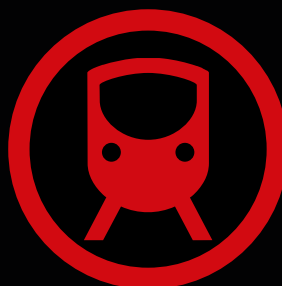


Climate adaptation and resilience plan

Transport for Wales





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At a glance

Transport for Wales

Transport for Wales (TfW) exists to drive forward the Welsh Government’s vision of a high-quality, safe, connected, affordable and accessible transport network that the people of Wales are proud of.

Our vision

“To create customer-focused services through a safe transport network of which Wales is proud”

Our work focuses on improving connectivity – by planning, commissioning and managing efficient transport networks and by drawing on the best skills from across industry, government and society. Together, we’re creating a transport network fit for the future, that contributes to the long-term sustainability of Wales and of those communities connected to us, achieving the seven well-being goals of the Well-being of Future Generations (Wales) Act 2015.

Our purpose

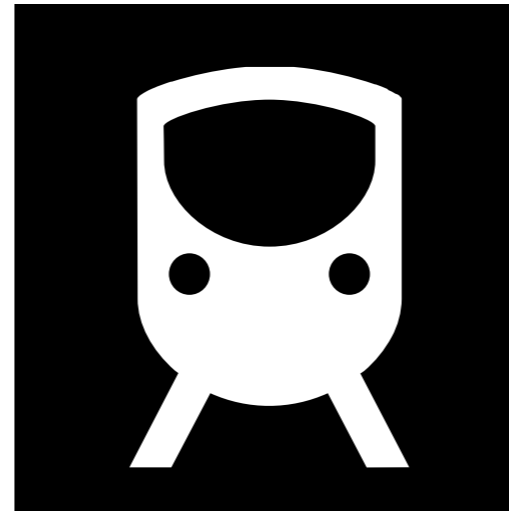
“To provide sustainable transport services that keep Wales moving”

A better, more integrated public transport network is a key driver in the delivery of the Welsh Government’s national strategy: Prosperity for all. Transport connects people and communities, underpins sustainable development and enables economic growth. Better public transport/services will result in real benefits for people, including better access to employment opportunities and better integration

Adverse weather on our network



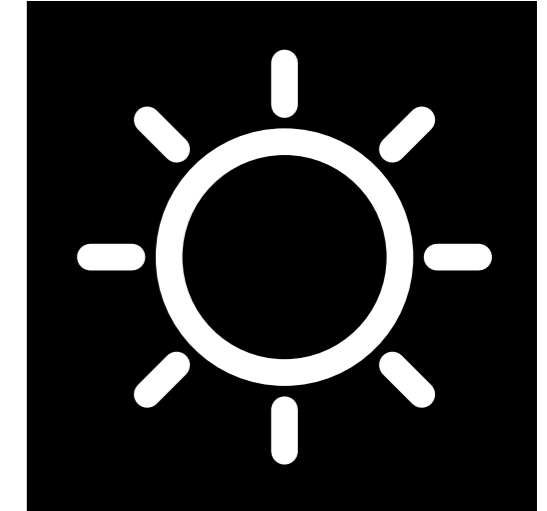
Three consecutive storms caused severe flooding across the CVL network in February 2020



Between 2020 and 2022, severe weather caused 253 hours of delays on the CVL network



444mm rainfall recorded at our Treherbert monitoring station in October 2022



Heat was the leading cause of service disruption in 2022/23



Approximately £180k delay costs due to flooding



66% of weather incidents in 2020/21 occurred during autumn and winter



Earth movements occurred throughout all seasons during 2020/21 and 2021/22



Climate change will influence the frequency and intensity of extreme weather events on our network in the future

Forewords



Leyton Powell
Director for Safety, Sustainability and Risk
Transport for Wales

Human induced climate change is a global challenge that requires coordinated efforts to reduce risk and ensure safety. As such, adaptation and resilience are two key strategies that need to be implemented in order to address the effects of climate change.

Climate adaptation focuses on reducing the vulnerability of communities, ecosystems, economies and infrastructure by preparing for potential impacts of climate change. Resilience looks at how we can build systems that can withstand or recover from extreme weather events or other impacts. In Wales, railway infrastructure needs to be adapted in order to ensure its resilience against the effects of climate change.

This includes investing in infrastructure improvements, and using innovative technologies in order to make it more resilient against floods and other extreme weather events.

We're already feeling the effects of climate change in Wales with storms Ciara, Dennis and Jorge causing major disruption to our network in 2020, followed by extreme heat in 2022 affecting our track and initiating responses to ensure the safety and well-being of our colleagues and passengers.

At Transport for Wales we have a responsibility to make sure that our transport network is safe for our colleagues and passengers, and that it's suitable to adapt to the future hazards our changing climate may bring. The work we're doing to transform our transport networks in Wales go beyond the benefits of new rolling stock, stations and timetables. We're transforming the network to ensure resilience, reduce disruption and to keep people moving.

Our railway network in Wales faces unique challenges from climate change. Historically, the network has been built to connect communities alongside rivers to allow a transition of movement for people and good from river to land. This means, as in the case of the Core Valley Lines, the network is extremely vulnerable to flooding and earth movements when faced with extreme weather.

This Climate Adaptation and Resilience plan is a key piece of work that ensures that we, as TfW, work as one team with our industry partners to keep our colleagues and passengers safe, informed and on track now and in the future.



Hayley Warrens
Climate Change Manager
Transport for Wales

The climate and ecological crisis is the biggest threat that humankind has ever faced. Climate scientists have been concerned about global warming for decades, but it is only in recent years that we have really started to take notice. A 2021 report noted that carbon dioxide levels in 2019 were higher than at any other point during the last 2 million years and as a result, our planet has warmed by more than 1°C since the start of the Industrial Revolution. This may not seem like a huge increase in temperature, but even warming of 0.5°C can have cause significant changes to our climate system.

The COP26 climate change conference in Glasgow was the turning point where the world realised that we really need to start taking urgent, collective action to respond to the climate crisis. It was agreed that limiting the extent of global warming should be achieved through global commitments to reduce emissions and investment in natural and technological solutions to help absorb carbon from the atmosphere. There are concerns that the actions agreed at COP26 will be too little, too late. Scientists and decision-makers have been particularly worried during the last couple of years that the damage to our climate system could already be done. In the summer of 2022, we had record breaking temperatures of over 37°C in Wales and over 40°C in England. The intense heatwave of July also saw the first Red Extreme Heat Warning being declared by the Met Office, as night-time temperatures exceeded 25°C. A major incident was also declared in London as wildfires rippled through the eastern side of the capital, destroying 14 homes, and putting people's lives in danger.

While reducing emissions will help prevent climate change getting any worse, there is a consensus that we must start acting urgently to ensure our infrastructure and communities are more resilient. We're already starting to see more severe storms in Wales – with the three storms of February 2020 (Ciara, Dennis, and Jorge) bringing widespread damage to our homes, business, and transport networks in Wales. As these events are likely to become more frequent and extreme, it is vital that we adapt and prepare for changes to our climate system that are already "locked-in". The Core Valley Lines network was built to connect the communities we serve in this region. This in turn has meant our rail assets are particularly vulnerable to flooding and earth movements during storms and periods of heavy rainfall due to the proximity of these settlements to hillsides and river systems. We're committed to providing the people of Wales with a transport network that is safe and accessible now in the future and this plan provides our customers and investors assurance that we're committed to ensuring that our assets are adapted and resilient to likely climate extremes we'll face. As climate science is continually emerging, it is likely that our climate risk profile will change over time. This plan, therefore, is considered as a working document and will be revised accordingly as our level of risk changes.

2022 has shown us that is crucial we start to consider the climate crisis as the real emergency it is. We must all work together to reduce our emissions from all that we do and increase our preparedness to reduce the impacts from climate-related risks.

Terms used in this document

Adaption - adjustments needed from individuals, communities and countries in response to changes to our planet's climate.

Adverse Weather – severe weather that causes unsafe conditions and increases the risk to health and safety.

Amey Infrastructure Wales (AIW) – responsible for management of the CVL assets, carrying out operation maintenance and renewals.

Cascading failures - a sequence of events where changes in one component lead to changes in other components.

Climate system - Earth's complex global system consisting of five major components, the atmosphere, the ocean, the cryosphere (including snow & ice), the biosphere and the land surface, each element is interconnected and interacts with each other.

Compound hazards – A weather or climate event that can trigger another event or more than one extreme event that happens simultaneously.

Core Valley Lines – the section of the rail network owned and maintained by TFW

Decarbonise – Reduce or remove carbon dioxide released as a result of a process or operation.

Electrification – The process of electrifying lines that will power new South Wales Metro on the Core Valley Lines with Overhead Line Equipment (OLE).

Extreme weather – Extreme weather includes unseasonal, rare and/or severe weather during an observed time range for a particular location. Extreme weather events can apply to rainfall, heat, snow, wind and/or storms, which can lead to impacts such as droughts and flooding.

Global warming – the long-term warming of the planet's overall temperature.

Hold the line – one of four approaches within the Natural Resources Wales - Shoreline Management Plan that maintains or changes the existing standard of protection.

Human-induced climate change – While climate change refers to the long-term shifts in temperatures and weather patterns and can be natural, since the 1800's human activities are the main driver of climate change due to burning fossil fuels.

Hydro-meteorological hazards – A process that is atmospheric, hydrological, or oceanographic that due to size and nature may cause substantial negative impact and can cause loss of life and severe disruption. In Wales, these include thunderstorms, coastal storm surges, flash floods and drought.

Industrial revolution - The industrial revolution, which occurred during the late 18th and early 19th centuries, is often regarded as a turning point in human history. It marked a significant shift from an agrarian economy to a machine-based manufacturing economy, powered by steam engines and other forms of fossil fuels. This revolution brought about remarkable economic growth and prosperity, but it also had a profound impact on the environment, including climate change.

Interacting risks - risk associated with climate change that are linked to other risks, there is often a ripple effect when one risk is affected, causing other risks to be exacerbated.

Inter-dependency – In terms of infrastructure, there are three types, physical (where one operation depends on services offered by another), geographical (multiple failures occur in close proximity) and cyber (where infrastructure depends on technology), systems that depend on another system to operate.

Lock in – when an action or decision taken initially to address a current issue but may exacerbate risk and vulnerability in the future due to climate change impacts, an example of this would be permitting a development on a known flood risk area.

Micro-climates – a localised climate that has a different set of atmospheric conditions to the surrounding area, for example at the bottom of a Valley.

Mitigation – Actions to limit climate change, usually those aimed at reducing emissions.

Modal shift – aim set out in the Welsh government transport strategy to encourage a change in people's transport habits to be more sustainable.

Nature-based solutions (NbS) - Working with nature to protect and enhance the environment as an alternative to traditional hard engineering practices, while providing societal benefits and contributing to climate change mitigation.

Net-zero – the actions needed to cut greenhouse gas emissions and move towards a low-carbon economy. The Welsh Government is committed to net-zero carbon emissions by 2050.

Physical assets – Infrastructure under TFW ownership that exist to deliver a service.

Representative Concentration Pathways (RCPs) – used as a method of predicting and modelling the future climate, capturing assumptions about economic, social and physical changes to the environment.

Resilience – The ability to prepare for, respond to and recover from impacts of climate change.

Social equity – A fair and just system that ensures everyone in the community has access to the same opportunities and outcomes.

Sustainable modes – Using walking, cycling, green trains, or public transportation for example as means of transport, which benefits both the environment and society

Tipping point – a critical threshold that when crossed, leads to large and often irreversible changes in the climate system, subsequently meaning a change of state to something that would have previously been described as stable.

Transport for Wales (TfW) – the body established by Welsh Government to deliver transport priorities in Wales.

Introduction

Climate change is the biggest threat to our civilisation and natural world. Evidence indicates that in 2022 our world was 1.15°C warmer than the 1850-1900 average and the years 2015-2022 are likely to be the eight warmest years on record. 2020 was the third-warmest, fifth-wettest and eighth-sunniest year on record in the UK.

Every year we're experiencing record breaking weather events. In summer 2022, multiple heatwaves around the world have led to wildfires and record temperatures in countries such as China. Record breaking rain in July and August led to extensive flooding in Pakistan. There were at least 1,700 deaths and 7.9 million people were displaced.

The heat-waves were unprecedented in the UK and we experienced record-breaking temperatures of 40.3°C in Lincolnshire and wildfires in London. A national emergency was declared by the UK Government as the Met Office announced the first ever red weather warning for heat-waves. Rail services were significantly disrupted, with services in areas covered by the red weather warning cancelled in order to keep colleagues and passengers safe.

The previous year also saw catastrophic flooding in west Germany and China, wildfires in Greece and unprecedented heat in Canada and Russia. Wales was severely impacted by three successive storms – Ciara, Dennis and Jorge - in February 2020, which resulted in significant levels of flooding and damage, particularly in the Valleys region. Two of the three wettest days on record occurred in 2020.

In the 1980s, scientists began to voice their concerns about global warming and in 1990 the Intergovernmental Panel on Climate Change (IPCC) released its first report which started to make the link between carbon dioxide (released by human activities) and increasing temperatures. In August 2021, the IPCC published their sixth assessment report and stated that **“it is unequivocal that human influence has warmed the atmosphere, ocean and land”**. Human influence is also said to have warmed the climate at an “unprecedented” rate in the last 2000 years. Commitments to decarbonise on a quest for net zero have evolved as world leaders respond to the latest scientific evidence.

Over the course of the century, it's likely that global temperatures will continue to rise despite efforts to curb emissions. In 2021, concentrations of the three main greenhouse gases (carbon dioxide, methane and nitrous oxide) reached record highs and provisional data indicates these levels increased further during 2021. As emissions continue to increase and our world continues to warm, extreme weather events will likely increase in their severity and frequency. In Wales storms are likely to get more destructive, winters will be wetter, and our summers will be hotter. As a transport operator, it is vital that we have an in-depth understanding of how these changes will affect infrastructure, operations, and the health and safety of our passengers and colleagues. We're particularly worried about how more intense and frequent winter rainfall will impact upon our Core Valley Lines network, as it is likely that the river systems in the valleys will be unable to cope with increased flow.

In 2019, Welsh Government declared a climate emergency and set a commitment to become net zero by 2050. TfW has developed policies and plans to ensure we're responding to the need to decarbonise the way in which we travel in Wales. There is overwhelming evidence that our climate is invariably changing due to current and past levels of emissions. This plan aims to respond to this evidence by acknowledging that we're likely to experience more extreme weather in Wales, despite efforts to mitigate climate change through decarbonisation, and we have to adapt and prepare accordingly.

Modal shift is at the heart of Llwybr Newydd – The Wales Transport Strategy, which includes a target of 45% of journeys to be made by public transport by 2040. Creating a climate-resilient network will be fundamental in supporting Welsh Government deliver on this target out to 2040 and beyond, whereby a sustainable transport network that is accessible in the face of climate extremes, enables uninterrupted modal shift through enhanced confidence in infrastructure safety and reliability. Climate resilience is considered a crucial component of enabling decarbonisation of the transport sector in Wales – limiting the extent of further climate change.

The plan includes an assessment of TfW's current vulnerability to extreme or adverse weather to provide an indication of how our network and services currently fair during these events. This analysis has helped us to identify areas of vulnerability across the network – allowing us to prioritise our climate adaptation planning going forward.

We have also included an overview of our approach to assessing climate risk, including the primary climate projections used for assessing climate risk on the Core Valley Lines network. This is supported by a high-level summary of the key climate risks affecting the transport sector in Wales, as identified in the third Climate Change Risk Assessment (CCRA), to provide an outline of the likely risks and climate hazards we'll face. Lastly, the plan details our governance framework for managing climate risk at TfW.

We'll soon be conducting comprehensive risk assessments to identify the likely climate change risks and opportunities which will affect our networks, operations and services, including CVL assets, buses and the new South Wales Metro. A CCRA will also be undertaken for all capital projects to ensure all future development mitigates climate risk as far as practicable, and potential opportunities are identified at the earliest opportunity. Once we have assessed our risk, we'll develop project-specific adaptation delivery plans to provide the strategic direction for resilience solutions. Going forward, each new capital project will include an accompanying plan specifying how the project will reduce climate risk and maximise opportunities.

This plan aims to provide our stakeholders assurance that climate resilience will be embedded into our new assets, maintenance programmes, and decision-making – ensuring our transport networks, services and future projects can withstand risks associated with increasingly worsening and more frequent future climatic hazards.



Why is TfW Adapting to Climate Change

Our changing climate

Policies and legislation

The Well-being of Future Generations (Wales) Act 2015

Latest advice and evidence

Vision and objectives

Why Transport for Wales is adapting to climate change

Our changing climate

Climate change is a large-scale, long-term shift in the planet's weather patterns or average temperatures. Changes in our climate system have occurred throughout Earth's history, where natural events like volcanic eruptions, wildfires and floods can dramatically affect our ecosystem. Earth's climate is governed by greenhouse gases in our atmosphere, which keeps our climate warm and hospitable. However, since the start of the Industrial Revolution, humans have been increasing the levels of greenhouse gases through activities such as burning fossil fuels and intensive agriculture.

In their 2021 report, the IPCC stated that, in 2019, carbon dioxide levels were higher than at any point in the last 2 million years¹. Current warming and changes in our climate system are unprecedented Earth's history and global temperatures have increased by 1.09°C since 1850. Each of the last four decades have been warmer than any decade since before the start of the Industrial Revolution, with the last six warmest on record globally. According to the Met Office State of the UK Climate assessments and the UK Climate Change Risk Assessment⁴, Wales and the rest of the UK is already starting to experience the impacts of climate change:



- » Across Wales, average land temperature in the decade 2010-2019 was **0.9°C warmer** than in the period of 1970 to 2010
- » Summer maximum temperatures in Wales are hotter, with temperatures **peaking at 31°C in the 2019** summer heatwave
- » 2020 was the **third warmest, fifth wettest and eight sunniest** on record
- » The top 10 warmest years in the UK and Wales have occurred **since 2002**



- » 2011-2020 was on average **0.3°C warmer** than 1981-2010 average
- » Sunshine hours have **increased by 6.1% in the UK and Wales** between the mid-1970s – mid-2010s and 2010-2019



- » February 2020 was the UK's wettest February on record **since 1862**
- » Annual mean rainfall in Wales has **increased by 2%** between the mid-1970s – mid-2010s and 2010-2019
- » The incidence of heavy rainfall events have **increased across the whole of the UK**
- » 6/10 wettest years on record (since 1862) in the UK have occurred **since 1998**



- » 2011-2020 had **16% fewer** days of air frost and **14% fewer** ground frost days
- » Air frost has not been observed to have significantly changed in Wales

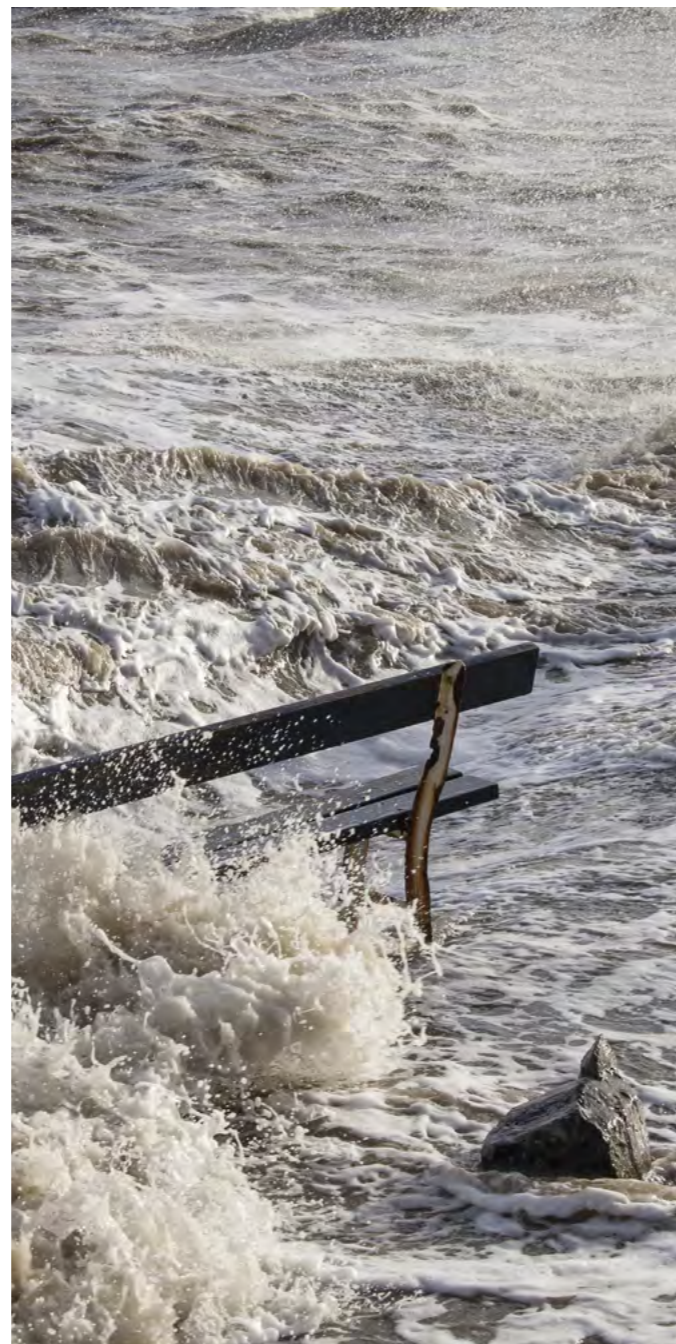


- » UK average sea-level has **risen by 1.2 – 1.6mm/year** since 1901 – it is unclear how these trends have changed in Wales

During recent decades, climate scientists have become increasingly concerned about global warming. In 2014, the IPCC released a special report documenting the likely impacts of 1.5°C warming. This stimulated interest amongst the United Nations and at COP21 in 2015, the Paris Agreement was drawn up.

The Paris Agreement is a legally binding pledge to prevent global temperature rise exceeding 2°C above pre-Industrial revolution levels (further ambition to limit the increase to 1.5°C). Following the agreement, the UK has set-out commitments to reach net-zero carbon emissions by 2050. However, despite these commitments, efforts to reduce emissions across the world do not appear to be ambitious enough, as the most recent report from the IPCC was deemed “code red” by the United Nations, due to its alarming observations and projections.

Despite best efforts to decarbonise within Wales, we’re reliant upon the commitments of all countries to reduce emissions to ensure the aspirations of the Paris Agreement are within reach.



Policies and legislation

The development of this plan has been directed by the remit to TfW from Welsh Government which is to “ensure all TfW operations delivered on behalf of the Welsh Ministers are designed and delivered based upon the latest data on climate change risk and impacts and robust climate change adaptation plans are in place”.

The TfW Climate Change Adaptation Plan has been informed by a suite of relevant climate change policies. These policies are (non-exclusive list):

- » Net Zero Wales (2021)
- » Net Zero Wales Carbon Budget 2 (2021-25)
- » Llwybr Newydd – The Wales Transport Strategy (2021)
- » Prosperity for All: A Climate Conscious Wales (2019)
- » Prosperity for All: A Low Carbon Wales (2019)
- » The Environment (Wales) Act 2016
- » Well-being of Future Generations (Wales) Act 2015
- » Active Travel (Wales) Act 2013
- » National Resources Policy for Wales

The plan is also informed by the UK Climate Change Act (2008) which contains specific requirements for climate change adaptation. The Act legislates the requirement for a UK Climate Change Risk Assessment to be carried out every five years, which provides a national summary of the risks likely to affect Wales.

The Environment (Wales) Act outlines the targets and legislation for net zero and decarbonisation in Wales. The Act also sets out the requirement for the sustainable use of resources, in addition to the management of flooding and coastal erosion – both of which are fundamental considerations of climate change adaptation.

Other, appropriate TfW plans have also been acknowledged during the development of this document. These plans include:

- » TfW Sustainable Development Plan (2019/20)
- » TfW Low Carbon Impact Strategy (2019/20)
- » TfW Biodiversity Action Plan (2019/20)
- » TfW Strategic Asset Management Plan
- » TfW Asset Management Policy

This plan has been produced in accordance with the latest scientific advice and documents which are referenced throughout. These include, but are not limited to:

- » Climate Change 2021, The Physical Science Basis - Intergovernmental Panel on Climate Change (2021)
- » Independent Assessment of UK Climate Risk – Climate Change Committee (2021)
- » Progress in Adapting to Climate Change, 2021 Report to Parliament - Climate Change Committee, 2021
- » Technical Report of the Third UK Climate Change Risk Assessment (CCRA3) – UK Climate Risk, 2021
- » Evidence for the third UK Climate Change Risk Assessment (CCRA3), Summary for Wales – UK Climate Risk, 2021
- » UK Climate Projections (UKCP18), Met Office Hadley Centre Programme – The Met Office, 2018

Through conscious consideration of all above legislation and documents, this plan aims to ensure it offers TfW with the most practicable pathway to climate resilience. The National Adaptation Reporting Power is set out in the Climate Change Act to direct reporting organisations on how they are addressing climate impacts. At the time of writing this report, the Act does not require TfW to report under this function.

The Well-being of Future Generations (Wales) Act 2015

The Well-being of Future Generations (Wales) Act 2015 is centred around seven connected goals. This plan supports Welsh Government to create a “Resilient Wales” by ensuring TfW networks are adapted to withstand the impacts of future climate change. Creating resilience will underpin the successful delivery of the six other, well-being goals.



TfW exists to drive forward the Welsh Government’s vision of creating a “high-quality, safe, integrated, affordable and accessible transport network that the people of Wales are proud of.”



Vision and objectives

TfW exists to drive forward the Welsh Government’s vision of creating a “high-quality, safe, integrated, affordable and accessible transport network that the people of Wales are proud of.”

We’ll strive to deliver on this vision by enhancing the climate-resilience of our networks and operations through successful adaptation. The Core Valley Lines network is owned and managed by TfW, and we’re directly responsible for adapting this asset.

As many of our services run across non-TfW owned networks, we’ll work closely with other infrastructure owners (such as Network Rail) to adopt climate-resilience across the wider transport network.

To create customer-focused services through a safe transport network of which Wales is proud

Ensure climate change resilience is embedded in everything we do

Assess climate change risks across all TfW networks and operations

Design and implement solutions that reduce the impacts from future climate change

Enable timely recovery from the impacts of adverse weather

Collaborate with external partners to reduce TfW’s vulnerability to cascading failures

Current vulnerability to adverse weather

Analysis of adverse weather impacts on the CVL

Number of incidents caused by adverse weather

Service disruption resulting from adverse weather

Weather-related incidents by section of the CVL network

Costs associated with weather-related service disruption

Current system for monitoring weather

Storm Dennis case study

Adverse weather defines weather conditions that are severe enough to affect work environments and health and safety. These conditions affect our rail network every year. From heavy rainfall to high winds, adverse weather can present complex challenges when keeping a reliable and safe train service. There's a range of measures to limit or resolve the impacts of severe weather, often resulting in service disruption and associated costs.

The term extreme weather refers to climate events where the weather is unexpected, unusual, severe, or unseasonal. The impact of extreme weather on the rail network can vary annually, with some years experiencing harsher winters or intense storms. For instance, February 2020 was one of the wettest Februarys since 1766 in Wales. Consequently, the unusual levels of precipitation resulted in significant flooding along stretches of our network.

If unprepared, both adverse and extreme weather can significantly affect our network operability, performance, and safety. Climate change will likely influence the frequency and intensity of extreme weather events in Wales, where heatwaves will become hotter and longer in duration and winters will be much wetter. Welsh transport networks could become particularly exposed to climatic hazards if we do not fully understand our existing vulnerability to adverse and/or extreme weather.

As part of our vulnerability assessment of the Core Valley Lines network (our owned asset), we've conducted analysis of weather-related incidents which have adversely impacted performance. Understanding the vulnerability of the Wales and Borders network is outlined in Network Rail's Wales and Western Route Weather Resilience and Climate Change Adaptation Strategy.

TfW took over ownership of the CVL (from Network Rail) on 28 March 2020, limiting the availability of weather-related performance data. We've performed in-depth scrutiny of this data to help us understand how weather incidents have affected the CVL performance.

Low adhesion, caused by moisture, leaves, and other contaminants on the rail lines, impact performance during autumn. As adhesion-related incidents are the result of seasonal influences, rather than adverse weather, they have been discounted from this analysis and will be managed separately.

Analysis of adverse weather impacts on the Core Valley Lines

Number of incidents caused by adverse weather

Since taking ownership of the CVL there have been more than 120 weather-related incidents. At 33%, high winds are responsible for the highest percentage of incidents overall, followed by earth movements at 28%.

During 2021/22, high winds accounted for 45% of total incidents, with Wales experiencing 100mph winds during storm Eunice. Train services were severely affected during the storm, whereby 22 units were damaged and 42% of trains were cancelled.

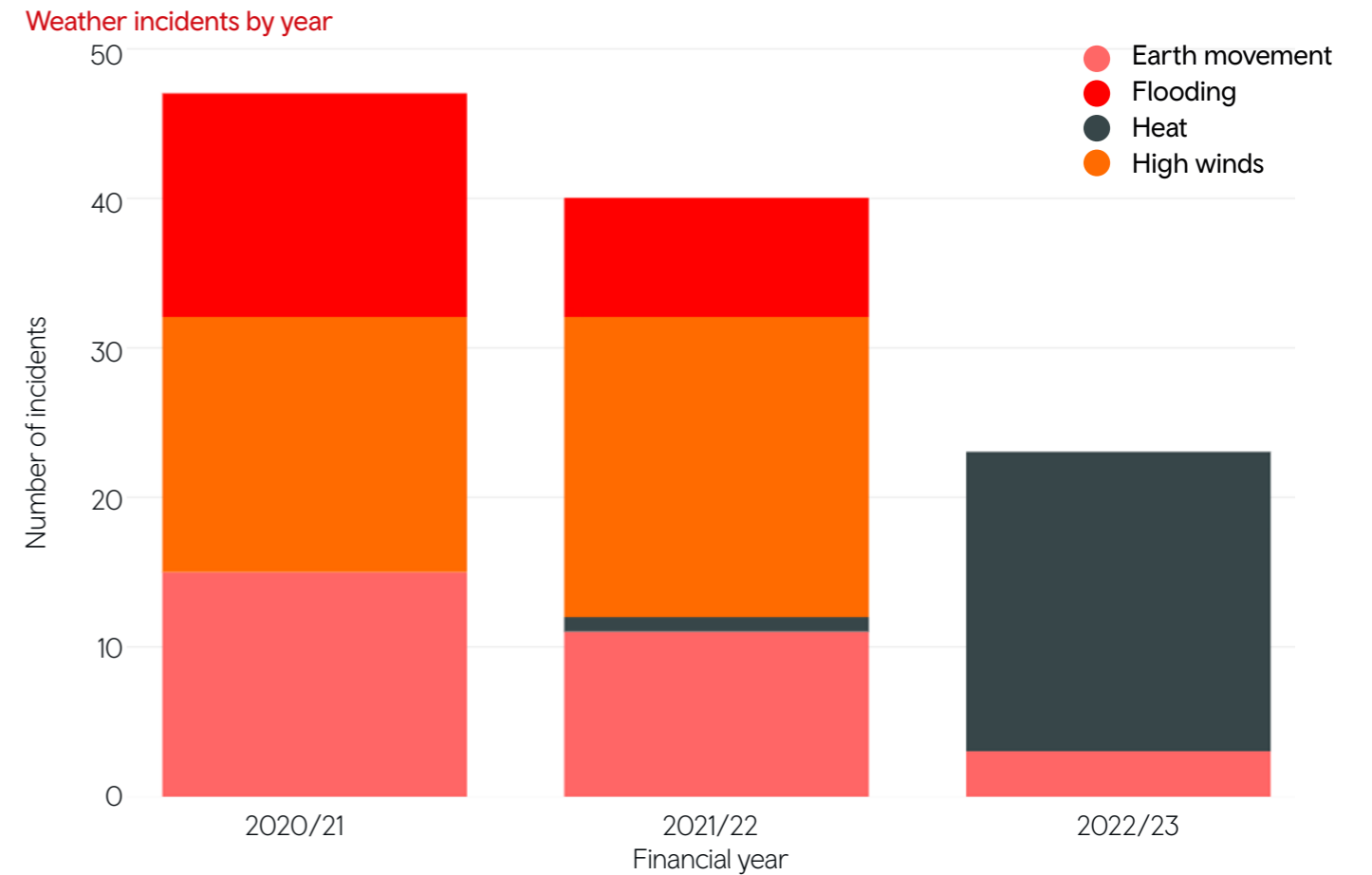
Within the first two years of CVL ownership, there was only one heat-related incident recorded, while we recorded 20 heat related incidents in 2022, predominantly in July and August when rail temperatures exceeded the critical rail temperature so precautionary measures were put in place. It's predicted that the occurrence of heat-related disruption is likely to increase as Wales' climate warms and the procedures in which high temperatures are dealt will require adapting. Since taking ownership of the CVL, rigorous maintenance procedures have been put in place by our Asset Management team to reduce the impact of rail buckling during extreme heat.

The hot weather experienced in summer 2022 significantly affected the performance of the train service, predominantly due to types of fleet that were overheating, the network was also subject to blanket speed restrictions.



The graph below illustrates how weather-related incidents are changing progressively year by year, exposing further vulnerabilities and reinforcing the need for adaptation. The analysis was conducted in December 2022, therefore a full picture of weather incidents during this reporting year (2022/23) was unavailable.

As we move into early 2023, it's expected that increasing flood and wind-related incidents will drive up the overall yearly figure for 2022/23. There are also likely to be more incidents of flooding on the network during all years other than those shown on the graph, as flood water below the rail head is not considered to affect safety and performance and the trains can continue to run.



Service disruption resulting from adverse weather

Since taking ownership of the CVL, extreme and adverse weather resulted in a total of 268 hours of delays. High wind was the primary cause accounting for 40% of all weather-related delay minutes, followed by flooding with 36%. Flooding incidents can take longer to remediate, as rail infrastructure can sustain lasting damage that requires ongoing repair. Totalling 164 hours of delay time, 2021/22 experienced the highest number of delays, with flooding and high winds the primary causes. In October 2021, many of the recorded flooding and high wind incidents are attributed to Storm Arwen. Storm Dennis resulted in similar incidents during February 2020; a case study of this event is illustrated at the end of this section.

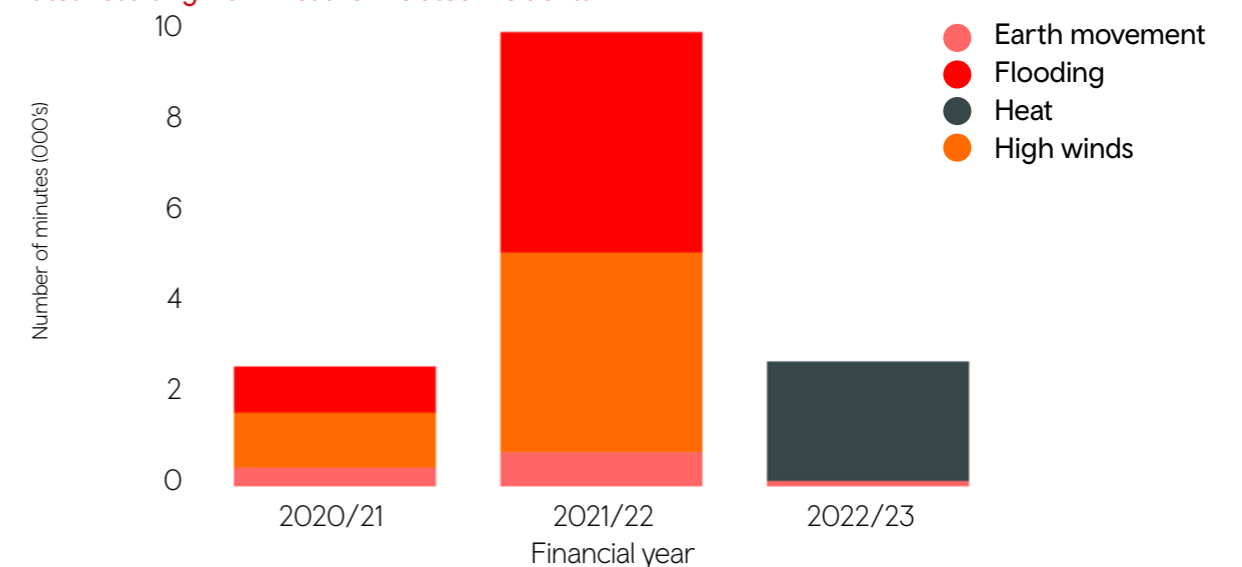
Earth movement delays have increased by 83% between 2020/21 - 2021/22 and are likely to increase as we progress throughout the decade as our climate continues to change. When earth movements occur, they are largely a consequence of hydro-meteorological hazards due to reduced soil cohesion and/or erosion of soil particles. Depending on the amount of water, the slope may also undergo material changes, causing the structure to become unstable. The CVL has sections of track that are particularly vulnerable, so speed restrictions are often put in place when the threat of earth movement is likely. Within the three-year period, there has been no service cancellations due to earth movements and only 20 heat-related cancellations. With extreme heat events, speed restrictions are likely to be implemented instead of cancellations to enable us to continue operating services. Speed restrictions are an example of an existing resilience measure implemented to reduce the risk of weather-related impacts on our rail network.



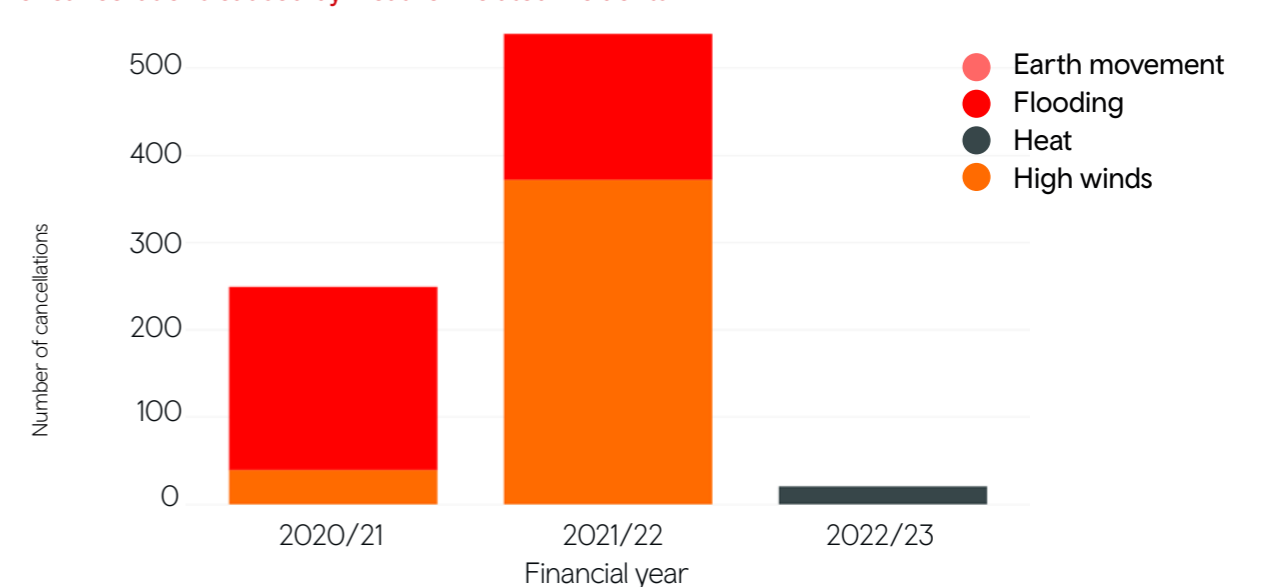
539 service cancellations occurred in 2021/22, the most in any year, with flooding being the primary cause.

One flood near Caerphilly, caused 27 hours of cancellations and changed 64 services. Flooding is currently the most significant risk to service operability on the CVL.

Delay minutes resulting from weather-related incidents



Number of cancellations caused by weather-related incidents



Weather-related incidents by section of the CVL network

The following graph illustrates the sections of infrastructure that are susceptible to weather-related risks. The area between Mountain Ash and Abercynon was noticeably more affected than other sections, with 34 earth movements recorded in this segment of track alone.

Flooding and high winds were the primary incidents affecting the network, impacting 17 and 29 sections respectively.

The most incidents were reported in

- » Caerphilly (5),
- » Cardiff (4)
- » Merthyr Tydfil to Abercynon (4)
- » Pontypridd to Porth (4)
- » In the remaining locations 1 - 3 incidents occurred

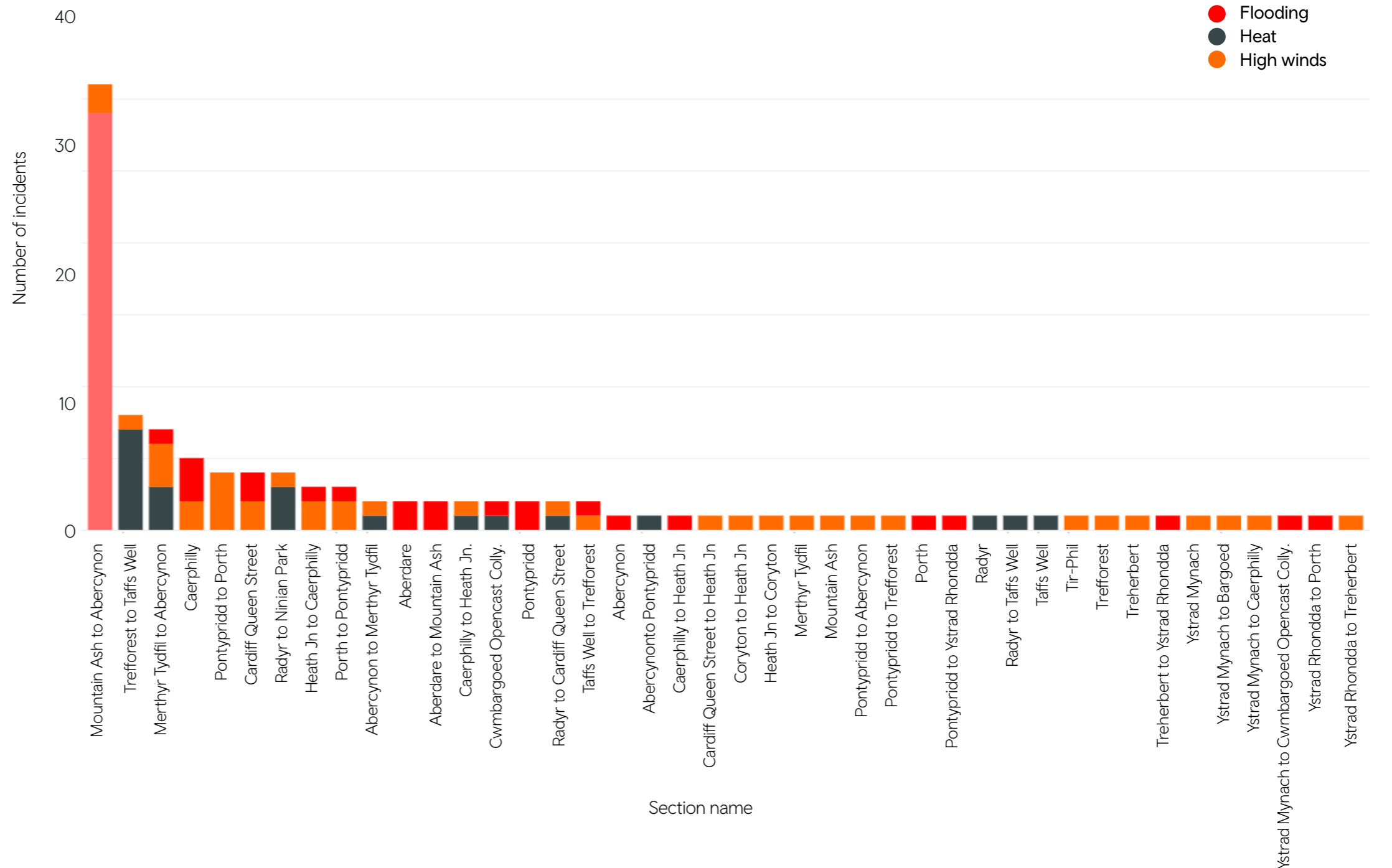
There are likely to be more incidents of flooding than those recorded, due to non-logging if flooding was below the railhead.

There were the most incidents related to heat at;

- » Treforest to Taffs Well (7)
- » Merthyr Tydfil to Abercynon (3)
- » Radyr to Ninan Park (3).

Overall, this analysis shows the sections of the CVL that are currently most vulnerable to extreme or unseasonal weather; informing the prioritisation of climate risk mitigation on the network. Some sections may continue to be vulnerable due to adaptation challenges and interdependencies such as land ownership.

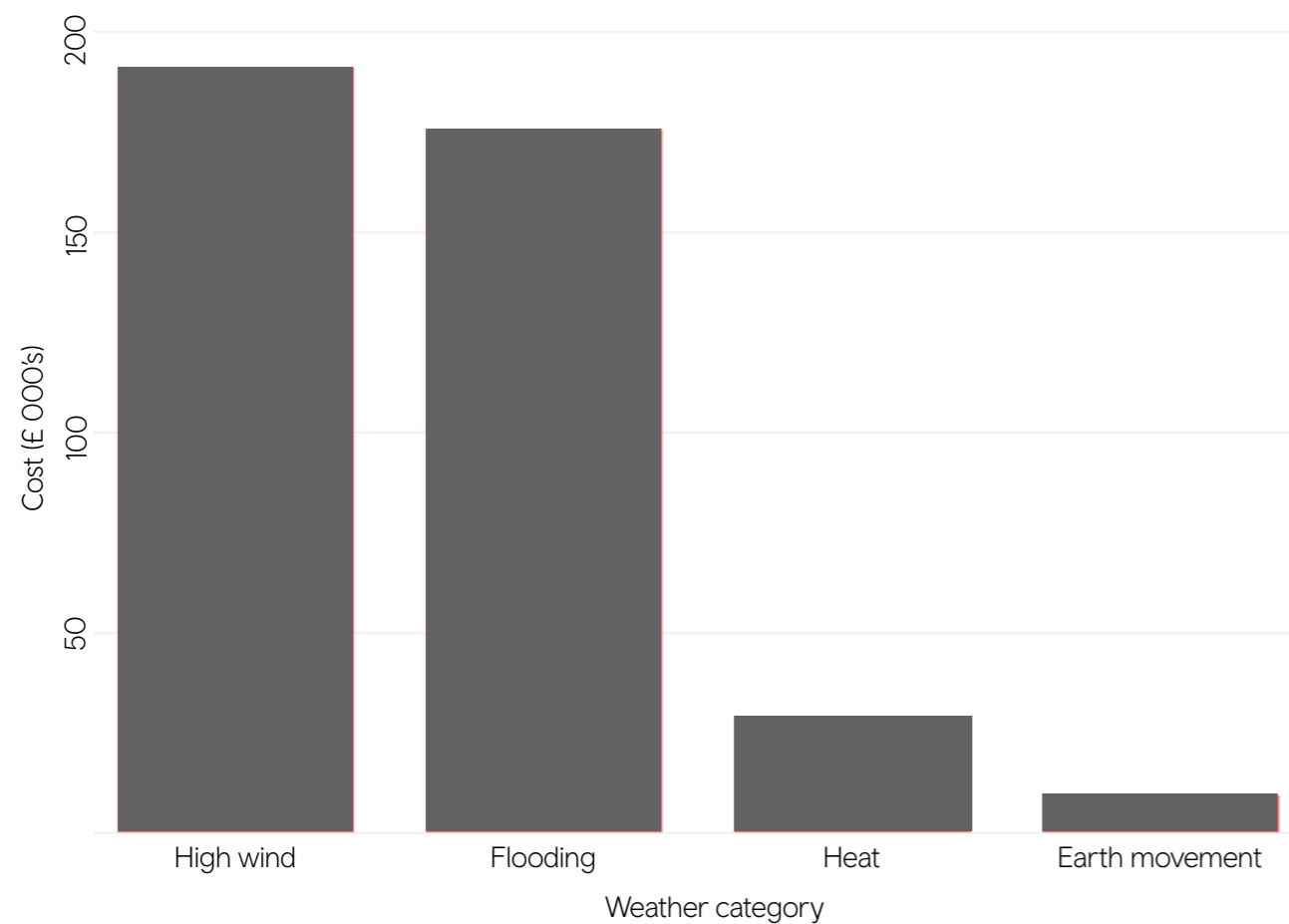
Adverse weather incidents on the network



Costs associated with weather-related service disruption

When service disruption occurs, there are costs that flow both ways between the Infrastructure Manager and train operator). These costs cover delay impacts such as passenger compensation and replacement bus services. The data below illustrates the weather-related incidents where resultant service disruption has an associated cost impact.

Costs from weather-related delays
February 2020 - October 2022



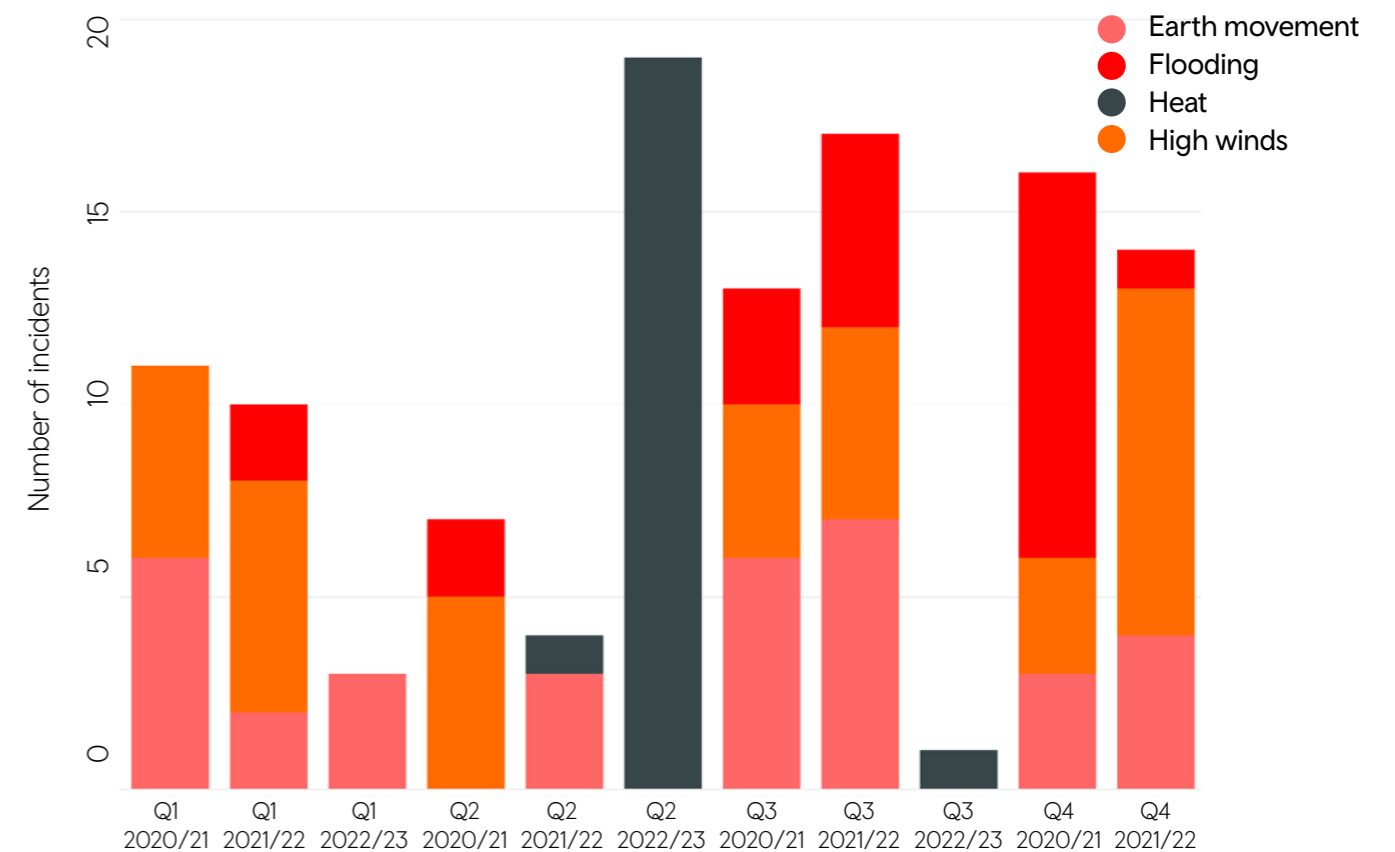
During 2020/21, 55% of weather incidents on the CVL occurred during quarters three and four (autumn and winter); 68% also occurred during the same period in 2021/22. In both years, high winds and flooding accounted for 37 and 23 weather incidents respectively; affecting the network most severely during Q4 (winter).

High wind is likely to have caused more issues in autumn and winter (Q3 and Q4) due to branches, trees and debris being blown onto the train track. Analysis of weather incidents since 2020/21 shows that heat-related incidents can occur for a prolonged period, not just at the height of summer. The occurrence of earth movements does not seem to be seasonal and occur throughout the year.

2022/23 experienced an increased number of heat-related incidents, with twenty incidents logged compared to one during the previous year. Most incidents were logged during Q2 (June-August), but some were still causing issues on the network during Q3 (September-December). At the time of analysis, incident data for 2022/23 Q4 was incomplete.

As we progress through the century, climate change is likely to increase the amount of flood, high wind and earth movement events during the winter (Q3 and Q4), while heat incidents are expected to adversely affect the network during the summer (Q2).

Weather-related incidents by quarter (2020/21 – 2022/23)



Current system for monitoring weather

We contracted Amey Infrastructure Wales (AIW) to deliver infrastructure management and transformation of the CVL. Previously, AIW managed weather data for TfW via Network Rail's MetDesk forecasting system. MetDesk forecasting splits the whole of Wales into three areas – North, Mid and South Wales – with the data relating to 12km grids and only two weather stations in the CVL area. This has presented challenges in terms of the accuracy of forecasting, especially when sections of the network cross different grid squares and/or valleys.

To monitor the CVL resilience, several weather stations have been installed to better understand weather patterns across the network. The unique geography of the South Wales Valleys contributes to the existence of micro-climates, the different locations of these stations allow for a more effective response during extreme or adverse weather conditions, additionally local weather conditions will be studied for future resilience. Weather stations have been strategically placed to understand weather difference within regions.

7 weather stations have been installed at the following locations:

- » Cardiff Bay
- » Pontypridd
- » Treherbert
- » Aberdare
- » Merthyr Tydfil
- » Cymbargoed
- » Rhymney

Each weather station is powered by batteries and a solar panel unit. The weather stations will supply us real-time data on the following weather variables:

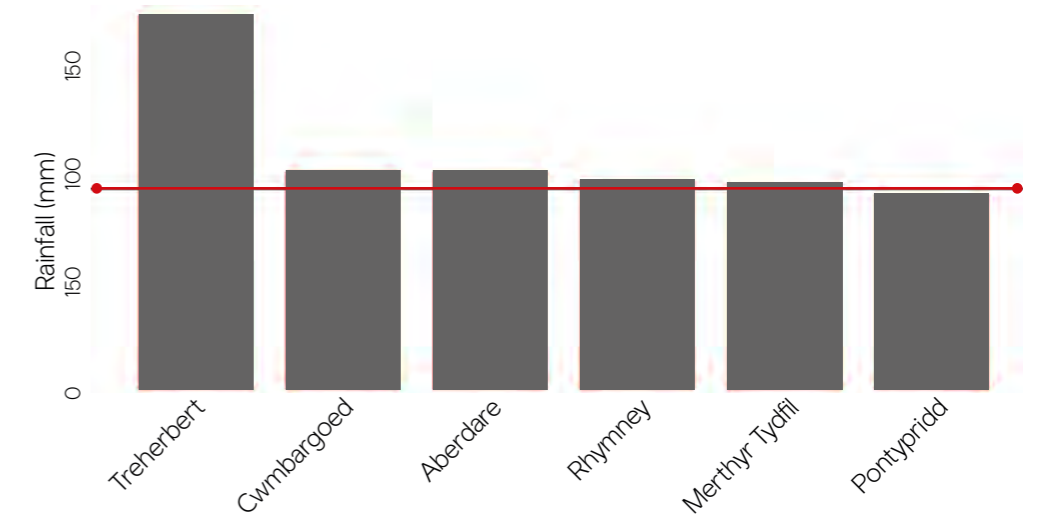
- » Wind speed and Direction
- » Wind gusts
- » Humidity
- » Total rainfall
- » Hourly rainfall
- » Temperatures
- » Barometric pressure
- » UV Index
- » Solar Radiation
- » Evapotranspiration
- » THSW (Temperature Humidity Sun Wind) Index
- » Soil moisture profile (at Cwmbargoed only)
- » Leaf Wetness (at Cwmbargoed only)

The weather station at Cymbargoed has a long-range antenna that checks an active earth movement site for soil moisture and leaf wetness – increasing our resilience at times of adverse weather. Rainfall differentiation within September and October at each of the weather stations can be seen on the next page. This analysis helps us understand how local micro-climates can influence conditions felt on the ground in comparison to the overview presented in regional projections. Almost half of the entire month's rainfall was recorded at the Treherbert weather station in just one day. However, a prolonged period without precipitation was previously recorded at Treherbert, leaving the infrastructure vulnerable to events such as flash flooding and earth movements.

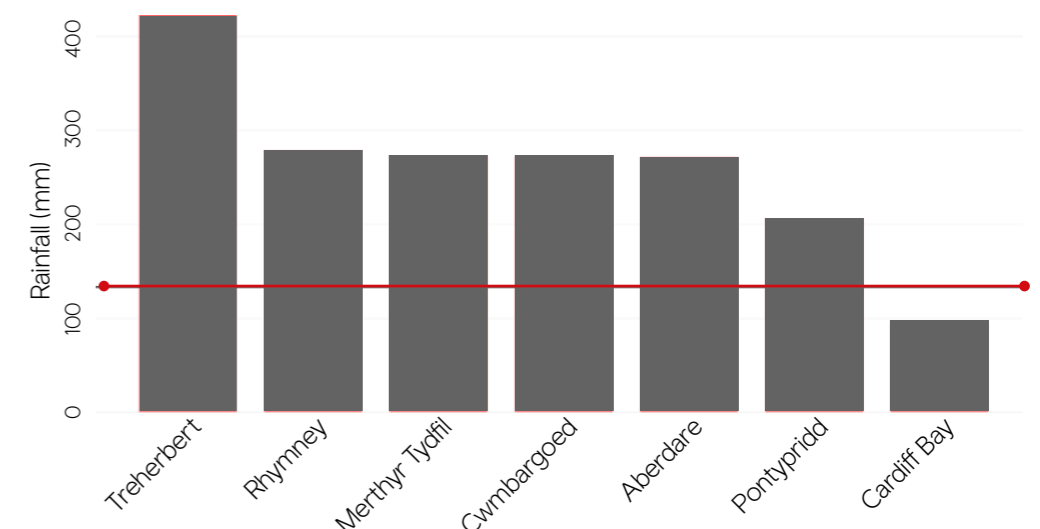
All weather stations except Cardiff Bay reported higher rainfall than usual for October. Treherbert weather station recorded 444mm of rainfall within October, more than triple the amount expected in October for the South Wales Region. Winds speeds also vary with 40mph and 13 mph recorded on the same day during October. This information will help teams recognise hazards that might arise from wind, such as falling trees and wind-blown objects, allowing resources to be directed to these areas.

We'll use the same national alert levels for weather risk used by Network Rail. The Asset Management team will closely watch forecasting at these sites, through desktop and mobile applications, helping our teams respond to and prepare for any adverse weather events that affect the CVL. We can also monitor local air quality through the installation of added equipment, and we'll explore the potential for air quality monitoring across the CVL.

Rainfall during September 2022



Rainfall during October 2022



Storm Dennis case study

Storm Dennis occurred 15-16 February 2020 and saw widespread high winds and heavy rainfall across the UK. South Wales was severely impacted by the storm, with 157.6mm of rainfall being recorded at Crai Resr in Powys. Significant flooding occurred as rivers reached capacity, resulting in traffic disruption, property damage and people being evacuated.

An estimated 900 tonnes of water per second was flowing down the River Taff at the peak of the flood, which is enough to fill an Olympic sized swimming pool in 3 seconds.

The level of the River Taff at Pontypridd was 5.324m (compared to a usual level of 1.2m) on 16 Feb 2020, which is the highest level ever recorded on the river at this location. All rivers that flow within the CVL area reached their peak flow, with many bursting their banks.

The storm caused significant impacts across the Core Valley Lines, between 15-16 February 2020, 32 incidents were reported as a result of the storm. The majority of incidents were flooding-related and resulted in 744 minutes of delays, many sections of the track were inoperable due to high water levels, debris washed on the track and damage to signalling equipment.

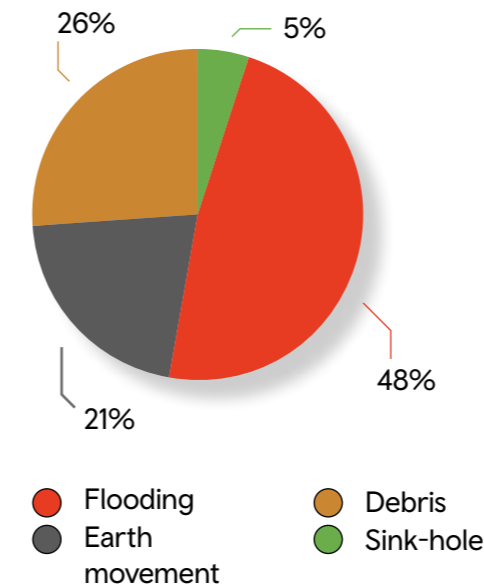
Overall, eight lines were closed temporarily – five due to flooding and three because of earth movements. One sinkhole incident between Bargoed and Tir-phill stations caused 558 minutes of delays. Due to the widespread impact of the storm, many alternative routes of travel had also been impacted, meaning areas within the local community were inaccessible.

Although the initial response to the storm took approximately 3 days to recover and reopen lines, there have been knock-on effects and damage to the infrastructure that meant temporary precautionary speed restrictions were put in place and are still in place today, impacting passengers' long term.

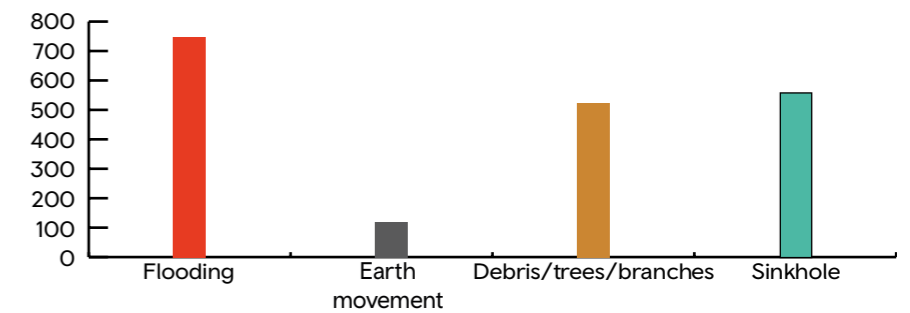
Due to the timing of the event aligning with asset transfer, it's unclear the true recovery time or costs related to Storm Dennis. Remedial works are still ongoing from Storm Dennis, with one section of track likely to reach over £2.5 million in repair costs.

It's likely that the CVL network is going to be increasingly vulnerable to similar events in the future.

Incidents on the CVL during Storm Dennis



Delay Minutes caused by Storm Dennis-related Incidents on the CVL



157.6mm

of rainfall being recorded at Crai Resr in Powys. Significant flooding occurred as rivers reached capacity

744

Flooding resulted in 744 minutes of delays, as services were inoperable on some sections of the track.

8

In total, eight lines were closed. Five due to flooding and three because of earth movements on tracks.

Many parts of the railway are located adjacent to the river and liable to flood if river levels increase by more than a couple of metres. Areas of the CVL that are of particular concern are Cwmbach on the River Cynon, Mountain Ash on the River Cynon, Trehafod on the River Rhondda, Dinas Rhondda on the River Rhondda, and Taff's Well on the River Taff.



Vulnerability to future climate change

Future climate change projections for Wales

Climate projections for our assets

Rainfall – Projected mean change during winter

Rainfall projections – Summer and winter 1-day extremes

Temperature projections – Average change during summer

Temperature projections – Summer extremes

Sea-level rise

Summary of key climate change risks likely to impact TfW

Interacting risks

Vulnerability to future climate change

Future climate change projections for Wales

We're already starting to see the impacts of climate change in Wales. Annual mean rainfall in Wales has increased by 2% between 2010-2019. The heatwaves of summer 2022 saw Wales' hottest temperature record broken, with a new high of 37.1°C recorded in Flintshire.

On 19th July 2022, our weather monitoring equipment in Aberdare recorded a high of 34.1°C and on the 14th August a temperature of 35.1°C was observed in Pontypridd.

If we do nothing to curb emissions, it is possible that global warming of 4°C could be possible by the end of the century. Warming of this magnitude is likely to result in exceeding tipping points in our climate system. In a 4°C warming scenario and with the current level of adaptation, [Wales could expect annual flooding damages \(in £m\) to increase by 64% by 2080.](#)

While limiting the extent of climate change through emissions reductions and removals remains essential for Wales, global warming to some degree is already considered "locked in" due to past consumption of fossil fuels. Adaptation to climate change becomes increasingly critical.



Climate projections for our assets

Climate scientists at the Met Office Hadley Centre have produced climate projection data to indicate how climate change will likely affect us in the UK. The first series of UK climate projections were produced 1998 (UKCP98) and subsequently in 2002 (UKCP02), 2009 (UKCP09) and 2018 (UKCP18). For UKCP18, UKCP09 data was built upon using cutting-edge projection tools and climate science to provide updated observations and climate change projections out to 2100 in the UK and globally.

The Climate Change Committee advised that good climate adaptation should "prepare for 2°C warming, assess the risks for 4°C". However, UKCP18 scenarios do not align explicitly with 2°C and 4°C, so this principle is difficult to explicitly apply.

UKCP18 climate scenarios are based on Representative Concentration Pathways (RCP). RCPs are capture assumptions about the influence of future economic, social, and physical changes on levels of greenhouse gases within a set of climate scenarios. The pathways help model changes in concentrations of greenhouse gases which could lead to more solar energy being retained in the atmosphere than what is lost (global warming).

There are four different RCPs, ranging from RCP2.6 (a pathway where greenhouse gas emissions are strongly reduced) to RCP8.5 (a pathway where greenhouse gas emissions continue to grow unmitigated). The following table illustrates the range of projected temperature change for each climate scenario (RCP).

RCP	Change in temperature (°C) by 2081-2100
2.6	1.6 (0.9-2.3)
4.5	2.4 (1.7-3.2)
6.0	2.9 (2.0-3.7)
8.5	4.3 (3.2-5.4)

We've developed a TfW Climate Change Risk Assessment (CCRA) Framework and accompanying document to standardise the organisations assessment of climate risks and opportunities. The document is based upon the UKCP18 climate projections which relate specifically to a 25km grid square covering our owned-assets in the CVL region.

Projection data has been sourced from the Met Office dataset to help our engineers/designers assess climate risk for temperature, precipitation, climate extremes (temperature and precipitation), humidity and sea-level rise.

As our service provision grows, we'll look to develop further guidance to support the assessment of climate risk on our wider transport network. Network Rail utilise their own [Climate Projections Guidance](#) to support the assessment of climate risk across the Wales and Borders network.

Maintaining current and future passenger safety is the primary objective of climate adaptation, we'll assess climate risk across our assets and services on the CVL for high and very high levels of global warming scenarios:

RCP6.0 (high global warming scenario).

This pathway is roughly equivalent to +2°C warming.

RCP8.5 (very high global warming scenario).

This pathway is roughly equivalent to +4°C warming.

The UKCP18 projections are provided in a 10-90th percentile range (lowest likely values to highest likely values) to indicate the scale of in uncertainty of the projected future change in each climate variable. Projections are for summer and winter only, to understand how temperature and rainfall are likely to change during these key seasons for the railway.

Due to uncertainties in ice sheet response to warming temperatures, we'll assess coastal climate risk against the very high warming scenario only to determine the projected mean rate of sea-level change that could affect our assets in the Cardiff Bay area. All mean sea-level projections are at the 95th percentile, providing us with a worst-case scenario reference case.

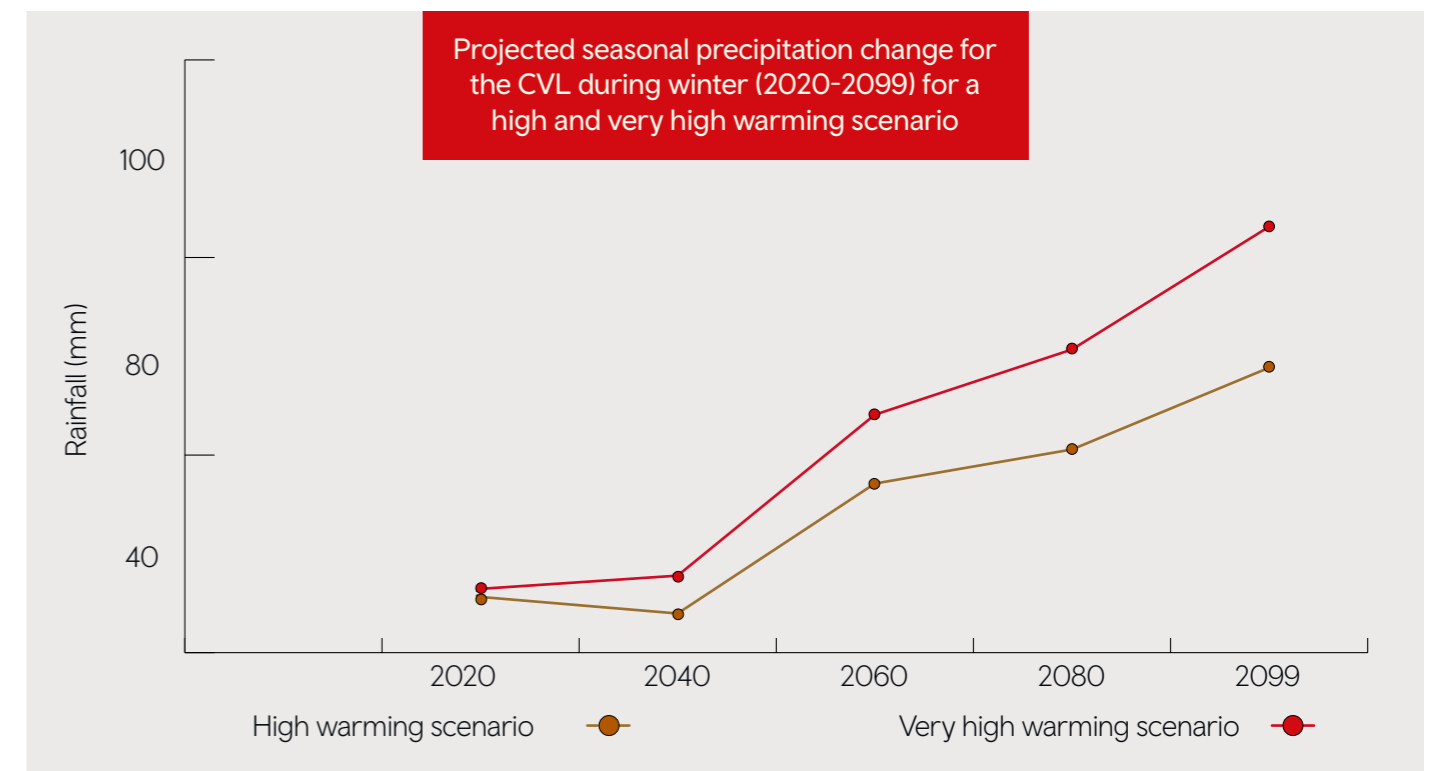
For assessment of future river and surface-water flood risk under climate change, we're referring to [Welsh Government's Flood Consequences Assessment: Climate change allowances guidance](#).

The headline findings for the CVL suggest that summers will become hotter and drier, with periods of intense rainfall. Winters will become milder and much wetter, with an increase in daily rainfall. Temperature extremes could exceed 40°C by 2060 which could lead to periods of drought. However, precipitation extremes are projected to be worse during the summer than the winter, which could lead to increased occurrence of surface-water flooding. Sea-level along the Cardiff coastline is also set to steadily rise throughout the century, increasingly rapidly towards the 2100.

Rainfall – Projected mean change during winter

The graph below shows us the likely percentage change in the amount of rainfall (precipitation) we receive across the CVL during winter in a high (+2.8°C) and very high global warming scenario (+4°C).

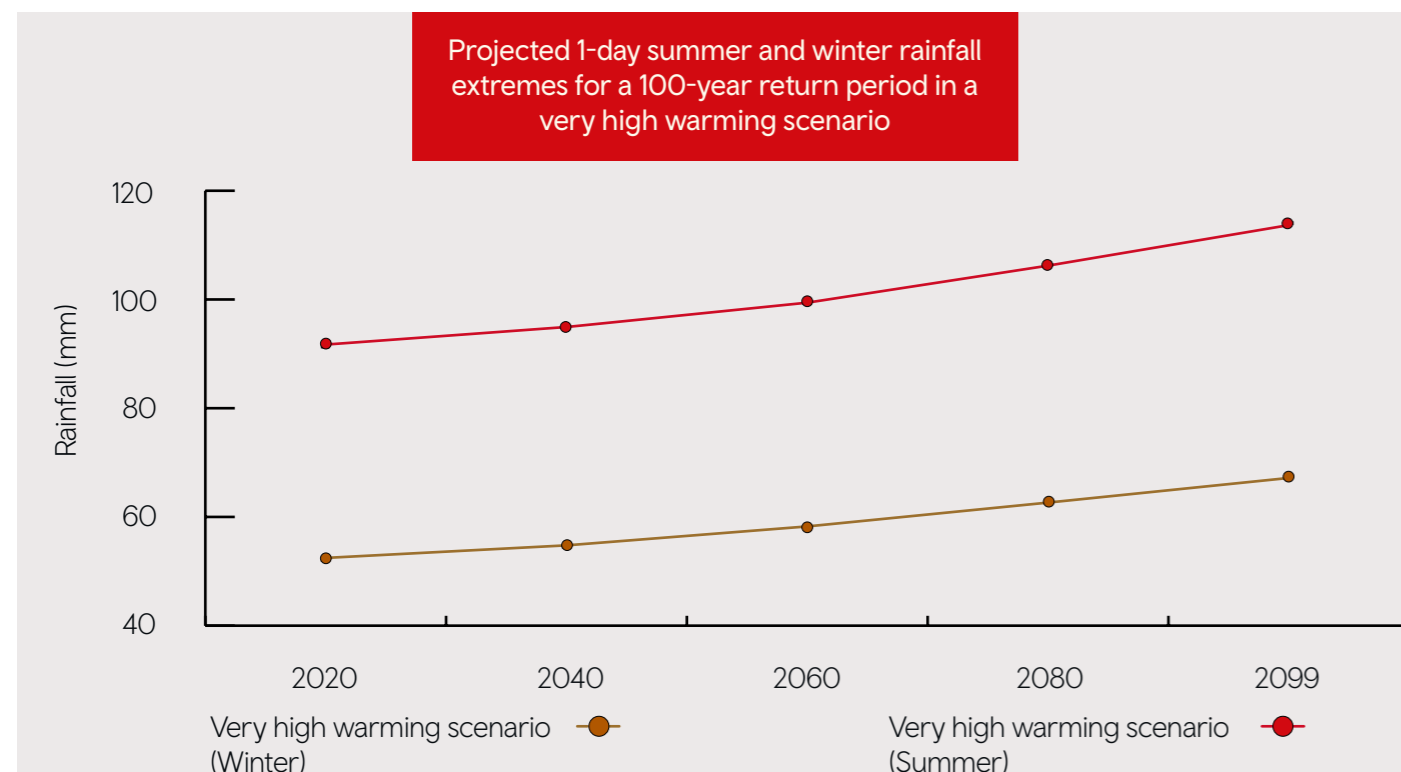
Under the very high global warming scenario, we could see a potential 83% in winter rainfall by the end of the century. All projections are measures at the 90th percentile against a 1981-2000 baseline.



Rainfall projections – Summer and winter 1-day extremes

Extreme 1-day rainfall (for a 100-year return period) is projected to progressively worsen for the CVL throughout the century. By 2080, we could see 1-day summer rainfall extremes of up to 106mm in a very high warming scenario. By this epoch, we could see winter extremes of 63mm for the same scenario. Projections are for a 100-year return period at the 90th percentile. Short term, intense periods of rainfall in the summer could lead to flash flooding, especially after prolonged periods of heat where the ground dries and hardens. Due to the immediacy of the response needed, flash floods present significant risks to our network safety and service operability.

Extreme events, such as Storm Dennis, are expected to increase in frequency and severity due to climate change. The consensus is that storms will become more destructive, and winds will be stronger. Global projections indicate that extreme rainfall events are likely to become wetter and 30% more frequent, however this will vary regionally around the world

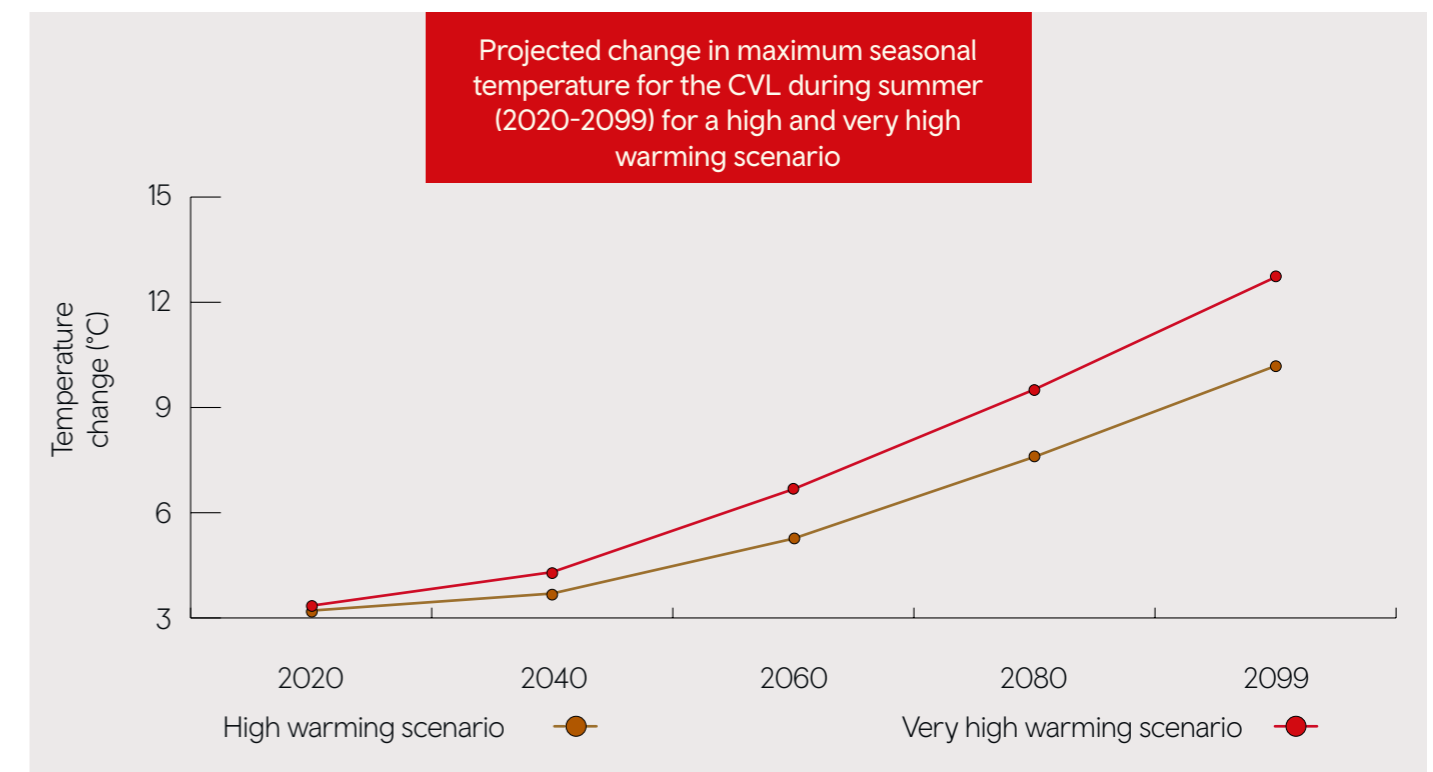


Temperature projections - Average change during summer

Our temperature projections for the CVL indicate the average projected change in minimum, mean and maximum temperature for the summer and winter season. The following graph indicates the likely change in maximum summer temperature between 2020 and 2099.

If the world warms by more than 4°C, maximum summer temperatures in the CVL are expected to increase by 12.7°C by 2099. Our current baseline maximum temperatures are 20°C. All projections are at the 90th percentile against a 1981-2000 baseline.

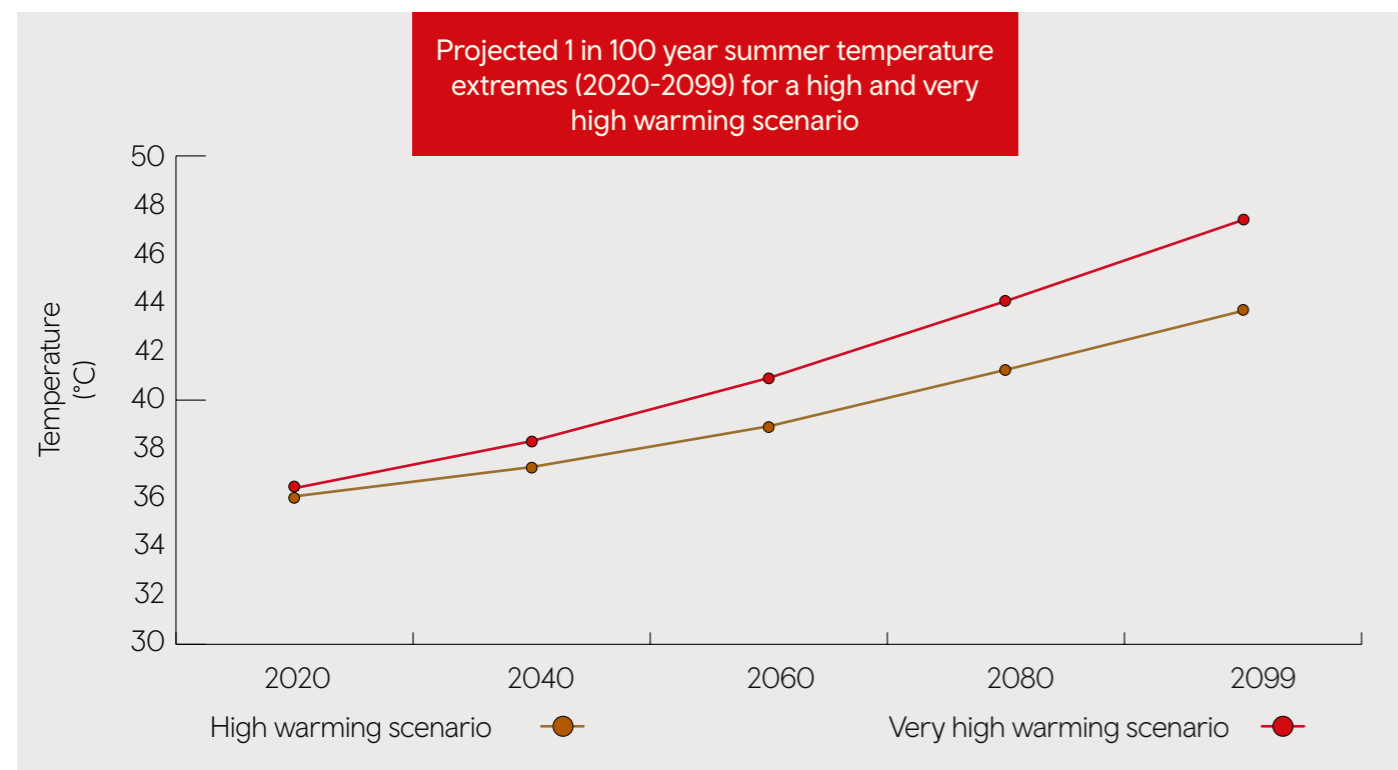
Between 2020-2099, mean summer temperatures are projected to increase by 70% in a very high warming scenario (RCP8.5). This will lead to more sustained, high temperatures throughout the summer season, leading to significant overheating risks for our assets and uncomfortable conditions for our customers and colleagues.



Temperature projections – Summer extremes

Global projections indicate that if the world warms by 4°C, heatwaves that would have occurred once every 50 years before the Industrial Revolution will likely occur 39.2 times every 50 years and will also be 5.3°C hotter. However, the change in the frequency and intensity of such events will vary dependent on where you are in the world.

The UKCP18 projections for summer temperature extremes indicate that by 2099 we'll experience highs of 44°C and 47°C under a high and very high warming scenario respectively. The projections in the graph are at the 90th percentile for a 100-year return period and measured against a 1981-2000 baseline.



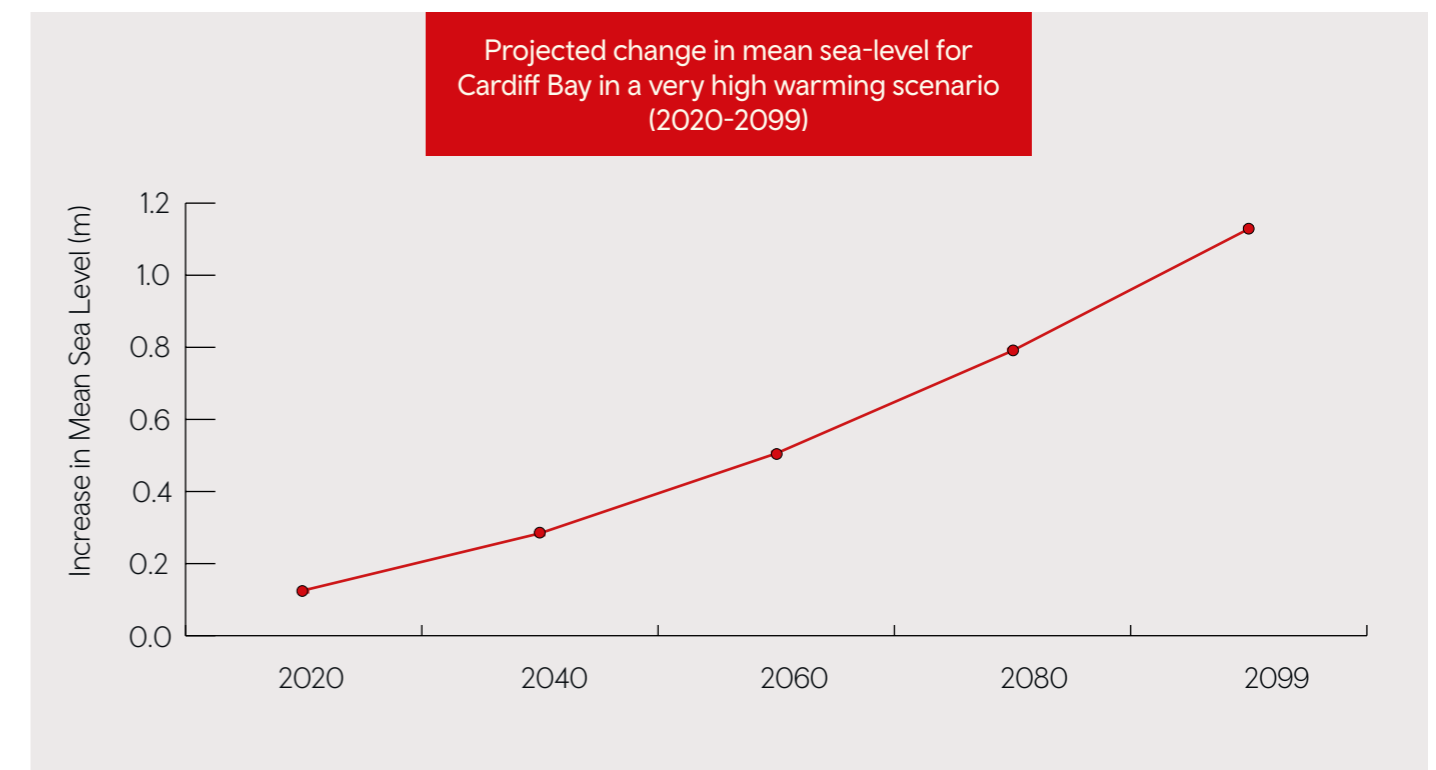
Sea-level rise

By the end of the century, mean sea-level along the Cardiff coastline could be as much as 1.13m higher if the world warms by more than 4°C under a very high warming scenario. Present coastal defences along the Cardiff coastline provide protection from flooding at a return period of 100 years, under current observations for mean sea level. However, analysis of the impact of sea-level rise on the standard of coastal defences estimate that with an increase in mean sea level of 0.35m, the current 100-year time-frame for protection could be reduced to 23 years.

The Cardiff Bay area will be at increasing risk of compounded climate risks due to the risk of riverine, surface-water and coastal flooding.

We'll perform flood risk assessments to measure our coastal based asset vulnerability to strengthen their resilience.

We'll also work closely with the Severn Estuary Coastal Management Group, as well as other core stakeholders such as Natural Resources Wales, to understand how coastal defences along the Cardiff coastline will be maintained and/or enhanced to provide our assets with sufficient protection against coastal flooding and erosion.



Governments worldwide are now starting to acknowledge that warming will continue throughout the course of the 21st century and adaptation is likely to become a key focus of climate change response planning in the years to come

Summary of key climate change risks likely to impact TfW

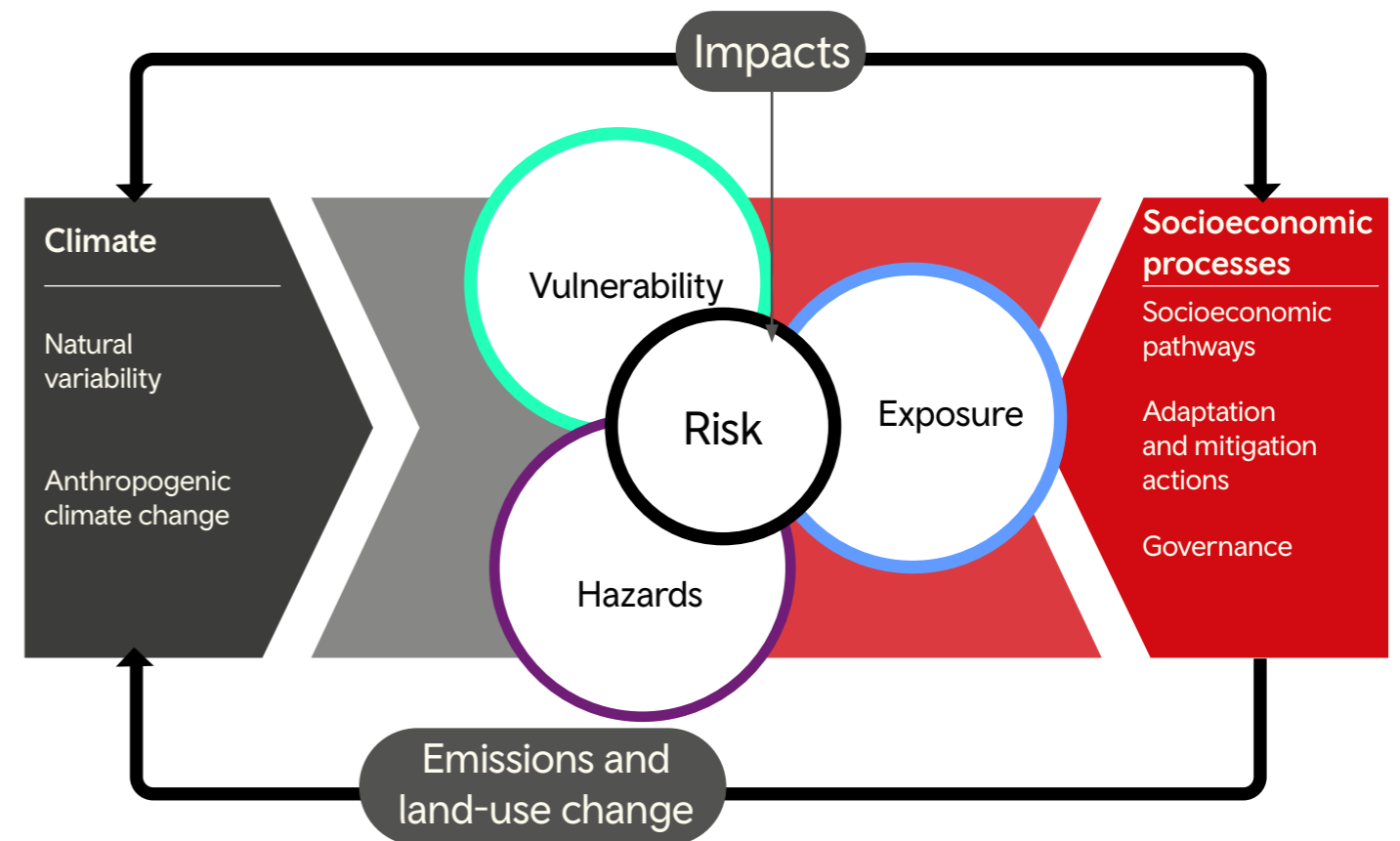
Climate-related risks arise from the interaction of the evolving exposure and vulnerability of human, socio-economic, and biological systems with changing physical characteristics of the climate system.

Projections indicate that our climate in the CVL will invariably continue to change, exposing new hazards and vulnerabilities.

The following diagram illustrates the inter-dependency between these factors and how they influence the process where climate risks become impacts.

For rail assets, the exposure to more frequent and severe extreme weather events poses significant risks to their longevity, reliability, operability and safety. Such hazards could also affect our supply chain, due to increased insurance premiums or adversely impacted transport routes.

We need to understand any potential vulnerabilities on our networks to minimise the extent of the impact caused by climate change-induced hydro-meteorological hazard



Climate risks could either be chronic (building up over time) or acute (the result of an extreme event). The Core Valley Lines (CVL) network is particularly exposed to both chronic and acute risks, whereby our assets are vulnerable to changes in rainfall patterns (chronic) and heatwaves (acute).

The extent of a chronic or acute climate risk is influenced by a combination of the climate hazard, the vulnerability and exposure of the asset. In a simplistic example, the risk to transport infrastructure from extreme heat – the hazard – involves the heat tolerance of rail infrastructure – its vulnerability – and the spatial location of rail infrastructure relative to the extreme heat – its exposure.

The transport sector is almost continuously subjected to hydro-meteorological hazards which impact upon operational efficiency, with railway infrastructure being particularly exposed and vulnerable to extreme weather.

This is representative for the rail sector in general and these relationships will likely differ per network/region. For instance for networks exposed to storm surges, this could lead to flooding, affecting signalling/electrical equipment.

It is likely that these relationships become more complex and adversely affected, as hydro-meteorological events become more frequent and intense with climate change.

The evidence is clear that our climate is changing, and we're already starting to witness the impact of more extreme weather conditions in South-east Wales. The geography of South Wales, with its upland relief, river systems and micro-climates, is likely to increase the vulnerability of the Core Valley Lines network to these impacts.

The UKCP18 climate projections for the CVL indicate that these changes will become more intense from 2040-2050 onwards – amplifying considerably towards the latter part of the century. The impacts of extreme weather on the Welsh transport network will become more and more critical, as the intensity of change increases, with high temperatures presenting the most extensive hazard, as it has the potential to adversely affect all rail assets

The existing CVL network has been built with the current and past climate in mind - with assets expected to operate at full capacity for more than 50 years. Therefore, to ensure continued network resilience as our climate changes in Wales, we'll begin assessing climate risk across all our networks and operations, with a view to integrate climate adaptation into long-term railway planning, design and management process. These assessments will begin in 2023 and will be conducted via a combination of desk and field based appraisals utilising the TfW Climate Change Risk Assessment Framework and Guidance.

In the absence of this data, a high-level review of the third UK Climate Change Risk Assessment has been conducted with a focus on the rail sector in Wales to indicate the likely risks we'll face.

Relationship between climate risk and rail assets

	Railway civils	Railway structures	Track	Signalling	Electrical	Overhead wiring	Telecoms
High temperatures	●	●	●	●	●	●	●
Low temperatures	●	●		●		●	●
High Winds	●	●		●		●	
High sea-level and storm surges	●	●	●				
High rainfall	●	●	●				
Lightning and electrical storms	●	●					
Low rainfall	●						



The climate change risk assessment for our network and operations will be designed and delivered based upon the latest data on climate change risk and impacts

Summary of climate change risks to infrastructure networks (from UKCCRA3) that are relevant to the CVL rail network

Risk	Cause	Impact for TfW	Future considerations
Risks to infrastructure networks from cascading failures	<ul style="list-style-type: none"> » Coastal, river or surface-water flooding » Lightning strikes/high winds » Heatwaves 	<ul style="list-style-type: none"> » Compound hazards » Power outages » Equipment failure » IT and communications failure » Travel disruption and delay » Freight delays » Impacts on passenger livelihoods and local businesses » Rural communities cut off 	<ul style="list-style-type: none"> » Increased likelihood of flooding and extreme weather events in 2°C and 4°C warming scenarios » High magnitude risk for Wales by 2050 & 2080 in both scenarios » Risk of lock-in increases due to growing reliance on electricity for decarbonisation
Risks to infrastructure services from river and surface water flooding	<ul style="list-style-type: none"> » Extreme weather events/storms » Intense, prolonged periods of rainfall » Exceeding infiltration rates leading to soil saturation » Urbanisation of local area » Discharge into rivers exceeds capacity 	<ul style="list-style-type: none"> » Damage to rail track and assets » Equipment failure » Transport accidents » Health and safety risks » Disruption of water supply » Localised travel disruption/delay » Cascading disruption down the network » IT and communications failure » Freight delays » Power outages as flooding impacts electricity network » Slope/embankment failure » Rural communities cut off » Impacts on passenger livelihoods and local businesses 	<ul style="list-style-type: none"> » 345km track and 30 stations in Wales at risk of river flooding, a large proportion will most likely be within CVL » 809km track and 79 stations in Wales at risk of surface water flooding - as above, risks increased for CVL » Potential doubling of surface water flooding risk (up to 100% for railway lines) projected by the 2080s » Risk of surface water flooding increases in absence of adaptation » Potential for lock-in if flood defences / storm-water systems are under-engineered to cope with projected changes in climate » Geography of South Wales may mean that the Core Valley Lines network becomes increasingly exposed to extreme rainfall events

Risk	Cause	Impact for TfW	Future considerations
Risks to infrastructure services from coastal flooding and erosion	<ul style="list-style-type: none"> » Increase in average global sea levels due to glacial retreat and thermal expansion » Storm surges during extreme weather » Inadequate/absent coastal defences » Underlying coastal morphology » Additional discharge from rivers and estuaries 	<ul style="list-style-type: none"> » Scour at the foot of coastal defences » Compound flooding » Damage of track and assets » Equipment failure » Localised travel disruption/delay » Cascading disruption down the network » Freight delays » Health and safety risks » Power outages as flooding impacts electricity network » IT and communications failure » Slope/embankment failures » Impacts on passenger livelihoods and local businesses 	<ul style="list-style-type: none"> » 312km of track and 12 rail stations in Wales at significant risk of coastal flooding - Cardiff Bay likely to be one of these locations » Risk of coastal flooding to rail track could increase by 60% by 2080 » Risk of coastal flooding to stations increases by 10% by 2080 » Increased coastal erosion in areas where population growth and development encroach into low-lying coastal areas » Risk of lock if flood defences are not upgraded to withstand future scenarios » Risk of compound events likely for urbanised estuarine/coastal areas, ie. Cardiff Bay
Risks to bridges and pipelines from flooding and erosion	<ul style="list-style-type: none"> » Prolonged and intense periods of rainfall » Extreme weather events (storms) » High peak river flows » Extreme temperatures » Urbanisation of local area » River/surface water flooding » Shrink-swell of materials due to fluctuating wetting and drying 	<ul style="list-style-type: none"> » Bridge failure/damage » Transport accidents » Health and safety risks » Localised travel disruption/delay » Cascading disruption down the network » Freight delays » Slope/embankment failures » Track/asset damage » Equipment failure 	<ul style="list-style-type: none"> » Increased winter precipitation in 2°C and 4°C warming scenarios will increase scour at bridge foundations due to higher peak river flows » 20% allowance for climate change within bridge design likely to be exceeded in warming future scenarios, increasing risk of scour » Risk of lock-in due to bridge design lives of 50-100 years » Risk of thermally-induced stresses in bridge structures and drying out of embankments leading to accelerated weathering-related deterioration, as temperatures increase

Risk	Cause	Impact for TfW	Future considerations
Risks to transport networks from slope and embankment failure	<ul style="list-style-type: none"> » Prolonged periods of intense rainfall » Extreme temperatures (heat) leading to desiccation cracking » Freeze-thaw and shrink-well » Upland topography » Age/construction of embankments 	<ul style="list-style-type: none"> » Derailment » Transport accidents » Cascading disruption down the network » Health and safety risks » Localised travel disruption/delay » Impacts on passenger livelihoods and local businesses » Freight delays » Rural communities cut off » Track/asset damage » Equipment failure » Scour-related embankment failure due to high peak river levels and flooding 	<ul style="list-style-type: none"> » Railway cuttings at significant risk of high-impact slope failures in 2°C and 4°C warming scenarios » Coal tips in SW Wales at high risk of future failure – many are near to the rail network » Rising temperatures and increasing precipitation expected to increase the rate of deterioration processes » Extreme weather, coupled with ageing, less compacted assets, may cause a higher rate of failure
Risks to transport from high and low temperatures, high winds and lightning	<ul style="list-style-type: none"> » Extreme temperatures (heat or freezing) » Extreme weather, such as winter storms, causing high winds and lightning » Ageing assets » Dependence of equipment on electricity and electric components » Cascading failures 	<ul style="list-style-type: none"> » Track buckling, overhead cable sagging, signal failure » Speed restrictions » Fallen branches/trees and debris on the line » Equipment failure » Line-side fires » Power outages » Transport accidents » Health and safety risks » Travel disruption/delay » Freight delays » Rural communities cut off » Track/asset damage » Impacts on passenger livelihoods and local businesses » Cascading failures » Opportunities arising from fewer snow and ice days to reduce winter maintenance costs » Reduced number of maintenance days due to exposure of colleagues to heat stress 	<ul style="list-style-type: none"> » Modern signalling is more susceptible to heat due to its dependence on electricity » Eight-fold increase in the annual cost of buckling likely by the 2080s under a high emissions scenario » The heatwave season is expected to expand from July–August to May–September by the 2040s » In a 4°C warming scenario, Wales is projected to experience up to 40+ days with temperatures above 26°C by 2080 » Longer growing seasons expected to increase vegetation growth rates, increasing the number of tree-related faults and disruption

Interacting risks

Our transport networks will be directly affected by some climate change risks – flooding of rail track, for example – but some impacts are not discrete and can cascade through multiple sectors.

Assessing climate change risk should take into consideration the complex interdependencies with other variables such as other infrastructure sectors, supply chain and local geography. Running our services is dependent on external factors such as energy supply, telecommunications, and a robust supply chain.

It is possible that climate hazards could render our services inoperable due to impacts outside our direct control.

Climate interdependencies also work in reverse, whereby many stakeholders, such as local communities and business, are dependent on us operating a reliable service.

An assessment of interacting climate risks should also be undertaken to identify those which have the potential to affect the overall severity of the risk or trigger others.

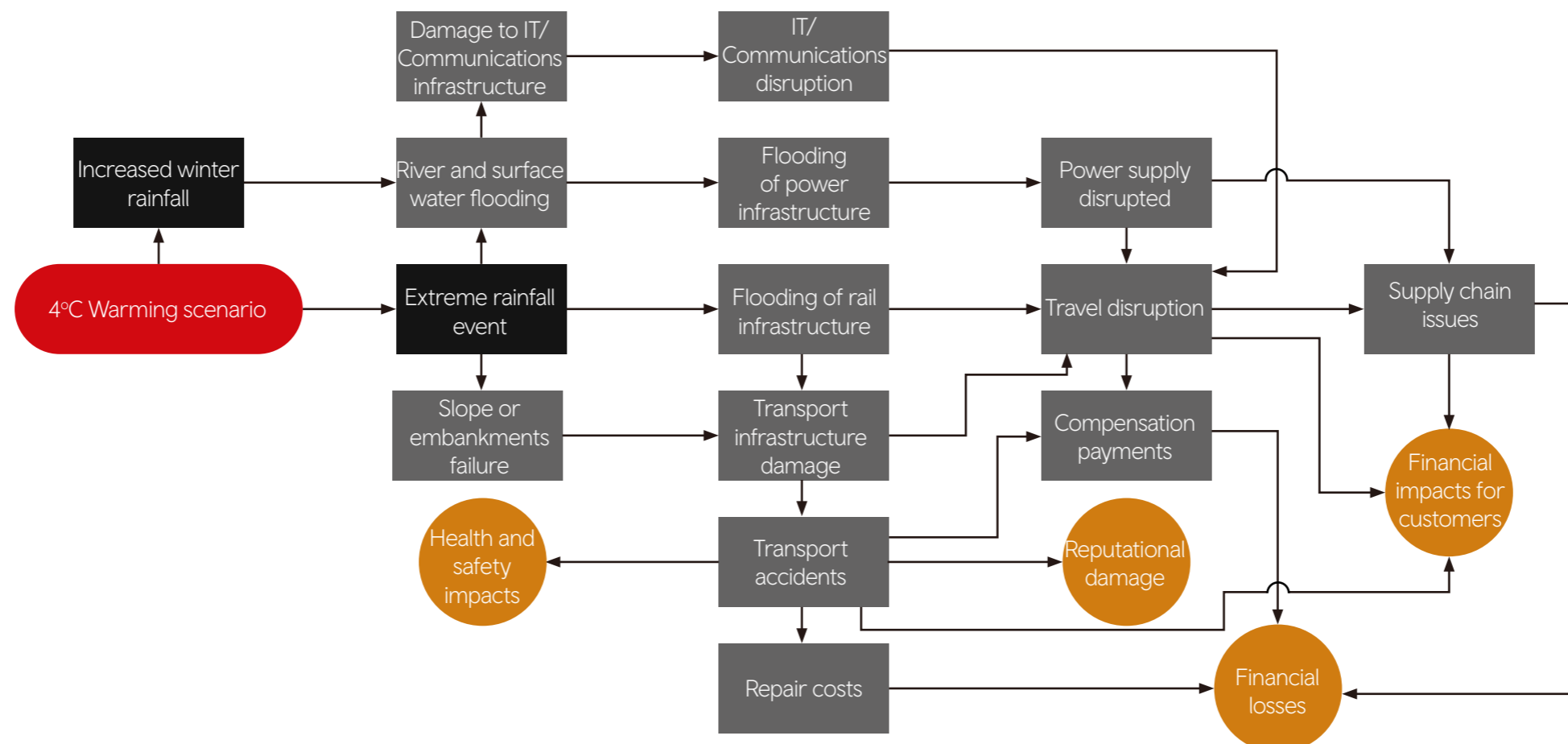
Interacting risks can be:

- » Compound - risks occur when one or more climate drivers affect each other to increase the magnitude or overall severity of the risk.
- » Cascading - risks result when one risk triggers multiple other risks – high winds lead to power and telecoms failures > widespread transport disruption > economic impacts (eg. supply chain issues).
- » Aggregated - risks occur when unrelated hazards (such as flooding and disease outbreak) happen simultaneously, exacerbating the level of overall impact.

A framework will be developed, based upon research conducted in support of the third UK Climate Change Risk Assessment, to ensure climate change risk assessments consider potential interacting risks that are likely to impact upon TfW networks and services.

The aim of the framework is to identify any complex risks presented by interdependencies. The risk of cascading failures may make climate resilience more challenging for TfW due to our dependence on other infrastructure providers to operate services. The following flowchart provides an example of the type of interacting climate change risks TfW is likely to encounter

Rainfall-induced cascading failures in a very high warming scenario





A resilient TfW

Climate Change Adaptation Framework

Building resilience into our operations

Governance, standards and guidance

Flood risk

Health and well-being of our passengers and colleagues

Building resilience into our operations

Co-benefits of climate resilience

A Low Carbon Wales

Socio-economic prosperity

Co-benefits of climate resilience

Socio-economic prosperity

Building climate-resilience into all that we do

Framework for climate adaptation

Climate adaptation consists of a series of actions that have the potential to reduce the negative impacts of global warming, while maximising benefits that are occurring now or will occur in the future.

Good adaptation should act to minimise the risks and maximise the opportunities presented from climate change.

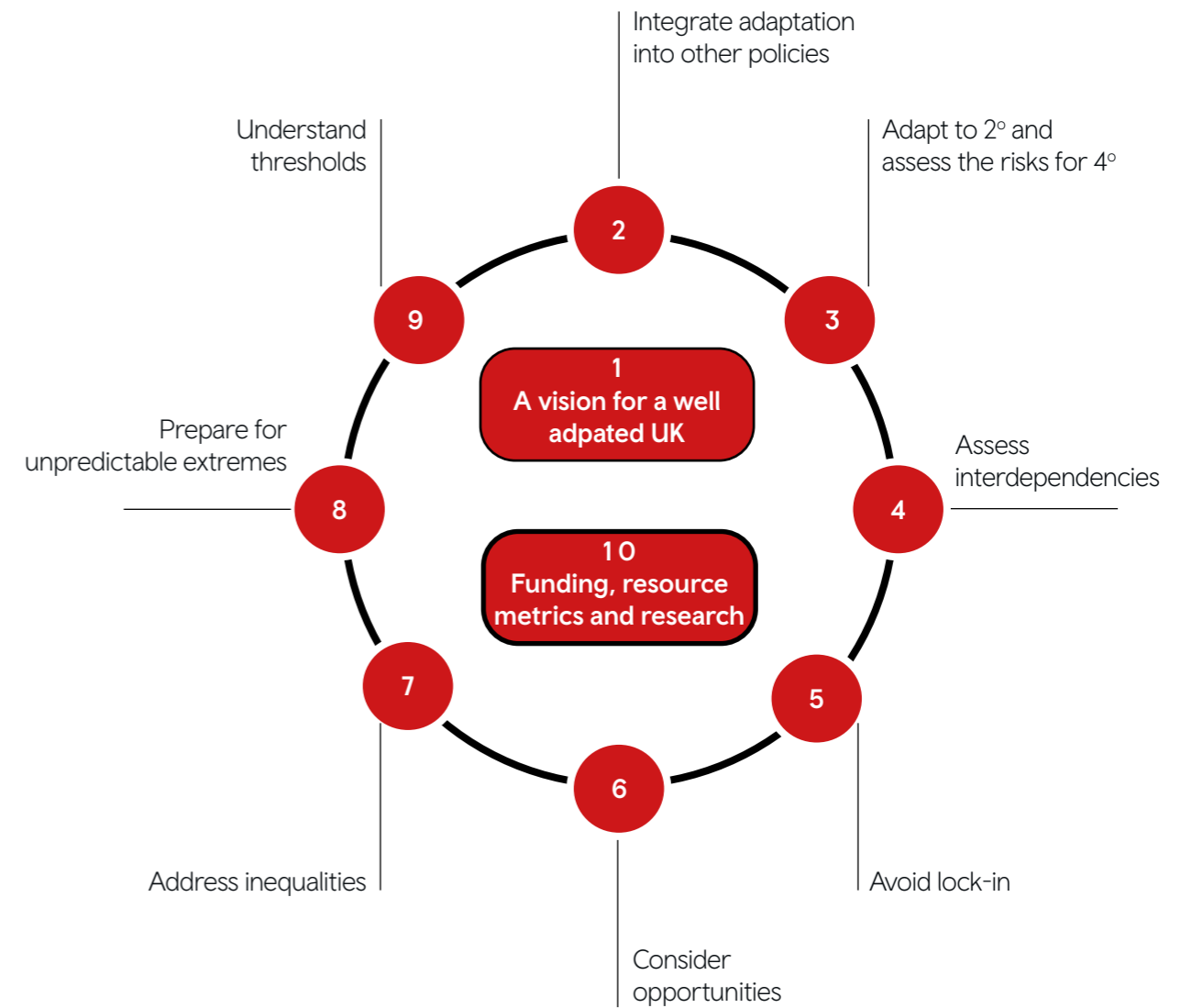
These can include:

- » Maximising socio-economic benefits
- » Maximising opportunities for biodiversity and natural environment enhancements
- » Having a neutral/positive effect on social equity
- » Minimise negative consequences that result from human-induced climate change, for example flooding

The UK's Climate Change Committee recommend following a series of ten principles for good adaptation. These principles are integral to this document and future climate-resilience delivery plans.



10 principles for good adaptation



Adaptive capacity, standards and guidance

The CVL Climate Change Adaptation Working Group will lead on the implementation of a specific CVL Climate Adaptation Delivery Plan which focusses on increasing the resilience of our owned rail assets. The working group will report into the overarching Climate Adaptation Steering Group which has been set up to provide TfW with the strategic direction and level of accountability to monitor our progress to increase our adaptive capacity to climate change. More detail can be found in the Governance section of this plan.

The intention of this plan is to create a network that can endure the impacts presented by extreme and/or adverse weather conditions now and in the future.

Our Asset Management team already have robust procedures in place to respond to provide an existing level or resilience to present day extreme/adverse weather

These standards and guidelines include:

- » Network Rail Drainage Standard - NR/L3/CIV/005
- » Hot weather guidelines for Permanent Way - 8000-1 Issue 02
- » Environment and Social Performance Policy – NR/L1/ENV/100
- » Environment and Social Minimum Requirements NR/L2/ENV/015 (followed by our Programme Management Office)

We'll conduct a comprehensive climate change risk assessment across the CVL network to ensure we're able to identify vulnerabilities and review existing procedures to so we can respond to extreme weather events.

Understanding our climate change risk requires assessment and threshold testing against appropriate climate change scenarios. A guidance document has been developed to provide engineers and designers with a robust framework for assessment of climate risk through the autonomous application of UK Climate Projections (UKCP18). The document will provide TfW with a consistent resilience level through an approved framework for threshold testing against climate scenarios applicable to the CVL. Additional guidance will also be developed to support the assessment of climate change risk on assets/services outside of the CVL.

The International Standards Organisation (ISO) have created a specific standard for climate change adaptation – ISO 14090:2019. The standard provides organisations with an internationally-regarded framework for the consideration of consider climate change adaptation when designing and implementing policies, strategies, plans and activities.

We're working towards aligning our adaptation planning to the ISO 14090:2019 standard to support us embed resilience across our maintenance, design, construction, and operational programmes.

This work will be further expanded to explore how we can enable cost-effective assessment of organisational capacity for climate adaptation, through the implementation of adaptation pathways. The pathways methodology is an innovative approach to climate planning which establishes a series of sequential actions that may be taken over time based on defined thresholds and trigger points.

The pathways approach helps organisations effectively plan and manage the costs associated with climate adaptation by understanding the trigger points when a system may fail. We're exploring how the British Standards Institute standard BS 8631: Adaptation to climate change - Using adaptation pathways for decision making, can support our adaptation planning through the identification of trigger points for investment in resilience enhancements.

We'll consult on the development of guidance for the implementation of adaptation pathways for the CVL.



Increasing our resilience to flooding

Traditionally, the rail infrastructure has been built following major community centres, originally built in close proximity to the river Taff, or between valleys. This historic infrastructure exposes the track, buildings and rolling stock to high risk from flooding, earth movements and damage from extreme weather.

Analysing of severe weather impacts on our network has indicated that flooding is one of our primary risks. Existing CVL rail infrastructure has been built following major community centres near to rivers or between valleys. Resultantly, our track, station buildings and rolling stock are exposed to elevated risk of riverine flooding. As our communities have further urbanised, our vulnerability to surface-water has increased due to reduction in free-draining ground. Appendix 1 illustrates our present-day flood risk across the CVL network.


Our in-house weather forecasting system will enhance our monitoring capability and preparedness for extreme rainfall and flood risk via real-time observation of weather conditions in the CVL region. This will ensure we're able to respond timely in the event of forecasted heavy rainfall and storm events which will increase our susceptibility to flooding on the track.

We presently follow existing regulatory guidelines to assess flood risk when carrying out any development works in the CVL. These guidelines contain allowances to ensure uplift for climate change is factored into design and construction. The Climate Change Committee have expressed concerns that existing climate change allowances used across the rail industry are likely to be exceeded in future climate scenarios

Our Climate Change Risk Assessment Framework requires users to assess flood risk by referring to [Welsh Government's Flood Consequences Assessments: Climate change allowances](#). As the CVL is a flood-prone region, we'll also consult on a more robust approach for the assessment flood risk which aligns to the +2°C and +4°C warming scenarios. We'll also look to ensure these climate change scenarios are reflected in a revised CVL flood risk map.

UKCCRA3 indicated that an estimated 312km of track and 12 stations in Wales are at significant risk of coastal flooding. Coastal flood risk could increase by as much as 60% by 2080 and current projections show that sea-levels could rise by around 1.13m in Cardiff Bay by 2100 under a very high warming scenario. Sea-level rise coupled with more frequent and severe storms could result in increased wave action and coastal erosion.

Due to vertical land movement and variations in ocean temperature and currents, the extent of sea-level rise is difficult to predict. The Severn Estuary Shoreline Management Plans management policy consists of a "hold the line" approach for the next 100 years. We'll assess coastal flooding and erosion risk following [Welsh Governance guidance](#) and consult with wider stakeholders, to ensure we're developing appropriate levels of preparedness for our assets in the Cardiff Bay area.



An estimated 312km of track and 12 stations in Wales are at significant risk of coastal flooding.

Co-benefits of climate resilience

Health and well-being

Climate change is likely to increase the frequency and intensity of extreme events, such as heat-waves, which can negatively impact upon our health and well-being.

The 2022 heatwave was unprecedented in the UK, with record-breaking temperatures of 40.3°C seen in Lincolnshire and devastating wildfires in and around London. A national emergency was declared by the UK Government as the Met Office announced the first ever red weather warning for heat-waves. Rail services were significantly disrupted, with services in areas covered by the red weather warning cancelled to keep staff and passengers safe. The 2018 UK heatwave resulted in 864 heat-related deaths, overheating thresholds exceeded in hospitals and an estimated 40-50% increase in rail asset failure

Global heating could also alter the geographic distribution of vector and water-borne diseases – increasing the risk of pandemic outbreak. Flash flooding risk is also expected to increase during the summer months, with the severity of extremes increasing for every 0.5°C of warming. It presents direct risks to the safety of passengers and colleagues, in addition to indirect risks such as infections, water-borne diseases and mental health impacts.

We're committed to safeguarding the safety and well-being of our customers and colleagues now and in the face of future climate change. We'll develop management and response plans to reduce the impact of extreme weather and disease outbreaks on the health and well-being of our customers and colleagues.

A low carbon Wales

A Low Carbon Wales aims to decarbonise the transport sector by increasing modal shift from the private car to sustainable methods of travel (including walking and cycling).

We're committed to supporting the Welsh Government deliver on its decarbonisation targets by facilitating demand reduction, modal shift and a switch to low carbon technologies.

While reducing emissions is vital to limit the extent of further climate change, it's highly possible that changes to our climate system are locked-in due to past emissions and lack of cohesive, global ambition to decarbonise at an earlier stage.

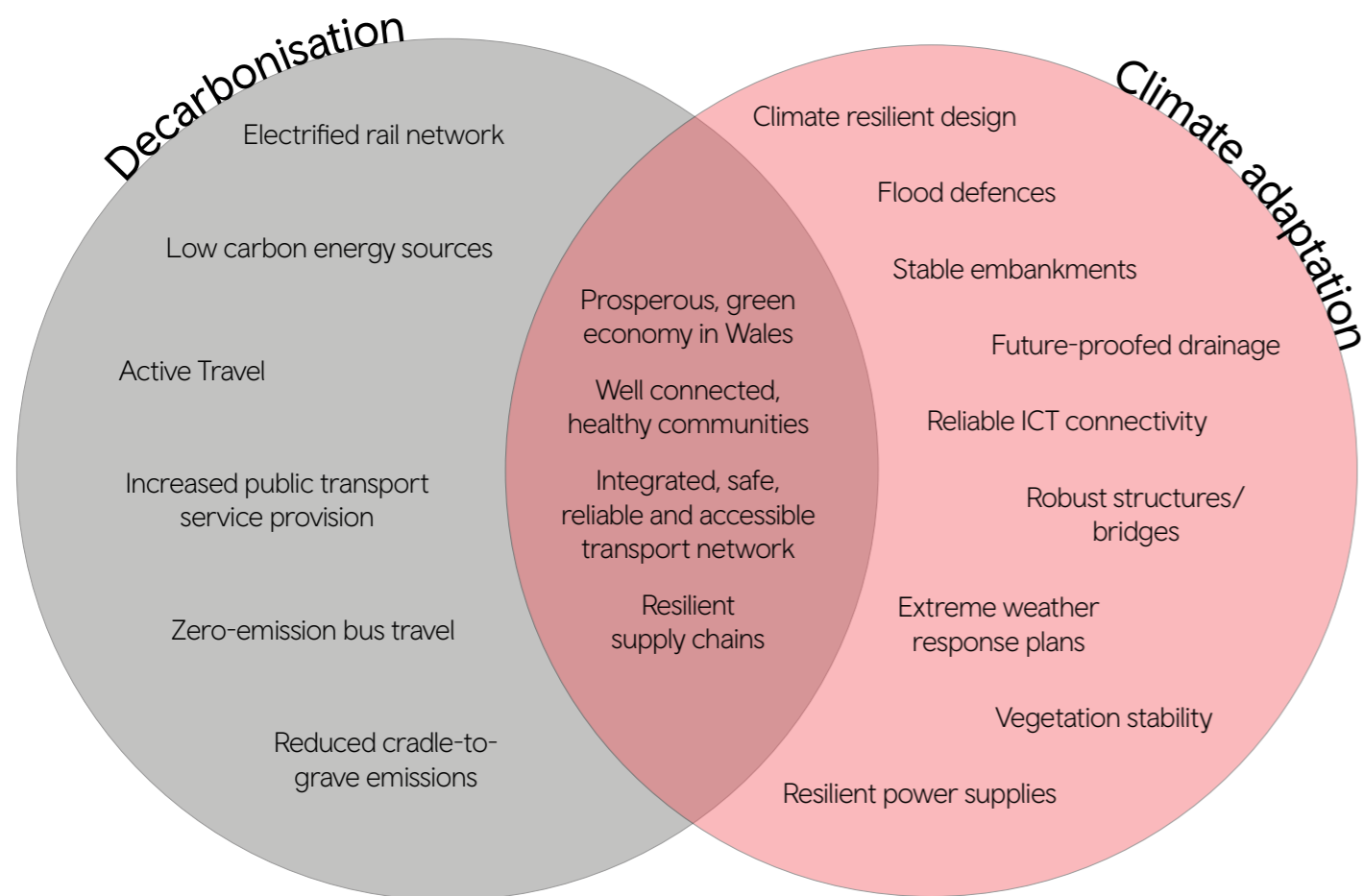
Impacts such as extreme rainfall events, could cause disruption to active travel networks and rail services due to flooding. Severe storms could also result in power outages, affecting services operated by electrified transport.

There is a risk to delivering on Wales' net zero targets for the transport sector if climate change adaptation does not complement efforts to mitigate emissions.

Climate adaptation is core to supporting Welsh Government deliver on its net zero agenda, by ensuring our networks are operable, accessible, safe and reliable in the face of climate change impacts. The objectives in this Plan aim to support, enable and sustain widespread modal shift by reducing the impact and ripple effect of current and future extreme weather on our public and active travel networks in Wales, ensuring they're safe, accessible and reliable now and in the future.

The following infographic illustrates the co-benefits that could be realised if effective decarbonisation and climate adaptation of the transport sector go hand-in-hand. The co-benefits have a Wales-wide impact and are aligned with the Wellbeing of Future Generations (Wales) Act goals.

Co-benefits of effective decarbonisation and climate adaptation of the transport sector in Wales



The concept of climate change lock-in refers to those actions or decisions which have the potential to increase future climate risk or cause irreversible change. For example, more severe and frequent storms under climate change could result in more power outages across Wales, locking-in risks for the transport sector as our reliance on electrification grows.

We aim to reduce locked-in risks by taking prompt action to adapt our networks and operations to climate change impacts, while also ensuring that the actions we deliver to decarbonise our activities don't further worsen our exposure to climate risk.

We'll ensure decarbonisation projects are subject to an assessment of climate risk and we'll also collaborate with infrastructure partners to ensure any potential locked-in cascading failure risks are captured and managed.

We're committed to supporting the Welsh Government deliver on its modal shift and net-zero targets by creating a transformational public transport service that responds to the needs of the people and communities of Wales and its borders.

Climate change presents a threat to the long-term resilience of these services with more intense and more frequent extreme weather causing damage or disruption. We'll be assessing climate risk across all our transport operations to identify potential impacts on our existing services and future connectivity growth.

The objectives in this Plan aim to support, enable, and increase widespread sustainable travel by reducing the direct and cascading impact of extreme/adverse weather on transport networks in Wales, ensuring they're safe, accessible, and reliable now and in the future.

Socio-economic prosperity

The impacts of climate change will not be borne equally or fairly, between rich and poor, men and women, and older and younger generations. Vulnerable groups are more likely going to suffer from the impacts of climate change, as they are unable to adapt to or recover as effectively from events such as flooding.

Failing to create a climate-resilient transport network threatens economic prosperity and community connectedness due to poor service reliability, long-term inaccessibility, and supply chain disruption. Welsh public transport networks connect many communities to economic hubs such as Cardiff.

This connectivity is threatened as this infrastructure becomes increasingly vulnerable to the effects of extreme rainfall events, storms, and land movement.

Poor connectivity and service reliability could adversely impact upon the financial productivity of those people who depend upon public transport to get to work, and those small, rural communities whose income is derived from tourism.

By aligning our work to the Well-being of Future Generations (Wales) Act, our Climate Adaptation and Resilience Plan supports Wales reduce inequality and climate injustice by striving to create a transport network that can cope with, and recover well from, climate change hazards. Effective climate adaptation of our networks and operations has the potential to realise mutual socio-economic co-benefits by connecting communities to economic hubs and enabling the people of Wales to travel where they want to go, when they need to do it.

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Nature-based solutions (NbS)



We believe that you can't tackle the climate crisis without responding to the nature crisis with the same level of ambition. The UK is one of the most nature-depleted countries globally and in the bottom 10% for biodiversity. Restoration of our natural spaces and biodiversity is critical to society's adaptation to climate change; symbiotically reversing nature losses while also responding to a changing climate.

Nature-based Solutions (NbS) draw on natural systems and/or processes to help mitigate the impact of climate change through blue/green infrastructure (BGI), avoiding the requirement for manufactured materials and heavily engineered solutions. Adapting to climate change through natural measures offers a crucial opportunity to improve resilience while mitigating long-term climate change via carbon capture and storage.

NbS can deliver a range of environmental, social, and economic co-benefits. Natural capital projects can lead to job creation while also reducing health inequalities by ensuring a fair distribution of health benefits from green spaces, especially for vulnerable communities who are disproportionately affected by chronic health conditions or reduced access to nature.

From an economic perspective, greening cities, for example, can also areas attractive to new investors, residents, and visitors. Adapting to climate change by working with nature is often far less costly to implement than hard engineering measures.

An example of how NbS can help the rail industry adapt to climate change are natural flood management schemes, which can reduce the risk of flooding on rail networks, by allowing areas near to rivers to naturally flood, rather than the railway itself. Strategic tree planting schemes, particularly on embankments could help reduce run-off rates and improve soil stability, while also providing shading to mitigate the risk of track buckling and overheating in our stations during periods of hot temperatures. However, the suitability of such schemes must be counter-balanced with essential track-side vegetation management which is carried out to ensure trains run safely and to minimise disruption.

To mitigate the health and well-being impact of extreme heat events, green roofs could be installed on our assets. These help to regulate indoor temperatures while also improving local air quality, alleviating flood risk, and creating micro-habitats for biodiversity.

A recent study by Glasgow University found that there are limited examples of successful nature-based climate adaptation within the rail industry and significant knowledge gaps which may deter uptake⁵. Nevertheless, NbS schemes will be evaluated in terms of their suitability on our assets following a comprehensive assessment of climate change risk to identify potential opportunities for nature-based adaptation. We'll collaborate with any neighbouring landowners (where relevant) and key stakeholders, such as Natural Resources Wales to ensure effective implementation.

We'll work closely with Network Rail to ensure NbS are considered when evaluating opportunities for climate change adaptation on the Wales and Borders network.

Action plan for climate resilience

Our Action Plan for Climate Resilience exists as the first step in our journey of increasing . The action plan is centred around a series of actions and measures identified to help us increase our knowledge of our climate change risk

As our understanding of how climate change will affect us in the Wales will invariably evolve, this action plan will form as live document and will be reviewed on a 5-yearly basis.

Over the coming years, additional transport services will come under the TfW umbrella. Climate change risk assessments will be undertaken for each additional service and resultant resilience plans developed accordingly.

A large number of the actions will be resourced and funded through our operations. It's likely that our climate resilience programme will be dependent on further investment and funding and we'll work closely with Welsh Government to explore funding options.

Action	Target Completion Date	Internal Stakeholders	External Stakeholders
Set up an overarching TfW Climate Change Adaptation Steering Group and a CVL-focussed Climate Change Adaptation Working Group.	Spring 2022	<ul style="list-style-type: none"> » Climate Change team » Asset Management team » Wider TfW departments 	<ul style="list-style-type: none"> » Amey Infrastructure Wales » Welsh Government » Natural Resources Wales
Embed the climate change adaptation standard ISO 14090:2019.	Summer 2023	<ul style="list-style-type: none"> » Climate Change team » Climate Change Adaptation Steering Group » CVL Climate Change Adaptation Working Group » Asset Management team 	<ul style="list-style-type: none"> » External consultants » Network Rail » Amey Infrastructure Wales
Develop management and response plans for extreme weather events and outbreaks of invasive species/emerging pests and diseases	Winter 2023	<ul style="list-style-type: none"> » Communication & Engagement team » Climate Change Adaptation Steering Group » Safety team » TfW Rail » Climate Change team » Ecology and Biodiversity team » CVL Climate Change Adaptation Working Group 	<ul style="list-style-type: none"> » Amey Infrastructure Wales » Rail Safety and Standards Board » Welsh Government » Network Rail
Facilitate the coordination of a cross-discipline Climate Change Adaptation Working Group for Welsh Infrastructure Owners to support the development of management for cascading failures	Summer 2023	<ul style="list-style-type: none"> » Climate Change team » Climate Change Adaptation Steering Group » CVL Climate Change Adaptation Working Group » Asset Management team » Wider TfW departments 	<ul style="list-style-type: none"> » Welsh Government » Network Rail » Western Power Distribution » SP Energy Network » Dwr Cymru » Amey Infrastructure Wales » Natural Resources Wales » Rail Safety and Standards Board

Action	Target Completion Date	Internal Stakeholders	External Stakeholders
Develop a framework and climate projections guidance document to support the assessment of climate risk	Autumn 2022	<ul style="list-style-type: none"> » Climate Change team » Climate Change Adaptation Steering Group » CVL Climate Change Adaptation Working Group » Asset Management team 	<ul style="list-style-type: none"> » External consultant support » Amey Infrastructure Wales
Produce weather-related impact assessments for the CVL, focusing on: Flooding, earth movements, heat, lightning, sea-level rise, wind, extreme cold, heat and fog	Autumn 2023	<ul style="list-style-type: none"> » CVL Climate Change Adaptation Working Group » Asset Management team » Climate Change team 	<ul style="list-style-type: none"> » Amey Infrastructure Wales » Natural Resources Wales
Embed the requirement climate change risk assessments into all TfW major projects (such as North Wales Metro) and existing policies	Spring 2024	<ul style="list-style-type: none"> » Programme Management Office » Communications & Engagement team » Climate Change Adaptation Steering Group » Climate Change team 	<ul style="list-style-type: none"> » Amey Infrastructure Wales
Conduct a comprehensive assessment of climate risk across the CVL network, including stations and depots	Summer 2023	<ul style="list-style-type: none"> » Asset Management team » CVL Climate Change Adaptation Working Group » Climate Change team » Safety team 	<ul style="list-style-type: none"> » Amey Infrastructure Wales » Rail Safety and Standards Board
Develop a Climate Adaptation and Resilience Delivery Plan for the CVL network, including drainage and earthworks	Summer 2023	<ul style="list-style-type: none"> » Asset Management team » CVL Climate Change Adaptation Working Group » Climate Change team 	<ul style="list-style-type: none"> » Amey Infrastructure Wales » Welsh Government » Natural Resources Wales

Action	Target Completion Date	Internal Stakeholders	External Stakeholders
Develop a vegetation management plan	Autumn 2024	<ul style="list-style-type: none"> » Rail Asset Management team » CVL Climate Change Adaptation Working Group » Climate Change team » Ecology and Biodiversity team » Safety team 	<ul style="list-style-type: none"> » Natural Resources Wales » Amey Infrastructure Wales » Network Rail » Rail Safety and Standards Board
Develop climate change adaptation pathways (supported by BS 8631: Adaptation to climate change - Using adaptation pathways for decision making) for the CVL	Winter 2023	<ul style="list-style-type: none"> » Climate Adaptation Steering Group » CVL Climate Change Adaptation Working Group » Rail Asset Management team » Climate Change team 	<ul style="list-style-type: none"> » Welsh Government » Amey Infrastructure Wales
Conduct research into Nature-based Solution schemes and develop implementation guidance	Spring 2024	<ul style="list-style-type: none"> » Climate Adaptation Steering Group » CVL Climate Change Adaptation Working Group » Climate Change team » Ecology and Biodiversity team 	<ul style="list-style-type: none"> » Amey Infrastructure Wales » Natural Resources Wales



Governance, monitoring and reporting

Governance and monitoring

Our governance framework for climate adaptation and resilience

Reporting on climate risk and resilience

Governance and monitoring

Increasing our resilience and capacity to adapt to climate change will require collaboration between multiple teams to coordinate the delivery of our strategic climate resilience objectives. This will be enabled through a robust governance framework for climate adaptation and resilience; providing TfW with the accountability and assurance functions for monitoring our changing climate risk profile and progress to deliver on the strategic objectives within this Plan.

Our governance framework for climate adaptation and resilience demonstrates the reporting functions of core internal stakeholders and working groups. Due to the scale of impact resulting from climate risk, successful delivery of our strategic climate adaptation objectives will be dependent on effective collaboration between these core stakeholders. Our Executive Leadership team (ELT) will oversee the management of our resilience activities to ensure they align with TfW's corporate vision of a "high-quality, safe, integrated, affordable, and accessible transport network that the people of Wales are proud of." The governance framework will support ELT deliver on this vision by providing an auditable process for the management of climate change risks and delivery of resilience activities. The framework also provides assurance to ELT and Board that risks are being managed under TfW's agreed appetite for risk and adaptation investment decisions are centred around safeguarding the safety and operability of our network and operations in the face of more extreme weather.

Board oversight of TfW's climate risk appetite will be coordinated by the Audit and Risk Committee (ARC). ARC will be responsible for monitoring the quality of TfW's reporting on climate risk and adaptation and our internal controls for climate change risk management and compliance.

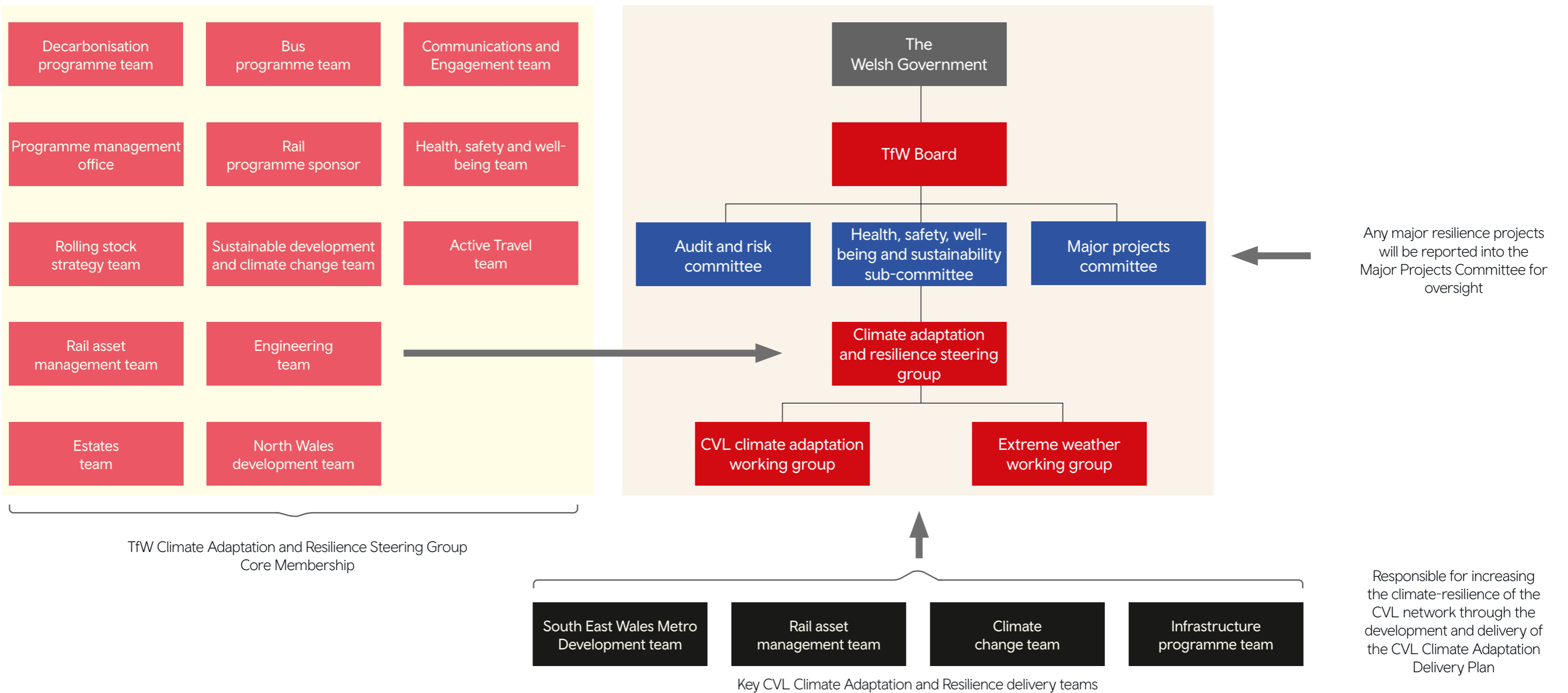
The Health, Safety, Well-being and Sustainability Committee reports to the Board on TfW's performance against climate adaptation KPIs. The Committee will also monitor compliance of our adaptation activities against relevant climate change legislation and will make recommendations for activities that enhance progress and promote continuous improvement.

The Climate Adaptation and Resilience Steering Group will provide an effective assurance function for managing TfW's climate change risks and opportunities. The Group will meet monthly and will be responsible for twofold reporting on TfW's climate change risks (to the Audit and Risk Committee) and the delivery of adaptation measures (to the Health, Safety, Wellbeing and Sustainability Committee). The core internal membership of the Steering Group is summarised within the framework.

The Climate Adaptation and Resilience Steering Group will report any major resilience projects to TfW's Major Projects Committee (MPC) on an ad-hoc basis. This will enable the MPC to have oversight of the progress of major resilience projects across the organisation. The MPC will be responsible for the decision-making, investment decisions and project delivery of major resilience projects at TfW. The CVL Climate Change Adaptation Working Group will coordinate the assessment of climate risks and delivery of resilience activities with a specific focus on our owned assets – the Core Valley Lines. The Group will report into the Climate Adaptation and Resilience Group on progress to increase adaptive capacity of the CVL network. Various internal delivery teams will feed into the CVL Climate Adaptation Working Group to support the delivery of this work; however, these stakeholders could expand as the resilience workstreams evolve. The Rail Asset Management, Infrastructure Programme and Climate Change teams will provide the tactical support to both the assurance function and delivery of the climate resilience workstreams.

Increasing our resilience and capacity to adapt to climate change will require collaboration between multiple teams to coordinate the delivery of our strategic climate resilience objectives

Our governance framework for climate adaptation and resilience



Reporting on climate risk

The UK Adaptation Reporting Power is a legislative requirement under the Climate Change Act (2008) for certain organisations to produce 5-yearly reports on their level of climate risk and proposals for adapting to climate change. Train Operating Companies, such as Transport for London, are required to report on their adaptation progress via this mechanism, however, there is currently not a similar reporting power for organisations in Wales.

Our governance framework provides a consistent and accountable approach for adaptation reporting to Welsh Government if required. This is supported by following best practice and aligning our climate risk and adaptation reporting to the Taskforce on Climate-related Financial Disclosures (TCFD) recommendations. The TCFD guidelines provide a structured framework for reporting on climate risk and adaptation in line with core corporate operational functions: Governance, Strategy, Risk Management, and Metrics and Targets.

TCFD recommended disclosures for climate risks and opportunities

Governance	Strategy
<ul style="list-style-type: none"> a) Describe the board's oversight of climate-related risks and opportunities. b) Describe management's role in assessing and managing climate-related risks and opportunities 	<ul style="list-style-type: none"> a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term. b) Describe the impact of climate-related risks and opportunities on the organization's business, strategy, and financial planning. c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.
Risk management	Metrics and targets
<ul style="list-style-type: none"> a) Describe the organization's processes for identifying and assessing climate-related risks. b) Describe the organization's processes for managing climate-related risks. c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management 	<ul style="list-style-type: none"> a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process. b) Disclose Scope 1, Scope 2, and if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks. c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets

The overarching recommendation within the TCFD Governance pillar is for a company to disclose “how climate-related risks and opportunities are assessed by the company’s management and overseen by the board”. TfW’s climate adaptation and resilience governance framework has been designed to align with this principle so that our Board have clear oversight of our climate change risk profile. This enhances customer understanding of how our Board and management are keeping our networks safe and accessible through effective accountability and scrutiny for the climate risk management and mitigation

Governance, monitoring and reporting roles

Governance

- » The Audit and Risk Committee (ARC) will be responsible for monitoring the quality of TfW’s reporting on climate risk and adaptation and our internal controls for climate change risk management and compliance. ARC will make recommendations to Board about the acceptable level of climate risk for TfW.
- » The Health, Safety, Wellbeing and Sustainability Committee will provide assurance to the TfW Board that its interests and accountabilities in regard to climate adaptation and resilience are appropriately managed, and robust measures are in place in relation to matters arising out of the Climate Adaptation and Resilience Plan.
- » The Climate Adaptation and Resilience Steering Group will provide an effective assurance function for the management of climate change risks and opportunities across the business.
- » The CVL Climate Adaptation Working Group will provide the technical capabilities and expertise for identifying and managing climate-related risks to CVL assets. The Working Group will oversee the coordination of the CVL Climate Adaptation and Resilience Delivery Plan delivery.
- » The Major Projects Committee will monitor the deliver of any major resilience projects across the organisation providing a focus for decision-making and project delivery.

Monitoring

- » ARC will monitor our changing risk profile through close observation our our adaptation investment decisions and climate change risk identification and management processes.
- » The Health, Wellbeing, Safety and Sustainability Committee will review performance against climate adaptation KPIs and make recommendations for activities that enhances progress and promote continuous improvement. The Committee will also monitor compliance against relevant climate change legislation.
- » The Climate Adaptation Steering Group will be responsible for monitoring our progress to enhance our adaptive capacity through the implementation of appropriate control measures, including appropriate policies, plans, activities and investment decisions aimed at increasing our climate change adaptive capacity.
- » The CVL Climate Adaptation Working Group will identify annual CVL Climate Adaptation and Resilience Delivery Plan KPIs and milestones, for agreement and sign off by the Climate Adaptation and Resilience Steering Group.

Reporting

- » ARC will report on TfW’s changing climate risk profile (in line with TCFD requirements) and adaptation investment decisions to Board.
- » The Health, Safety, Well-being and Sustainability Committee will report on TfW’s progress to deliver on its climate adaptation and resilience strategic objectives and KPIs.
- » The Climate Adaptation and Resilience Steering Group will report quarterly to ARC on TfW’s climate change risks in line with TCFD recommendations. The Steering Group will report to the Health, Safety, Wellbeing and Sustainability Committee on delivery of climate adaptation measures.
- » Any major resilience projects will be reported by the Climate Adaptation and Resilience Steering Group to the Major Projects Committee on an ad-hoc basis.
- » The CVL Climate Adaptation Working Group will provide quarterly progress reports to the Climate Adaptation and Resilience Steering Group on the management of CVL climate risks and performance against strategic climate resilience KPIs.

Communication and engagement

As our climate continues to warm throughout the 21st century, we'll start to witness an increase in extreme and/or adverse weather in Wales. It's also possible that warmer temperatures could also affect the distribution and emergence of pests and diseases. If we're not prepared, these risks could significantly impact upon the health and safety of our customers, and reliability of our services.

It's essential that we keep our customers informed about our plans to increase our response levels to climatic risks. We'll develop a bespoke communication and engagement strategy to help us engage with the communities we serve about our climate resilience objectives. The strategy will provide reassurance to our customers that maintaining a safe and accessible transport network remains central to our vision, despite our changing climate.

We hope that by keeping the public informed about our plans to prepare for the impact of extreme weather conditions on our network and services, our customers will feel confident travelling via sustainable modes in Wales, now and in the future.

We also appreciate that climate change presents far-reaching risks other than those which may affect our physical assets. We intend to develop specific communication and engagement plans to keep our customers and colleagues informed about how we'll prepare and respond to health and wellbeing risks associated with heatwaves, flooding, storms and emerging pests and diseases. The plans feed into our overarching preparation for such events, helping us minimise impact to human health.

We'll engage with our customers and local communities to obtain feedback on our climate resilience plans. This will be delivered via community consultation sessions to help us understand local knowledge on weather-related vulnerabilities on the network and surrounding area. We're also keen to hear local people's views on our climate resilience priorities.

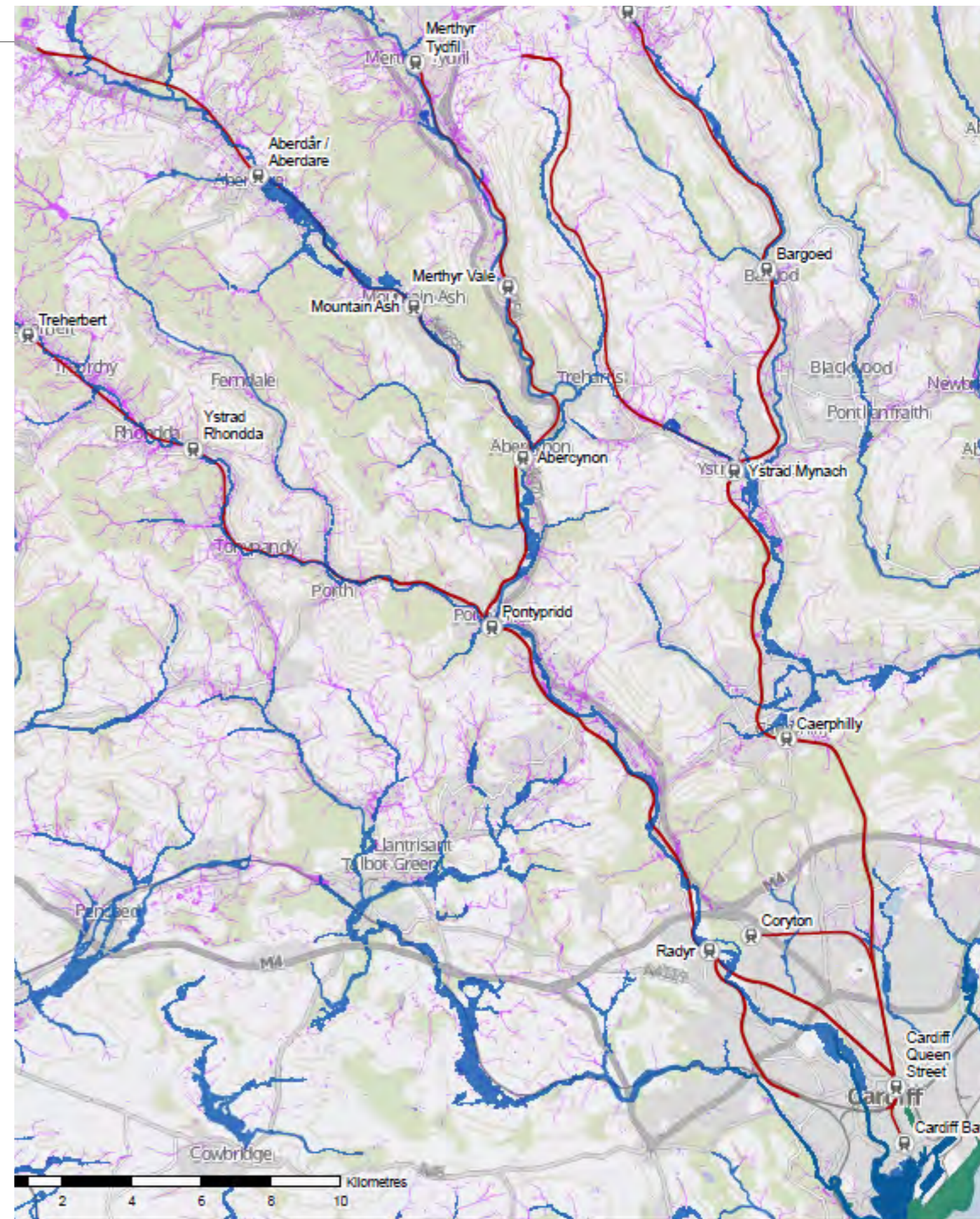
Due to the scale and potential impact of climate change hazards and/or adaptation solutions, we'll need to develop strong working relationships with external partners, such as Natural Resources Wales and local landowners. We also aim to work collaboratively with other infrastructure owners to help us understand and manage cascading climate risks, where the cause is outside of our direct control.



Appendix 1

Flood risk on the Core Valley Lines

The following map highlights the flood risk from rivers, sea and surface water on the CVL.



- Railway Station
- Railway Track
- Flood Risk From Rivers
- Flood Risk From Sea
- Flood Risk From Surface Water and Small Watercourses



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Project Title
Climate Change Adaptation Plan

Drawing Title
High Flood Risk across the Core Valley Lines

Drawing Status
For Information

