and damage to vehicles. Coastal flooding is also a risk that can lead to water ingress and subsequent circuit failures and the overwhelming of electrical equipment leading to degradation of controls, indications, and warnings.

## Earthworks:

**The highest percentage of potential climate-related risks are associated with combination hazards. For example:**

- Extreme and/or prolonged rainfall can result in saturation of soil and weathering of rocks, which could result in failure of susceptible earthworks from ground instability.
- Higher temperatures and dry periods could dry out the soil and possibly weaken the roots of vegetation, resulting in failure of assets from destabilised soil cuttings/ embankments/ mixed cuttings.
- High temperature variance, high winds, or extreme rainfall and low temperatures could also potentially result in destabilised soil cuttings/ embankments/ mixed cuttings.
- Seasonal temperature variations and/or large diurnal changes could pose a risk of long-term degradation of earthworks due to cyclical processes such as freeze thaw and seasonal shrink/ swell.

Landslide near Lochailort

Dalguise Viaduct

## Structures:

**The highest percentage of potential climate-related risks are associated with combination hazards, sea-level, and precipitation. For example:**

- High winds and rainfall may increase maintenance costs and possibly increase the risk of scour and erosion due to the accumulation of storm debris.
- Higher rainfall totals may result in an increase of hydrostatic pressure which could lead to ground movement.
- Higher rainfall may also increase the risk of flooding which could lead to reduced performance, the potential for hydrodynamic loading (exacerbating scour and flooding) and the potential for water ingress and subsequent damage.
- High temperature variance may result in the weathering of structures due to freeze thaw action.
- Prolonged dry spells may cause soils to dry, resulting in changes in loading to the extrados of the tunnel linings.
- Sea-level rise may result in erosion, weathering, and scour, potentially leading to failure of susceptible assets and increasing maintenance costs. Damage to sea walls and defences specifically could result in a reduced level of protection. Sea-level rise might also cause flooding of tunnels, affecting their functionality.

Telecoms mast

## Telecoms:

**The highest percentage of potential climate-related risks are associated with precipitation, temperature, and combination hazards. For example:**

- Extreme and/or prolonged rainfall may cause asset failure through water ingress. Flooding can also lead to the washing away of telephone post foundations, damaging cables, and telephone instruments, causing a loss or degradation of services.
- Higher temperatures may lead to overheating and pose a subsequent risk of loss of service or reduction of coverage and disruption to service.
- Storms and high winds may result in asset failure through damage to antennas and buildings, which may result in loss of service or reduction of coverage. This can also occur from electrical storms and lightning.

Dumfries Station

## Buildings:

**Extreme and/or prolonged rainfall could result in water ingress to buildings, resulting in damage to buildings and associated contents, and failure of building services (e.g., electrical, and mechanical systems).**

- Higher temperatures could result in overheating in buildings, resulting in welfare challenges for users and potential failure of building services.
- Increases in vegetation growth and leaf fall could lead to blocked rainwater goods, subsequently resulting in water ingress of buildings causing damage to building fabric and / or services.
- Water ingress and damage to buildings may also arise from dislodged or damaged roofing from high winds and storms.
- Prolonged periods of wet or dry conditions could lead to ground movement, which may result in damage to buildings and associated contents and services.



OLE at Glasgow Central

## Electrification and Plant:

**The highest percentage of climate-related risks are associated with precipitation, temperature, and other meteorological factors. For example:**

- Extreme and/or prolonged rainfall could lead to saturation of foundations / ground, which could cause overhead line equipment (OLE) structures to move due to subsidence.
- Higher temperatures could also cause the sagging of contact wires, resulting in emergency speed restrictions and failure of overhead line equipment. High temperature variance also may lead to expansion of conductors and insulators causing long term issues.
- Lightning strikes elsewhere on the network could lead to indirect damage to equipment.

Arrochar & Tarbet Station

## Lineside:

**The highest percentage of climate-related risks are associated with combination hazards and precipitation. For example:**

- Combination risks include tree fall, leaf fall, wildfire, vegetation growth, ground instability, and drought.
- High winds and prolonged rainfall could lead to tree destabilisation, as does mass movement. Tree species are also at risk of failure from new diseases due to general changes in climate. Periods of drought could additionally place stress on trees and exacerbate the issue of diseases. Lightning strikes also pose a risk of damage and fire to trees, and subsequent risks to infrastructure.
- There is potentially a heightened risk of lineside fire due to drier and hotter summer conditions drying out vegetation. Vegetation is also impacted by warmer and wetter conditions, leading to increased growth, and requiring additional maintenance. However, this also poses a risk of the spread of existing invasive non-native species.
- Ground instability can lead to wall failure.


Washout event, Kyle Line, 2023

## Track:

**The highest percentage of potential climate-related risks are associated with temperature and precipitation. For example:**

- Higher temperatures could increase the risk of track buckles during hot weather and could lead to increased maintenance costs associated with the management of track in hot weather.
- Higher temperatures could increase the likelihood of service affecting measures having to be put in place to mitigate the risks of hot weather.
- Heavy and extreme rainfall events could lead to increased risk of flooding and loss of track geometry, or increased rates of track geometry deterioration.
- Accumulations of snow and ice could cause blocking of points.





# Risk Interdependencies

The climate change risk assessment looked at risks to specific asset classes, however, it is important to acknowledge that due to the nature of our network, climate-related risks are cross-organisational, and a cross-sectoral issue.

Our infrastructure assets operate holistically and depend on one another to function appropriately and safely. They also have interdependence with other key infrastructure outside of the rail network.

As a result, our engineers and asset owners work in collaboration with multiple stakeholders (Fig.12) to ensure that our assets are fit for purpose and are able to safely provide services across Scotland. Some of these key stakeholders are illustrated below.

In addition to the climate-related risks we face directly as an organisation, we understand that we are also susceptible to disruption when climate-related risks materialise in other key sectors that we are dependent on. For example, we have high dependence on the resilience of the power network for providing electricity for our fleet of electric trains. Likewise, other sectors have high dependence on our operations.

These risk interdependencies, particularly between operators of critical national infrastructure, were the focus of a preliminary piece of research carried out by Network Rail as part of the Adaptation Reporting Power report submission in 2021. The high-level results of this study are summarised in Figure 13.

We plan to undertake additional work to build on the results of that preliminary piece of research during the lifecycle of this plan – see Section 5.

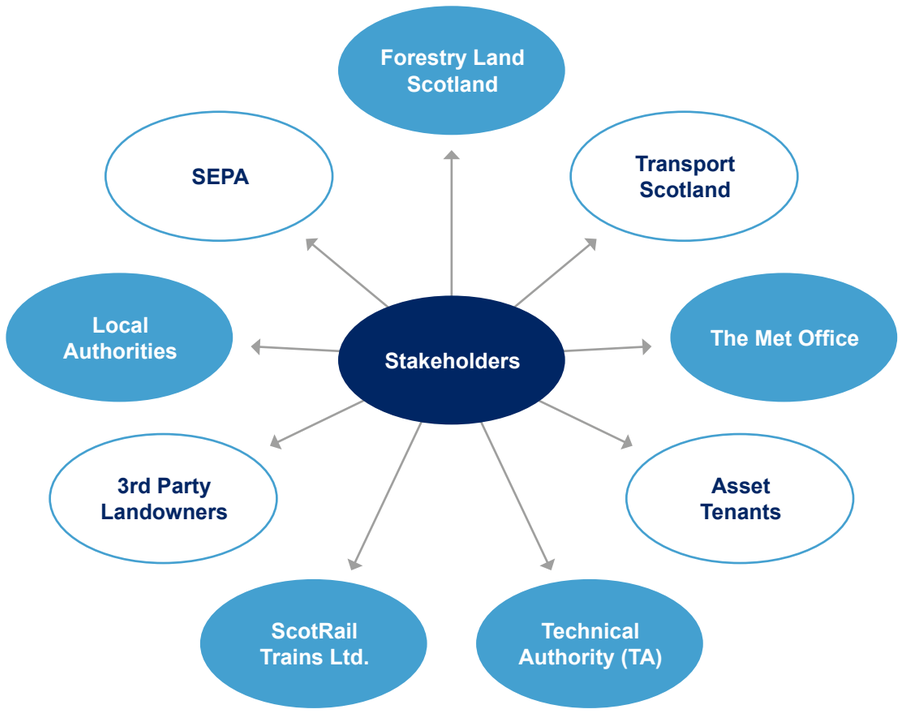



**Figure 12** – Mapping of Network Rail Scotland stakeholders.

Dependency from Network Rail

Dependency on Network Rail

Co-dependency

High climate risk

Medium climate risk

Low climate risk

## Power sector

- Reliable power supply for traction, signalling and other operational equipment and buildings e.g. depots and stations
- Risks include station closure, unpowered trains and inoperable signals and network controls

## Telecoms and ITC

- Operations and controls
- Corporate activities

## TOCs and FOCs

- Adherence to operational and temporary rules (speed restrictions, closures) due to weather and climate impacts
- Appropriate fleet maintenance

## Supply chain

- Materials and services provided through agreed frameworks e.g. ballast, steel, design and construction services and those required for emergency responses

## Water and wastewater companies

- Water and waste water service provision to stations, depots and offices and surface water management in urban catchments

## Airports and ports

- Predictable demand patterns and effective management of passengers and freight on and off site

## Flood Risk Management Authorities

- Environment Agency, Scottish Environment Protection Agency, Natural Resources Wales, Internal Drainage Boards, Canals and
- Rivers Trust Maintenance of flood and water management assets

## Gas networks

- Gas heating for domestic use (our offices, depots, and operated stations, including waiting rooms)

## Other UK businesses

- Goods and services outside agreed supply chain services frameworks

## Road transport

- National Highways, Transport Scotland, Welsh Government, Local Authorities, and bus, tram and haulage operators
- Reliable access and flows of passengers and freight to and from stations and depots

## Regulators

- Department for Transport, Office of Road and Rail: Funding for resilience and adaptation, and for reliable and efficient services
- Environment Agency, Natural England, SEPA, Natural
- Resources Wales, local authorities: Environmental legislation e.g. abstraction licences, protected species licences

## Emergency services

- Fire, ambulance and police services to our assets, covering major incidents relating to our staff, operators and customers

**Figure 13:** Network Rail's climate interdependencies: See the interdependencies section of the Adaptation Reporting Power submission for more information.

## Power sector

- Supplies of bulk fuel to power generation sites and reliable commute

## Other third-party landowners

- Potential damage to each other's assets and land from inadequate/failed drainage, falling trees or other windborne items.
- Potential for collaboration on land, water and vegetation

## Regional transport authorities and forums

- Shared asset co-dependencies e.g. split ownership of embankments
- Reliable service with smooth flow of passengers, maintenance access, water management, reliable service, diversion capacity

## TOCs and FOCs

- Operational and well-maintained rail infrastructure

## Power sector

- Maintenance access

## Road transport

- National Highways, Transport Scotland, Welsh Government, Local Authorities, and bus, tram and haulage operators
- Reliable service, commuting, capacity for passenger and freight diversion during service interruption, e.g. weather events or asset failures, maintenance access and water management

## Airports and ports

- Reliable railway enabling smooth passenger freight flow to and from ports and airports and a reliable commute

## TOCs and FOCs

- Efficient rail services delivering customer expectations and ensuring revenues, reliable commuting, asset maintenance, access and water management

## Canals & Rivers Trust

- Access to each others' assets

## Local authorities

- Reliable railway supporting the local economy, commuting and contributions to air quality and greenhouse gas targets

## Flood Risk Management Authorities

- Environment Agency, Scottish Environment Protection Agency, Natural Resources Wales, Internal Drainage Boards, Canals and Rivers Trust
- Collaboration on new flood protection
- Access (and permits for access) to each other's assets/land and water management

## Airports and ports

- Capacity for passenger and freight diversion during service disruption in other transport modes (e.g. weather events, asset failures), maintenance access, water management

## Road transport

- National Highways, Transport Scotland, Welsh Government, Local Authorities, and bus, tram and haulage operators
- Reliable railway enabling smooth passenger and freight flows to and from the road network

## Water and wastewater companies

- Access for maintenance
- Management of drainage from track and water company systems

## Gas networks

- Maintenance access

## Flood Risk Management Authorities

- Environment Agency, Scottish Environment Protection Agency, Natural Resources Wales, Canals and Rivers Trust, Internal Drainage Boards
- Water management and maintenance of assets designated as coastal, estuarine and river defences

## Telecoms and ITC

- Maintenance access

## Local authorities

- Asset maintenance, access and water management

## Other UK businesses

- Reliable freight and passenger transport

## Other UK business

- Revenues and services

Section 04

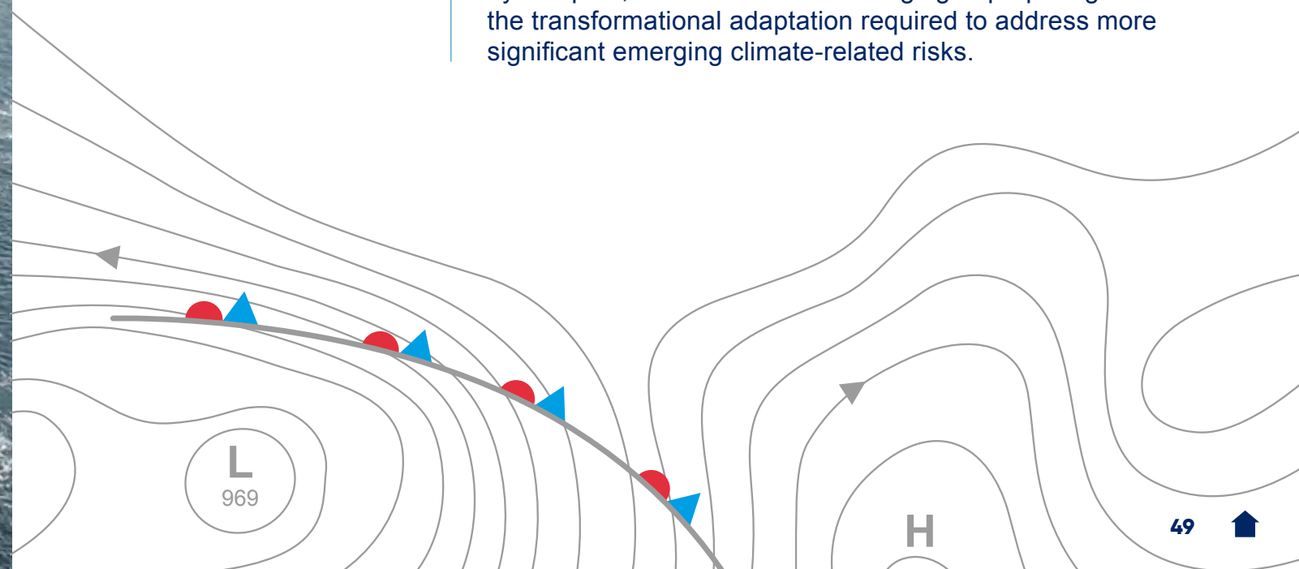
# Climate ready approach

Wemyss Bay



## Summary:


- Our approach to enabling and increasing the resilience of our railway, in response to adverse and extreme weather, as well as longer term changes in our climate, is continually improving and maturing.
- Our ability to prepare for, respond to and recover from adverse and extreme weather events has improved in recent years. Creation of a 24/7 weather desk staffed by trained meteorologists being one key improvement.
- Many improvements have been driven by the Weather Risk Taskforce. This group is working through action plans associated with the findings of independent reports into the management of Earthworks and our weather forecasting capabilities and operations.
- Detailed plans have also been produced outlining how we manage adverse and extreme weather from an operational perspective, and outlining how we proactively prepare for known seasonal challenges.
- Improvements have also been made in how we respond to weather-related damage to our infrastructure, with key areas of Scotland's Railway working together to ensure the railway is recovered as safely and efficiently as possible.
- In addition, previous plans, such as Network Rail's Control Periods 5 and 6 Weather Resilience and Climate Change Adaptation Plans, and ScotRail's Climate Change Adaptation Plan – have detailed work undertaken to increase the resilience of our infrastructure assets.
- This work continues into the next five-year period covered by this plan, with a new focus emerging of preparing for the transformational adaptation required to address more significant emerging climate-related risks.

# Climate Ready Approach

## Weather and Climate Resilience Classifications

**Our approach to enabling and increasing the resilience of our railway, in response to adverse and extreme weather events, as well as longer term changes in our climate, is continually improving and maturing.**

To help better communicate our approach to improving the resilience of our railway, a 'weather and climate resilience classification' system has been produced for the purpose of this plan (Figure 14).

This classification system is intended to help showcase the variety of work we undertake to manage weather and climate-related risks on our railway. It also helps draw out the distinction between weather resilience and climate resilience which have key differences and requirements.

There are three distinct timescales over which our interventions operate – detailed below. In practice, how we respond to, and manage, weather and climate-related risks will nearly always involve a combination of the interventions explored in this classification system as opposed to working in isolation.

### 1 Preparedness, response and recovery:

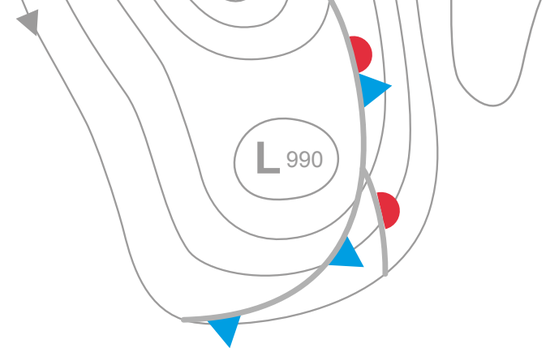
This is our short-term (hours to seasons) response to adverse and extreme weather events. Activities here operate in the pure 'weather resilience' space and set out how we prepare for and manage the impacts of extreme weather on our railway in the days and seasons ahead.

### 2 Proactive intervention:

This is our short to medium term (seasons to years) response that branches the weather to climate resilience space. Activities here set out how we proactively prepare our infrastructure assets for adverse and extreme weather, and often how design changes can be implemented to prepare for future changes in climate.

### 3 Transformational adaptation:

This is our long-term (years to decades) response to preparing for significant anticipated changes in our climate. As our approach to understanding climate risk matures, and we develop longer term adaptation strategies, more activity will occur in this space.




**Weather and climate resilience classifications**

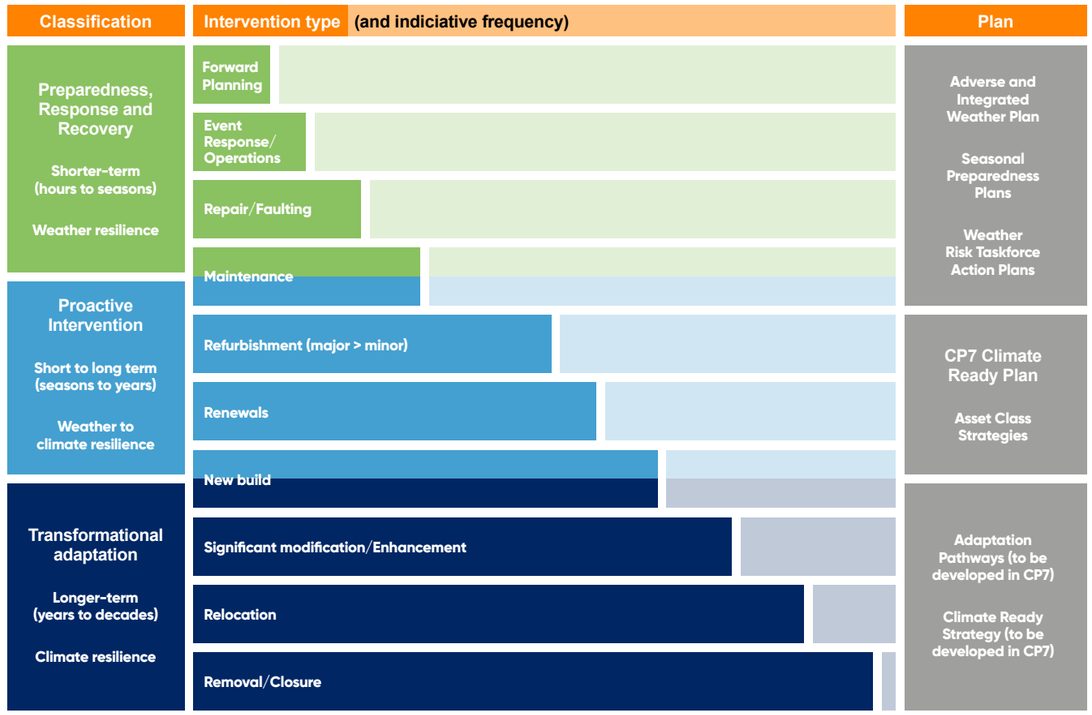



**Figure 14:** Weather and climate resilience classifications – this diagram outlines the different approaches we can take to delivering weather and climate resilience. Its intended use is to highlight the temporal and strategic distinction between weather and climate resilience.

# Preparedness, response, and recovery

## Weather Operations Team

Scotland was the first Network Rail route to recruit and deploy Weather Operations Delivery Managers (WODMs).

WODMs are weather specialists who bring a background in meteorology to railway operations. They work 24/7/365 on a rotating shift, always providing coverage. WODMs monitor current and forecast weather conditions and provide live weather analysis to key communities across Scotland's Railway, including control and engineering teams.

This bespoke analysis is then integrated into how we respond to extreme and adverse weather. For example, WODMs can advise on the location of emergency speed restrictions that can be triggered by forecast extreme weather.

## Adverse and Integrated Weather Plan

The way in which we manage, and respond to, adverse and extreme weather continues to be improved and is detailed extensively in the Scotland's Railway Adverse and Integrated Weather Plan.

The plan provides a systematic and structured approach detailing how the Scotland route responds to the threat of adverse weather, the triggers and monitoring regime that determine when action needs to take place, what that action will be and who will implement the required action. The plan is reviewed annually, ensuring that guidance is current.

In practice, Network Rail Control receives a daily forecast (by 03:00hrs) from their contracted weather forecast provider. This details the forecast for the current day, in addition to a forecast for the subsequent four days. Control will distribute this forecast and draw attention to the weather alert status.

Using additional forecasting tools and insight, our WODMs who staff the internal Network Rail weather desk will issue a more detailed forecast focused on the likely hazards to specific lines, with further forecast updates issued through the day after each model update or as conditions require.

The weather alert status is a red / amber / green warning level determined by forecast weather conditions. For example, if gusts of 60mph or over are forecast this will trigger an extreme red alert for areas affected.

The issuing of a red alert then formally starts the 'extreme weather response process'. This is a five-stage process that covers:

- **Awareness** – ensuring all relevant stakeholders are informed.
- **Preparation** – this includes scheduling of an Extreme Weather Action Teleconference (EWAT) attended by meteorologists, asset engineers, control colleagues, maintenance teams and representatives of train and freight operating companies.
- **Respond** – this includes active monitoring of weather conditions on the ground by front-life staff. It also includes calling unplanned emergency EWAT conferences if the weather is worse than predicted, affects an unexpected part of the network or impact on the infrastructure is greater than expected.
- **Recover** – this includes the convening of service and performance recovery conferences. These conferences help determine priorities and establish robust timescales for recovery of the network, and to understand train and freight operator's priorities and timescales for service.
- **Review** – the final stage sees a review of the route's preparedness and response to the weather event in question, this includes highlighting best practice, seeing where plans failed (and learning from that) and reviewing the accuracy of the weather forecast throughout the period.


Preparing for winter weather

## Seasonal Preparedness Plans

Network Rail Scotland prepares seasonal plans for summer (to manage hot weather), winter (to manage cold and stormy weather) and Autumn (to manage the impact of leaf-fall). These plans are generally delivered by our Maintenance teams.

The primary aim of these plans is to ensure treatment proposals are robust enough for the predicted impact of adverse and extreme weather. In turn, this should help to minimise any performance and safety impacts of inclement weather.

Plans are generally created months in advance, for example in 2023 the summer plan was prepared and published by March, the autumn plan by September and the winter plan by October.

In the development of these plans, Network Rail Scotland will consider which measures taken in previous years have worked well, and which measures haven't performed as expected. Lessons learned from this influence revised plans. To support this process, end of season reviews are held.

The plans are discussed regularly by Network Rail's wider Seasonal Team at Seasonal Management meetings. These are usually held three or four times a year and would have members of each Route attend.

The following sorts of activities are incorporated into a typical seasonal plan.

**Summer:**

- Engineers will 'stress' sections of track in known hot-spot areas to help them cope with sudden rises in temperature and will paint some rails white in key locations to reflect the sun, keeping them up to 10°C cooler and helping prevent buckling (image below).
- Engineers will adjust the tension in some overhead electric power lines to help prevent sagging and keep trains running in hot conditions.
- Remote temperature monitoring equipment will be installed on rails at known hotspots allowing decisions on whether to implement speed restrictions to be made in real-time when necessary for safety reasons.

Preparing for summer


Preparing for autumn

**Autumn:**

- Specialist rail-head treatment trains and multi-purpose vehicles will be deployed to help clear leaves from the line (the railways equivalent to black ice on roads). They use high-pressure water jets to clean the rails before coating them with a sandy gel that sticks to them, helping improve train wheels' grip.
- ScotRail will tweak timetables during autumn to make its timetable more resilient against the adverse conditions that the change in weather can bring.
- In 2023, a train fitted with cryogenic equipment was trialled in the Edinburgh area. This shoots dry ice pellets onto the rails, causing leaves to crack and break away to leave a clean, dry surface behind for trains to grip onto (image above).

**Winter:**

- Cutting back overhanging trees that could be affected by high winds or snow.
- To help keep passengers moving a special winter fleet can be deployed, complete with snowploughs, hot air blowers, steam jets, brushes, scrapers and anti-freeze to clear snow and ice from the tracks.

These seasonal preparedness plans will continue to be produced over the course of this plan cycle (2024 to 2029) and will be continually improved based on lessons learned.

## Response and Recovery

In the event a weather-related incident causes infrastructure damage to the network, teams of engineers will be deployed to respond. This is coordinated by Control with updates from site recorded in the Control Log which is used to manage the response across the network.

Depending on the scale of the incident, emergency response is undertaken though local maintenance teams or through Works Delivery and supply chain partners; all of which have teams on-call throughout the year.

During periods of adverse or extreme weather, maintenance teams will coordinate staff in the affected areas to respond to any potential incident such as survey track, clear fallen trees, or pump flood water. Where larger scale incidents occur, the Works Delivery team are engaged alongside our reactive contractors to access the issue and plan the response. These incidents are typically where extreme weather has resulted in the track being washed away or where landslips have occurred blocking the track

Over the last five-years, the way in which Scotland responds to emergencies has improved following detailed review of incidents and development of capabilities in the route.

Asset disciplines have developed approaches to managing reactive works, including seeking ways to reduce the need for reactive works (versus proactive). For example, Track engineers are looking at increasing the use of remote condition monitoring as part of a move toward more predictive rather than reactive maintenance.

Where reactive works are required, there are ring-fenced reactive workbank allowances included in asset planning for Control Period 7.

## Weather Risk Taskforce

Following the derailment at Carmont in August 2020, Network Rail commissioned two independent reviews. The reviews looked at Network Rail's capability to understand and manage adverse weather, with a particular focus given to earthworks and drainage asset management.

The aim of these reviews was to equip Network Rail with an enhanced knowledge base and competencies, and to provide recommendations to deliver these enhancements.

Initially two reviews were undertaken:

- Weather forecasting capabilities for extreme rainfall (led by Dame Julia Slingo).
- Earthworks and drainage engineering (led by Lord Robert Mair).

Following the extreme heat experienced in July 2022, additional reviews were commissioned to investigate how Network Rail manages, and responds to, hot-weather incidents. Those were:

- Weather forecasting capabilities for heat (led by Dame Julia Slingo) Track and Overhead Line engineering (led by Sir Douglas Oakervee).
- Operational weather management standards, policies, and practices (led by Simon Lane).
- Communications and planning for disruptive events (led by Anthony Smith).

Delivery of action plans associated with these independent reviews is being overseen by the Weather Risk Taskforce established for Scotland. Additional action plans associated with the recommendations made in the Rail Accident Investigation Board report into the Carmont incident are also overseen by this group.

The Weather Risk Taskforce in Scotland meets regularly to review progress on delivery of the Action Plans. The group is comprised of representatives from Network Rail, ScotRail and Transport Scotland.

Good progress has been made to date; highlights include:

- Deployment of new weather forecasting tools into Scotland's Railway Integrated Control.
- The Weather Desk noted above that has been set-up in Control, staffed by trained meteorologists.
- Improved aerial survey capabilities have been achieved with a dedicated helicopter, based at Cumbernauld, for earthworks inspections and aerial surveys. This now forms part of business-as-usual activity and is invaluable after heavy rain and storms.
- A Slope Safety Review Group has been established and meets every four weeks to accelerate progress against weather resilience plans.
- Deployment of Earthworks Failure Detection (wireless tiltmeter systems) to 130 sites across the route, enabling live landslip detection.
- We have delivered additional resources in the key areas of drainage inspection, operations control, and geotechnical asset management.

To date, the Taskforce's actions have generally been more focussed on current operational resilience – for example the Weather Desk or enhanced drainage inspection capacity.

Example actions associated with the Weather Risk Taskforce are outlined in Appendix B1. Actions are provided there for awareness only as their implementation and monitoring are governed directly by the Taskforce.

Rannoch Viaduct (2024)

## Maintenance

Our maintenance activities ensure our infrastructure assets are maintained in a condition that allows them to operate safely, and reliably. In short, it is the day-to-day upkeep of the network.

In Network Rail Scotland, maintenance activities are coordinated from four Maintenance Delivery Units (MDUs) at Glasgow, Edinburgh, Motherwell, and Perth. Those teams deliver maintenance activities across the 2,800 miles of track, as well as the rest of the network which includes the hundreds of bridges, tunnels, telecoms, signals, power supply systems, level crossings, stations, operational buildings, vegetation, and fencing.

Teams undertake inspections visually, as well using remote monitoring systems. In addition, they carry out preventative and reactive maintenance on a 24/7 basis – all to keep the railway safe, support a reliable train service, and comply with legal and other obligations.

Scotland's Railway is accountable for the planning and delivery of maintenance activities, establishing decision-making criteria for asset maintenance prioritisation, and managing data and information to measure maintenance performance. This activity is supported by Network Rail's Technical Authority, which has responsibility for developing the processes, standards and procedures, decision-support tools, and monitoring technology for maintenance.

From a weather and climate perspective, proactive maintenance activities are the first physical line of defence in ensuring safe operations during periods of inclement weather.

For example, maintenance activities include:

- Clearing leaves and silt from drainage pipes to allow them to handle their designed capacity / volume of water.
- Routine clearance of vegetation from areas immediately next to track, in cuttings, embankments and from structures – where its presence could cause damage or obstruct views.
- Using tamper and ballast regulators to redistribute ballast – the stones beneath the track that give support – and compact it beneath the sleeper so that it maintains the track geometry.
- Monitoring our infrastructure by fitting measurement equipment to trains to identify potential flaws in the rail that need to be fixed.

Activities carried out in support of seasonal preparedness plans, and in responding to damaging events when they occur are also generally delivered by our maintenance teams.

As well as proactive maintenance of infrastructure assets, maintenance teams play a crucial role in returning the railway to operational service after extreme weather-related events.


Installation of rockfall prevention measures at Ratho (2024)

# Proactive Intervention

## Network Rail Asset Interventions

Network Rail Scotland's approach to enhancing the resilience of its assets against adverse and extreme weather events, as well as longer term changes in climate has previously been detailed in its Weather Resilience and Climate Change Adaptation (WRCCA) Plans.

There have been two WRCCA Plans covering Control Period 6 (2019-2024) and Control Period 5 (2014-2019). The most recent WRCCA Plan set out, over 27 actions, a series of planned activities that would help increase the resilience of our railway infrastructure against adverse and extreme weather, as well as longer term changes in climate.

Good progress is being made against delivery of this plan, despite some planned activity being impacted by financial pressures and reprioritisation of works during the Control Period.

Highlights of works concluded so far include:

- Over £30m of investment targeted at reducing the risk of earthwork failure at high-risk locations.
- Targeted interventions to reduce risk of flooding at 15 locations, with another 11 locations due to be completed.
- Targeted interventions at 50 high-risk scour sites (see case study).

In addition, a dedicated Weather Resilience and Climate Change Adaptation Strategy Manager post was created during the plan cycle.

Moving forward, the actions previously recorded in these WRCCA Plans are being integrated into this overarching Climate Ready Plan (2024 to 2029) that also incorporates ScotRail activity. The approach to asset resilience outlined in this plan has had to respond to the challenging financial climate in which we are currently operating.

As in other industries with large asset bases with long operational lives, the investment profile for asset renewals is not always smooth. In facing trade-offs, we have developed an affordability-driven approach to renewals expenditure for the next five-years, which will transition asset workbanks from more full renewals to a blend of full renewals and life extending interventions. This will result in a projected reduction in the Composite Sustainability Index in CP7, which measures the long-term sustainability of the railway.

We will focus activities on providing a safe and reliable railway, while reducing costs in the next five-year period. This will impact overall asset condition, but we believe that potential risks can be mitigated by applying more targeted refurbishment and maintenance interventions. Safety risk and strategic route sections will ultimately serve to guide investment.

From a weather and climate resilience perspective, work planned in the next five-years is focused on where resilience can be accrued as an additional benefit when intervening, as opposed to pure resilience schemes driven by known weather and climate-related challenges.

We'll protect safety with a thorough programme of targeted renewals and maintenance interventions, with activities focussed on maintaining levels of safety and reliability.

Expanded use of remote monitoring (e.g., tilt meters and water telemetry), surveying techniques (e.g., helicopter, lidar and train-borne CCTV) and improvements to forecasting capabilities (e.g., development of a new national weather forecasting and decision platform), will all help to manage residual weather-related impacts. The use of measures such as emergency speed restrictions will also help to manage any potential safety risks.

In addition, the enabling activities planned and set out in this plan (Outcomes 1, 2 & 4 of this plan) will allow for a greater understanding of the risks associated with climate change on our infrastructure. Further details on the approach to funding activities on our infrastructure can be found in the Network Rail Scotland Strategic Business Plan[11] and in Section 5 of this plan.






## Case study: Scour schemes

**In 2023, Network Rail and its contractor Story completed a £34m programme of works to protect several bridges across Scotland's Railway.**

Over four years, specialist engineers worked on 50 structures to safeguard them against scour damage.

Scour damage happens when fast-flowing water erodes material around the foundations and is the leading cause of bridge failures on the railway over the last 100-years, which can result in having restrictions placed on them.

Working mainly from river level, much of the work at each bridge involved setting up a portable dam system to reduce the water flow.

A scour mattress was laid to the contours of the riverbed and the pockets were filled with concrete. The mattress was then covered with the original riverbed material, so the area looks the same as it did prior to work starting.

It's all designed to extend the lifespan of these structures, as the majority were built in the late 19th century, while helping to protect them against weather damage as part of a wider maintenance programme.

Inver viaduct, Dunkeld (2023)

ScotRail passenger service

## ScotRail's Approach

Managing climate change risk is essential to ScotRail to maintain a safe reliable service and where this is not possible, manage disruption and ensure normal service recovers as soon as possible. The risks from climate change and extreme weather events are understood and resilience is built into relevant processes, procedures, and activities.

Climate change risk has been incorporated into their Environmental Management System making it an integral part of key procedures. ScotRail have produced an internal Climate Resilience Plan, the plan outlines the current and future actions required to manage the impacts of climate change, as well as embedding their operational response to climate impacts in their Resilience Plan.

The Resilience Plan that sets out the organisation's process to clearly identify how it deals with situations or events which will have a severe impact on its capability to operate services.

ScotRail has identified key positions within the organisation who are trained and available to implement the company Resilience Plan in line with guidelines and criteria determined under its Grant Agreement with ScotRail Holdings.

In recent years, ScotRail has had to respond to several extreme weather events. This has highlighted many challenges for the business. Additional measures have since been put in place to help cope with similar events, such as more frequent meetings of the Emergency Weather Action Team. However, extreme and adverse weather events in the last few years have emphasised the need to regularly review current and anticipated climate risks in more detail.

To ensure that all types of weather-related incidents are dealt with effectively, efficiently, and safe, ScotRail Trains Ltd and Network Rail have developed a key route strategy. The strategy provides details of a planned reduction in the availability of the infrastructure because of extreme weather which could or is severely affecting the whole route. This would only be implemented in a major weather event affecting the whole route.

For adverse weather events which are not classified as major, contingency plans exist which are held within Control. These plans detail, by line of route when and where a reduction in services is required due, for example, points failures, broken rails, unit failures and non-major weather events. Implementation of any plans will be undertaken by the Control Duty Manager to support and aid service recovery.





# Transformational Adaptation

## Enhancements

Enhancement schemes generally involve the construction of new, or improvements to existing infrastructure that enable service changes, increased network capacity and connectivity, and better performance, which deliver wider social and economic benefits. They are funded separately to the schemes set out in Control Period business planning.

In Scotland, key enhancements delivered by Scotland's Railway are also supporting Scottish Government policy to deliver a net zero Scotland by 2045 by decarbonising traction across the network.

Infrastructure enhancements will be required to deliver electrification infrastructure along with accessibility improvements to encourage modal shift to more sustainable transport. In delivering these infrastructure interventions, the impacts, and opportunities in relation to climate resilience will be increasingly considered as new and improved data and information on climate risks becomes available.

## Planned Improvements

Work to better understand where a more transformational approach to managing emerging climate-related risks is outlined in Section 5 of this plan. As changes in our climate intensify, a business as usual, incremental approach to achieving resilience will likely not be suitable for some locations.

Our approach to identifying and acting on these locations will be rooted in a maturing approach to using available climate science data and information. As outlined in Section 5, we will further develop our climate risk assessment capabilities and processes over the lifecycle of this plan.

As we continue to develop our understanding over coming years, we will use that new insight gained to develop adaptation pathways for the assets / lines of route that we believe will require a transformational approach to adaptation.

An adaptation pathway is an approach that allows decision-makers to take proactive climate change adaptation interventions whilst dealing with the uncertainty that exists in the extent to which our climate will change.

Other planned transformations include increasing the use of nature-based solutions and finding more opportunities to collaborate with third parties to support activities undertaken outside the railway boundary (e.g., catchment-based flood management schemes).

This includes, for example contributing to the development of Scotland's next Flood Resilience Strategy, and SEPA's National Flood Risk Assessment.

In addition, we will engage with Scotland's Public Sector Climate Adaptation Network (chaired by Adaptation Scotland) and seek opportunities for collaboration through that network.

Section 05

# Action plan

Gourock





## Climate ready plan summary:

| | |
|---|---|
| Objective: **Increase our adaptation capability maturity score from 2.5 to 4 as measured by the Rail Safety and Standards Board rail sector adaptation capacity assessment** | |
| **Outcome 1** | **The decisions we make are based on a maturing understanding of climate-related risk (See Appendix A1 for the detailed action plan)** |
| **Milestone 1** | **A revised approach to undertaking physical climate change risk assessments of our infrastructure is delivered** |
| **Milestone 2** | **The scope of our climate risk assessment activities is expanded to consider additional forms of climate risk (e.g., transition and operational climate risks)** |
| **Outcome 2** | **A long-term climate adaptation and resilience strategy increasingly guides investment (See Appendix A2 for the detailed action plan)** |
| **Milestone 3** | **Long-term climate change adaptation plans are delivered for the most at-risk route sections / locations** |
| **Milestone 4** | **A long-term climate change adaptation strategy is delivered for Scotland's Railway** |
| **Outcome 3** | **Our assets are made increasingly resilient to acute weather events, as well as longer-term changes in climate (See Appendix A3 for the detailed action plan).** |
| **Milestone 5** | **A programme of business-as-usual asset resilience activities is delivered** |
| **Outcome 4** | **Our 'climate ready journey' is underpinned by a maturing level of risk, assurance, competence, and data insights. (See Appendix A4 for the detailed action plan).** |
| **Milestone 6** | **A programme of risk and assurance activities is delivered to improve confidence in weather and climate resilience decision making** |
| **Milestone 7** | **Routes to weather and climate resilience competence are established** |
| **Milestone 8** | **An enhanced approach to how we review, and monitor, the impact of weather events on our railway is delivered** |

**Table 1:** Summary of the key Climate Ready Plan objectives, outcomes, and milestones

# Action Plan

**In developing our Climate Ready Plan, we have considered:**

- The requirements of our funder and regulator, e.g., those outlined in the High-level Output Specification from Transport Scotland (see Section 2).
- What we need to do to actively contribute to key national legislative and policy commitments e.g., the targeted outcomes of Scotland's National Adaptation Programme.
- The findings of relevant studies conducted in recent years, for example the findings of reports associated with the Weather Risk Taskforce (Section 4) and Targeted Assurance Reviews by the ORR.
- Funding and resource available to Network Rail Scotland over the next five-years and the next annual ScotRail planning cycle.

The actions we set out in our plan have been developed to help us respond to the above considerations, and to deliver four key outcomes we have set ourselves; those are:

1. Ensuring the decisions we make are based on a maturing understanding of climate-related risk.
2. Developing a long-term climate adaptation and resilience strategy to increasingly guide our investment decisions.
3. Delivering a programme of asset refurbishments and renewals that deliver resilience to acute weather events, as well as preparing for longer term changes in climate.
4. Delivering new and improved risk, assurance, competence, and data processes to underpin our climate ready journey.

In addition, we have mapped planned actions against the ORR's 11-levers of weather resilience that were produced as part of the Earthworks and Drainage Weather Resilience Targeted Assurance Review (See Appendix B2).

## Outcome One

### Risk Assessment and Data

**The decisions we make are based on a maturing understanding of climate-related risk.**

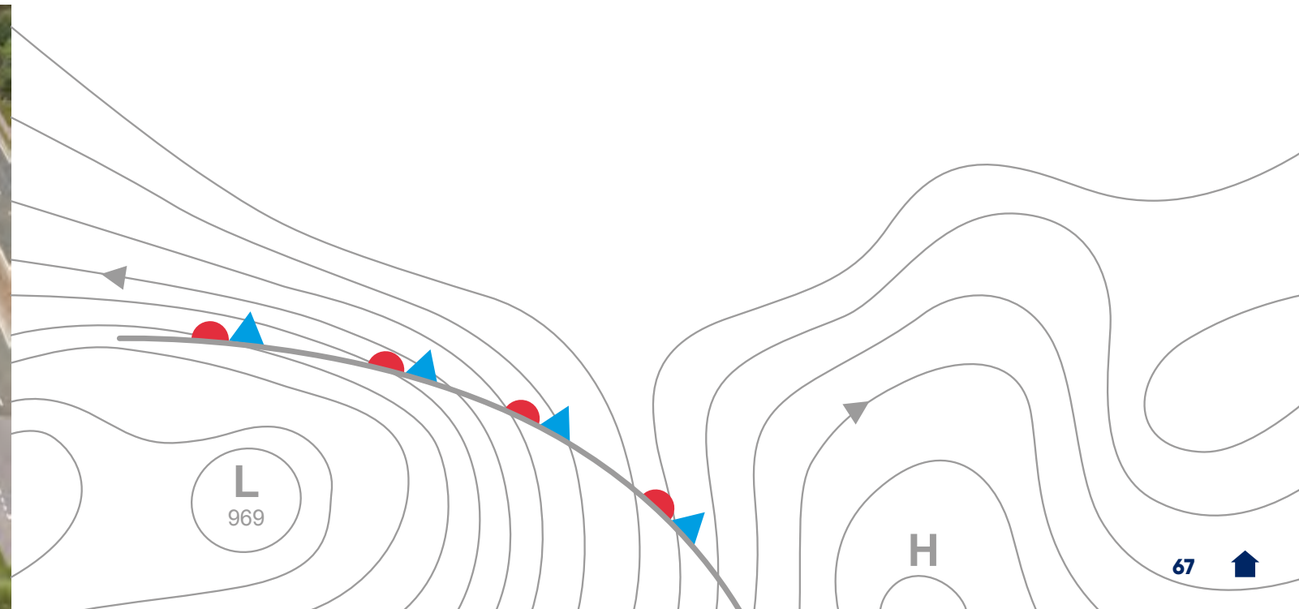
There are a series of activities planned to expand the scope of, and make improvements to, our climate risk assessment processes. Specifically, our plan is to:

- Review what access to climate and natural hazard data we have and assess its suitability. Commissioning of new and improved data, where required, for use in climate risk assessments would then follow.
- Build on progress made so far in understanding the future climate risks our railway is exposed to by moving toward asset specific assessments of risk that consider the hazard, vulnerability, and exposure of the assets in question.
- Move away from qualitative assessments of risk toward quantified risk assessments where possible and of value – drawing in the best available climate and asset data.
- Expand the scope of our physical climate risk assessments beyond assets to better consider risks to our people, operations, and risk interdependencies with other infrastructure operators.
- Expand the scope of our climate risk assessment in general, to begin considering key transition climate risks that our railway and organisation may be exposed to.

Funding for activities associated with this outcome will be derived from a funding pot of £3.7 million allocated to Network Rail Scotland's Engineering and Asset Management Directorate. Where required, ScotRail will allocate funding from their annual operational expenditure.

See Appendix A1 for the action table.

Slochd, Highland Mainline



## Outcome Two

### Strategy and Pathways

**A long-term climate adaptation and resilience strategy increasingly guides investment.**

The development of adaptation pathways is a flagship deliverable of this plan.

An adaptation pathway is an approach that allows decision-makers to take proactive climate change adaptation interventions whilst dealing with the uncertainty that exists in the extent to which our climate will change.

Practically, a sub-set of very high-climate risk locations, assets, or asset types exposed to irreversible climate risk (e.g., coastal erosion) will be identified. These will be locations where a complex long-term strategy will be required to manage the climate risk(s) of concern.

Detailed, site-specific climate-related hazard modelling will be undertaken for these locations, and a range of adaptation solutions / options developed.

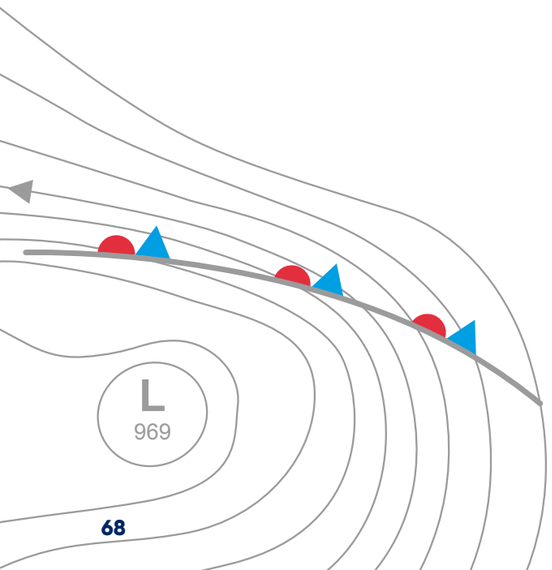
Understanding the economic, social, and environmental implications of the options developed will form a key part of the analysis undertaken.

The pathways approach will lay the foundations for a longer-term climate change adaptation strategy for our railway that allows us to:

- plan for, prioritise and stagger investment in adaptation options at high-risk locations across a timeframe longer than set funding cycles.
- identify the climate adaptation and resilience decisions that need to be taken now, as well as decisions that can be taken at a later stage in the future.
- identify trigger points that would prompt when investment is required at those high-risk locations.
- translate a complex long-term strategy for increasing the resilience of our railway into a series of more manageable deliverables that also support communication and consultation with stakeholders.

Funding for activities associated with this outcome will be derived from a funding pot of £3.7 million allocated to Network Rail Scotland's Engineering and Asset Management Directorate. Where required, ScotRail will allocate funding from their annual operational expenditure.

See Appendix A2 for the action table.






## Outcome Three

### Asset Resilience

**Our assets are made increasingly resilient to acute weather events, as well as longer-term, more chronic changes in climate.**

**Approach to resilience**

As outlined in Section 4, Network Rail's approach to asset resilience over the next five-year control period is focused on where resilience can be accrued as an additional benefit when intervening, as opposed to pure resilience schemes driven by known weather and climate-related challenges.

Asset workbanks are also transitioning from more full renewals to a blend of renewals and life extending interventions of assets. Where renewals are programmed, the approach has been to direct them at high-risk assets that will be either worn out, obsolete, or have degraded to a state where safe operation and reliable performance can no longer be achieved.

To help identify and measure the weather and climate resilience benefits of planned interventions on infrastructure assets, the National Network Rail Climate Change Adaptation Team led a piece of work to review what resilience benefit is achieved against each of the different intervention types that make up the asset workbanks.

To do this, each intervention type was individually assessed for the resilience benefit it provides, and a percentage of the cost that can be tagged to resilience identified. For example, intervention on drainage assets which help to address the risk of heavy rainfall and flooding score high in terms of resilience benefit.

An additional lens of whether the intervention is being undertaken in response to a weather or climate-related challenge, or whether the driver is not weather or climate-related, but resilience is still accrued was applied. The definitions for these classifications can be found in Table 2.

| Resilience Definitions |
| --- |
| **Primary Resilience Activity** |
| **Pure resilience:** These are activities that are being undertaken solely for the purpose of improving our network's resilience to extreme weather. |
| **Business-as-usual:** These are activities which are generally driven by poor asset condition as well as weather condition challenges. In undertaking this work an improvement in asset condition is delivered as well as a clear improvement in weather resilience. |
| **Secondary Resilience Activity** |
| These are 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).<br><br>Or activities where just by the nature of intervening makes the asset more resilient (e.g. modern standards are more resilient than asset is currently designed to). |

**Table 2:** Defintions of primary and secondary reislience.

## Investment Plan

The results of this initial workbank review provided a high-level indication of weather and climate-related resilience spend planned for the next five-year period (Table 3).

| High-level investment breakdown by asset class | | |
|---|---|---|
| **Asset** | **CP7 Forecast (£m)** | **Primary Benefit (£m)** |
| Track | 502 | 6.25 |
| Off-track | 44 | 2.17 |
| Level crossings | 23 | |
| Signalling | 286 | 9.71 |
| Structures | 412 | 42.60 |
| Earthworks | 207 | 166.21 |
| Drainage | 122 | 111.25 |
| Telecoms | 37 | 0.77 |
| E&P | 86 | 13.09 |
| Buildings | 101 | – |
| **Total** | **£1821** | **£352.05** |

**Table 3:** High level resilience spend, calculated using central NR adaptation team's methodology.

In Scotland, we took the results of this top-down exercise and further refined them through a bottom-up analysis of asset team workbanks, to identify specific schemes proposed for completion over the next five-years that make up the actions outlined in our plan (Table 4).

When compared to the previous Network Rail Control Period (2019-2024), there is, on paper, an increase in spend planned on the resilience of our assets.

This increase can be explained due to:

- an increase in funds available to Network Rail's Lineside and Drainage assets
- the inclusion of activity planned by asset teams that was not included in previous plans, primarily actions associated with Track, and an expanded set of actions for Signalling.
- a series of one-off investments taking place during the life cycle of this plan (e.g., Glasgow North Electrics renewal and the building wrap refurbishment initiative).

Auch Viaduct

| Asset Class / Action Type | £m |
|---|---|
| **Buildings** | **£10.1** |
| Critical Lineside Building refurbishment programme | £10.1 |
| **Earthworks** | **£113.3** |
| Soil cutting renewals | £71.6 |
| Embankment renewals | £26.0 |
| Rock cutting renewals | £14.6 |
| Earthworks monitoring | £1.1 |
| **Electrification and Plant** | **£21.5** |
| Overhead line equipment renewal | £20.5 |
| Remote condition monitoring | £1 |
| **Lineside and Drainage** | **£100.3** |
| Tree & vegetation management | £54.0 |
| Pipe refurb | £3.2 |
| Pipe renewals | £20.4 |
| Pipe new builds | £10.4 |
| Ditch/ channels refurb | £1.7 |
| Ditch/ channels renewals | £4.4 |
| Ditch/ channels new builds | £4.9 |
| Chamber refurbs | £0.2 |
| Chamber new builds | £0.6 |
| Chamber renewals programme | £0.5 |
| **Signalling** | **£45.3** |
| Aster tracks replacement | £6.0 |
| Axle counter train detection | £20.0 |
| Points (hydraulic fluid) | £15.0 |
| Level crossing (wind resilience) | £0.6 |
| Axle counter (Winchburgh Tunnel) | £0.5 |
| Miniature stop lights (fog) | £3.2 |
| **Structures** | **£52.1** |
| Tunnel active water management | £2.8 |
| Underbridge scour | £21.6 |
| West of Scotland culvert strategy | £9.1 |
| Coastal and estuarial defences maintenance | £15.3 |
| Retaining wall scour protection refurb | £3.3 |
| **Track** | **£92.3** |
| Plain line renewal | £34.1 |
| S&C renewal | £11.5 |
| Track drainage renewal | £46.7 |
| **Total** | **£434.9** |

**Table 4:** Summary of key resilience interventions planned and expected costs.

Lochailort on Mallaig line

## Asset Summaries

The following tables outline our approach to climate resilience for our asset types. A more detailed breakdown of the actions planned for delivery can be found in Appendix A3.

### Table 5: **Buildings – Approach to Resilience**

| | | |
|---|---|---|
| **Overview** | The key activity being monitored for our buildings assets is the Critical Lineside Building refurbishment programme. This will see the robustness of select assets improved by enhancing their ability to deal with heavy and prolonged rainfall, and by improving their ability to regulate temperature extremes. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our buildings assets include:<br>• Extreme and/or prolonged rainfall can lead to water ingress to buildings, resulting in damage to buildings and associated contents, and failure of building services (e.g., electrical and mechanical systems).<br>• Higher temperatures are anticipated to cause overheating in buildings, resulting in welfare challenges for users and potential failure of building services. | |
| **Interventions Planned** | Critical Lineside Buildings refurbishment | Combination of building wrap (improved robustness of fabric and internal environmental conditions) to high-voltage critical lineside buildings, and upgrading of mechanical and engineering systems to more efficient and resilient alternatives. |
| **Residual Risk** | To manage residual risk associated with the climate-related risks described above we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Carry out a programme of maintenance involving regular or targeted fabric repairs to lineside buildings where a building wrap solution isn't required.<br>• Additional activities such as station canopy refurbishments, platform renewals and refurbishment and other general fabric improvements to buildings will provide additional weather resilience.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. | |

### Table 6: **Electrification and Plant – Approach to Resilience**

| | | |
|---|---|---|
| **Overview** | The major intervention planned here is the mid-life refurbishment of the Overhead Line Equipment (OLE) in the Glasgow area. This work will include an upgrade to auto-tensioned OLE that is less susceptible to failures because of hot weather. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our electrification and plant assets include:<br>• Higher temperatures can cause the sagging of OLE contact wires, resulting in Emergency Speed Restrictions being implemented and OLE failures. High temperature variance also may lead to expansion of conductors and insulators causing long term issues. | |
| **Interventions Planned** | Overhead Line Equipment -renewal | Replacement of fixed-termination equipment in North Glasgow Electrics sections, to an auto-tensioned setup which is less susceptible to hot weather failures. |
| | Remote condition monitoring | Expansion of remote condition monitoring (RCM) capabilities across distribution and plant assets to improve asset management and maintenance capabilities. |
| **Residual Risk** | To manage residual risk associated with the climate-related risks described above we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Carry out a programme of maintenance and seasonal preparedness works, including adjusting the tension in some overhead electric power lines to help prevent sagging and keep trains running in hot conditions.<br>• The RCM capability on our assets will enable us to monitor performance and improve management of the assets during inclement weather, this is especially important for our pumping stations.<br>• Monitor performance of points heating to optimise performance and if required adjust heating setpoints accordingly.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. | |

## Table 7: **Earthworks – Approach to Resilience**

| | | |
|---|---|---|
| **Overview** | The earthworks renewals programme that covers soil cuttings, embankments, and rock cuttings, is the key activity being monitored. The renewal programme will see select earthworks renewed, reducing their likelihood of failure in periods of adverse and extreme weather. Renewal provides a particular improvement in performance of assets during periods of heavy rainfall, both short duration and prolonged. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our Earthworks assets include:<br>• Risk of earthwork failure because of an extreme rainfall event.<br>• Risk of earthwork failure because of prolonged wet spells. | |
| **Interventions Planned** | Soil cutting renewals | The likelihood Earthworks failing because of extreme and/or prolonged rainfall in identified areas across the route is significantly reduced by undertaking renewals schemes – carrying out major works that result in permanent changes to the asset. This includes, for example, full regrading, the installation of major retaining structures or other major support measures. |
| | Embankment renewals | |
| | Rock cutting renewals | |
| | Earthworks monitoring | The consequence Earthworks failing can be reduced by using remote monitoring – for example, the installation of wireless tiltmeters at potentially vulnerable locations. |
| **Residual Risk** | To manage residual risk associated with the climate-related risks described above we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Carry out additional targeted work in line with delivery of actions plans associated with the Weather Risk Taskforce.<br>• Carry out a programme of Earthworks maintenance involving regular or targeted cleaning of drainage, management of vegetation and vermin, and minor repairs.<br>• In addition, some assets not targeted for renewal will be refurbished – involving major repairs, local replacement, local re-profiling, or the installation of additional drainage works or local support across the route.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. | |

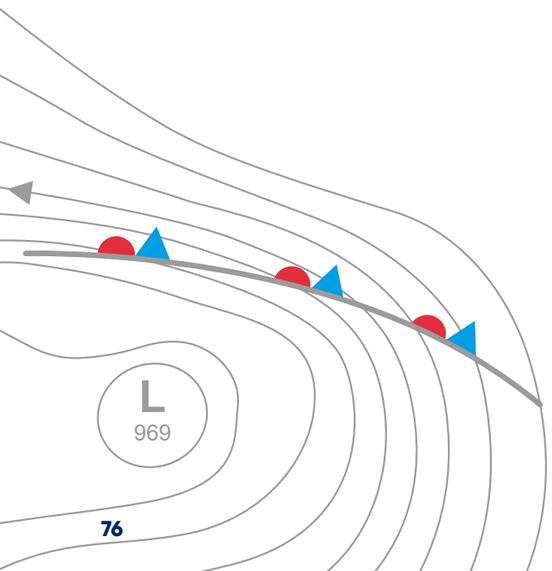
## Table 8: **Lineside and Drainage – Approach to Resilience**

| | | |
|---|---|---|
| **Overview** | Key activities being monitored include the management of lineside vegetation which can cause safety and performance impacts during periods of adverse and extreme weather (e.g., trees felled during high winds). For drainage assets, a programme of targeted renewals, refurbs and new builds will see the ability of certain areas to manage heavy and prolonged rainfall, and associated flooding, improved. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our Earthworks assets include:<br>• Extreme rainfall events can overwhelm the drainage system and culverts, resulting in asset failure and infrastructure flooding.<br>• Combination risks including tree fall, leaf fall, wildfire, vegetation growth, ground instability, and drought. | |
| **Inter-ventions Planned** | Pipe refurb | Carry out improvement works to existing pipes within the drainage system to improve the management of existing flow from catchment. Either by fixing defects, increasing capacity, improving management of system, or allowing future maintenance to be carried out more efficiently. |
| | Pipe renewals | |
| | Pipe new builds | To manage the flow of water where there is currently insufficient or non-existent drainage. Connecting where necessary the catchment into the existing drainage system, allowing water to travel to outfall. Improving overall capacity of the system, and improving resilience of the system by considering the effect of climate change. |
| | Ditch/ channels refurb | Carry out improvement works to existing ditches and channels within the drainage system to improve the management of existing flow from catchment. Either by fixing defects, increasing capacity, improving management of system, or allowing future maintenance to be carried out more efficiently. |
| | Ditch/ channels renewals | |
| | Ditch/channels new builds | To manage the flow of water where there is current in sufficient or non-existent drainage. Connecting, where necessary, the catchment into the existing drainage system, allowing water to travel to outfall. Improving the overall capacity of the system and improving resilience of the system by considering the effect of climate change. |
| | Chamber refurbs | Carry out improvement works to existing chambers within the drainage system to improve the management of existing flow from catchment. Either by fixing defects, increasing capacity, improving management of system, or allowing future maintenance to be carried out more efficiently. |
| | Chamber renewals | |
| | Chamber new builds | Installation of new catchpit chambers every 30m (maximum spacing) to allow inspection and maintenance of drainage pipes where there is currently insufficient or con-existent drainage, or to allow for change in direction of drainage system, e.g. Cess drainage to UTX. |
| | Tree and Vegetation Management | Management of lineside trees and vegetation to address hazardous trees, vegetation encroachment and autumn leaf-fall risk, with the aim to provide a safe, compliant, and ecologically diverse lineside. Includes a specific contribution to address hazardous trees and ash dieback. Does not include lineside tree surveys, third party trees and remote sensing workbanks. |

## Table 8: **Lineside and Drainage – Approach to Resilience**

| | |
|---|---|
| **Residual Risk** | To manage residual risk associated with the climate-related risks described above we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Carry out additional targeted work in line with delivery of actions plans associated with the Weather Risk Taskforce.<br>• Carry out a programme of Earthworks maintenance involving regular or targeted cleaning of drainage, management of vegetation and vermin, and minor repairs.<br>• In addition, some assets not targeted for renewal will be refurbished – involving major repairs, local replacement, local re-profiling, or the installation of additional drainage works or local support across the route.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. |

Drainage ditch / channel renewal




## Table 9: **Signalling – Approach to Resilience**

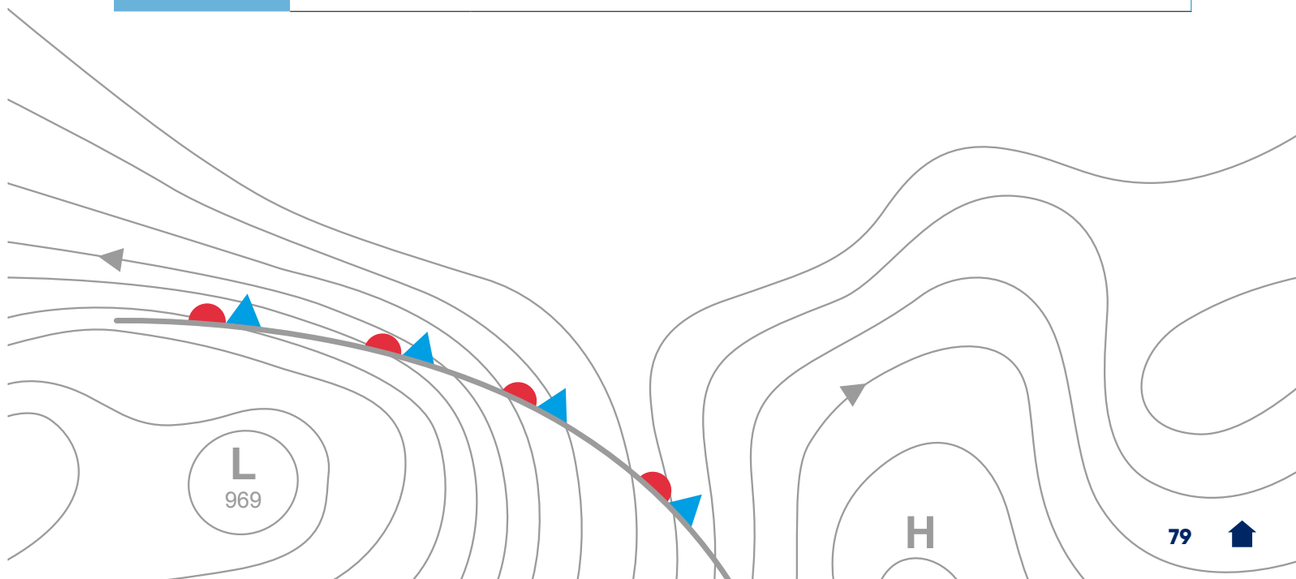
| | | |
|---|---|---|
| **Overview** | A mix of activities will be monitored for Signalling assets. This includes installation of axle counters at targeted locations which can have performance improvements during periods of heavy and/or prolonged rainfall. Replacement of hydraulic fluid in Points and Level Crossings with a type more tolerant of low temperatures will also lead to performance benefits. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our structures assets include:<br>• Higher temperatures are anticipated to cause overheating of electrical components and control equipment.<br>• Extreme and/or prolonged rainfall can lead to water ingress and shorting of circuits due to flooding. | |
| **Inter-ventions Planned** | Aster tracks replacement | Aster track circuits are a frequency-based train detection and are susceptible to lightning strikes and less tolerance to high temperatures, these will be converted to axle counters which are more resilient in both scenarios. |
| | Axle counter train detection | Axle counter train detection is more resilient in operating under high-water condition. Axle counters don't use the rail as method of detecting the train therefore they aren't affected when the track is saturated – more reliable. |
| | Points and level crossings (hydraulic fluid) | The preferred point operating equipment for Scotland region will largely be in-bearer clamp locks. Method of operation requires hydraulic fluid – recent improvements in understanding of the fluid viscosity has led to improved temperature tolerance (it can tolerate significantly lower temperatures). Modification to equipment design (snorkel valve) will also be rolled out in CP7 to improve temperature tolerance. |
| | Level crossing (wind resilience) | Incorporating circuit modifications to support increased barrier lower time in areas of high wind, to avoid unnecessary wrong side failures. |
| | Miniature stop lights | User Worked Crossings (UWC) prone to fog. Users of UWC use line of sight to determine whether a train is approaching. This is limited where fog is present. Addition of miniature stop lights gives the user a positive indication on the absence of a train. |
| | Axle counter | Where there are track circuits as the method of train detection in high water areas (tunnels, culverts etc), a common failure mode is to fail right side, 'Shows Occupied while Clear'. In this failure scenario, operations have to implement double block working, which has significant performance impact on busy line of route. An innovative overlay axle counter section is proposed, which will deliver duplicated train detection. When the track circuit fails in times of flooding, the signaller can revert to axle counter to avoid performance impact. |
| **Residual Risk** | To manage residual risk associated with the climate-related risks described above we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Trial new technologies to lower risk associated with overheating – for example the installation of the Haide Lemur Solar Absorption panels on 25 x Location Cases on the North Clyde route.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. | |

## Table 10: **Structures – Approach to Resilience**

| | | |
|---|---|---|
| **Overview** | A range of activities that provide resilience against adverse and extreme weather will be monitored. This includes further works to lower the risk of scour at vulnerable locations, and intervention at some coastal and estuarial defences to help manage the impact of storm surges and coastal erosion. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our structures assets include:<br>• Periods of heavy rainfall and associated flooding can increase the risk of scour.<br>• High temperature variance can result in the weathering of structures due to freeze thaw action.<br>• Sea-level rise may result in erosion, weathering, and scour, causing failure of susceptible assets and increasing maintenance costs. | |
| **Inter-ventions Planned** | Culvert Strategy | The likelihood of culvert failure across the route is significantly reduced in renewals schemes by carrying out major works that result in permanent changes to the asset which improve capacity of flow and reduce the risk of scour and undermining. |
| | Coastal and Estuarial defences maintenance | Refurbishing improves resilience to storm surges, large waves, and strong wind. Schemes include improvements to the toe of the defence to prevent scour and undermining. In addition, large waves can overtop defences and cause inundation, erosion, scour, loss of stability and structural damage. Installation of rock armour will protect vulnerable assets and repair areas of bank erosion. |
| | Underbridge Scour | Reducing the risk of scour can be achieved with the installation of a concrete mattress, concrete apron, or rock armour to protect abutments and piers, removing the chance of fines being washed out from river action. |
| | Tunnel Active Water Management | Installing active water control will improve train performance and reduce future maintenance costs. Active water control will be site specific, with likely mitigation being injecting grout behind the arch extrados but could also include drip drays installed to convey the water into track drainage. |
| | Retaining Wall Scour Protection Refurb | Scour and undermining of retaining walls pose significant safety and performance risks to the railway. Reducing the risk of scour can be achieved with the installation of a concrete toe, rock armour or a piling solution. |
| **Residual Risk** | To manage residual risk associated with climate change we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Increase the use of remote monitoring (e.g., water telemetry) for real-time monitoring of conditions and to inform safety measures (e.g., use of targeted speed restrictions).<br>• We have also increased budgetary provision for additional and enhanced examinations as an additional mitigation for reduced renewals.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. | |

## Table 11: **Track – Approach to Resilience**

| | | |
|---|---|---|
| **Overview** | Monitoring of track actions is a new addition compared to previous Network Rail WRCCA plans. The focus is on plain line renewal of high-speed lines where ballast, sleeper and rail are renewed, and where switches and crossing are being renewed to a new modern variant. Both types of intervention provide enhanced resilience against high temperatures. | |
| **Climate Risks** | Based on the results of our desk-based climate risk assessment (Section 3) the key climate-related risks for our track assets include:<br>• High temperatures may lead to track buckle which can cause derailment.<br>• Extreme rainfall events also create a risk of derailment due to loss of geometry caused by ballast washout/standing water. | |
| **Inter-ventions Planned** | Plain line renewal | Full renewal (ballast, sleeper, and rail) on high-speed and high tonnage lines. Renewal replaces older assets with modern components, construction standards and with Continuous Welded Rail track where possible. |
| | Switches and Crossings renewal | Renewal of S&C (resetting of asset condition to modern standards) and rationalisation and re-configuration of asset. |
| | Track drainage renewal | Renewal of track drainage, often with ability to handle larger volumes of water as per drainage standards. |
| **Residual Risk** | To manage residual risk associated with the climate-related risks described above we will:<br>• Implement the Adverse and Integrated Weather Management Plan during periods of inclement weather.<br>• Carry out a programme of maintenance and seasonal preparedness works, including 'stressing' sections of track in known hot-spot areas to help them cope with sudden rises in temperature, painting some rails white in key locations to reflect the sun, keeping them up to 10°C cooler and helping prevent buckling.<br>• Use of remote temperature monitoring equipment – installed on rails at known hotspots allowing decisions on whether to implement speed restrictions to be made in real-time when necessary for safety reasons.<br>• In line with Outcomes 1 and 2, work to better understand future levels of risk associated with our changing climate through development of new climate risk assessment methodologies and closer integration with new and emerging climate science. | |



## Outcome Four

### Assurance and Competence

**Our 'climate ready journey' is underpinned by a maturing foundation of risk, assurance, competence, and data insights.**

There are a series of activities planned to improve our internal capabilities to act on our advancing understanding of climate risk. Many of these activities are focussed on corporate risk and assurance, as well as outlining improvements to how we monitor, and act on, weather-related disruption performance data.

Planned activities include:

- Integrating and escalating new and emerging climate-related risks into Network Rail Scotland's existing risk management structure.
- Completing an annual review of our adaptation capabilities by using the Rail Safety and Standards Board (RSSB) adaptation capability assessment tool.
- Developing a competence framework aligned to the other key climate action areas Scotland's Railway is targeting for action, where relevant frameworks do not already exist.
- Developing a bespoke dashboard to monitor the impact of weather on our operations.
- Establishing a weather and climate resilience group to formalise roles and responsibilities in this space.

Funding for activities associated with this outcome will be derived from a funding pot of £3.7 million allocated to Network Rail Scotland's Engineering and Asset Management Directorate. Where required, ScotRail will allocate funding from their annual operational expenditure.

See Appendix A4 for the action table.

## Weather Risk Taskforce

This workstream covers the continued delivery of Action Plans associated with the independent reviews commissioned in response to the derailment at Carmont, and the recommendations made in the Rail Accident Investigation Branch report – see Section 4 for more information.

Funds for actions presented in this workstream are derived from operational and capital expenditure from Network Rail's Control Period 7 settlement.

Example actions being delivered by the Weather Risk Taskforce are included in Appendix B1. These actions are included for awareness only, their implementation and monitoring are governed by the Weather Risk Taskforce group specifically.

Actions being delivered here include continued funding of the weather desk now integrated into Scotland's Railway Control, continued use of aerial surveying of the network by helicopter, rolling out of additional remote monitoring capabilities and additional resourcing in key areas of drainage inspection.


West Coast Mainline

Section 06

# Governance and monitoring

Dalguise Viaduct

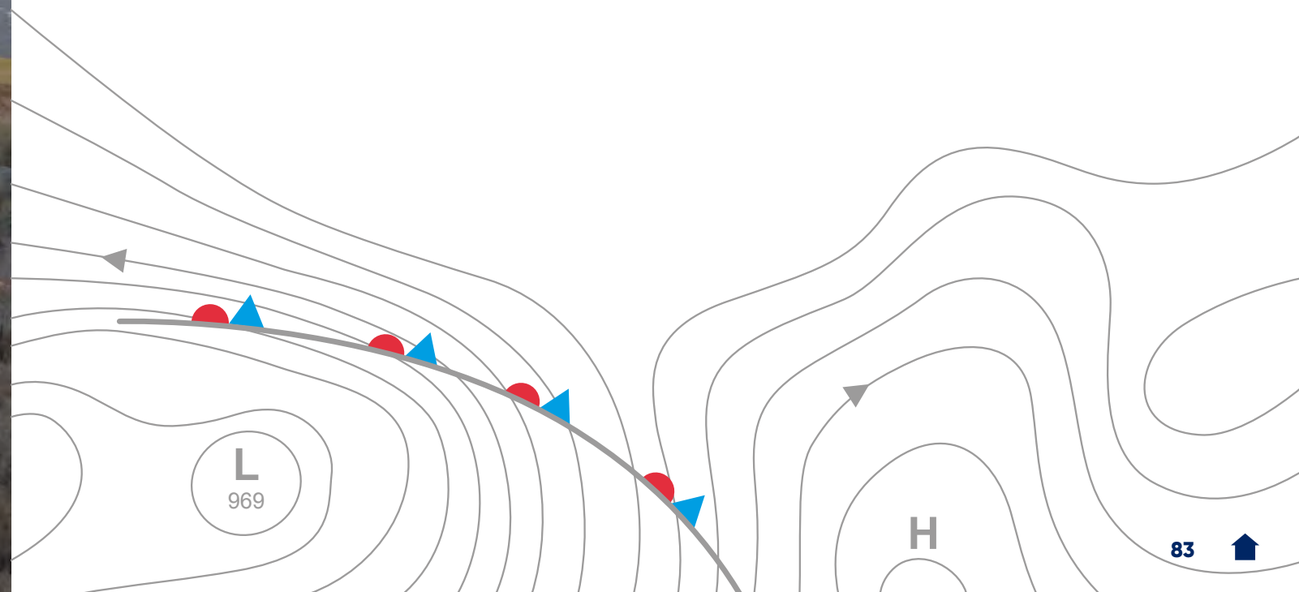


## Summary:


- Delivery of our ‘climate ready’ objectives is overseen by Scotland’s Railway Sustainability Board, made up of representatives from Network Rail, ScotRail and Transport Scotland.
- Insights from a range of existing indicators will initially be used to monitor the progress and impact of this plan.
- This includes performance related impacts such as schedule 8 costs and minutes, and number of adverse and extreme weather days issued.
- A more progressive leading indicator for resilience is required and work is planned to develop this – it will likely require the commission of bespoke research to investigate and trial potential resilience indicators.
- Progress against the actions will also be monitored and reported on through two key pre-existing mechanisms:

  (1) A quarterly update collated and provided to Scotland’s Railway Sustainability Steering Group.

  (2) A six-monthly progress report of Network Rail’s actions, submitted to Network Rail’s Technical Authority – collated with other Network Rail Regions and submitted to ORR.

# Governance and Monitoring

## Plan Governance

**There is a well-established governance structure that will oversee the activities set out in the plan. See Fig.15 for an overview of key governance groups.**

### Scotland's Railway

**Scotland's Railway Sustainability Board:**

Our Board, chaired by our Managing Director, advises, and supports on the delivery of Scotland's Railway climate action projects. The Board is made up of representatives from Network Rail, ScotRail and Transport Scotland. The Board provides oversight of our climate ready activities as part of its remit.

**Scotland's Railway Sustainability Steering Group:**

Drives forward continual development, and tracks progress of, delivery plan implementation for all priority areas of Scotland's Railway's Climate Action Plan – including this Climate Ready Plan. Any changes to the actions set out in this plan would require approval from the Steering Group with a formal change control process established for this purpose.

### Network Rail

Managing the impact of extreme and adverse weather, and planning for further changes in our climate, cuts across various areas of Network Rail in Scotland.

The Route Directorate has responsibility and oversight for the day-to-day operations of the railway, this includes overseeing the implementation of, and updates to, the Adverse and Integrated Weather Management Plan.

Elements of this responsibility are formally covered through the risk management process. Risks associated with the resilience of our operations during extreme or adverse weather, and associated mitigations, are reviewed quarterly as part of this process.

The Engineering and Asset Management Directorate has overall responsibility for the assets. Dedicated asset engineers provide advice and guidance on specific assets where there may be an increased risk of failure associated with impacts of weather. They also develop workbanks of planned interventions on the assets, with many of these interventions delivering weather and climate resilience benefits.

The Engineering and Asset Management Directorate also provides the oversight, and monitoring of, delivery of most Network Rail actions in this plan. A dedicated Weather Resilience and Climate Change Adaptation Strategy Manager provides strategic oversight of the activities set out in this plan and provides climate data, information, and insight to support other teams in taking more effective climate action. The role also coordinates regular monitoring and reporting activities and provides updates to the Sustainability Steering Group and Board.

The Director of Engineering and Asset Management is accountable for delivery of this plan. Progress on delivery will be reported every six months (April - September and October - March each financial year) through the Technical Authority to the Climate Change Adaptation Steering Group and to ORR.

In addition, delivery of the recommendations made in response to the derailment at Carmont are governed directly by the Weather Risk Taskforce, which is made up of representatives from Network Rail, Transport Scotland and ScotRail.

Our activities in Scotland are complimentary to the national level Network Rail governance structure. At the national level, the Environment and Sustainability Team owns 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 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. The Governance Section of Network Rail's Third Adaptation Reporting Power provides a deeper dive into the governance of 'adaptation.

### ScotRail

The impact of a changing climate and extreme weather cuts across multiple areas at ScotRail.

The Head of Sustainability oversees and co-ordinates the business strategy and Climate Resilience Delivery Plan outlining initiatives to be delivered up to March 2025. Progress is reported monthly.

The Performance Compliance & Analysis Manager carries out performance data analysis and produces and published the Disruption Handling Plan.

All environmental risks are included in the Environmental Management System Risk Register. Risks categorised as significant are then included in the strategic company Risk Register. Climate change and extreme weather are considered significant risks and included in the company register. Risks are reviewed and reassessed periodically.

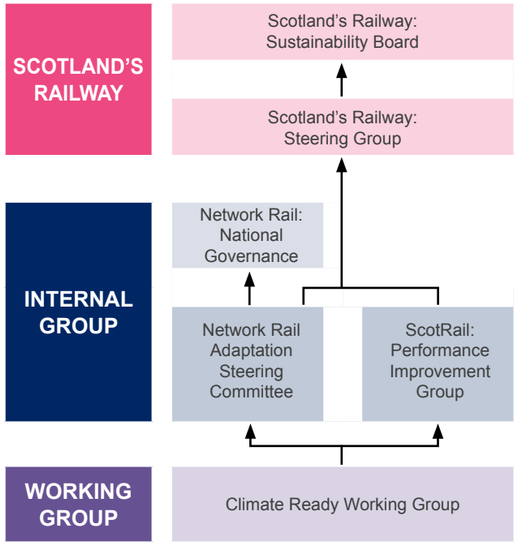



**Figure 15:** Key governance groups with oversight of our Climate Ready Activities. See Network Rail's Adaptation Reporting Power publication for a more detailed view of their internal governance structure.

# Monitoring Progress and Impact

Our approach to monitoring the progress, and impact, of our plan will mature over the life cycle of our plan.

To begin, a combination of insights derived from existing data we capture will be used to indicate the performance of this plan (Table 12).

This includes performance-based indicators such as Schedule 8 compensation payments attributed to weather (Section 1) and the number of adverse and extreme weather days issued on our railway.

We'll bring the relevant data together into a single-source dashboard (milestone 8) and undertake an historic analysis of this data. This longer-term, historic view over multiple control periods is required to see trends outwith highly variable annual data – a product of our variable climate. We want to integrate observed weather data directly into this dashboard and will assess the suitability of weather data sources for this purpose.

We'll also look to track wider investment in the resilience of our railway infrastructure through an addition to our 'authorised investment' process.

A new system of tagging planned projects based on the type of resilience they provide will be established – e.g., projects designed specifically to address a climate risk vs projects designed for another purpose but where a secondary resilience benefit is achieved. This process will enable us to track the cumulative investment in resilience during the lifecycle of this plan, which may ultimately be higher than what is forecast in this plan.

A goal of this plan (milestone 6) is to establish a leading indicator for climate resilience. We need this to help us better predict our future ability to respond to, and manage, adverse and extreme weather events, based on the effectiveness of interventions taken.

Generally, monitoring of climate adaptation and resilience initiatives is not as mature in comparison to, as an example, our decarbonisation initiatives.

This is recognised both internally and externally to Scotland's Railway, for example in the Climate Change Committees recent report on 'Investment for a well-adapted UK'. One of the key barriers identified to progressing adaptation activities is the lack of specific and measurable climate resilience standard and target.

We recognise this gap in the suite of indicators currently available to us and will work to address during the lifecycle of our plan.

Progress against the actions will be monitored and reported on through two key pre-existing mechanisms:

- A quarterly update collated and provided to Scotland's Railway Sustainability Steering Group
- A six-monthly progress report submitted to Network Rail's Technical Authority – collated with Network Rail's regions in England and Wales and submitted to ORR.

In addition, we will add an annual formal update of the Climate Ready Plan to this reporting sequence and take that to the Sustainability Board. We also expect that as our climate science and adaptation capabilities mature, we may wish to bring forward some activities and / or reprioritise others. We'll make any substantive changes during this annual update and seek their approval from our Sustainability Steering Group.

Any other actions that emerge due to the impacts of climate change will be assessed and any funding required outside of funds already allocated will be considered for funding through pre-existing investment panel processes.

| Data | Description |
|---|---|
| **Outcome One: Action Plan** | We'll use the status of the actions and associated milestones to track the plans progress (delivered, in-progress, late, removed, not yet started). |
| **Outcome Two: Action Plan** | We'll use the status of the actions and associated milestones to track the plans progress (delivered, in-progress, late, removed, not yet started). |
| **Outcome Three: Action Plan** | We'll track progress against Outcome Three slightly differently. It's made up of planned asset interventions (e.g., delivery of x number of Earthworks Renewals). We'll set an 80% delivered success rate for these actions to reflect changes to workbanks that happen during Control periods (e.g., schemes being amended based on more detailed site investigations or schemes deferred because of workbank re-prioritisation). |
| **Outcome Four: Action Plan** | We'll use the status of the actions and associated milestones to track the plans progress (delivered, in-progress, late, removed, not yet started). |
| **Schedule 8** | We'll use Schedule 8 delay minutes and costs attributed to adverse and extreme weather as a proxy for the resilience of the network, and until a better leading resilience indicator is developed. |
| **Scotland Passenger Performance Measure** | We'll use number of PPM failures attribute to adverse and extreme weather as a proxy for the resilience of the network, and until a better leading resilience indicator is developed. |
| **Route Status** | We'll track number of adverse and extreme weather days issued to allow, in time, for a longer-term trend in these days to be established. |
| **Weather and Climate Assessment** | We'll begin active tracking of use of the Weather and Climate Impact assessment tool. |

**Table 12:** Indicators that can be used to track, and monitor impact of, our Climate Ready Plan

# Appendix





## A: Climate Ready Plan – Actions:



## B: Supplementary Information:

## A1: Outcome 1 – Risk Assessment and Data

| Action Detail | | | Delivery Timescale | | Monitoring |
|---|---|---|---|---|---|
| **Code** | **Action Category** | **Action Description** | **Start Date** | **Delivery Date** | **Success Metric** |
| **Outcome One: The decisions we make are based on a maturing understanding of climate-related risk** | | | | | |
| **Milestone One** | **A revised approach to undertaking physical climate change risk assessments of our infrastructure is delivered** | | **01/04/2024** | **01/04/2026** | **Status of actions** |
| Action 1.1 | Weather / Climate Data | Undertake a review of available current and future climate and natural hazard data to be used in climate risk assessments | 01/04/2024 | 01/04/2025 | Excel database of climate and natural hazard datasets established and appraised for suitability in climate risk assessments |
| Action 1.2 | Weather / Climate Data | Commission creation of bespoke climate and natural hazard datasets for Scotland, and for use in climate risk assessments, if required | 01/04/2024 | 01/04/2025 | Commissioning of bespoke spatial data where required for Scotland |
| Action 1.3 | Weather / Climate Data | Use sensor data to assess if operational activities can be appropriately planned i.e., use of climate information to allow maintenance teams to make informed decisions on whether Winterisation works (salting and de-icing) are required | 01/04/2024 | 01/04/2026 | A report summarising potential actions and further development of data use in planning of operational activities |
| Action 1.4 | Climate Risk Assessment | Commission a review on how we currently assess future climate risk on our infrastructure assets | 01/04/2024 | 01/04/2026 | A report outlining how NR Scotland assesses climate risk on its infrastructure assets |
| Action 1.5 | Climate Risk Assessment | Develop an updated methodology for undertaking physical climate risk assessments on our infrastructure assets | 01/04/2024 | 01/04/2026 | An updated methodology and associated guidance for undertaking climate risk assessments on infrastructure assets |
| Action 1.6 | Climate Risk Assessment | Undertake a comparable physical climate change risk assessment to that carried out by Network Rail on ScotRail assets, including rolling stock fleet | 01/04/2024 | 01/04/2025 | ScotRail physical climate change risk assessment delivered |
| Action 1.7 | Climate Risk Assessment | Re-run our revised physical climate change risk assessment methodology (and include any climate science and data improvements) in support of CP8 planning | 01/04/2027 | 01/04/2028 | Revised climate change risk assessment scores of infrastructure assets to inform CP8 planning |
| **Milestone Two** | **The scope of our climate risk assessment activities is expanded to consider additional forms of climate risk (e.g., transition and operational climate risks)** | | **01/04/2024** | **01/04/2028** | **Status of actions** |
| Action 1.8 | Climate Risk Assessment | Undertake a project to establish a non-physical climate risk register (e.g., transition, operational and people-related climate risks) for Scotland's Railway | 01/04/2024 | 01/04/2026 | 1. A new climate risk assessment methodology and guidelines for assessing non-physical climate risks<br>2. A new climate change risk register for key non-physical climate risks |
| Action 1.9 | Climate Risk Assessment | Undertake a project, in collaboration with external partners, to better understand our key climate-related risk interdependencies with other infrastructure operators | 01/04/2024 | 01/04/2026 | A climate change risk assessment of physical interdependences / cascading climate-related risks with other infrastructure |

## A2: Outcome 2 – Adaptation Strategy and Pathways

| Action Detail | | | Delivery Timescale | | Monitoring |
|---|---|---|---|---|---|
| **Code** | **Action Category** | **Action Description** | **Start Date** | **Delivery Date** | **Success Metric** |
| **Outcome Two: A long-term climate adaptation and resilience strategy increasingly guides investment** | | | | | |
| **Milestone Three** | **Long-term climate change adaptation plans are delivered for the most at-risk route sections / locations** | | **01/04/2024** | **01/04/2027** | **Status of actions** |
| Action 2.1 | Planning and Strategy | Adaptation Pathways – screening and prioritisation: Identify a short-list of route sections / locations / asset groupings to undergo adaptation pathways analysis and development | 01/04/2024 | 01/04/2025 | A refined list of major climate risks and specific locations selected for adaptation pathway analysis and development |
| Action 2.2 | Planning and Strategy | Adaptation Pathways – hazard modelling and options assessments: Undertake detailed climate and natural hazard modelling of the route sections / locations selected for pathways analysis and an options appraisal of solutions to address identified climate-related risks | 01/04/2025 | 01/04/2026 | 1. Detailed route / location specific risk assessments<br>2. Appraisal of adaptation options for specific route / locations |
| Action 2.3 | Planning and Strategy | Adaptation Pathways – impact analysis: Undertake economic, social and environmental impact analysis of the range of adaptation options proposed to address the climate-related risks identified for route sections / locations selected for pathways analysis | 01/04/2025 | 01/04/2026 | Economic, social, and environmental impact reports and analysis of adaptation options appraisals |
| Action 2.4 | Planning and Strategy | Adaptation Pathways – strategic planning and engagement: Embed results of pathways analysis and development into Strategic Business Plan for CP8 and socialise results of pathways across relevant internal and external stakeholders (e.g., internal asset teams, ORR, Transport Scotland) | 01/04/2025 | 01/04/2026 | 1. An approach to embedding results of adaptation pathways into CP8 planning developed<br>2. Knowledge sharing sessions with key stakeholders |
| Action 2.5 | Planning and Strategy | Adaptation Pathways – comms and outreach: Publish results of pathways development and analysis as part of an adaptation strategy document for Scotland's Railway | 01/04/2026 | 01/04/2027 | Pathways comms resources developed and published (e.g., stakeholder engagement pack, infographics, strategy document) |
| **Milestone Four** | **A long-term climate change adaptation strategy is delivered for Scotland's Railway** | | **01/04/2024** | **01/04/2027** | **Status of actions** |
| Action 2.6 | Planning and Strategy | We will co-create with Scotland's Railway partners a coherent, single source long-term climate change adaptation and resilience strategy for Scotland's Railway | 01/04/2026 | 01/04/2027 | Production (and publication) of a long-term climate change adaptation strategy for Scotland's Railway |

## A3: Outcome 3 – Asset Resilience

| Outcome Three: Our assets are made increasingly resilient to acute weather events, as well as longer-term changes in climate (See Appendix A3 for the detailed action plan) | |
|---|---|
| Milestone Five | A programme of business-as-usual asset resilience activities is delivered |

| Asset Information | | Action Information | | | | Action Target | | | Delivery Year* | | | | | Climate Adaptation / Resilience | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset Class/ Lead Team | Sub-Asset Class | Category | Name | Location | Cost (£m) | Target | Unit | Monitoring | 7.1 | 7.2 | 7.3 | 7.4 | 7.5 | Benefit | Risks Addressed |
| Buildings | Critical Lineside Buildings | Refurb | Critical Lineside Building refurbishment programme | Route-wide | £10.1 | 18 | Schemes | Schemes delivered | 1 | 3 | 7 | 5 | 2 | Enhanced robustness of critical lineside estate against inclement weather and improved thermal insulation – protecting internal equipment from water ingress, wind damage and large temperature fluctuations | Addresses various risks, primarily those associated with water ingress into buildings (prolonged and/or heavy rainfall events) and protects internal services from temperature fluctuations and overheating |
| Lineside and Drainage | Pipe | Refurb | Pipe refurb | Route-wide | £3.2 | 7 | Schemes | Schemes delivered | 1 | 0 | 0 | 3 | 3 | Increased capacity of pipes within targeted drainage systems, enhancing the ability of the system to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Pipe | Renew | Pipe renewals | Route-wide | £20.4 | 21 | Schemes | Schemes delivered | 3 | 3 | 4 | 4 | 7 | Increased capacity of pipes within targeted drainage systems, enhancing the ability of the system to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Pipe | New build | Pipe new builds | Route-wide | £10.4 | 18 | Schemes | Schemes delivered | 2 | 4 | 1 | 6 | 5 | Increased capacity of pipes within targeted drainage systems, enhancing the ability of the system to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Ditch/ Channel | Refurb | Ditch/ channels Refurb | Route-wide | £1.7 | 5 | Schemes | Schemes delivered | 0 | 1 | 0 | 4 | 0 | Increased capacity / ability of ditches and channels to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Ditch/ Channel | Renew | Ditch/ channels renewals | Route-wide | £4.4 | 13 | Schemes | Schemes delivered | 2 | 3 | 1 | 4 | 3 | Increased capacity / ability of ditches and channels to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Ditch/ Channel | New build | Ditch/ channels new builds | Route-wide | £4.9 | 15 | Schemes | Schemes delivered | 2 | 2 | 1 | 6 | 4 | Increased capacity / ability of ditches and channels to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Chamber | Refurb | Chamber refurbs | Route-wide | £0.2 | 7 | Schemes | Schemes delivered | 1 | 1 | 1 | 1 | 3 | Increased capacity / ability of chambers to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |

*Delivery year numbers are provisional, and will likely change as the Control Period progresses

## A3: Outcome 3 – Climate Ready Assets

| Asset Information | | Action Information | | | | Action Target | | | Delivery Year* | | | | | Climate Adaptation / Resilience | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset Class/ Lead Team | Sub-Asset Class | Category | Name | Location | Cost (£m) | Target | Unit | Monitoring | 7.1 | 7.2 | 7.3 | 7.4 | 7.5 | Benefit | Risks Addressed |
| Lineside and Drainage | Chamber | New build | Chamber new builds | Route-wide | £0.6 | 19 | Schemes | Schemes delivered | 2 | 4 | 2 | 6 | 5 | Increased capacity / ability of chambers to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Chamber | Renew | Chamber renewals programme | Route-wide | £0.5 | 20 | Schemes | Schemes delivered | 2 | 3 | 4 | 5 | 6 | Increased capacity / ability of chambers to process/handle increased volumes of water | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Lineside and Drainage | Vegetation | N/A | Tree & vegetation management ** | Route-wide | £54.0 | tbc | tbc | tbc | tbc | tbc | tbc | tbc | tbc | Removal of lineside trees and vegetation with potential to obstruct lines and damage infrastructure if impacted by high winds. Can reduce the risk of impacts associated with adhesion by removing source of leaf-fall risk | Reduces indirect risks associated with high winds and adhesion |
| Electrification and Plant | OLE | Renew | OLE renewal | Glasgow North Electrics | £20.5 | 33 | STK | Single Track Kilometres delivered | / | 3 | 10 | 10 | 10 | Auto-tensioned OLE equipment is less susceptible to failure as a result of hot weather – therefore will reduce the number of service affecting failures experienced | Addresses risks associated with prolonged and / or high temperatures – and impact they can have on sagging of vulnerable contact wires |
| Electrification and Plant | Fixed Plant | Monitoring | Remote condition monitoring | Route-wide | £1 | 30 | Sites | Sites delivered | / | / | / | / | / | Enables proactive monitoring and responses to be generated prior to the occurrence of service affecting failures – including monitoring impacts of severe and adverse weather and potential negative impacts | Doesn't directly address a climate risk, rather is providing data and intelligence that helps manage / monitor risks |
| Earthworks | Soil Cuttings | Renew | Soil cutting renewals | Route-wide | £71.6 | 205 | Schemes | Schemes delivered | 47 | 40 | 57 | 41 | 20 | Likelihood of failure is significantly reduced with each renewals scheme and the design life takes into account climate change predictions; currently majority of renewals projects aim for circa 125 years design life with regular maintenance | By improving condition of vulnerable assets, they become inherently more resilient against risks associated with prolonged and/or heavy rainfall |
| Earthworks | Embank-ments | Renew | Embankment renewals | Route-wide | £26.0 | 54 | Schemes | Schemes delivered | 12 | 15 | 4 | 13 | 10 | Likelihood of çfailure is significantly reduced with each renewals scheme and the design life takes into account climate change predictions; currently majority of renewals projects aim for circa 125 years design life with regular maintenance | By improving condition of vulnerable assets, they become inherently more resilient against risks associated with prolonged and/or heavy rainfall |
| Earthworks | Rock Cuttings | Renew | Rock cutting renewals | Route-wide | £14.6 | 94 | Schemes | Schemes delivered | 10 | 16 | 11 | 16 | 41 | Likelihood of failure is significantly reduced with each renewals scheme and the design life takes into account climate change predictions; currently majority of renewals projects aim for circa 125 years design life with regular maintenance | By improving condition of vulnerable assets, they become inherently more resilient against risks associated with prolonged and/or heavy rainfall |

*Delivery year numbers are provisional, and will likely change as the Control Period progresses

**Our lineside vegetation management programme will be confirmed in Control Period.

## A3: Outcome 3 – Asset Resilience

| Asset Information | | Action Information | | | | Action Target | | | Delivery Year* | | | | | Climate Adaptation / Resilience | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset Class/ Lead Team | Sub-Asset Class | Category | Name | Location | Cost (£m) | Target | Unit | Monitoring | 7.1 | 7.2 | 7.3 | 7.4 | 7.5 | Benefit | Risks Addressed |
| Earthworks | Soil Cuttings Rock Cuttings Embank-ments | Monitoring | Earthworks monitoring | Route-wide | £1.1 | 241 | Volumes | Volume delivered | 46 | 47 | 50 | 50 | 48 | Early warning systems and alerts allow identification of failure events in real time before trains encounter failures, and cameras allow determination of impact of failure on the running line, allowing for the passage of trains while solutions are developed | Doesn't directly address a climate risk, rather is providing data and intelligence that helps manage / monitor risks |
| Signalling | Train Detection | Renew | Aster Tracks Replacement | Blair Atholl to Dalwhinnie | £6.0 | 6 | Interlock-ing areas | Interlocking areas delivered | 1 | 2 | 3 | | | Aster track circuits are a frequency based train detection and are susceptible to lightning strikes, these will be converted to axle counters which are more resilient | Risks associated with electrical storms |
| Signalling | Train Detection | Renew | Axle Counter Train Detection | Fife, Perth and Arbroath | £20.0 | 11 | Interlock-ing areas | Interlocking areas delivered | 1 | 2 | 3 | 1 | 4 | Axle counter train detection is more resilient in operating under high-water condition. Axel counters don't use the rail as method of detecting the train therefore they aren't affected when rail is underwater – more reliable | Risk associated with heavy and prolonged rainfall, and associated surface water flooding |
| Signalling | Points / level crossings | Renew | Points / level crossings | Route-wide | £15.0 | 60 | Points ends / level crossing pumps | Points ends / level crossing pumps delivered | 12 | 12 | 12 | 12 | 12 | The likely preferred point operating equipment for Scotland region will largely be in-barer clamp locks. Method of operation requires hydraulic fluid – recent improvements in understanding of the fluid viscosity has led to improved temperature tolerance (it can tolerate significantly lower temperatures). Level crossing barriers also utilise hydraulic fluid to activate the pumps to operate the barriers. These will have targeted fluid replacement to improve performance | Risks associated with low temperatures (both very cold days and prolonged cold spells) |
| Signalling | Level Crossings | Refurb | Level Crossing (wind resilience) | Route-wide | £0.6 | 6 | Level crossings | Level cross-ings circuit modifications delivered | 1 | 1 | 2 | 1 | 1 | Incorporating circuit modifications to support increased barrier lower time in areas of high-wind, to avoid unnecessary wrong side failures | Risks associated with high-winds |
| Signalling | Level Crossings | Renew | Miniature stop lights | Route-wide | £3.2 | 8 | Level crossings | Level crossing sites delivered | 1 | 1 | 2 | 2 | 2 | User Worked Crossings prone to fog. Users of UWC use line of sight to determine whether a train is approaching. This is limited where fog is present. Addition of miniature stop lights gives the user a positive indication on the absence of train | Fog / poor visibility |
| Signalling | Train Detection | Monitoring | Axle counter | Winchburgh Tunnel | £0.5 | 1 | Sites | Sites delivered | | 1 | | | | Performance resilience in high flood risk sites | Doesn't directly address a climate risk, rather is providing data and intelligence that helps manage / monitor risks |
| Structures | Culvert | Renew | West of Scotland Culvert Strategy | WHL | £9.1 | 37 | Schemes | Schemes delivered | 5 | 4 | 11 | 9 | 8 | Enhanced robustness of under track assets against adverse weather – Replacing a culvert offers an opportunity to increase the design capacity to accommodate modern trends for adverse weather, reducing risk of localised flooding, scour, undermining | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |

*Delivery year numbers are provisional, and will likely change as the Control Period progresses

## A3: Outcome 3 – Asset Resilience

| Asset Information | | Action Information | | | | Action Target | | | Delivery Year* | | | | | Climate Adaptation / Resilience | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asset Class/ Lead Team | Sub-Asset Class | Category | Name | Location | Cost (£m) | Target | Unit | Monitoring | 7.1 | 7.2 | 7.3 | 7.4 | 7.5 | Benefit | Risks Addressed |
| Structures | Coastal and Estuarial Defences | Maintain | Coastal and Estuarial defences maintenance | Route-wide | £15.3 | 8 | Schemes | Schemes delivered | 1 | 3 | 1 | 3 | 0 | Refurbishing Coastal and Estuarial defences to improve resilience to storm surges, large waves and strong wind. Targeted approach to lay rock armour in locations determined to be high risk of scour and erosion | Storm surges and high winds. Reducing scour and erosion risk |
| Structures | Scour Underbridge | Refurb | Underbridge Scour | Route-wide | £21.6 | 26 | Schemes | Schemes delivered | 1 | 6 | 6 | 6 | 7 | Reduced risk of scour and undermining, improved performance, removes need for inspection during adverse weather events | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Structures | Replace-ment and Strengthen-ing Tunnel | Renew | Tunnel Active Water Management | Structures East – Edinburgh, E&G, ECML, and Borders | £2.8 | 2 | Schemes | Schemes delivered | 0 | 0 | 0 | 1 | 1 | Enhance resilience to water ingress. We expect to see rain events become more frequent. Active water control will reduce ingress into the tunnel improving the life expectancy of assets and increased performance. | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Structures | Scour Retaining Wall | Refurb | Retaining Wall Scour Protection Refurb | Route-wide | £3.3 | 2 | Schemes | Schemes delivered | 1 | 1 | 0 | 0 | 0 | Reduced risk of undermining of structure leading to loss of support and potentially fouling gauge | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Track | Plain Line | Renew | Plain line renewal | East Coast, West Coast and Edinburgh to Glasgow Mainlines | £34.1 | 17.135 | Km | km delivered | 3.4 | 4.6 | 3.6 | 5.7 | 3.5 | Replacement with modern components with higher thermal tolerances | Short duration and prolonged periods of rainfall and associated flood risks. Can also reduce risks associated with earthwork failures |
| Track | Switches and Crossings | Renew | S&C renewal | Kilmarnock | £11.5 | 1 | Schemes | Schemes delivered | | | 1 | | | Renewal of older type Switches & Crossings with modern variants improves resilience against hot weather | Extreme high temperatures / hot days |
| Track | Drainage | Renew | Track drainage renewal | Route-wide | £46.7 | 42.874 | Km | km delivered | 8.57 | 8.57 | 8.57 | 8.57 | 8.57 | Improved track drainage with enhanced capacity to deal with larger volumes of water | Short duration and prolonged rainfall events |

*Delivery year numbers are provisional, and will likely change as the Control Period progresses

## A4: Outcome 4 – Assurance and Competence

| Action Detail | | | Delivery Timescale | | Monitoring |
|---|---|---|---|---|---|
| **Code** | **Action Category** | **Action Description** | **Start Date** | **Delivery Date** | **Success Metric** |
| **Outcome Four: Our 'climate ready journey' is underpinned by a maturing foundation of risk, assurance, competence, and data insights.** | | | | | |
| **Milestone Six** | **A programme of risk and assurance activities is delivered to improve confidence in weather and climate resilience decision making** | | **01/04/2024** | **01/04/2026** | **Status of actions** |
| Action 4.1 | Risk and Assurance | Establish a weather and climate resilience group for Scotland's Railway to formalise roles and responsibilities in this space, oversee delivery of this plan, and to encourage collaboration on other related activities (e.g., the development of Seasonal Preparedness Plans) | 01/04/2024 | 01/04/2025 | Group formally established |
| Action 4.2 | Risk and Assurance | Ensure ScotRail's Business Continuity Plans address climate resilience requirements for ScotRail | 01/04/2024 | 01/04/2027 | Documented plans in place for operational continuity where systems impacted by extreme weather |
| Action 4.3 | Risk and Assurance | Complete an annual review of Network Rail Scotland's capacity and ability to adapt to impacts of climate change e.g., by using Climate Sense CaDD assessment and/or Adaptation Scotland's Capability Framework | 01/04/2027 | 01/04/2029 | An annual adaptation capability assessment |
| Action 4.4 | Risk and Assurance | Complete an annual review of ScotRail's capacity and ability to adapt to impacts of climate change e.g., by using the Climate sense and RSSB CaDD assessment and/or Adaptation Scotland's Capability Framework | 01/04/2027 | 01/04/2029 | An annual adaptation capability assessment |
| Action 4.5 | Risk and Assurance | Undertake a Risk and Control Self-Assessment specific to long-term climate risk and resilience – allowing us to feed through, and escalate where appropriate, the climate risks of greatest concern into corporate risk mgmt. processes | 01/04/2024 | 01/04/2025 | Climate adaptation RCSA created and maintained in support of Sustainability Enterprise Risk |
| Action 4.6 | Risk and Assurance | Undertake a review of the weather and climate impact tool | 01/04/2024 | 01/04/2025 | A series of proposed improvements to tool delivered to Network Rail's Technical Authority for consideration |
| Action 4.7 | Risk and Assurance | Commission research to develop a series of new weather and climate resilience indicators and metrics for Scotland's Railway, to enhance our ability to track/measure performance | 01/04/2024 | 01/04/2026 | Production (and publication) of a long-term climate change adaptation strategy for Scotland's Railway |
| Action 4.8 | Risk and Assurance | Develop climate scenarios to stress-test decisions we make as an organisation – for example, using the Network for Greening the Financial System's Climate Scenarios or the UK Socioeconomic Scenarios hosted by the UK Climate Resilience Programme | 01/04/2024 | 01/04/2026 | Scenario analysis / stress testing project undertaken in collaboration with Risk Team |
| **Milestone Seven** | **Routes to weather and climate resilience competence are established** | | **01/04/2024** | **01/04/2025** | **Status of actions** |
| Action 4.8 | Competency | Establish the criteria to achieve weather and climate resilience competency aligning to the sustainability competency matrix | 01/04/2024 | 30/09/2024 | Weather and climate resilience competency matrix established outlining routes to achieve Awareness, Understanding, Leading and Expert levels of competency |
| Action 4.9 | Competency | Identify routes to competency through the identification of available training resources | 01/04/2024 | 01/04/2026 | 1. Available resources identified and listed under the relevant competency levels<br>2. Identify any gaps in training resources |

## A4: Outcome 4 – Assurance and Competence

| Action Detail | | | Delivery Timescale | | Monitoring |
|---|---|---|---|---|---|
| **Code** | **Action Category** | **Action Description** | **Start Date** | **Delivery Date** | **Success Metric** |
| Action 4.10 | Competency | Undertake review of training options and the recourses required to ensure there are routes to achieve all levels of weather and climate resilience competency | 01/10/2024 | 13/12/2024 | Production of a plan outlining additional training resource needs and any funding requirements |
| Action 4.11 | Competency | Secure endorsement from senior management to roll out | 13/12/2024 | 31/03/2025 | Competency matrix is presented to and endorsed by senior management |
| Action 4.12 | Competency | Communicate the competency matrix and available routes to competency to Scotland's Railway | 31/03/2025 | 12/12/2025 | 1. Weather and climate resilience competency matrix is communicated to all of Scotland's Railway<br>2. Those with line management responsibilities are briefed on the Weather and Climate resilience competency matrix<br>3. Weather and climate resilience competency matrix is published on microsite |
| **Milestone Eight** | **An enhanced approach to how we review, and monitor, the impact of weather events on our railway is delivered** | | **01/04/2024** | **01/04/2025** | **Status of actions** |
| Action 4.13 | Reporting | Undertake a review of how we analyse, and report on, disruption caused by adverse or extreme weather and suggest planned improvements | 01/04/2024 | 01/04/2025 | A review report and improvement plan |
| Action 4.14 | Reporting | Develop a standardised template for reporting on the impact of adverse and extreme weather on our railway | 01/04/2024 | 01/04/2025 | 1. A standardised template<br>2. Agreement on threshold of event which triggers a review, as well as expected ad-hoc requests |
| Action 4.15 | Weather / Climate Data | Develop a weather and climate resilience data dashboard to provide a single source of truth for key weather and climate-performance related data | 01/04/2024 | 01/04/2025 | 1. A Power BI (or equivalent) dashboard<br>2. Communications to raise awareness of new dashboard<br>3. Data being actively used / integrated into post-disruptive weather event analysis |
| Action 4.16 | Weather / Climate Data | Undertake a review of available historic weather data / observations to identify most suitable data for use in analysis of climate trends | 01/04/2024 | 01/04/2025 | A review of available data and recommendations on data to use going forward |
| Action 4.17 | Weather / Climate Data | Undertake a review of adverse and extreme weather thresholds for Scotland to assess their suitably and identify opportunities to make improvements / feed into national review | 01/04/2024 | 01/04/2025 | A report appraising suitability of current adverse and extreme weather thresholds for Scotland and recommended improvements |

## B1: Weather Risk Taskforce – example activity

| Weather Risk Taskforce – Actions summarised here for awareness. | | | | |
|---|---|---|---|---|
| **Business Area** | **Activity** | **Description of activity 2024 to 2029** | **Work package / Action Plan** | **Taskforce Theme** |
| DRAINAGE | Additional Drainage Inventory | Increased capability to sustain inspection and maintenance of a larger drainage asset base | Slope Review Group – AP7 | Process |
| DRAINAGE | Drainage and Earthworks Resource | Increased capability to increase resource in engineering and asset management disciplines | People – AP6 | People |
| EARTH-WORKS | Earthworks Catchment Studies | Assessment of catchment areas at 135 sites and potential impact on earthworks | Water Catchment and Concentration features – AP18 | Process |
| DRAINAGE | Steep Slopes and Granular Drainage | Assessment of steep slopes with granular drainage features, and intervention to improve drainage design details on a smaller subset of high consequence assets | A9.16 Slope safety review group | Process |
| DRAINAGE | Drainage high risk review output | Water catchment and concentration features including high risk drainage site review and mitigation | Water Catchment and Concentration features – AP18 | Process |
| EARTH-WORKS | Monitoring Technology | Deployment of remote monitoring technology, wireless tiltmeters and drainage monitoring including maintenance of monitoring technology deployed in CP6 | Slope assessment and observational monitoring | Technology |
| EARTH-WORKS | Slope assessment and observational monitoring | Slope assessment and observational monitoring including scheme development for mitigation solutions | Slope assessment and observational monitoring – AP18 | Process |
| EARTH-WORKS | Geohazard Assessments / Third Party Slopes | Third party natural slopes assessment/risk reduction solutions and Geohazard Assessment | Slope Review Group – AP18 | Process |
| EARTH-WORKS | Whole Earthwork Approach | Increased earthworks and drainage renewals including a whole earthworks approach – £15.8m included within Earthworks spend in Table 3 (Climate Ready Asset Plan) | Slope Review Group – AP13 | Process |
| EARTH-WORKS | High consequence earthworks output | High consequence earthworks risk assessment and review, includes limited opportunity for mitigation | Slope assessment and observational monitoring – AP13 | Process |
| EARTH-WORKS | Helicopter and aerial survey techniques | Sustain dedicated helicopter resource | Slope Review Group – AP13 | Technology |
| EARTH-WORKS | Enhanced Coverage LIDAR of Route | LIDAR of natural slopes for GeoHazard Assessment and to support catchment modelling | Slope Review Group – AP13 | Technology |
| OPERATIONS | Weather Operations Desk Managers | Resource to maintain the weather desk | People | People |

## B2: The ORR 11 levers of resilience – example activity

| Discipline | Action | Description / Benefit | Source |
|---|---|---|---|
| **Neighbours and Catchment** | | | |
| ALL | Lineside neighbour engagement | Continue with our lineside neighbour and stakeholder notification process when major works are planned – led by our external communications and projects teams | Business as Usual |
| EARTH-WORKS | Catchment analysis | During CP7, catchment analysis will be undertaken to identify concentration features that could activate a large debris slide | Strategic Business Plan |
| DRAINAGE AND LINESIDE | Catchment analysis | Use of the Catchment Analysis Tool – a national dataset showing catchment delineation, peak flow computation and water threat index on the Network Rail estate – improving knowledge of the water environment of our infrastructure | Business as Usual |
| ALL | Nature-based solutions | Seek opportunities to collaborate with a range of stakeholders to address shared climate-related risks (e.g., flooding) – using nature-based solutions to address these risks | Business as Usual |
| LINESIDE | Lineside vegetation management | Additional funds for management of vegetation in CP7 to reduce impact of, for example, felled trees blocking lines of route | Outcome 3 |
| **Whole Systems** | | | |
| ALL | Climate Ready Plan | Bringing track and train together under one climate change adaptation plan | Climate Ready Plan |
| EARTH-WORKS | Whole earthworks approach | Applying whole earthworks approach to renewals acknowledging the interdependence between earthworks assets and water management assets | Strategic Business Plan |
| **Monitoring** | | | |
| EARTH-WORKS | Remote condition monitoring (wireless tilt meters) | Early warning systems and alerts allow identification of failure events in real time before trains encounter failures, and cameras allow determination of impact of failure on the running line | Climate Ready Plan (Outcome 3) |
| STRUC-TURES | Water level telemetry | Real time monitoring of water levels on railway structures | Strategic Business Plan |
| SIGNALLING | Axle counter train detection | More resilient in operating under high-water condition. Axle counters don't use the rail as method of detecting the train therefore they aren't affected when rail is underwater – more reliable | Climate Ready Plan (Outcome 3) |
| ELECTRIFI-CATION AND PLAN | Remote condition monitoring capabilities across distribution and plant | Enables proactive monitoring and responses to be generated prior to the occurrence of service affecting failures | Climate Ready Plan (Outcome 3) |

## B2: The ORR 11 levers of resilience – example activity

| Discipline | Action | Description / Benefit | Source |
|---|---|---|---|
| DRAINAGE AND LINE-SIDE | Trackwater | A smart sensor system for use in catchpits to monitor water and silt levels and help prevent flooding. The system enables proactive flood management through the continuous capturing of data, analysis, and reporting of asset conditions in real time | Strategic Business Plan |
| **Forecasting** | | | |
| ALL | Weather Operations Desk | Full-time Weather Desk in Control staffed by trained meteorologists – providing tailored weather forecast | Business as Usual |
| ALL | Rail Operations Weather Service | New digital forecasting platform that is replacing the existing Network Rail Weather Service | Weather Risk Taskforce (national) |
| ALL | Convective and frontal rainfall tools | Advanced warning of potentially disruptive rainfall events and implementation of precautionary | Weather Risk Taskforce (national) |
| **Design Redundancy, Reliability and Resistance** | | | |
| See Appendix A3 | | | |
| **Intervention Extents** | | | |
| EARTH-WORKS | Whole earthworks approach | Applying whole earthworks approach to renewals acknowledging the interdependence between earthworks assets and water management assets | Strategic Business Plan |
| ALL | Asset standards | Asset policies and standards being updated by Network Rail Technical Authority to reflect long-term climate change projections | Network Rail Environmental Sustainability Strategy |
| **Asset Knowledge** | | | |
| ALL | Hazard and criticality mapping / true cost R&D | Network Rail Technical Authority led research and development project to improve access to climate hazard data and intelligence on true cost of weather/climate disruption to the railway | Network Rail Environmental Sustainability Strategy |
| ALL | Climate change risk assessment | Improvements to be made to our approach for undertaking climate change risk assessments – allowing us to better evaluate climate risk and prioritise action to resolve | Climate Ready Plan (Outcome 1) |
| ALL | Adaptation Pathways | Development of long-term adaptation pathways for vulnerable assets – expanding knowledge base of what adaptation actions may be required and when | Climate Ready Plan (Outcome 2) |
| **Funding and Risk** | | | |
| See Network Rail Scotland's CP7 Delivery Plan | | | |
| **Awareness and Implementation** | | | |
| See Appendices A1, A2 and A4 | | | |

## B3: References


1 Network Rail Scotland, Strategic Business Plan for CP7 (2023) (last accessed 14/03/24)

2 Met Office, Eastern Scotland Climate Profile (last accessed 14/03/24)

3 International Journal of Climatology, State of the UK Climate 2021 (last accessed 14/03/24)

4 Met Office, UK and Regional Series database (last accessed 14/03/24)

5 Dynamic Coasts, Research Summaries (2021) (last accessed 14/03/24)

6 Adaptation Scotland, UK Climate Projections Summary for Scotland (last accessed 14/03/24)

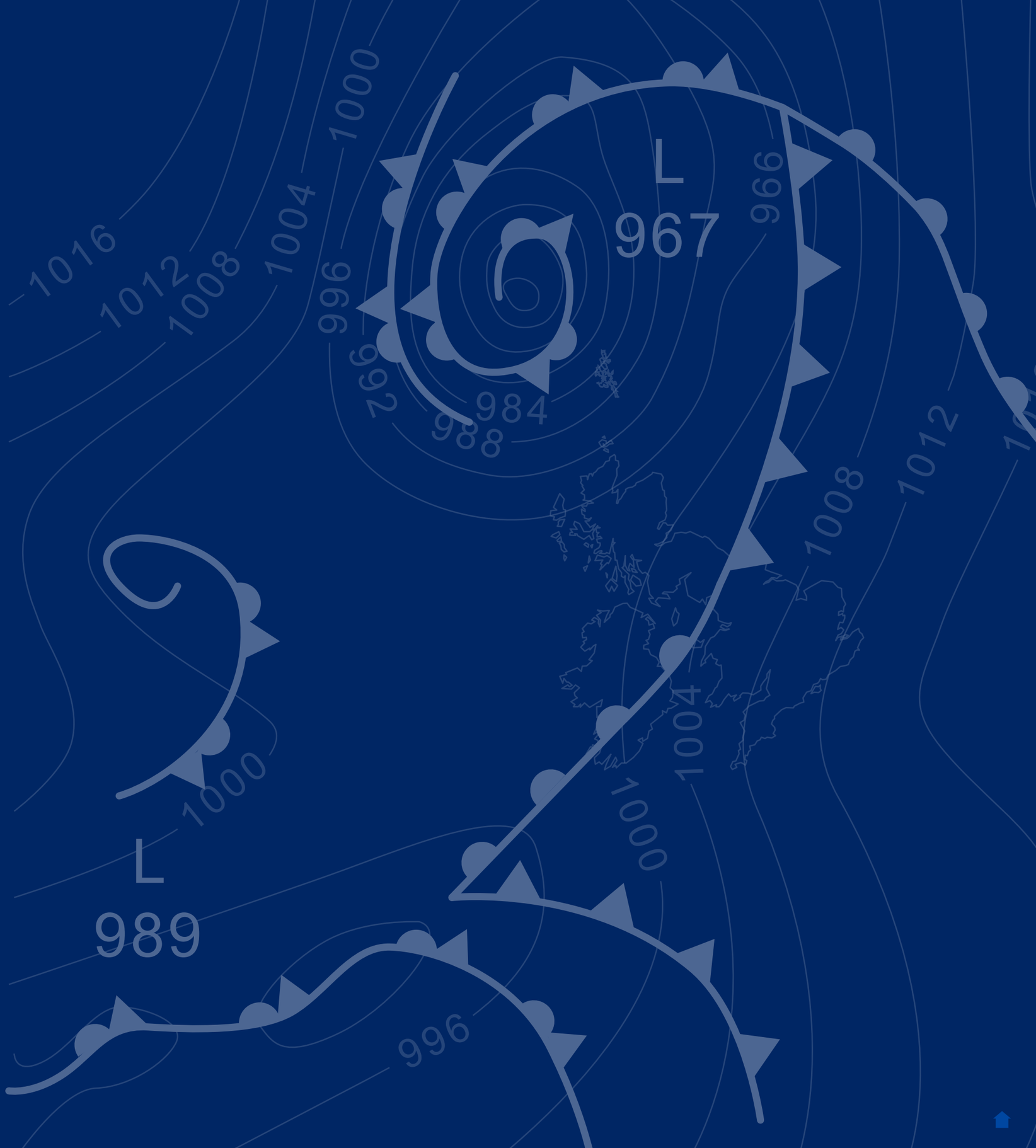
7 Network Rail, Climate Change Projections Guidance Note (last accessed 14/03/24)

8 Transport Scotland, High-level Output Specification for Control Period Seven (2023) (last accessed 14/03/24)

9 Network Rail, Environmental Sustainability Strategey 2020 – 2050 (2020) (last accessed 14/03/24)

10 Network Rail, Adaptation Reporting Power – 3rd submission (2021) (last accessed 14/03/24)

11 Network Rail Scotland, Strategic Business Plan for CP7 (2023) (last accessed 14/03/24)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SCOTLAND'S RAILWAY

GREENER IN THE MAKING