# Climate Change Adaptation Pathways

Methodology and guidance for long term strategy development

20 August 2024

NR/GN/ESD41 Issue 2

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## Version Control

This version of the guidance note provides a significant update to version 1 issued in 2022. It provides a revised process and sets out the detailed methodology for how to deliver adaptation pathways for Network Rail. It is a living document and will be updated based on experience of running the process.

| Version | Date of issue | | Author | Reviewed by |
|---|---|---|---|---|
| 1 | November 2022 | Introduction to adaptation pathways and the overarching approach to be taken in Network Rail | Lisa Constable | |
| 2 | 20 August 2024 | Wholesale update of guidance incorporating content from version 1 but providing a new process and the detailed methodology for how to deliver adaptation pathways for Network Rail | Lisa Constable | Ernan O'Farrell, Julie Gregory, Regional Climate Change Adaptation Leads |

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# 1. Introduction

## *Purpose*

Network Rail Regions have committed to developing long term climate change 'Adaptation Pathway' strategies and investment plans by the end of control period 7 (CP7: 2024 – 2029) as set out in Environmental Sustainability Strategy[1] and each region's CP7 Weather Resilience and Climate Change Adaptation Plan[2]. This will deliver on requirements in the CP7 High Level Output Specification which specifies:

| | |
|---|---|
| *England and Wales* | 30. Network Rail must also demonstrate its development of plans for climate change adaptation for CP7 through updating its Regional Weather Resilience and Climate Change Adaptation Plans and **developing long-term strategies to influence future investment in the railway**. The Secretary of State expects a collaborative approach across relevant sectors and stakeholders to address these issues[3]. |
| *Scotland* | Continue towards creating a railway for Scotland that maximises the benefit of planned renewals and improves resilience in the face of the risks and impacts associated with climate change, through targeted physical climate change adaptation works on assets, continual improvements to climate risk assessment processes and **development of a longer-term adaptation strategy**[4] |

In addition, there are a number of other expectations for infrastructure operators to develop long term climate change strategies including the Department for Transport Adaptation Strategy, Parliamentary Joint Committee on National Security Strategy, the Resilience Strategy and the Third National Adaptation Programme.

Climate adaptation and resilience investment decisions are delegated to Network Rail Regions. Regions are expected to develop adaptation and resilience investment strategies in a way that is aligned to their bespoke regional requirements and comparable with other regions. The adaptation pathways approach will help to achieve this by providing a consistent way of recording investment decisions and scoring of climate-related risks.

This document sets out the framework for adaptation pathways at Network Rail including the expected outcomes in each region, guidance and the proposed methodology for developing adaptation pathways across all regions. The results will provide common insight and data for regions to use in developing longer-term adaptation strategies. Version 2 of the guidance provides a significant update to version 1 informed by learnings from a pilot project run in Southern Region in 2023-24. It provides a revised process and sets out the detailed methodology for how to deliver adaptation pathways for Network Rail. Further updates will be issued as the process is rolled out across the network.

[1] Environmental Sustainability Strategy - Network Rail

[2] Available from: Climate change adaptation - Network Rail

[3] Railways high level output specification 2022 - GOV.UK (www.gov.uk) - paragraph 30 p9

[4] Scottish Ministers' High Level Output Specification (HLOS) - Control Period 7 - 2024 – 2029 | Transport Scotland – paragraph 3.37 bullet 3 p13

# 2. What are adaptation pathways?

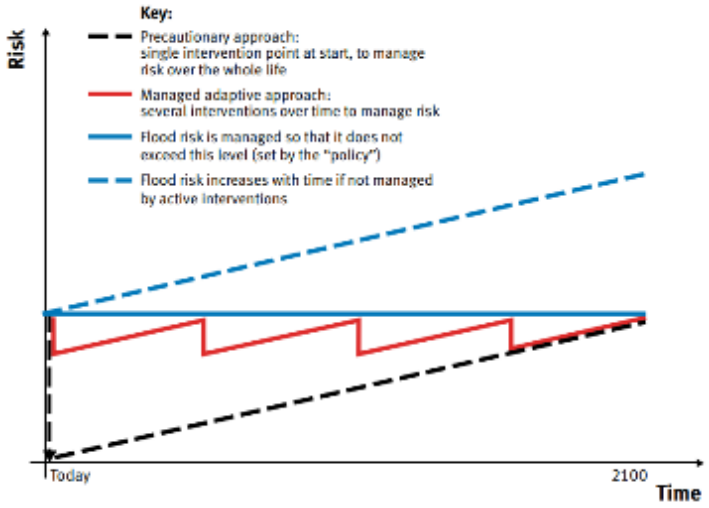
## *The broad concept*

Climate change is projected to have a wide range of impacts on the railway and there is no single solution to creating resilience across the network. The adaptation pathways approach allows decision makers (e.g. asset managers and strategic planners) to plan for, prioritise and stagger investment in adaptation options with trigger points and thresholds helping to identify when to revisit decisions or interventions. It is considered to be global best practice in adaptation planning as it supports strategic, robust, flexible and structured decision-making.

The adaptation pathways approach aims to help identify the most appropriate risk management options for a particular area.

Figure 1 shows how flood risk increases over time if it's not managed but it can be maintained at a chosen level through active intervention, either a single scheme to manage risk over the life of the project or a series of interventions over time.

Figure 1 Managing flood risk through active intervention (Environment Agency TE2100)




The approach enables organisations to make adaptation interventions at the right time, avoiding the cost of acting too early or too late. The underlying concept is straight forward and based around three questions:

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

By repeating these questions at different levels of climate impact, a sequence of interventions, or "pathways" can be constructed to keep the organisation on track to deliver its objectives over time. Each pathway results in a robust and flexible plan that is effective at any point in time between now and the distant future. This process produces a decision tree that offers asset managers, strategic planners, and decision makers options as they plan interventions in the coming control periods which will help deliver the long-term objectives.

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***Case study: Understanding the impact of Shoreline Management Plans on the railway across Wales & Borders***

Wales & Western Region has assessed the impact of Natural Resources Wales's Shoreline Management Plans on railway assets. In some areas, particularly along the Cambrian Coast, the plans intend to stop maintaining coastal defence assets meaning that sections of railway would become the 'first line of defence' from the sea when current barriers are breached. As the railway was not built as a coastal defence this leads to a series of questions and options for how we manage the railway in the future:

1. Rebuild the railway as a coastal defence – is this done reactively following storm damage or proactively to prevent future impacts?
2. Move the railway further away from the coast –potentially increasing the risk to local communities if the railway is not there to provide protection.
3. Stop using sections of railway and transport people by road.
4. Consider the need for a railway in the area if communities are forced to abandon towns such as Fairbourne.

These are complicated issues that the railway cannot make in isolation. It is important to bring together a range of stakeholders including local government, other infrastructure operators (e.g. power, roads, flood defences etc) regulators to consider the range of options and select a pathway to a future which achieves the objectives of all parties. Adaptation pathways is an approach which enables this to be done in a structured manner.

For further information see: Impact of Shoreline Management Plans on Wales & Borders – Interim Findings

## *Benefits of adaptation pathways*

Some of the key benefits of an adaptation pathways approach include:

- Adaptation pathways set out options for dealing with long term strategic challenges such as coastal realignment and enable action to be taken at the optimum time, reducing the costs of intervening too early or too late – not all decisions must be made immediately and options can remain on the table.
- By analysing vulnerability and options at a local/catchment/shoreline level, this approach allows for a granular understanding of the priority and cost of weather and climate change resilience investment for CP8 and the longer term.
- By setting out plans for infrastructure resilience in the long term (looking out to the end of the century and beyond), short-medium term actions can form the building blocks towards achieving long term goals.
- Helps focus and prioritise control period planning based on a maturing understanding of our changing climate, and associated risks and impacts, and agreed priorities across a wide group of rail industry and external stakeholders.
- Enables a more joined-up, holistic, systems approach to railway, transport, infrastructure and economic planning as a range of relevant stakeholders come together to explore options
- It promotes adaptive management and pursuit of 'low regrets' options to avoid a default to more precautionary, potentially unnecessary, approaches, enabling adaptation plans to be ongoing by incorporating robustness, flexibility and adaptability into the decision-making process.

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## *Approaches to developing adaptation pathways*

The approach to undertaking adaptation pathways was established in *BS 8631:2021 Adaptation to climate change. Using adaptation pathways for decision making - guide*[5] based on the Environment Agency's approach to the Thames Estuary 2100 project[6] which assessed options for the future of the Thames Barrier in London. Building on this, the practical application of adaptation pathways continues to develop through greater use. Network Rail is understood to be the first to use this approach on a large scale in a railway context and it is an opportunity for us to tailor the methodology to suit our requirements.

There are three broad approaches to developing adaptation pathways as outlined in *Table 1*. This document does not define which approach to take in different locations, however in reality it is likely that most will follow the performance oriented approach given the defined system within which the railway operates and the areas where we have control. Transition between pathway types may be required over time as planning extends beyond the control of the railway. For example where coastal realignment is proposed, a transformational pathway may be more apt; while for large low-lying areas at risk from flooding across multiple sectors, a multi-stakeholder oriented approach may be developed.

**Table 1 Review of adaptation pathways approaches (building on Werners et al, 2021)[7]**

| Performance threshold oriented | |
|---|---|
| **Key elements**<br>• Designed to address future adaptation needs in a well-defined area or system of interest (e.g. railway operations in a particular location)<br>• Interventions look to reduce/remove risk against specific performance metric(s) e.g. safety, asset failure, service reliability etc<br>• Interventions are organised incrementally into pathways to maintain performance/service levels under different climate scenarios<br>• Lead organisation: the asset/system owner would lead the project and come up with solutions with some input from stakeholders and interface with others but they ultimately have control over the outcome of the work. | **Approach**<br>• The project is approached from the perspective of needing to resolve a relatively well defined problem in a known location e.g. sea water inundation in a tunnel, erosion of cliffs along a section of coastal railway, flooding in a low lying area etc.<br>• External stakeholders are involved to bring additional expertise, ensure wider contexts are reflected in interventions (e.g. community needs) and the potential for partnership working (e.g. nature based solutions at a catchment level to resolve flooding in a city such as Leeds or Carlisle)<br>• The interventions can be relatively clearly defined at this stage and whilst some may require transformation of the way we operate (e.g. abandoning lines, moving/rebuilding the railway), we are in control of delivery of that process. |
| **Case studies**<br>• From a Network Rail perspective, locations such as Dover – Folkestone, Exeter to Newton Abbot<br>• The Environment Agency's Thames 2100 - the EA is responsible reducing the risk of flooding in London by maintaining flood defences and the Thames Barrier. The project looked at a range of interventions from raising defences, increasing flood plain volume, and building a new tidal barrage to manage the risk up to 2100. Network Rail was a stakeholder to this process as our assets are affected by the outcome but the EA is accountable for delivery of the overall scheme | |

[5] *BS 8631:2021 Adaptation to climate change. Using adaptation pathways for decision making - guide*

[6] Thames Estuary 2100 (TE2100) - GOV.UK (www.gov.uk)

[7] Based on Werners, Saskia & Wise, Russell & Butler, James & Totin, Edmond & Vincent, Katharine. (2021). Adaptation pathways: A review of approaches and a learning framework. Environmental Science & Policy. 116. 266-275. 10.1016/j.envsci.2020.11.003..

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## Multi-stakeholder oriented

| Key elements | Approach |
|---|---|
| • Focuses on the social and institutional components of pathway development including multiple drivers and multiple stakeholders with conflicting goals, interests and contested values<br>• Involves multiple organisations including asset and land owners affected by the risk<br>• Thresholds that are important for local people are used rather than changes in environmental conditions.<br>• Each pathway represents the interests of a particular stakeholder group<br>• Provide space for recognition and inclusion of non-scientific knowledge<br>• Lead organisation: likely to be a local authority, the Environment Agency or a consortium working together | • The starting point is the need of a wide area e.g. the Humber Estuary, Somerset Levels, South Yorkshire etc and brings a wide range of stakeholders together to identify the range of drivers and goals and to set adaptation against social needs rather than performance metrics of an individual organisation.<br>• Within the desired future defined by the stakeholder group, each organisation will have a different role to play. Network Rail could bring performance-oriented pathway options to the table and the selection of an appropriate way forward could be dependent on the needs of the wider community (e.g. decision to rebuild railway as a coastal defence or move it inland could be based on needs of other stakeholders) |

**Case studies**

- Poole Harbour/Holes Bay - There are some solutions for parts of the railway but there are much wider flooding concerns in the area. Any railway intervention would need to be delivered in parallel with wider geographical protection e.g. The freight line is at risk, Network Rail could raise the line but would be futile if the rest of port is underwater (see Southern Pilot Project documents for more detail).
- Somerset Levels – flooding and sea level rise will inundate very large areas of Somerset putting infrastructure and communities at risk. The stakeholder led approach brought affected parties together to identify interests, values and goals with a view to defining a future that meets the needs of everyone. The project identified high level options such as maintain/close the railway.

## Transformation oriented

| Key elements | Approach |
|---|---|
| • Process views pathways as broad directions of change that represent different strategic aims<br>• Does not assume current system performance to be satisfactory and addresses a potential need to transform values and governance arrangements to enable adaptation<br>• Lead organisation: Achieving these transformational pathways will likely involve adaptation pathways at different levels and through different approaches to achieve the change required. They are likely driven by national and regional bodies in collaboration with affected organisations | • The pathways are about fundamental change to the way we move or operate which don't have a defined means of achieving the goal at this stage. They would tend to be led by government (national or local) and would be supported by changes in governance and/or multiple policies of which the role of the railway is one. For example a significant mode shift from road to rail, or moving population centres over time will require changes in the provision of rail services. |

**Case studies**

- Non-adaptation related examples of this are the levelling up agenda or the transition to net zero.

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## *What does an Adaptation Pathways Assessment consider?*

The adaptation pathways approach explores a wide range of options with a view to identifying the optimal solution for a particular area. This is done through extensive internal and external collaboration and stakeholder engagement to identify priorities in a local area and ensure that all organisations' objectives are considered. These considerations include, but are not limited to:

| | |
|---|---|
| Railway assets | • Identification of strategic corridors that may be single points of failure and which need to be resilient to enable other strategic objectives to be delivered.<br>• Areas where transformation is required to maintain resilience can be identified e.g. coastal areas or low-lying flood plains like Somerset Levels where maintaining services in their current location/form will be untenable. |
| Local context | • Interdependent risks can be addressed by looking at the rail network as a national infrastructure system of systems coupling with power, flood defences, roads and other infrastructure.<br>• Interface between adaptation interventions and local biodiversity - nature based solutions could be developed with those done in collaboration with other organisations delivering catchment wide resilience<br>• Health and wellbeing of passengers and colleagues |
| Funding | • Partnership opportunities with others looking to invest in resilience such as local councils and flood risk authorities (e.g. Environment Agency). This would share the cost of schemes and maximise the associated benefit.<br>• The cost of different interventions can be discussed with funders to determine the most appropriate solution in an area (e.g. accept higher risk level/chance of disruption at lower cost or agree to fund the high cost option at some point in the future) |
| Strategic planning | • Horizon scanning to understand the challenges that are coming and enabling quicker responses to changes.<br>• Understanding the role of rail in a particular area in terms of social, economic and environmental benefits.<br>• Linking rail planning to spatial growth plans for sub-regions meaning new housing can be concentrated in locations that do not depend on cars for every trip and flood plains can be avoided.<br>• The future role of the railway can be considered with suitable alternatives e.g., bus rapid transit for rail routes that have less strategic value and are vulnerable to climate change. |

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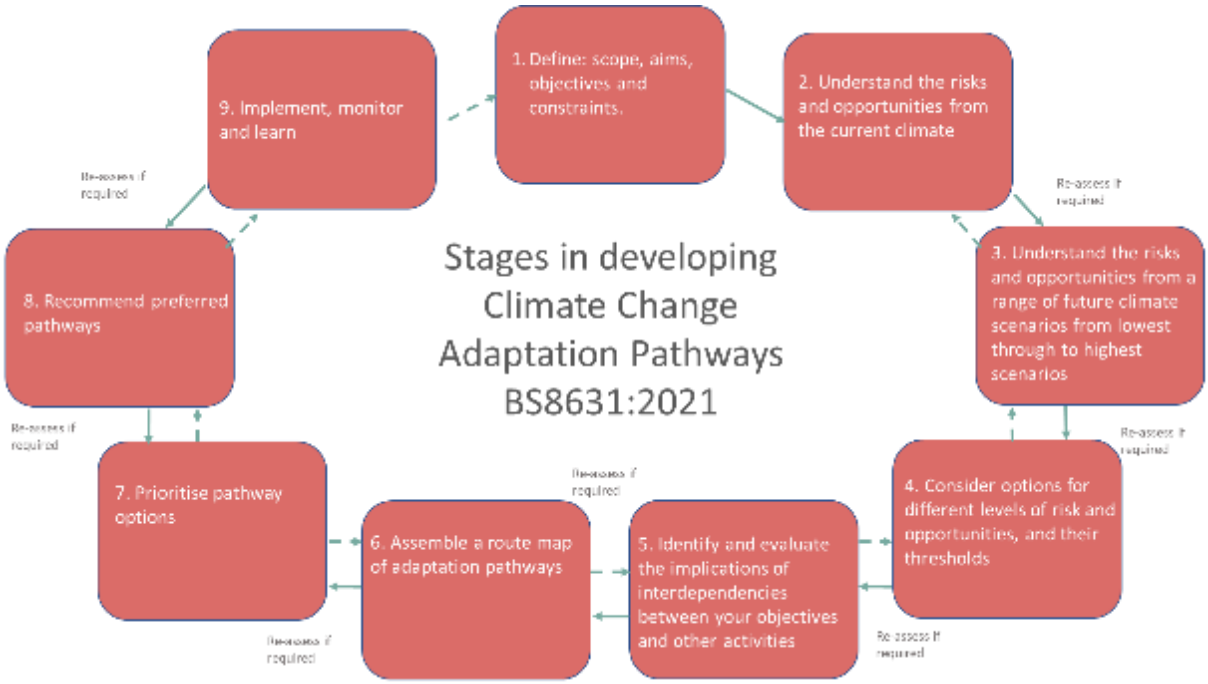
## How to develop adaptation pathways

*BS8631:2021 Adaptation to Climate Change – using adaptation pathways for decision making - guide* sets out a nine-stage process which is fundamental to the development of adaptation pathways and underlies the methodology outlined in this document. It involves definition of aims and objectives, assessment of current and future risk, identification of adaptation options at different levels of risk and opportunity, consideration of interdependencies, development and evaluation of pathways options. This process is repeated for each location for which a pathway is developed.

This document creates a wider process for delivery of a programme of adaptation pathways for multiple locations across the rail network integrating the stages outlined in the standard as referenced in each phase below. *BS8631:2021*[8] should be referred to for further detail.

Figure 2 BS8631:2021 Steps to develop climate change adaptation pathways




[8] *BS 8631:2021 Adaptation to climate change. Using adaptation pathways for decision making*

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# 3. Overview of the process

The nature of the railway with multiple assets affected by multiple weather variables in a single location and long linear routes across the country poses a challenge to the development of adaptation pathways, which are most easily applied to a single weather variable e.g. sea level rise or flooding. The process outlined in this document starts with an initial prioritisation across multiple criteria to identify locations for priority intervention. High-level, 'Rapid Adaptation Pathways Assessments (Rapid APAs)' are then undertaken for these locations to further sift for locations where more detailed modelling and options analysis is required to develop 'Full Adaptation Pathways Assessments' (Full APAs). The outputs of these two processes vary in the level of detail but ultimately provide an understanding of where and when intervention will be required in the railway and set out the pathways for achieving the strategic objectives in that particular location.

The adaptation pathways process develops an understanding of risk, creates a long term strategic plan of how to manage the railway and the outputs feed into asset strategies, control period planning, business cases for enhancement projects and long term strategic plans for the specific locations. The key activities are set out in Figure 3 with a summary of the process for delivery of this work set out in the remainder of this document presented in *Figure 4.*

Figure 3 Key activities in adaptation pathways development and strategy delivery

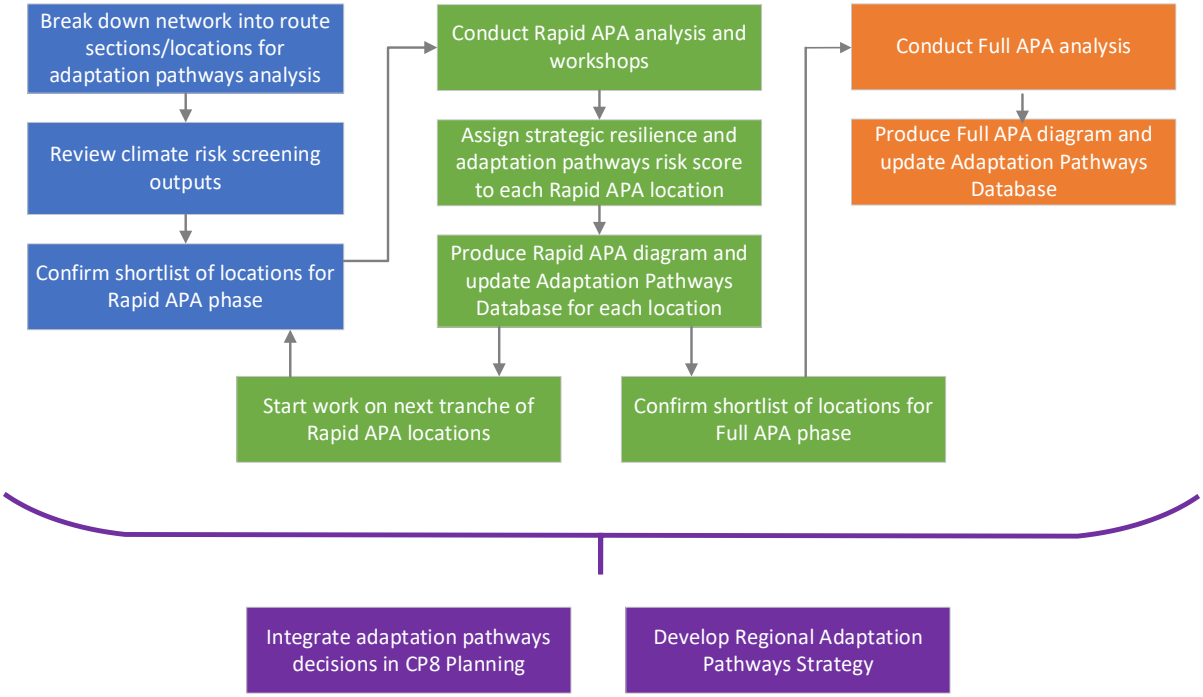

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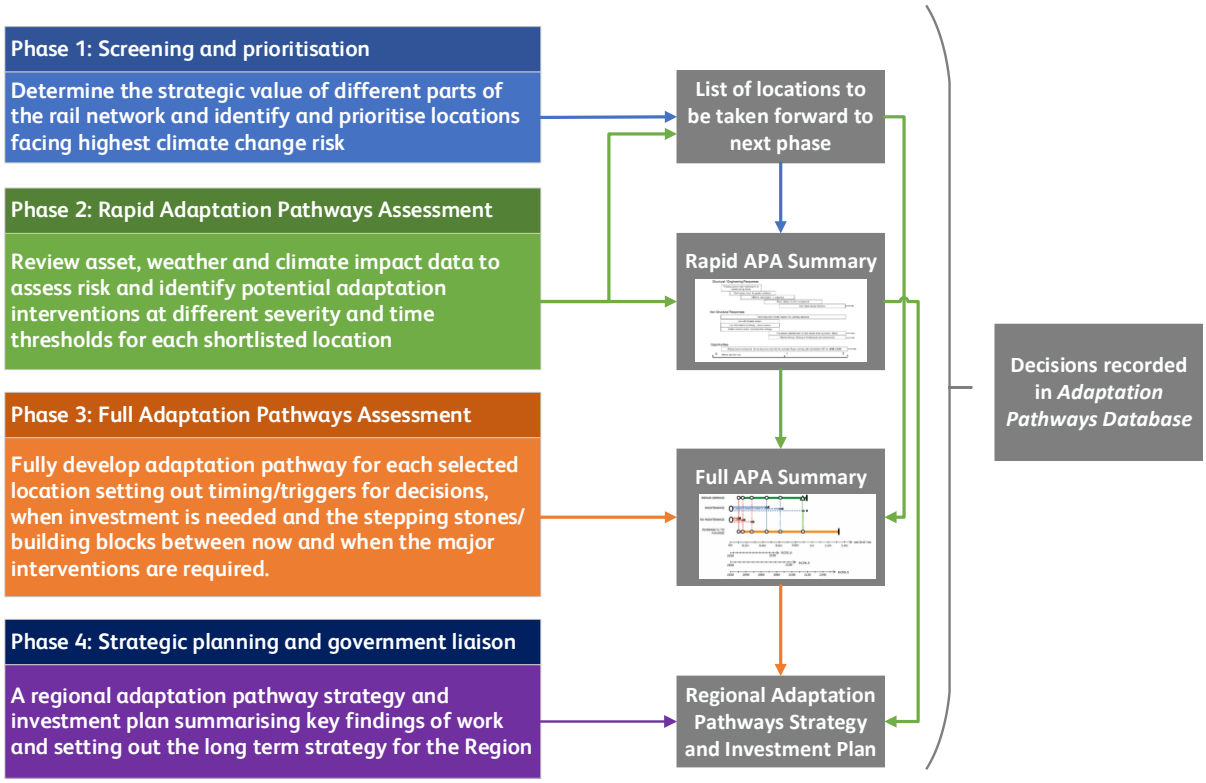
Figure 4 Overview of Network Rail Adaptation Pathways Process




## *Delivering the adaptation pathways programme*

The approach outlined here is designed to be led by an individual, henceforth referred to as a programme manager but their job title may be different. The programme manager coordinates a series of workshops with internal and external stakeholders to obtain views on vulnerability, risk and potential adaptation options. Locations where more detailed analysis is required could involve risk, options and cost modelling to inform choices for future management of the railway. Strategy development then brings together all information to prioritise options and recommend preferred pathways across the region.

### PROGRAMME MANAGEMENT

The programme manager will be responsible for the implementation of the programme as a whole, running the process outlined in this document and delivery of the expected outputs. They should have the following capabilities:

1. Strong understanding of the Regional network and climate vulnerable assets and services
2. Good project management skills
3. Good communication skills with both internal and external interested parties
4. Able to generate enthusiasm in the group

Ideally they would have:

- Experience of commissioning and using expertise in: economic analysis, strategic planning, social & environmental impact analysis, climate modelling.
- Business case development experience
- An understanding of climate change and the adaptation pathways process

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## STAKEHOLDER ENGAGEMENT

Development of long-term adaptation pathways strategies should be done through a participatory process with stakeholder engagement combined with an analysis of the projected climate changes and impacts to the end of the century and beyond to identify options for managing the risk in different parts of the network.

The work will require a wide range of expertise and a significant amount of effort. It will require clear strategic objectives and exec level buy in within regions and routes. It will also require a governance structure which ensures that the wealth of expertise, detail and effort applied to the programme remains focused on the strategic objectives of the Region and operates with the agreed resources. The programme manager and steering committee will define requirements based on the priorities within the Region and funding available.

A summary of the proposed different roles/groups of stakeholders is provided below. Not all the expertise or capacity to do this work lies within Network Rail. Exactly how these participants engage in the project can be defined by the programme manager but key roles are identified in *Table 2*.

**Table 2 Stakeholders involved in adaptation pathways assessment**

| Group | Role/participants |
|---|---|
| Steering Committee/ Programme Board | The Steering Committee will be responsible for ensuring that:<br>1. The process is implemented in line with these guidelines<br>2. Climate change resilience matters of Regional significance are recognised and addressed<br>3. Climate change resilience matters of strategic significance beyond the Region are recognised and addressed<br>4. Any issues affecting the regional programmes are escalated as required.<br>5. Outputs are fed into the CP8 Strategic Business Plan process<br>Its membership should include: a nominated executive sponsor, senior Regional management from the following functions: asset management, operations, strategic planning, economic analysis, and business planning. It would be beneficial to have Route Director to bring a different perspective. This committee will be able to draw on external advice where required. |
| Internal Experts | The internal experts who should be involved in this project include<br>• asset managers and operations leads or their representatives with knowledge of weather impacts on the railway across all asset functions (at regional/route level)<br>• Strategic planning<br>• Economic analysis<br>• Business planning<br>• Environment and sustainability<br>Participants will use their technical expertise and experience within the Region/routes to advise on: the strategic value of different parts of the rail network, vulnerable assets and services, climate risk levels, implications for safety and performance and thoughts on responses.<br>Different people will be involved in different elements of the programme depending on the location and the expertise required (e.g. OLE asset managers are more likely to be involved in projects focussing on heat than flooding). It would be beneficial to have a nominated lead from each engineering discipline to create ownership and simplify collaboration |
| External Advisors | Many organisations have an interest in Network Rail's resilience activities and have data, expertise and, potentially, funding that they may be able to contribute to solutions. External specialists with complimentary skills that can help understand how impacts can change with climate change could include representatives from Environment Agency, Scottish Environment Protection Agency (SEPA), Natural Resources Wales, Lead Local Flood Authorities, Coastal Groups, and Local Council flooding advisors, specialists in climate impacts on rail assets etc. These groups could be involved in workshops. |

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| | |
|---|---|
| Contracted specialists | Much of the work to conduct the adaptation pathways assessments may require specialisms and time not available to Regional staff. Specialist areas may include: adaptation pathways planners; asset and service climate resilience specialists; modellers; economic, social and environmental impact specialists, along with other capabilities as required. Some of this work could be contracted to Network Rail Design Delivery (NRDD). |
| National Adaptation Pathways Working Group | A national working group brings together programme managers and technical leads to share experience and best practice as these programmes are implemented in individual regions. The group may develop further national level data and processes to support delivery of the work across the country. Any issues requiring escalation would feed into the Climate Change Adaptation Working Group and from there to the Railway Fit for the Future Steering Group. |

## TIMING AND FUNDING REQUIREMENTS

The amount of time required to develop each region's first adaptation pathways strategy based on assessment of high priority locations depends on the level of detailed analysis and modelling required to understand the vulnerability and adaptation options for different locations going through the Full APA process. The level of analysis and modelling will depend on the funding available.

The initial outputs of the work should be complete in advance of the start of CP8 planning (around 2027) in order that the near-term interventions (within the first five years of the long-term adaptation pathways strategies) can be fully integrated into CP8 plans for 2029 – 2034 and funding obtained for their implementation. Discussions on options and agreement of the longer-term actions can take place during development of CP8 plans with a view to the final version of the strategy for high priority locations being completed by March 2029.

The intention is for all other locations to go through the adaptation pathways assessment process during CP8 and CP9 and for the full network to be covered before 2040. Some of the highest priority locations will need to go through review before this and the strategies will go through a rolling review and update going forward.

## RECORDING OUTPUTS AND DECISIONS

All decisions relating to adaptation pathways need to be recorded for future reference. Reports and materials should be organised and stored in a shared location for ease of access in the future when the original project team may have changed. A summary of these decisions and the results of this analysis will be recorded in a central database used by all Regions.

Each Region will develop adaptation pathways assessments in a manner appropriate to the needs of the region. The results of this work then need to be summarised in a format that is consistent between regions to enable comparison, further analysis and development of a national level overview of pathways and priorities. The Adaptation Pathways Database and templates for rapid and full APA diagrams set out below along with the risk scoring criteria will enable this consistent approach.

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## Adaptation Pathways Database

The *Adaptation Pathways Database* is the master record of all decisions in relation to the locations assessed during this project.

The plan is for a web-based tool to be developed to support collation of data and analysis of options. In the interim a template for recording information and decisions is available on the Adaptation Pathways SharePoint site.

A summary of key content is provided in *Table 3.*

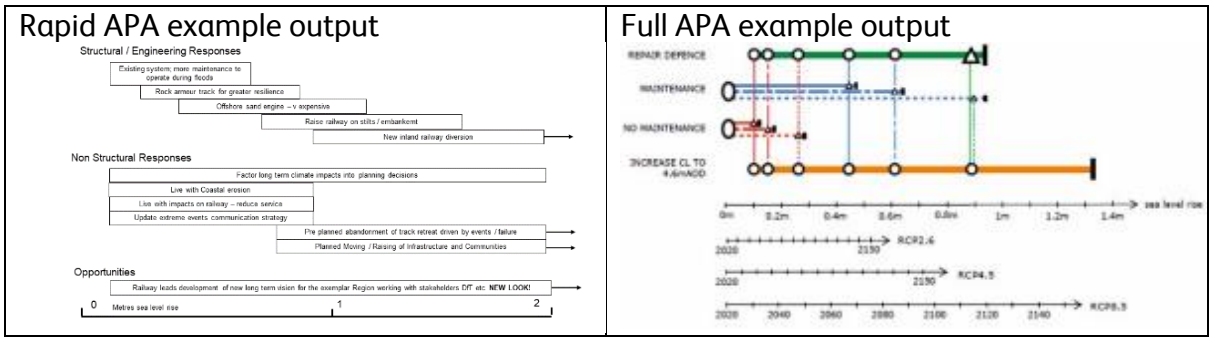
**Table 3 Adaptation Pathways Database overview of expected content**

| **Location**<br>Including reference numbers, recognised name of location, links with adjacent locations that should be considered at the same time | **Risk Score/priority**<br>Score from screening Priority for Rapid APA decided during sense check<br>AP risk score (*see Step 2.3*) | **Strategic importance to Region**<br>Does this location contain any critical infrastructure, key maintenance units/depots, route criticality, value of service etc, service interruption category (see *Step 1.1*) | **Action to be taken**<br>For each climate hazard indicate whether location is being taken forward to Rapid APA phase, in the next tranche to be analysis, on hold for future analysis or no further action. | **Reason for decision**<br>Record of decisions on why certain actions have been taken as well as dates for future review. This should include limitations and assumptions made |
|---|---|---|---|---|

## Rapid and Full Adaptation Pathway Assessment Graphics templates

The outcome of all Rapid and Full APAs shall be summarised in an adaptation pathways graphic in a format that is consistent across all locations in all regions. The plan is for a web-based tool to be developed to support analysis of options which will automatically produce consistent products in a manner similar to those presented in *Figure 5.* In the short term, the template on the Adaptation Pathways SharePoint site should be used for all locations.

**Figure 5 Illustration of the outputs of Rapid and Full Adaptation pathways Assessments**

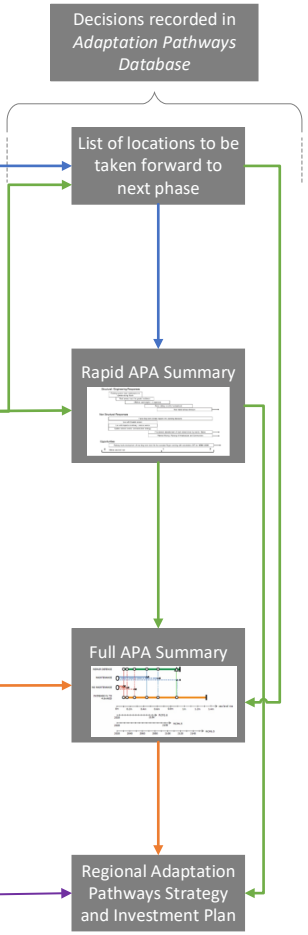


# 4. Phases of adaptation pathway development

A summary of the phased approach to developing adaptation pathways is set out in *Figure 6* and discussed in detail in this section.

**Figure 6 The adaptation pathways process and outputs**

| Activity | Process | Outputs |
|---|---|---|
| **Phase 1: Screening and prioritisation** | | |
| Determine the strategic value of different parts of the rail network and identify and prioritise locations facing highest climate change risk | Review outputs of screening and shortlist locations for Phase 2: Rapid Adaptation Pathways Assessment.<br>• Step 1.1 Desired level of strategic resilience<br>• Step 1.2 Review outputs of screening<br>• Step 1.3 Shortlist locations to be taken forward to Rapid APA phase. | • Shortlisted locations for Rapid APA process (Phase 2).<br>• Decisions recorded in Adaptation Pathways Database. |
| **Phase 2: Rapid Adaptation Pathways Assessment** | | |
| Review asset, weather and climate impact data to assess risk and identify potential adaptation interventions at different severity and time thresholds for each shortlisted location | Prepare for and deliver workshops to develop adaptation pathway for shortlisted locations:<br>Step 2.1Preparation and information gathering<br>Step 2.2 Planning and facilitating workshops<br>Step 2.3 Reporting and presentation of findings<br>Step 2.4 Rapid APA results analysis and planning way forward | • High level 'rapid' adaptation pathway and decision on level of risk climate change poses to the railway in each shortlisted location summarised in Rapid APA template.<br>• High risk locations to be taken forward to Phase 3.<br>• Risk score and decisions to be recorded in the Adaptation Pathways Database.<br>• Where appropriate, decisions recorded in other internal documents e.g. asset management strategies, business continuity plans etc. |
| **Phase 3: Full Adaptation Pathways Assessment** | | |
| Fully develop adaptation pathway for each selected location setting out timing/triggers for decisions, when investment is needed and the stepping stones/building blocks between now and when the major interventions are required. It shall set out how the approach addresses the needs of multiple stakeholders and agreements with external stakeholders on the actions to be taken. | Analyse risk and adaptation options in depth for selected locations. It could involve:<br>• Modelling of risk and engineering solutions,<br>• Engagement with external stakeholders,<br>• Economic analysis and<br>• Discussion to decide where and when adaptation should take place in a location. | • Detailed investigation of risk and adaptation options involving data modelling, stakeholder engagement, economic analysis etc to map out where and when adaptation should take place in that location.<br>• Full APA summarised in template provided<br>• Decisions to be recorded in the Adaptation Pathways Database and other internal documents e.g. asset management strategies, business continuity plans etc. |
| **Phase 4: Strategic planning and government liaison** | | |
| A regional adaptation pathway strategy and investment plan summarising key findings of work and setting out the long term strategy for the Region | Align to regional strategic planning approach | • Report consolidating findings from all Rapid and Full APAs presenting an overarching pathway strategy for the Region.<br>• Summary of report to be published. |



## *Phase 1: Screening and prioritisation*

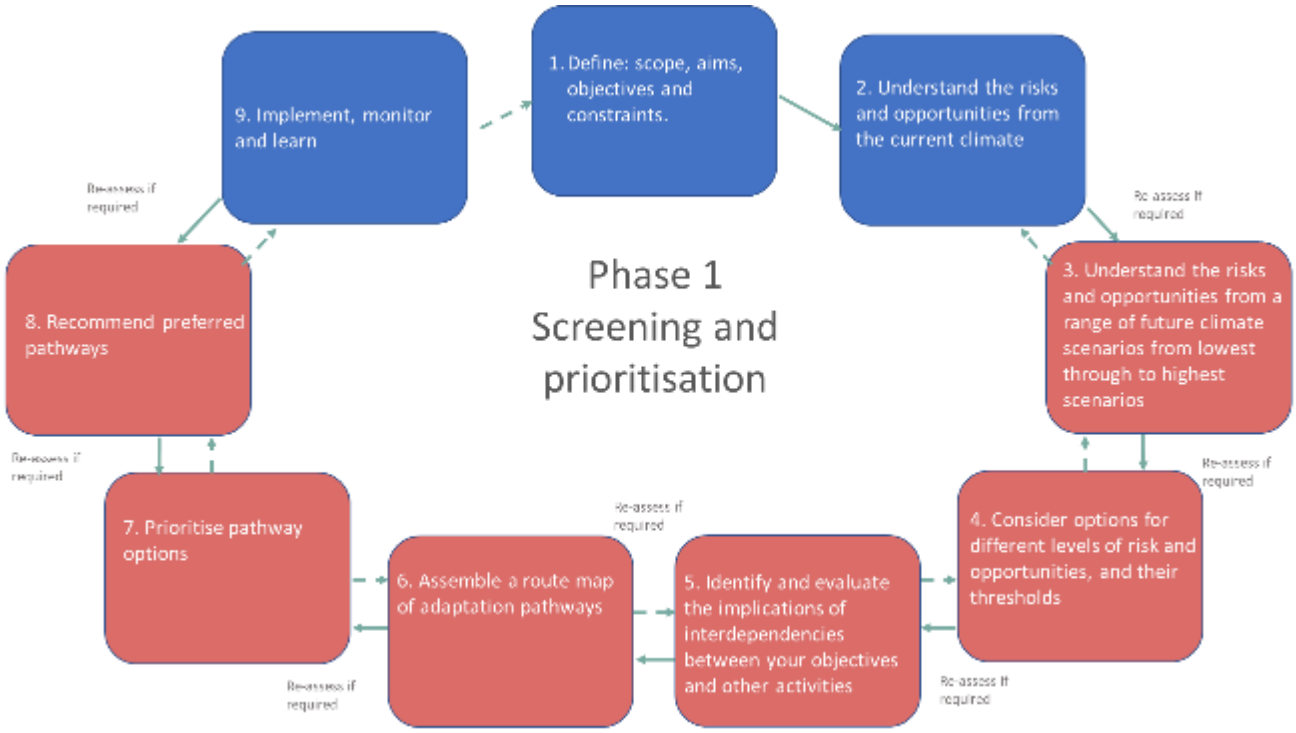
### RATIONALE

A screening or triage process is required to identify those areas facing the highest risk from climate change and prioritise locations requiring the most urgent action.

It is anticipated that, in each Region during CP7, around 20 – 30 locations will go through the Phase 2 Rapid Adaptation Pathways Assessment process to develop a high-level pathway with those deemed highest risk going through the Phase 3 Full Adaptation Pathways Assessment. As each adaptation pathway is completed, work should start on locations further down the priority list. The process is designed to be agile/flexible and over time a Regional picture will develop. Decisions taken now should be reviewed at least every ten years or following significant incidents to check whether assumptions on the speed and severity of climate change are aligned with the selected path of action.

Phase 1 primarily covers stage 1 of the BS8631:2021 adaptation pathways process defining the scope and aims of the programme. In doing so it will start to understand the risks from stage 2 at a high level. As the programme progresses and lessons are learned (stage 9), the scope and objectives can be reviewed before prioritisation and assessment of the next round of locations as illustrated in *Figure 7*.

**Figure 7 Phase 1 links to BS8631:2021 Stages in developing adaptation pathways**



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## EXPECTED OUTPUTS

The purpose of this phase is to define the strategic resilience requirements for the railway and shortlist locations to be taken through the Rapid APA process (Phase 2). All decisions shall be recorded in the *Adaptation Pathways Database.*

## RESOURCES TO SUPPORT THE PROCESS

### Climate risk screening

A initial screening assessment has been undertaken to support identification of locations around the railway network that are particularly vulnerable to climate change the future. The railway has been broken down into 2km grid squares with a score given to each square indicating the level of risk exposure at each location under different climate scenarios and the level of criticality to the rail network as a whole in that location.

The outputs of the screening process are available on the Adaptation Pathways SharePoint site and include:

- Maps showing relative climate risk under different climate scenarios and time frames
- An excel workbook listing grid squares and associated 'Engineers Line Reference' (ELR) that can be filtered by risk severity
- Key data points for each grid square including climate projections, flood risk, number and type of assets, underlying risk input data.

The tool is designed to help sift priority locations, when used in parallel with local knowledge and information. The outputs of the screening tool are indicative and will require review and sense checking at a regional level, and is not designed to be the sole source of information used when developing regional priorities. See Step 1.2 below.

## DEFINING LOCATIONS

The APA methodology outlined in this document will likely be applied at different scales based on the climate-related risks a region is looking to address. For example, the methodology could be applied to a site level where there is a significant climate-related risk that could result in a material change to physical properties of the site/location/asset (e.g., a section of track at risk of being undermined by coastal erosion). Or, the methodology could be applied at route/regional level to inform a strategy for dealing with climate-related risks that may materialise over a much larger area (e.g., the risk of widespread heat and associated impacts on track route/region wide)

The terms 'location' and 'area' have been used in this document to refer to the area under investigation for an adaptation pathways assessment. Adaptation pathways can be conducted at different spatial scales along the railway.

The climate risk screening has broken the network into 2km grid squares to provide risk scores. The level of effort required to deliver Rapid APAs for all grid squares at this level of granularity is prohibitive. The screening process should look to aggregate these grid squares into manageable chunks in line with the following:

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- **Regional level** - for non-geographical risks like impact of heat on all of a particular asset type, a route or region wide Rapid APA could support development of a plan for managing the risk
- **Strategic route level** (~100 miles of track[9]) - an initial assessment can be done at a high level for strategic route sections to identify weak points and map out the timing for developing adaptation pathways/intervention at those local level locations
- **Local route level** (<10 miles of track) – assess the weak points between junctions or stations etc that may have formed a weak point in the strategic assessment to obtain more detailed understanding of the issues and adaptation options for the area
- **Site level** (<1 mile of track) - They can be done for a single location which experiences a particular problem with a climate hazard and a pathway for managing the impact over time can be defined e.g. flooding at Chipping Sodbury.

It is envisaged that 20 – 30 rapid APAs will be conducted during CP7. It is likely that many of these will be local or site level, although strategic route level may be appropriate for longer sections that are subject to the same climate risk (e.g. heat). By 2040 each Region is required to complete adaptation pathway assessments for all grid squares aggregated to a maximum of local level. This will take time and the strategic assessments will help prioritise where to focus the more detailed analysis in the short term.

## DELIVERING PHASE 1 OUTPUTS

This phase of work involves reviewing the outputs of the screening and shortlisting locations to be taken through to *Phase 2: Rapid Adaptation Pathways Assessment*. The work can be undertaken by the project team in consultation with a small number of asset management, strategic planning and operations colleagues and/or others as appropriate.

### Step 1.1 Desired level of strategic resilience for the network

There are multiple methods for determining network and railway system criticality but none of these consider the extent to which we are able to withstand service interruptions for varying durations which is an important consideration when it comes to determining the priority of locations and decisions around options for adaptation pathways. Before we prioritise locations for assessment, it is useful to define the level of strategic resilience we need to build into the network. *Table 4* sets out the definitions for categorising the desired strategic resilience levels for different lines of route.

**Table 4 Resilience categories and definitions**

| Resilience category | Definition |
|---|---|
| Resist | the railway system in this part of the network must be able to resist shocks and stresses to prevent an impact on infrastructure and services |
| Rapid recovery | the railway system in this part of the network must be able to absorb shocks and stresses to minimise the impact on services and quickly recover from the event to restore expected levels of service (within 24 hours) |
| Bounce Back | the railway system in this part of the network could accept a short term interruption to services but must be able to bounce back to operations quickly after repairs have been carried out following incidents (up to a week) |
| Repair | the railway system in this part of the network could accept an interruption to services while repairs are carried out following incidents (weeks to months) |
| Close | the railway system in this part of the network could be partially/fully closed if extreme weather and climate change make it impossible to maintain services. |

[9] Distances are indicative and will vary depending on specifics e.g. distance between major stations or junctions

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In determining the resilience category, the value/criticality of the railway along different lines of route could be considered in line with the following questions:

**What is the value/criticality of the railway in the area?**

- Is there critical infrastructure in the area, are routes to/from it at risk and have they been captured?
- Is the line strategically important from a value of service or freight perspective or does it play a significant role in connecting otherwise isolated communities, act as a diversion for closures on other lines etc?
- What level of service do Key Route Strategies require?

**What interdependencies exist in the area?**

- Are there known interdependencies with other infrastructure operators in an area e.g. canals, station/track owned by another, power/telecoms infrastructure etc?
- How important is the railway to reducing social deprivation given the economies of local towns?
- Where are the areas of future growth/strategic significance for the railway e.g. future housing developments, Northern Powerhouse etc?

The output of this step is categorisation of different lines of route in the Region according to risk appetite and the extent to which service interruptions can be tolerated. An illustrative example of this type of thinking is shown in *Figure 8*. The results shall be recorded in the Adaptation Pathways Database.

Figure 8 Thought map of determining resilience for lines of route (this is purely illustrative and is not confirmed strategy)

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## Step 1.2 Review outputs of screening

The outputs of the screening process are based on high level, national datasets and may produce results that, when reviewed at a regional level do not reflect the current understanding of risk and criticality in a certain area. For example, the screening may screen-out areas that actually need to be screened-in, based on subject matter expert knowledge e.g. an area may flag as high flood risk but the railway is on a viaduct above any possible high water mark or it may flag as medium risk but is on the line transporting nuclear waste which is high criticality.

The outputs from the screening should be sense checked and validated by Regional expert knowledge to see if they correspond to known locations or are recognised locations of strategic importance. The following should be considered in addition to questions listed in Step 1.1 when reviewing the screening results:

**Have the right locations been identified?**

- Does the list of high risk locations correspond to known problem sites with recurring weather impacts?
- Is there any region specific data or analysis which can be used in addition to the screening outputs to determine priority?
- Are there any known poor condition assets or those that regularly suffer failures which are not due to be refurbished/renewed during CP7?
- Have recent or planned renewals removed/reduced the risk highlighted in the screening?
- Could some grid squares and/or ELRs be grouped together to form a larger area for analysis or could a long ELR be broken up to better cover defined risk areas.
- How do the grid squares and/or ELRs align with the 'Register of Corridors' under the regional asset strategy?

## Step 1.3 Shortlist locations to be taken forward to Rapid APA phase.

It is anticipated that around 20 – 30 site and local level locations will be shortlisted and run through the Rapid APA process through the course of CP7. Those deemed highest risk should go through the Full APA process. As each adaptation pathway is completed, work should start on locations further down the priority list as time and budget allow.

A decision should be taken as to which climate hazards are going to be the focus of analysis based on the review of the risk screening and an initial assessment of the vulnerability. This should also consider compound impacts where for example intense rainfall following hot dry weather leads to great run-off, or a combination of onshore winds and sea level rise in a storm surge increase coastal impact. These should be those where the risk is most significant or where the risk increases considerably as a result of climate change and will likely require a step change in the way we manage the area and/or significant intervention (in line with the desired level of resilience determined in Step 1.1).

Based on the above considerations, an updated priority score should be given to each location with decisions recorded in the Adaptation Pathways Database.

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## *Phase 2: Rapid Adaptation Pathway Assessment*

### RATIONALE

Rapid Adaptation Pathway Assessment (Rapid APA) is a way to review weather and climate impact information and make high level decisions on potential options to manage risk, based on the views of experts familiar with the area and assets in the location in question. It considers at a high level the following:

- **The value of the railway in the case study area** using a number of framings: strategic value (measure against Great British Railway Transition Team strategic objectives[10]) value of service, and PESTLE (Political, Economic, Social, Technological, Environmental).
- **How climate impacts are likely to change** with different levels of change up to a low probability but high consequence scenario (called High++ in adaptative pathway terminology but also referenced as High Impact and Low Likelihood
- **What actions are needed to address current and future climate risk** – what low/no regrets options can be implemented in the near term as we prepare for the longer term?
- **The indicative thresholds at which those interventions need to be implemented** and trigger levels where they may need to be supplemented by additional adaptation interventions to ensure the stretch of line remains operational
- **Whether there are conditions under which closure of the line would need to be considered** and, if so, what those conditions would be e.g. close over winter but open in summer or close permanently.

This process will be run for every shortlisted location and the outputs will be a high-level thought map of adaptation measures and a decision as to whether or not the risk is high enough to require further, more detailed analysis. The aim is to develop a decision tree for each location which identifies, at a high level, the types of adaptation actions which could be undertaken at different trigger points ahead of thresholds being exceeded.

Phase 2 covers stages 1 – 4 of the BS8631:2021 adaptation pathways process developing a high level understanding of the current and future risks and opportunities from climate change and identification of options for managing different levels of risk and their thresholds. There is an element of stage 1 involved for each individual pathways project building on the work undertaken during Phase 1 as illustrated in *Figure 9*.

[10] See: https://gbrtt.co.uk/wp-content/uploads/2022/05/Strategic-Objectives-Slide-English-NEW-1536x901.png

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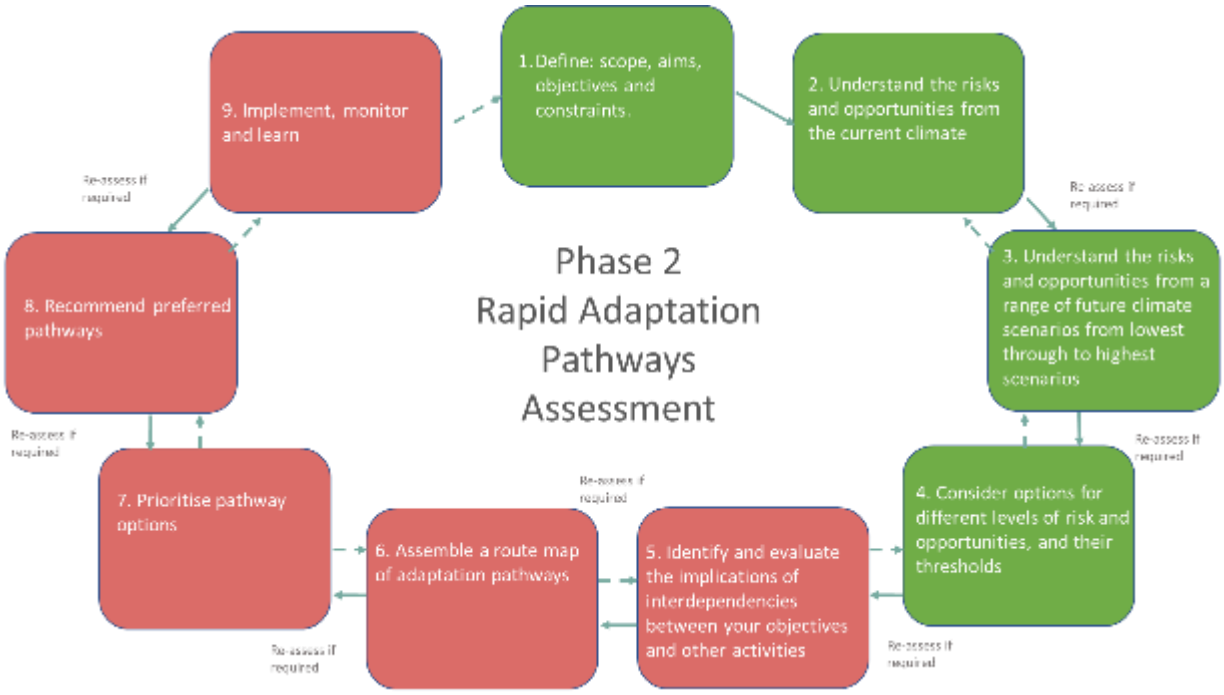
Figure 9 Phase 2 links to BS8631:2021 Stages in developing adaptation pathways




## EXPECTED OUTPUTS

By the end of this phase, each shortlisted location shall have:

- a high level 'rapid' adaptation pathway diagram,
- a decision relating the level of risk climate change poses to the railway in that area, whether this is near or long term and whether transformational change may be required, and
- whether the location is being taken forward for a Full APA in Phase 3.

It is anticipated that around 20 – 30 locations will be shortlisted and run through the Rapid APA process through the course of CP7.

The outputs shall be in the format and using the risk scoring criteria set out in Step 2.3 and decisions shall be recorded in the Adaptation Pathways Database.

Where appropriate, asset strategies, asset management plans, business continuity plans, and integrated weather management plans and other documents shall be updated to ensure the decisions made during this project are actioned at the appropriate time. For example trigger levels, design notes for repairs/replacement should an asset fail etc.

## DELIVERING PHASE 2 OUTPUTS

This phase involves the following steps which are discussed in further detail below:

2.1 Preparation and information gathering

2.2 Planning and facilitating workshops

2.3 Reporting and presentation of findings

2.4 Rapid APA results analysis and planning way forward

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## Step 2.1 Preparation and information gathering

### Purpose and expected output

A considerable amount of preparation is required in advance of the Rapid APA workshops to ensure that sufficient information is available to inform discussion. This step outlines the type of information that could support vulnerability analysis and the development of adaptation options and will produce:

- Climate change impact thresholds for each climate hazard,
- Maps and other materials to support discussion at workshops in Step 2.2.

### Information and useful resources

The basic information that would be useful for each location includes:

- Information on current and previous weather related hazards/risks
- Maps illustrating the location of the railway in relation to current and future hazards[11]
- Performance and socio-economic data for the area in question
- Climate change scenarios and climate impact data
- Background information on the location including any long term strategies in place for the area

The outputs of the climate risk screening provide meta data for every grid square setting out key parameters relating to risk levels. A web-based visualisation tool is planned to support collation of data in advance of workshops – updates on this will be provided during 2024. Given that this is national level data, there will still be a need to visualise hazards and vulnerabilities at a local level using information from GeoRINM and other sources. *Table 5* provides an overview of information needs and links to useful resources. The materials from the Southern Pilot Project (see Adaptation Pathways SharePoint site) provide a useful case study and starting point from which to develop the approach in each Region.

**Table 5 Overview of information needs and useful resources**

| Information need | Rationale and useful resources |
|---|---|
| Historic weather impacts | It is likely that those areas at highest risk already experience weather impacts to a greater or lesser extent. Gathering information of extreme events and the impacts experienced to date (as far back in time as possible) will provide a useful understanding of how the impacts affect the area may change in the future and where the key risks lie. This could come in the form of anecdotal evidence from colleagues familiar with the location such as Seasons Delivery Managers and Route Control and from performance and asset failure datasets<br><br>**Useful resources:**<br>• Weather Impact PowerBI of Schedule 8 and 4 delays and cancellations<br>• Past weather conditions from MetDesk or Met Office records |

[11] The Southern Adaptation Pathways Pilot Project commissioned Network Rail's Engineering Services Design Delivery (NRDD/ESDD) to support development of asset maps and materials for the Rapid APA workshops but were not able to provide a clear scope of what was required due to the innovative nature of the work. NRDD produced a lessons learned report which outlines ways in which the process could be streamlined in future. The advice outlined here is based on the experience and recommendations of the team involved with the Southern pilot project see SharePoint site

| | |
|---|---|
| | • Fault Management System and other incident recording systems<br>• Asset records<br>• Met office state of the climate reports<br>• Connect and external news articles |
| Maps | Sketch maps illustrating the location of the railway and different assets in relation to key hazards are invaluable when considering future risks. The maps do not need to be perfect, they need to give a general sense of where things are in relation to the hazards to trigger discussion. The number of maps should be kept to a minimum to ease discussion and they should include:<br>• Location of key assets – structures, drainage, track height above sea/river level, lineside equipment such as signal boxes, location cabinets, sub stations etc.<br>• Flood extents now and into the future (river, surface and coastal flooding as a minimum)<br>• Coastal erosion risk and shoreline management plans where relevant<br>• Risk screening scores for each grid square in area under investigation<br>• Included different scales if necessary to visualise risk<br><br>**Useful resources**:<br>• Climate risk screening metadata<br>• NRDD lessons learned report from Southern Pilot (see SharePoint site) |
| **Performance and socio-economic data** | Engage with the System Operator Economic Analysis Team and Regional Strategic Planning Teams to provide a summary of key performance and socioeconomic information relating to the area in question. Some of this is available in the climate risk screening metadata.<br>• Number of trains per hour<br>• Number of passengers per hour/day<br>• Number of freight trains and tonnage per hour/day<br>• Whether the line is strategically important from a freight perspective or plays a significant role in connecting otherwise isolated communities, acts as a diversion for closures on other lines etc<br>• The economies of local towns and the importance of the railway to reducing social deprivation (transport related social exclusion)<br>• What existing rail strategies cover the area and where are there areas of future growth/strategic significance for the railway e.g. future housing developments, Northern Powerhouse, other infrastructure like Hinkley Point and new enterprise/industrial areas etc<br><br>**Useful resources:**<br>• MOIRA database<br>• Network Rail Freight Forecasting Tool<br>• ONS Population and Jobs by Middle Layer Super Output Area (MSOA) see here<br>• ORR estimates of station usage<br>• Transport Related Social Exclusion |
| **Climate change scenarios** | Defining the future climate in which we will be running the railway requires use of climate change projections.<br><br>The Rail Industry has agreed to the use of standard climate change scenarios across the sector in order to ensure equivalence in risk assessments and adaptation plans. These scenarios are set out in detail in NR/GN/ESD23 Climate Change Projections Guidance Note.<br><br>For the purposes of the rapid and full APAs, climate scenarios and impact thresholds **shall** consider the medium and high scenarios as set out in the guidance and appropriate High Plus Plus (H++) scenarios e.g. for sea level rise. This is to ensure the worst-case risk is understood and informs decision making. Detailed design of interventions should be based on Network Rail standards and requirements at the time of implementation (as set out in NR/GN/ESD23) |

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| | |
|---|---|
| | **Useful resources:**<br>• NR/GN/ESD23 Climate Change Projections Guidance Note.<br>• Met Office UK Climate Projections<br>• Met Office climate change frequency calculator tool (currently in development)<br>• Climate Risk Indicators (uk-cri.org)<br>• Integrated climate change risk assessment<br>• Current and future flood risk – Adaptation Pathways Database contains indication of flood zone for each location for different future time frames – use of the raw data on GeoRINM is restricted – Regional WRCCA Leads should have access.<br>• Current flood risk:<br>  • England - Check the long term flood risk for an area in England - GOV.UK (www.gov.uk) (this is due to be updated in 2024)<br>  • Scotland - Flood Maps \| SEPA - Flood Maps \| SEPA<br>  • Wales - Natural Resources Wales / Check your flood risk on a map (Flood Risk Assessment Wales Map)<br>• Government guidance on climate change allowances for river flow, sea level etc<br>  • England - Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk)<br>  • Scotland - SEPA Technical Flood Risk Guidance for Stakeholders<br>  • Wales Climate change allowances and flood consequence assessments \| GOV.WALES |

## Developing climate change thresholds

Thresholds are the points at which the performance of assets or services become unacceptable and require further adaptive intervention.

Impact thresholds should be created for each climate hazard setting out the level of impact expected with increasing levels of climate change. It is important that thresholds are practical both in terms of what the threshold defines (e.g. frequency of impact or occurrence of a certain severity of impact), and how that variable/feature is measured. The threshold needs to be identifiable near real time rather than delayed so that risk isn't introduced into the system prior to action being taken.

The resolution of the thresholds should be appropriate to the location being investigated e.g. peak river flow varies by catchment, sea level rise is greater in the south than the north of the country and temperature and precipitation levels vary by geography. It may be appropriate to develop a core set of thresholds (see Appendix 1 for example) that is valid for the majority of the Region with slight tweaks being made for specific locations depending on localised projections and local resilience levels e.g. some (on higher ground for example) will be able to withstand a much greater peak rainfall trigger threshold vs. others that are cut straight through an aquifer.

The case study in Appendix 2 describes an imaginary scenario to indicate what might trigger thresholds and what the responses might be. What is "unacceptable" can be a matter of judgement and depends on appetite for risk and expected service levels.

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## Step 2.2 Planning and facilitating workshops

### Purpose and expected outputs

The easiest way to gather information relating to Stages 2 – 4 from *Figure 9* from experts on the risk to a particular location is through a workshop where they get to share their views rather than trying to interview multiple people and then get approval of findings. It is anticipated that workshops will be held to run around 20 – 30 locations through the Rapid APA process through the course of CP7.

This step involves planning and facilitating these workshops with the outputs being materials and a record of discussions to feed into Step 2.3. This section sets out some suggestions and useful resources to support this work.

### Suggested approach to workshops

#### In person vs online

The Southern Adaptation Pathways Pilot Project went through four rounds of workshops with improvements made to the agenda and process at each round. Online and in person workshops were held with advantages to both. One of the key advantages to online sessions was the ability for people to add notes and thoughts directly onto maps and whiteboards making it easier to collate thoughts. It was also easier and more efficient for producing and editing draft Rapid APA diagrams. However, the in person discussions were much richer where people were able to bounce ideas off each other more easily.

A possible hybrid approach could be for online tools such as a 'Mural' board to be used to support discussions in a room. The materials from the Southern pilot project are available on the Adaptation Pathways SharePoint site for reference.

#### Participants

Fundamental to the success of this project is the involvement of engineering and asset management colleagues familiar with the assets, previous weather impacts and current plans for managing the risk. Without asset management colleagues in the room, discussions will be based on high level assumptions and will need validation by the asset management team at a later date.

Suggested workshop participants include:

- Facilitator(s) and note taker(s)
- Climate change expert
- Engineering and asset management staff familiar with the location/ main discipline being covered
- Strategic planners and economic analysts (if desired)
- Route Services/Property representatives for stations/depots etc in location
- Others as desired (inclusion of some external stakeholders could add significant value to the Rapid APA process).

It can be difficult getting time in people's diaries for this work, particularly those individuals who are required at a lot of the sessions. It is important that this project is seen as high

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priority with senior level endorsement and engagement. Getting sessions in diaries well in advance and building the Rapid APA sessions into existing meetings or holding a number at a time (Southern ran four workshops covering eight locations) could increase participation. Having the first couple in person to get people familiar with the process and having others held virtually might also help.

### Agenda and facilitation plan

The workshop needs to take people through a complex thought process considering multiple data sources. At a high level, the following key items should be covered, but not limited to:

- Overview, and determining and agreeing the value, of the railway in the area/ how this may change in the future - context of the location
- Understanding current weather risks/vulnerability
- Work through how climate vulnerability changes over the century up to high scenarios
- Explore options for different vulnerability levels and their different thresholds of viability, including end state options
- The indicative thresholds at which those interventions need to be supplemented by additional adaptation interventions to ensure service is maintained
- Map out initial Rapid APA diagram (see *Figure 10*)
- Review of strategic value and how this might influence Rapid APA diagram selections/decisions e.g., timing of interventions, scale of interventions
- Finalisation of Rapid APA diagram

#### Useful resources

The Adaptation Pathways SharePoint site contains a wide range of materials from the Southern Pilot including a draft agenda and facilitation plan based on what worked effectively in the Southern Pilot. It could be a starting point for workshops which will naturally evolve as the facilitators and participants become familiar with the process.

## Step 2.3 Reporting and presentation of findings

#### Purpose and expected outputs

Each Region will develop adaptation pathways assessments in a manner appropriate to the needs of the region. The results of this work need to be summarised in a format that is consistent between regions to enable comparison, further analysis and development of a national level overview of pathways and priorities.

This section sets out the required format for Rapid APA diagrams and the risk scoring criteria and categories.

#### Expected output

- A Rapid APA diagram for every location in required format.
- Adaptation risk scores for every location recorded in the Adaptation Pathways Database alongside an update to the actions/decisions relating to the location in question.

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## Adaptation risk scoring

A key strategic decision will be the level of risk facing each location and the level of detail to develop adaptation plans for each climate hazard. The strategic resilience category defined in Step 1.1 should feed into the decisions around risk scores. The risk levels to be used are summarised in *Table 6* below with the criteria for the adaptation risk levels presented in *Table 7*.

Table 6 Adaptation pathways risk levels

| Key | |
|---|---|
| **Risk Level** | **Colour Code** |
| Low (L) | |
| Future Risk without transformational risk (FR) | |
| Future Risk with transformational risk (FR+T) | |
| Near Term Risk without transformational risk (NTR) | |
| Near Term Risk with transformational risk (NTR+T) | |

Table 7 Adaptation pathways risk scoring criteria

| Risk Level | Risk criteria |
|---|---|
| **Low** | Not affected by climate impacts up to RCP8.5 (90 %) in 2100 |
| **Medium or Future Risk (FR)** | • Not affected by current climate impacts.<br>• Adaptation action will not be required before 20 % (?) of the 2100 RCP8.5 (90 %) scenario[12] (see Appendix 1).<br>• There is no need for transformational adaptation in scenarios up to 2100 RCP8.5 (90 %) scenario e.g. route closure or re-routing<br>• When using this definition use the acronym "FR" |
| **High or Near Term Risk (NTR)** | • Adaptation actions will be required between current climate 20 % (?) of the 2100 RCP8.5 (90 %) scenario (see Appendix 1).<br>• There is no need for transformational adaptation in scenarios up to High++ 2100 e.g. route closure or re-routing<br>• When using this definition use the acronym "NTR" |
| **Transformational Risk (+T)** | • There is possible need for transformational adaptation e.g. route closure or re-routing between current climate and High++ climate scenarios.<br>• Transformational Risk may be present in either "Future Risk" or "Near Term Risk".<br>• When using these definitions indicate the presence of this risk by adding "+T" to the risk code i.e.<br>  • Future Risk including Transformational Risk use the acronym "FR+T"<br>  • Near Term Risk that included Transformational Risk use the acronym "NTR+T" |

## Rapid APA reporting format

The findings from each Rapid APA workshop should be written up in a short summary report detailing the key elements of the discussion. The key elements of the pathway developed shall be presented in a format similar to *Figure 10*. which provides an illustration of the

[12] Use of High ++ scenarios should be considered when developing thresholds and may replace the RCP8.5 scenarios referenced here if applicable.

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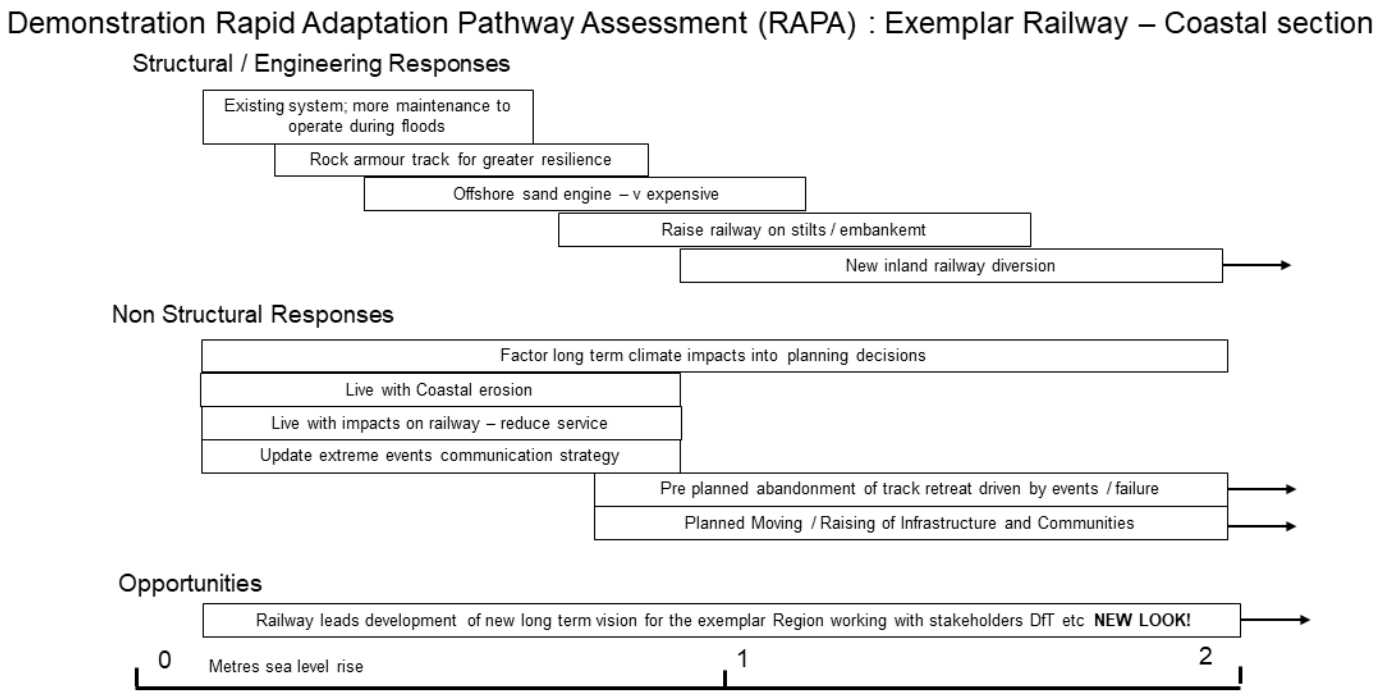
outputs of the Rapid APA discussions – further examples are available from the Southern Pilot Project documentation available on the Adaptation Pathways SharePoint Site.

Figure 10 Illustration of the output of a Rapid Adaptation pathways Assessment (Rapid APA)




The plan is for a web-based tool to be developed to support collation of data and analysis of options which will automatically produce consistent products. In the meantime, and at the start of the project, a template to guide development of the Rapid APA diagrams is available on the Adaptation Pathways SharePoint site..

### Useful resources

- Strategic resilience from Step 1.1
- Adaptation risk scoring criteria at start of this section
- Appendix 2 – Illustration of risk screening
- Holes Bay Rapid APA Report (Southern Pilot Project on SharePoint site)
- Dover – Folkstone Rapid APA Report (Southern Pilot Project on SharePoint site)
- Summary of Rapid APA outcomes presentation (Southern Pilot Project on SharePoint site)
- Rapid APA diagram template (Adaptation Pathways SharePoint site)

## Step 2.4 Rapid APA results analysis and planning way forward

The outputs of the Rapid APAs should be reviewed to determine which will be taken forward for more detailed analysis. Those falling into the following categories should be considered as candidates for a Full Adaptation Pathway Analysis (Full APA):

- Future Risk with transformational risk (FR+T)
- Near Term Risk without transformational risk (NTR)

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- Near Term Risk with transformational risk (NTR+T)

At this stage, the list of locations next in line for analysis based on screening and prioritisation should go through the Rapid APA process outlined above. Those selected for Full APAs should go through the process outlined in Phase 3.

All decisions regarding each location must be recorded in the Adaptation Pathways Database.

Where appropriate, asset management plans, business continuity plans, integrated weather management plans, and other documents as appropriate, shall be updated to ensure the decisions made during this project are actioned at the appropriate time. For example trigger levels, design notes for repairs/replacement should an asset fail etc.

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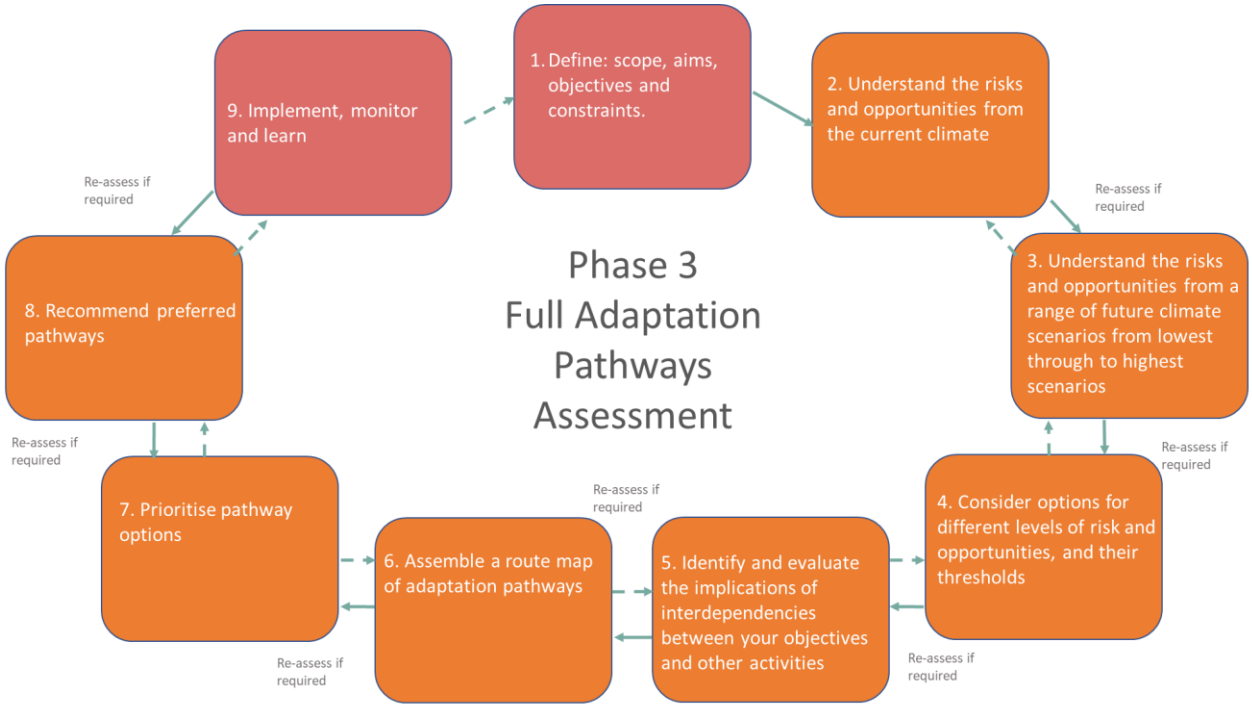
## *Phase 3: Full Adaptation Pathway Assessment*

### RATIONALE

The Full Adaptation Pathways Analysis (Full APA) phase is where a very detailed understanding of risk and adaptation options is developed for selected high risk/priority locations. The overarching process is similar to the Rapid APA and repeats stages 2 – 4 of the BS8631:2021 adaptation pathways process at more granular detail. It expands the assessment to cover stages 5 – 8 which could involve modelling of risk and high-level feasibility assessment of engineering solutions, engagement with external stakeholders, economic analysis and discussion to decide where and when adaptation interventions should take place in that location. This is illustrated in *Figure 11*.

**Figure 11 Phase 3 links to BS8631:2021 stages in developing adaptation pathways**




### EXPECTED OUTPUTS

The output of this phase will be a fully developed adaptation pathway for each location selected for a Full APA including an indication of costs for interventions in the short to medium term. It shall set out the timing/triggers for decisions, when intervention is needed and the stepping stones/building blocks between now and when the major interventions/investments are required. It shall set out how the approach addresses the needs of multiple stakeholders and agreements with external stakeholders on the actions to be taken.

The outputs shall be in the format outlined below and all decisions shall be recorded in the Adaptation Pathways Database.

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Where appropriate, asset management strategies, business continuity plans and integrated weather management plans shall be updated to ensure the decisions made during this project are actioned at the appropriate time. For example, trigger levels, design notes for repairs/replacement should an asset fail etc.

## DELIVERING PHASE 3 OUTPUTS

Network Rail is at the forefront of adaptation planning and there are limited examples of application of this approach to a railway network.

The Southern Adaptation Pathways Pilot Project is still working through the Full APA phase for two locations (Dover to Folkestone and Holes Bay). Further guidance on how to approach this phase will be provided as we work through the process and define best practice for delivering this work through collaboration between regions.

The remainder of this section sets out some of the considerations for delivery of Full APAs in relation to stakeholder engagement, data gathering, analysis and pathway development and reporting of findings. Further guidance will be provided as an appropriate methodology emerges through discussion at the National Adaptation Pathways Working Group.

### Broaden stakeholder engagement

- Given the importance of the railway to communities and connectivity, any decisions we make which may have a wider effect must be made in collaboration with others.
- There is significant potential for partnership working and development of holistic solutions with wide benefits that can only be identified through collaboration with others.
- Many external stakeholders are really interested in Network Rail's adaptation pathways project and are keen to get involved. There is likely to be an enthusiastic response when inviting people to participate and the process will gain significant benefit as a result.
- Involve local and national government and regulators early in the process in those areas where transformation is required which could have large socio-economic impacts (e.g., part of full closure of lines). This will help with Phase 4 and with getting buy in and funding for our preferred approach going forward. Community engagement may be appropriate in some areas where transformation is required in a relatively short timeframe.
- Involve other Regions and Route Services where locations are on key national routes or close to borders.
- Connect with external stakeholders including (but not limited to) the following:

| | |
|---|---|
| • Environment Agency<br>• Natural Resources Wales<br>• Scottish Environment Protection Agency<br>• Local authorities and councils etc<br>• Highways agencies<br>• Environmental groups such as Natural England, Wildlife Trusts etc<br>• Community groups in the area e.g. Heritage Railways | • Other infrastructure managers e.g. power, telecoms, water, canals etc depending on interdependencies in the area<br>• Risk Management Authorities such as regional flood and coastal committees; lead local flood authorities; local authorities; and internal drainage boards |

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## Data gathering

- Organisations like the Environment Agency and Regional Flood and Coastal Committees have detailed risk modelling information that could provide valuable insight to the risk to the railway. It may also save Network Rail from commissioning analysis that already exists or could potentially be undertaken by others on our behalf at little or no extra cost. Network Rail has data sharing agreements and MOUs (memorandum of understanding) with some of them.
- Commission more detailed maps/modelling to improve understanding of vulnerability.
- Assess the sensitivity of long life assets to slow onset climate changes and extreme events to help understand the risk from high impact, low likelihood events.
- Improve understanding of thresholds and tipping points
- Commission engineering options analysis for potential short/medium term solutions including cost: benefit analysis
- More detailed understanding of strategic impacts associated with all of the potential options
- Obtain more detailed economic and social data
- The University of Leeds[13] did some work on local adaptation pathways for coastal transport infrastructure in 2022 and the paper sets out an approach to threshold analysis and modelling that could be applied or adapted in some locations.

## Analysis and pathways development

- Determine which risks are being looked at in detail and how they interact. Update the Adaptation Pathways Database with decisions around adaptation to lower level risks (e.g. focus on coastal erosion, manage heat and wind risks through business as usual standards etc)
- Where a location faces multiple weather hazards impacting multiple assets all requiring more detailed analysis, consider the best way to bring this together through individual pathways merged into one based on timings etc
- Focus on the positives from delivering adaptation from a longer term sustainability perspective as well as prevention of impacts
- Work with internal and external stakeholders through workshops and other means to review and understand findings and develop options further
- Identify partnerships and opportunities to use nature based solutions and low carbon options to manage risk.
- Identify interdependencies between risks and adaptation actions, seeking opportunities to address any potential for cascading risk, maximising benefits from adaptation synergies and mitigating any potential conflicts between actions.
    - Where appropriate, add adaptive interventions to manage interdependent and cascading risks and adjust economic, social and environmental benefits to take account of these adjustments
    - Where appropriate add, remove or amend interventions and adjust pathway sequences to improve benefits/eliminate conflicts
- Work with local authorities, regulators and government to determine appropriate solutions for areas with particularly sensitive socio-economic/political contexts

[13] Dawson, David and Mortleman, Tamsin (2022) Adaptation Pathways for Vulnerable Coastal Transport Infrastructure. Available at SSRN: https://ssrn.com/abstract=4152866 or http://dx.doi.org/10.2139/ssrn.4152866

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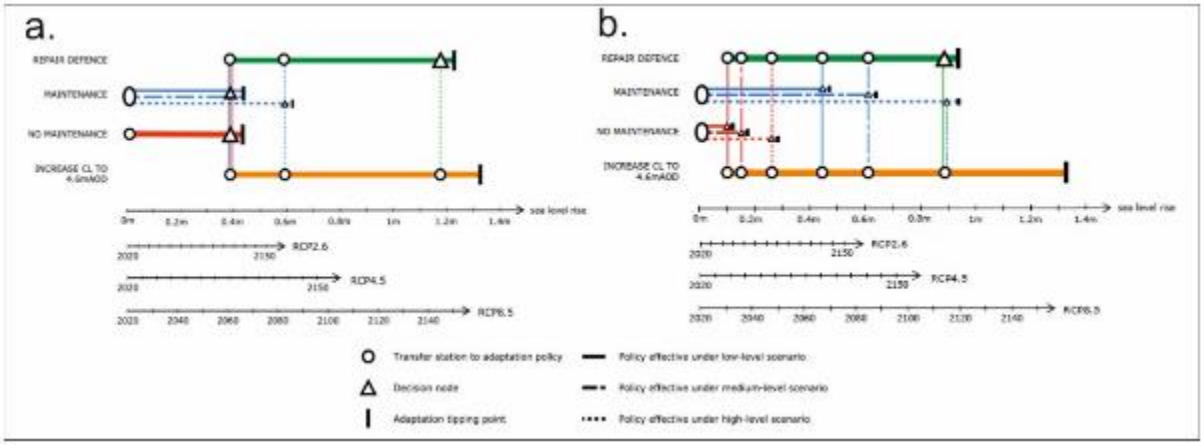
## Full APA reporting and presentation of findings

The findings from the Full APA should be written up into a short summary report detailing the key elements of the assessment. The options and trigger points shall be summarised in a diagramme illustrating the detailed pathway for adapting the area to climate change in a format similar to that illustrated in *Figure 12*.

**Figure 12 Adaptation route maps for the Exmouth Branch Line based on 1 in 200 yr standard of protection**[14]




## RESOURCES TO SUPPORT THE PROCESS

The plan is for a web-based tool to be developed to support collation of data and analysis of options which will automatically produce consistent products in a manner similar to *Figure 12*.

Further resources developed through the Southern Adaptation Pathways Pilot Project will be made available on the Adaptation Pathways SharePoint site once the project concludes and communicated through the National Adaptation Pathways Working Group.

[14] Dawson, David and Mortleman, Tamsin (2022) Adaptation Pathways for Vulnerable Coastal Transport Infrastructure. Available at SSRN: https://ssrn.com/abstract=4152866 or http://dx.doi.org/10.2139/ssrn.4152866

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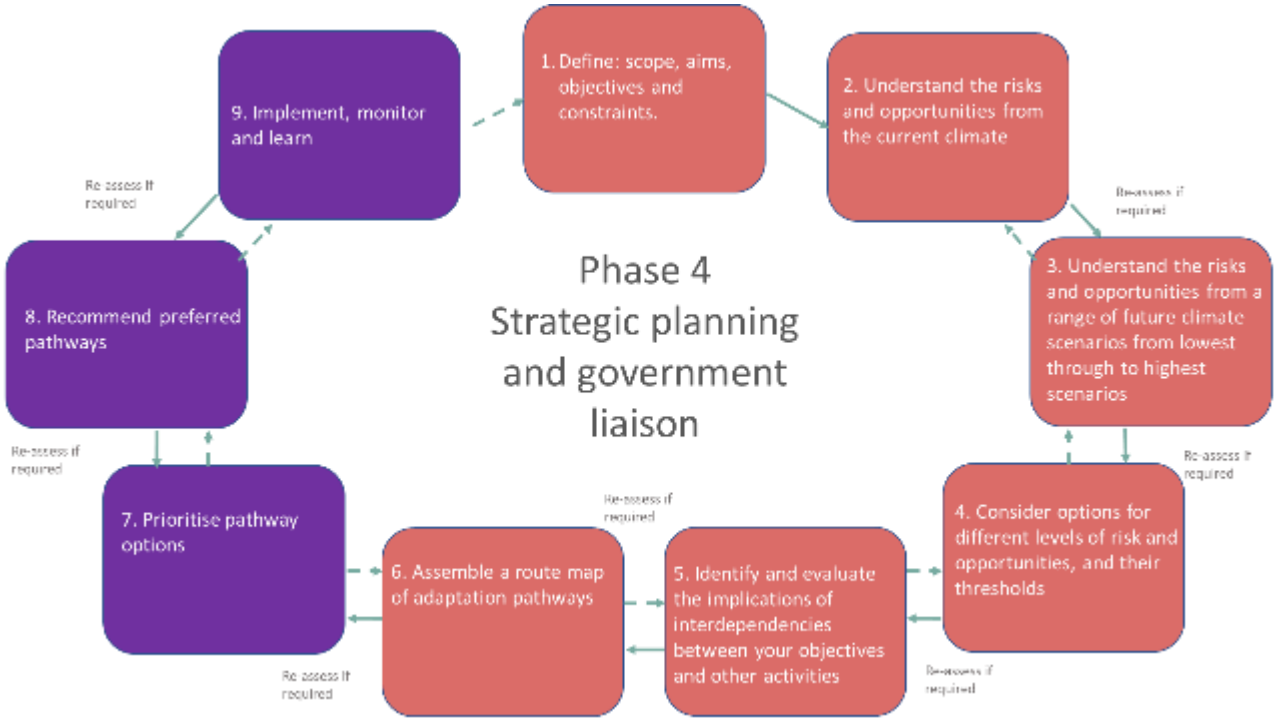
## *Phase 4: Strategic planning and government liaison*

### RATIONALE

This phase involves consolidation of the findings from all Rapid and Full APAs into an overarching pathway strategy for the Region. It will set out priorities for investment in forthcoming control periods, and longer-term requirements over the next 50 – 100 years. A key priority is defining work that needs to be included in CP8 planning which starts around 2027. Engagement with funders will be needed to bring them on board with proposed solutions and for funding to be provided at the appropriate time. This work covers stages 7 – 9 of the BS8631:2021 adaptation pathways process with the outputs of stage 9 feeding into the prioritisation and screening for the next tranche of assessments.

Figure 13 Phase 1 links to BS8631:2021 Stages in developing adaptation pathways




### EXPECTED OUTPUTS

The first regional adaptation pathway strategy and investment plan based on high priority locations in the form of an overarching report summarising they key findings of all the work of this project and setting out the long term strategy for the Region with associated investment plan.

The strategy will:

- summarise key vulnerabilities, key transformation actions required and the estimated costs/investment needs in the short to medium term.

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- It will provide an initial indication of where and when key investments will be needed, a plan for CP8 and CP9 from an asset management perspective and an overview of the plan for progressing work on adaptation pathways in in CP8 including investigating existing locations in more detail where necessary and the plan for assessing the next tranche of locations.

Approval of the strategy by the Regional executive team and Network Rail executive leadership team. Endorsement by government (Department for Transport, Transport Scotland and/or Welsh Government) and ORR.

## DELIVERING PHASE 4 OUTPUTS

Further guidance will be provided as the work above progresses. The approach should align with the regional approach to strategic planning to ensure it is fully integrated within business-as-usual processes.

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# Appendices

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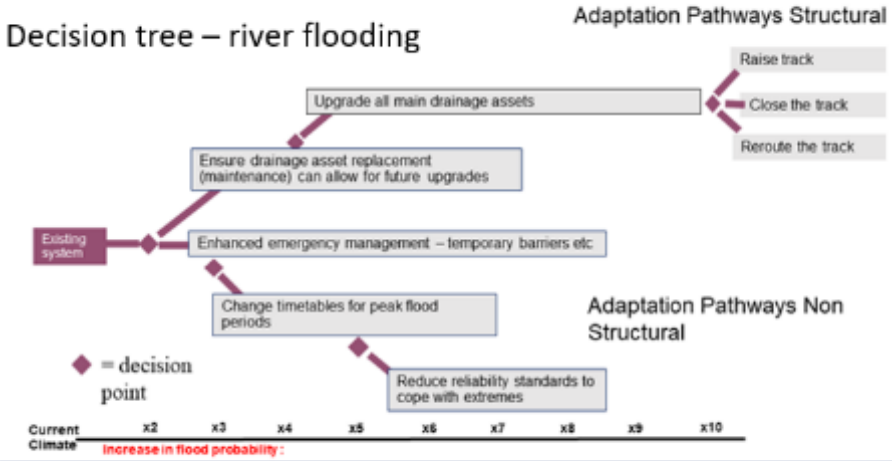
# Appendix 1 Impact thresholds

## Climate impact thresholds – case study example




### Case Study

The decision tree describes pathways of adaptation options in response to increased fluvial flooding along an imaginary length of track. It shows the 'thresholds' at which planners have decided a next adaptation step will be required, and what the options would be. The 'Threshold descriptions' describe the conditions at which change is made and options at those points.

In this imaginary example, the track is in an area that is already flood prone. Measures have already been taken to make assets more resilient during fluvial flooding. The result is that while the track will be closed at the same level of flooding as in the past, the onset of closure will be later than past events and the re-opening of the track will be quicker.

### Threshold descriptions

| **Flooding Probability increases x2 compared to current climate** e.g. current 1 in 200 event becomes 1 in 100 event | **Flooding Probability increases x3 compared to current climate** e.g. 1 in 300 event becomes 1 in 100 event | **Flooding Probability increases x4 compared to current climate** e.g. 1 in 400 event becomes 1 in 100 event | **Flooding Probability increases x5 compared to current climate** e.g. 1 in 500 event becomes 1 in 100 event | **Flooding Probability increases x10 compared to current climate** e.g. 1 in 1000 event becomes 1 in 100 event |
|---|---|---|---|---|
| If flood frequency doubles two options are identified. Either or both could be taken:<br>1. Ensure asset maintenance and replacement makes future upgrades convenient<br>2. Enhance emergency response procedures for flood events | If flood frequency increases by 300% change timetables for peak flood periods | Upgrade drainage assets including initiatives to divert water and "slow the flow" of water to the flood risk areas, | At this frequency flood interruptions are becoming a new normal. An option here is to reduce reliability standards to manage customer expectations | At this frequency of flooding services deliverable through incremental adaptive measures become unacceptable. There needs to be transformational change. Options include: raise, close or re-route the track.<br>The answer will depend upon the assessment of route criticality, and technical response options available at the time. |

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UK changing climate impact levels between current (2020) and High++ 2100 scenario

| | 2000 | 20% | 40% | 60% | 80% | 2100 | Source | Comments |
|---|---|---|---|---|---|---|---|---|
| Fluvial Flood Risk ( % increase in peak river flow) | 0 | 17 % | 34 % | 51 % | 68 % | 85 % | EA/Defra | |
| Surface Flood Risk ( % increase in Rainfall Intensity) | 0 | 14 % | 29 % | 43 % | 58 % | 72 % | Climate Change Committee | ('2080s' is defined as 2070-2115. Average increase in rainfall intensity is 85 % to mid-2092. 1975 baseline gives a total increase of 90.34 % to 2100. From 2000 to 2100 there is an increase of 72 % ) |
| Storm ( % increase in storm Intensity) | 0 | 14 % | 27 % | 41 % | 54 % | 68 % | Climate Change Committee | (H++ scenario was for 2070-2100. Average increase in days of strong wind are 65 % in 2085. 1990 baseline gives a total increase of 75.25 % to 2100. From 2000 to 2100 there is an increase of 68 % ) |
| Sea Level Rise (metres) | 0 | 38 | 76 | 114 | 152 | 1.9 | EA/Defra | |
| Drought (Days) | 0 | 9 % | 18 % | 26 % | 35 % | 44 % | Climate Change Committee | (H++ scenario was for 2070-2100. Increase in summer drought is 67 % in 2100. 1950 baseline. From 2000 to 2100 there is an increase 44 % ) |
| Heat (Degrees C) | 0 | 1.94 | 3.88 | 5.82 | 7.76 | 9.7 | Climate Change Committee | '2080s' is defined as 2070-2115. Increased average summer (June, July, August) maximum temperature is 30°C to mid-2092. 1975 baseline starts at 18.6°C (Source - Met Office website). Total increase of 12.172°C from 1975 to 2100. From 2000 to 2100 there is an increase of 9.7°C) |

# Appendix 2 Illustration of risk screening during Rapid APA

## Fictional mainline between Brizzle and Extown

An 80 mile stretch of line is broken into four local route sections. The table summarises the changing risk profile along the route.

| | | Track section | | | |
|---|---|---|---|---|---|
| Risk Level High++ 2100 Without Adaptation | | 1 | 2 | 3 | 4 |
| Climate Change Impacts | Fluvial flood risk | NTR | NTR+T | L | FR |
| | Surface flood risk | FR | FR | FR | FR |
| | Ground water flood risk | L | L | L | L |
| | Coastal flood risk | NTR+T | L | L | L |
| | Heat | NTR | NTR | NTR | NTR |
| | Wetting/Drying | NTR | NTR | NTR | NTR |
| | Schedule 8 and Schedule 4 | NTR+T | NTR+T | NTR | NTR |

**Fluvial flood risk**

**Section 1** crosses a river close to the coast. With increasing peak flows driven by a combination of increasing river levels and sea level rise this can increase flood and scour risk which requires adaptive responses at 20 % of the High++ 2100 scenario. This is part of a larger area with high flood risk but most of this stretch of the line will be protected from fluvial flood risk that would disrupt rail services because of the relatively high population. Most of the section is lightly populated and less likely to get either fluvial or coastal flood protection. This exposes the rail to significant flood and scour risk.

**Section 2** moves into a sparsely populated low-lying fluvial flood risk area. NR has made significant improvements to the resilience of this stretch of track. The strategy is to accept occasional closures but to be able to minimise the duration of the closure. Up to 60 % of the High++ 2100 scenario this strategy is likely to remain relevant. Environment Agency stress testing of its fluvial flood protection infrastructure shows that some areas could experience 4-5m of flooding at 60 % of the High++ 2100 scenario. It is unlikely that the Environment Agency will add to fluvial flood protection beyond this level. There is a risk that overtopping of the track will become unacceptably frequent from 60 % of the High++ 2100 scenario. Closure or re-routing would then need to be considered as an option.

**Section 3** has minimal fluvial flood risk.

**Section 4** includes a section that is prone to closure through flooding. Recent improvements to resilience mean that acceptable services are likely to continue beyond xx % of the High++ 2100 scenario. Further adaptation measures are likely to be required beyond that level of climate change.

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**Surface water flood risk**
Occasional disruption may occur within acceptable limits up to xx % of the High++ 2100 scenario. Some hot spots are likely to emerge as peak rainfall increases beyond that climate scenario. Emerging surface water flooding hot spots will need to be monitored and a more detailed plan developed as the new risks are better understood.

**Ground water flood risk**
Ground water flooding may be an aggravating factor in fluvial flood risk. It is unlikely to significantly change fluvial risk thresholds.

**Coastal flood risk**
Section 1 crosses a river close to the coast. This area is lightly populated. It is questionable whether the Environment Agency will construct coastal flood protection in this area. Combined sea level rise and fluvial flooding will increase the risk of scour and occasional closure up to xx % of the High++ 2100 scenario. This will be a continuing issue as sea level rise and peak river flows both increase throughout the century. From 60 % of the High++ 2100 scenario there is a risk that coastal flooding will cause unacceptably frequent closure. Although permanent covering in water is unlikely, the frequency of covering means that closure or re-routing would need to be considered as an option.

**Heat**
Increasing temperatures will make the need for adaptation to track, electrical systems and buildings very likely before reaching xx % of the High++ 2100 scenario along the route.

**Wetting/Drying**
A number of cuttings and embankments along these track sections are close to their shear point under the current climate. Increased flood risk and intensity of rainfall along with increasingly dry summers in the near term are likely to increase soil heave and the risk of landslides on cuttings and embankments. Adaptation measures are required.

**Performance**
An indicator of “unacceptable” impact will be the potential disruption to performance. The risk rating is therefore set at the highest risk level for that section:

1. Section 1 is Extreme risk due to the potential for closure or re-routing due to coastal flooding
2. Section 2 is Extreme risk because of the potential for closure or re-routing due to fluvial flooding
3. Sections 3 and 4 are high risk due to the likelihood that increasing heat will require adaptation in the near and longer term.

A Summary of the options identified above are presented below:

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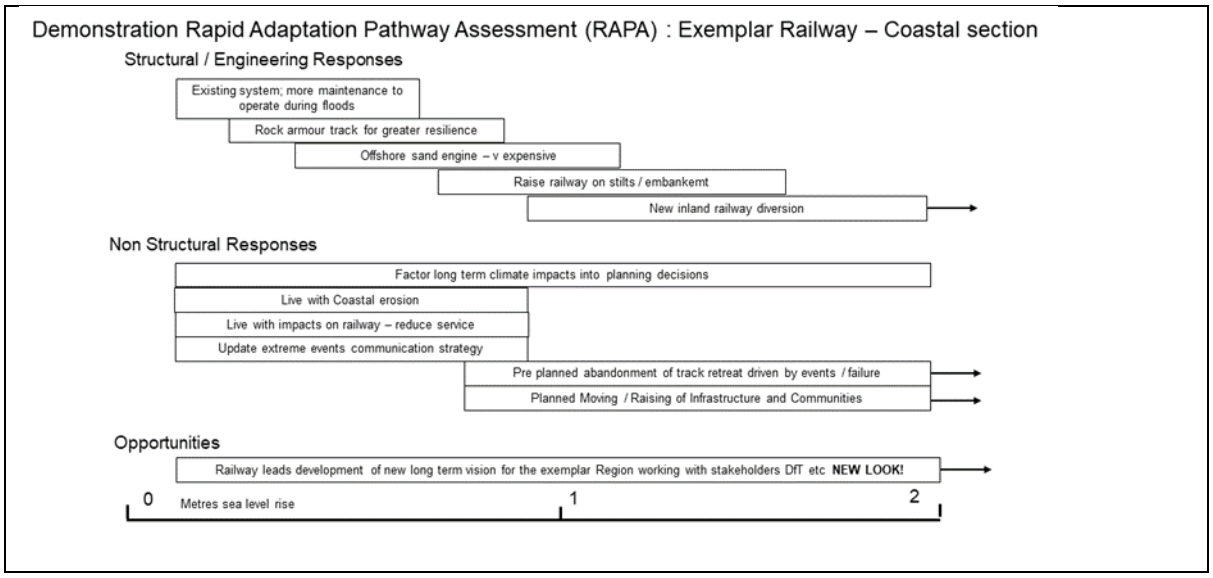
Demonstration Rapid Adaptation Pathway Assessment (RAPA) : Exemplar Railway – Coastal section
Structural / Engineering Responses
Existing system; more maintenance to operate during floods
Rock armour track for greater resilience
Offshore sand engine – v expensive
Raise railway on stilts / embankemt
New inland railway diversion
Non Structural Responses
Factor long term climate impacts into planning decisions
Live with Coastal erosion
Live with impacts on railway – reduce service
Update extreme events communication strategy
Pre planned abandonment of track retreat driven by events / failure
Planned Moving / Raising of Infrastructure and Communities
Opportunities
Railway leads development of new long term vision for the exemplar Region working with stakeholders DfT etc NEW LOOK!
0
Metres sea level rise
1
2