

Review of Network Rail's WRCCA Planning for Operational Property Assets

Office of Road and Rail

26th February 2026

Quality information

Prepared by	Checked by	Verified by	Approved by
Various	Principal Sustainability Consultant	Sustainability Advisory Lead	Technical Director

Revision History

Revision	Revision date	Details	Authorized	Name	Position

Distribution List

# Hard Copies	PDF Required	Association / Company Name

Prepared for:

Office of Road and Rail

Prepared by:

AECOM Limited
1 Wellbrook Way
Girton
Cambridge CB3 0FW
United Kingdom

T: +44 (0)1223 488 000
aecom.com

© 2026 AECOM Limited. All Rights Reserved.

AECOM Limited ("AECOM") has prepared this Report for the sole use of Office of Road and Rail ("Client") in accordance with the terms and conditions of appointment (ref no ORR/CT/25-38), dated 20th October 2025 ("the Appointment").

AECOM shall have no duty, responsibility and/or liability to any party in connection with this Report howsoever arising other than that arising to the Client under the Appointment. Save as provided in the Appointment, no warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by AECOM.

This Report should not be reproduced in whole or in part or disclosed to any third parties for any use whatsoever without the express written authority of AECOM. To the extent this Report is reproduced in whole or in part or disclosed to any third parties (whether by AECOM or another party) for any use whatsoever, and whether such disclosure occurs with or without the express written authority of AECOM, AECOM does not accept that the third party is entitled to rely upon this Report and does not accept any responsibility or liability to the third party. To the extent any liability does arise to a third party, such liability shall be subject to any limitations included within the Appointment, a copy of which is available on request to AECOM.

Where any conclusions and recommendations contained in this Report are based upon information provided by the Client and/or third parties, it has been assumed that all relevant information has been provided by the Client and/or third parties and that such information is accurate. Any such information obtained by AECOM has not been independently verified by AECOM, unless otherwise stated in this Report. AECOM accepts no liability for any inaccurate conclusions, assumptions or actions taken resulting from any inaccurate information supplied to AECOM from the Client and/or third parties.

Executive Summary

This report seeks to review Network Rail (NR)'s Weather Resilience and Climate Change Adaptation (WRCCA) plans as they relate to operational assets, particularly how these plans address climate risk and resilience for buildings.

This report draws out best practices, common barriers, and opportunities for improvement to support NR's building portfolio and its resilience to climate change. The findings are supported by a digital survey and through interviews with technical specialists from NR and the Department of Transport, who were consulted with the aim of providing specialist knowledge covering a range of relevant topics and a wider industry perspective.

Headline Findings

An initial document review was undertaken on NR documentation related to climate change and resilience to determine how buildings are considered in WRCCA planning, and other associated documents. The categories of documents reviewed included Strategies & Policies, Regional WRCCA, Strategic Business and Delivery Plans, various Weather / Climate Change Documents and Records of Failures provided by NR. These documents were evaluated on a scale of 0-7 for eight different questions relating to different themes of climate resilience as they relate to buildings.



Assessment of high-level strategy links to actionable interventions

NR was found to have a robust framework in place for linking high-level strategies to regionally actionable interventions. Though some gaps were also identified.

Strengths:

- **Mandatory requirements:** Integration into PACE; embedding climate resilience assessments allows strategic goals to influence project design and delivery.
- **Standardised Tools:** NR provides a WRCCA Cost Benefit Decision-Making Tool and climate scenarios allow consistency across regions and projects. No examples of the WRCCA Cost benefit Decision Making Tool have been reviewed therefore we have been unable to assess or evaluate the effectiveness or consistency of application of the tool
- **Stakeholder Engagement and Collaboration:** Designers are required to liaise with internal stakeholders (e.g., RAM) to align interventions with broader organisational goals.

Gaps:

- **Document clarity** on WRCCA as it relates to buildings; where the connection between strategies and actions is not explicitly documented for buildings, it could lead to inconsistent application of resilience measures.
- **Regional variations:** Although the guidance notes aim for standardisation, regional differences in interpretation or application could create disparities in outcomes, especially given that interventions are mainly driven and owned by the Regions
- **Monitoring, reporting and feedback:** The absence of a feedback loop to assess the effectiveness of implemented interventions could limit opportunities for continuous improvement
- **Traditional building codes and standards** can limit engineers' ability to fully respond to climate and weather-related hazards. NRs Climate and Adaptation Manager confirmed that NR is in the process of updating design standards.

Evaluation of how heritage and pre-modern building asset groups are treated

Our review of NR documentation relating to heritage assets and climate change adaptation within buildings found:

- No direct references to heritage or listed buildings within regional WRCCAs
- NR documentation on climate resilience has no focus on heritage buildings
- NR documentation of heritage buildings has very limited reference to climate change, with no description of climate hazards or risks that are specific to heritage buildings, or to which they are most vulnerable

AECOM has assessed climate risks to which heritage buildings are more vulnerable and included adaptation measures suitable for use in heritage buildings. These risks and adaptation measures relate to extreme wind, wind-driven rain, subsidence, wildfires, pests, flooding, and snow/ice.

Assessment of alignment with risk-based and performance-based principles

The regional WRCCA plans were evaluated for their alignment with best-practice methodology as it relates to WRCCA planning for buildings. This related to the management, mitigation and assessment of risk, in addition to the targeting of relevant sustainability standards and codes for compliance.

Identification of good practice approaches to strengthening

Different good practice approaches to strengthening were explored to identify examples how asset vulnerabilities can be addressed through proportionate, performance-based interventions that enhance either resilience to severe weather and/or assets' abilities to recover from weather events.

A range of adaptation frameworks were explored, including *Climate Risk Assessment Guidance for the Transport Sector* and the *Local Partnerships' Climate Adaptation Toolkit and Risk and Opportunities Matrix*, the *UK Green Building Council's (UKGBC) Framework for Measuring and Reporting of Climate-related Physical Risks to Built Assets*, *EU-level technical guidance on adapting buildings to climate change*, *The Association of University Directors of Estates Climate Change Adaptation and Resilience Guide*, *The Better Buildings Partnership 'Guide to Climate Resilience Strategies for Commercial Real Estate*, *The UK Cabinet Office's Keeping the Country Running: National hazards and infrastructure*

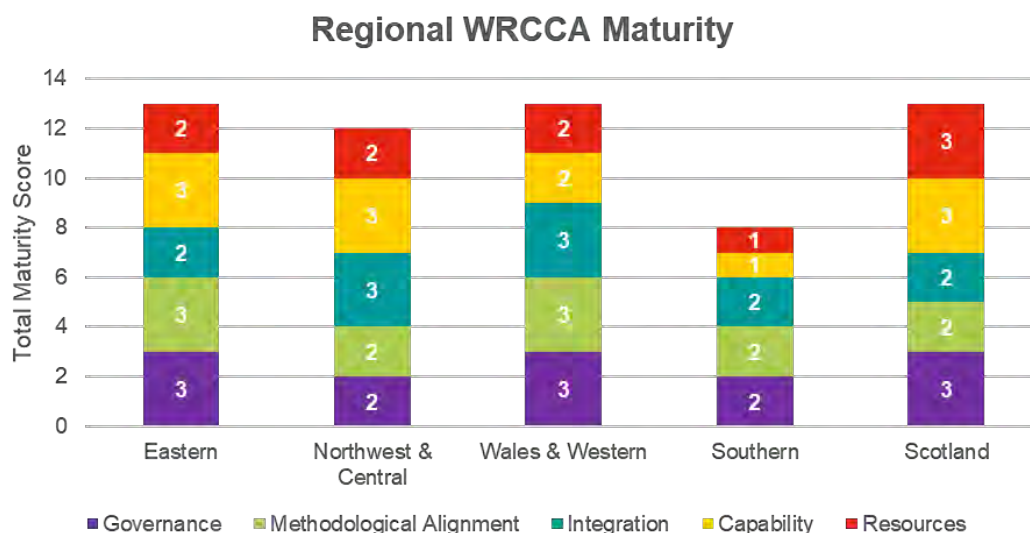
Although these approaches differ to one another, they provide several insights and key considerations at an organisational level:

- Ongoing monitoring of risk assessment and consideration of interdependencies are fundamental elements of climate change adaptation frameworks.
- Consider implementing a hierarchy of measures, prioritising passive systems which enable an adaptive management of risks over the implementation of solutions that require active operation and maintenance.
- Integrate climate change considerations into current plans, procedures and processes, and ongoing projects rather than them being treated as separate costs.
- Consider how collaboration between business units and with external stakeholders can improve the implementation of adaptation practices

Good practice approaches for structural strengthening were also explored, and while some of the documents do not focus on strengthening with respect to climate change in particular, they represent industry best practice for structural work on existing buildings, which can help to inform how NR assesses their building portfolio.

Benchmarking Maturity

The Regional WRCCA Plans were benchmarked for maturity against industry best practice with the purpose of evaluating the current state of climate adaptation and strengthening resilience across NR assets and to inform what could be improved ahead of Control Period 8 (CP8).



Overall, the Wales & Western and Scotland WRCCA plans are the most advanced, achieving strong scores in governance, methodological consistency and integration. By contrast, the Southern region produced the least developed WRCCA plan, with notable weaknesses in the reporting of resource allocation and the demonstration of technical capability.

Across all regions, resources were the lowest scoring thematic area. While this does not necessarily indicate a lack of funding for improving climate resilience, the WRCCA plans generally contain limited resources allocated for the primary benefit of increasing the climate resilience of buildings. Governance was the highest scored theme, with a good overall summary of the leadership structure and decision-making process provided by most regions.

Opportunities for improvement were identified across all regions, particularly regarding the limited specificity of codes and standards within the WRCCA plans. The Eastern region was the only one to reference relevant ISO standards directly and indicate targets for compliance.

Recommendations for ORR

To strengthen climate adaptation and resilience within NR's building assets, it is recommended that the ORR leverage its broad regulatory powers—including the Network Licence, periodic reviews, reporting, guidance, and enforcement—to set clear expectations, monitor progress, and intervene where necessary. ORR should require standardised climate risk reporting, establish robust KPIs, and conduct targeted regional and asset-specific reviews to enable effective oversight and continuous improvement. Enhanced governance, annual maturity assessments, and assurance protocols will clarify accountability and drive compliance, while guidance and best practice dissemination will support capability uplift across regions. To manage organisational change fatigue, ORR should monitor staff engagement, change management processes, and HR metrics, enabling resilience initiatives to be implemented sustainably. These actions, sequenced for short- and medium-term delivery, will enable ORR to proactively manage climate risks, support evidence-based decision-making, and adapt regulatory focus as priorities evolve—ultimately safeguarding the safety, efficiency, and sustainability of Britain's rail infrastructure. This report lists recommendations framed around regulatory judgement, action and posture, aligning to ORR's regulatory role and powers.

Table of Contents

Executive Summary	5
1. Review of Network Rail's WRCCA Planning for Operational Assets	1
1.1 Introduction.....	1
1.1.1 WRCCA Review Planning objectives.....	1
1.1.2 Report structure.....	1
1.2 Methodology	2
1.2.1 Document Review Summary Methodology	2
1.2.2 Document Review Assumptions and Limitations	3
1.2.3 Thematic Analysis Mapped to Themes of Resilience, Risk and Asset Strategy Methodology	4
1.2.4 Benchmarking Summary Methodology	4
2. Initial Document Review	6
2.1 Results of Review	6
2.1.1 Results from the Qualitative Assessment.	6
Regional Strategic Business Plans	6
Regional Delivery Plans.....	6
Regional WRCCA Plans	6
Strategies & Policies	7
Weather / Climate Change Reports	7
Records	7
2.1.2 Results overview from the semi-quantitative assessment	7
2.1.3 Document Review Conclusions	10
3. Thematic analysis mapped to the themes of risk, resilience and asset strategy	11
3.1 Assessment of high-level strategy links to regionally actionable interventions	11
3.1.1 The framework for translating strategy into actionable interventions	12
3.1.2 Mandatory standards and requirements	14
3.1.3 Structured guidance for implementation	15
3.1.4 How practical Adaptation Measures are Embedded in Project Planning	18
3.1.5 Regional delivery plans.....	18
3.1.6 Alignment with strategic goals	19
3.1.7 Gaps and potential consequences	19
3.2 Evaluation of heritage and pre-modern buildings	20
3.2.1 Introduction.....	20
3.2.3 Definition of Heritage and Pre-Modern Buildings.....	20
3.2.4 Climate related hazards.....	21
3.2.5 Existing Network Rail guidance	21
3.2.6 Vulnerabilities of pre-modern and heritage buildings	22
3.2.7 Addressing risks specifically for heritage buildings	25
3.2.8 Other considerations.....	28
3.2.9 Unintended consequences	28
3.2.10 Consents and permissions	28
3.3 Alignment with risk-based and performance-based strengthening principles	28
3.3.1 Defining strengthening to existing assets and climate-related hazards	29
3.3.2 Network Rail's approach to strengthening	29
4. Initial Gap and Benchmarking Summary Matrix.....	36
4.1 Good practice approaches to strengthening	36
4.2 Adaptation frameworks	36
4.3 Building-level adaptation.....	40
4.4 Structural strengthening.....	41
4.4.1 Examples of good practice	42

4.5	Good NR Practices Identified in Interviews with Network Rail Central Technical Leads and with Key Stakeholders	42
4.5.1	Identify specific strategies and tools used to mitigate climate risks. Highlight lessons learned and transferable practices	42
4.5.2	Understand stakeholder engagement and partnerships models.....	45
4.5.3	Explore the use of technology and analytics in resilience planning	45
4.5.4	Digital Survey Response Summary	46
5.	Benchmarking Summary Matrix.....	47
5.1	Benchmarking of WRCCA planning maturity across regions	47
5.1.1	Purpose and & Objectives	47
5.1.2	Results.....	47
6.	Recommendations to support ORR's regulatory considerations.....	50
6.1	Recommendations for ORR Actions	50
6.1.1	The Network Licence	50
6.1.2	Cascade of Approaches: from signalling expectation to enforcement	52
6.1.3	Recommendations for climate change and hazard management for building assets	52
	KPIs and Acceptance Criteria (Regulatory Assurance).....	53
6.1.4	Risks and Mitigations.....	54
6.1.5	Summary	54
	Appendix A Analysed Documents.....	55
	Appendix B Document Review and Scoring Matrix Tool	1
	Appendix C AI Agent Summary Tables.....	1
	Appendix D Document copies	2
	Specific strategies and tools used to mitigate climate risks, lessons learned and transferable practices	2
	Understand stakeholder engagement and partnerships models.....	3
	Explore the use of technology and analytics in resilience planning	4
	Appendix E WRCCA Maturity Evaluation	1
	Appendix F Good Practice case studies	1
	Network Rail Adaptation Pathways	1
	Department for Transport's 'Fit for Changing Climate? Adapting the UK's transport system'	1
	Sustainable Rail blueprint	1
	Adaptation and resilience in HS2	2
	San Diego International Airport climate resilience plan	3
	Adaptation of Melbourne's Metropolitan Rail Network in response to climate change	4
	Association of University Directors of Estates Climate Change Adaptation and Resilience Guide	5
	Appendix G Digital Survey Responses and Analysis	7

Figures

Figure 1: Report Structure Flowchart	1
Figure 2: Number of documents by category	8
Figure 3: Results by theme or question.....	8
Figure 4: Results by theme or question.....	9
Figure 5: Overview of how climate resilience strategy, policies and standards cascading to regional level	12
Figure 6: WRCCA Impact Assessment and Cost Benefit Analysis	15
Figure 7: Adapted from Weather resilience and climate change assessment process (from NR Climate Change Projections Guidance Notes, Issue 3, dated 2023.	15
Figure 8: Weather Resilience and Climate Change Assessment Process	16
Figure 9: Examples of NR heritage buildings, as shown from left to right: Downham Market (Grade II listed), Stamford Railway Station (Grade II listed), Edinburgh Waverley station (Category A listed).....	20
Figure 10: Condition Sustainability Index equation. *Percentage Average Remaining Life (PARL)	22
Figure 11: Potential risks and opportunities associated with heritage and pre-modern buildings.....	25
Figure 12: Addressing overheating through reducing heat gains and removing excess heat.....	26

Figure 13: Risk-based approach to performance-based design (adapted image, based on 'Strengthening of existing buildings: an introduction', IStructE, 2021).....	29
Figure 14: Monitoring and reporting flowchart (UKGBC, A Framework for Measuring and Reporting of Climate-related Physical Risks to Built Assets, 2022).....	37
Figure 15: Adaptation hierarchy for buildings (adapted from the EU-level technical guidance on adapting buildings to climate change, Ramboll, 2023).....	38
Figure 16: Integrating the climate change into processes and procedures (adapted from the AUDE Climate Change Adaptation and Resilience Guide).	39
Figure 17: Components of the infrastructure resilience (adapted from the UK Cabinet Office's Keeping the Country Running: National hazards and infrastructure).	40
Figure 18: Stewardship elements of the Genius of Place Wheel (NR CP7 Buildings and Architecture Policy)	43
Figure 19: Regional WRCCA Maturity Analysis.....	47
Figure 20: Regional WRCCA Maturity Bar Graph	48
Figure 21: Study methodology and key outcomes per stage.	5

Tables

Table 1: Example of the Level of Detail (LoD) assessed for a particular theme in one document.....	3
Table 2: Definition of the scoring categories.....	3
Table 3: Relevance and level of accuracy for the AI agent used	3
Table 4: Maturity Themes	4
Table 5: Maturity Ratings.....	5
Table 6: Initial WRCCA Review Summary	6
Table 7: Documents reviewed by category.....	7
Table 8: Analysis of results.....	9
Table 9: Summary of NR/L2/ENV/015 building and building systems requirements	13
Table 10: Summary of interventions outlined in current Regional Delivery Plans.....	18
Table 11: 'More action needed' risks and opportunities (adapted from UK CCRA3).....	21
Table 12: Alignment scoring descriptors.....	30
Table 13: Eastern Region alignment with risk-based and performance-based strengthening principles for buildings.....	30
Table 14: North West & Central Region alignment with risk-based and performance-based strengthening principles for buildings.....	32
Table 15: Scotland's Railway alignment with risk-based and performance-based strengthening principles for buildings.....	33
Table 16: Southern Region alignment with risk-based and performance-based strengthening principles for buildings.....	34
Table 17: Wales & Western Region alignment with risk-based and performance-based strengthening principles.....	34
Table 18: Achieving exemplary performance for responding to climate change.....	40
Table 19: Summary of network licence applications to climate resilience & leverage	50
Table 20: Regulatory and policy requirements	51
Table 21: Key recommendations and regulatory levers.....	53

Abbreviations

Abbreviation	Definition
SuDS	Sustainable Drainage Systems
EPC	Energy Performance Certificate
CSI	Condition Sustainability Index
RICS	Royal Institution of Chartered Surveyors
HES	Historic Environment Scotland
IStructE	Institution of Structural Engineers
CIBSE	Chartered Institute of Building Services Engineers
ESR	Network Rail's Environmental and Social Minimum Requirements (ESR)
ESA	Environment and Social Appraisal
WRCCA	Weather Resilience and Climate Change Impact Assessment
GRIP	Governance for Railway Investment Projects
RAM	Route Asset Manager
ALARP	As Low As Reasonably Practicable
ESMP	Environment, Social and Management Plan
PACE	Project Acceleration in a Controlled Environment
CCRA3	Third UK Climate Change Risk Assessment
WDR	Wind-driven rain
ISO	International Standards Organisation
BEAP	Building Energy Audit Process
TOCs	Train Operating Companies
HVAC	Heating, Ventilation, and Air Conditioning

1. Review of Network Rail's WRCCA Planning for Operational Assets

1.1 Introduction

This report presents the outcome of the Review of NR's WRCCA Planning to assess core policies, strategies and standards relating to building asset groups within Network Rail's (NR) Operational Property (Buildings) portfolio, focusing on Weather Resilience Climate Change Adaptation (WRCCA) in planning and supporting documentation. The work covered in this report has been delivered in accordance with the AECOM proposal "Review of NR's WRCCA Planning for Operational Property (Buildings) assets" as approved by ORR on 20th October 2025 (contract reference ORR/CT/25-38).

This outcome of this review assesses how NR's WRCCA Plans reflect the principles of strengthening existing buildings and provide an initial understanding of NR's shift to code-based compliance to a performance-based approach, for its building asset groups in its Operational Property portfolio.

1.1.1 WRCCA Review Planning objectives

The objectives of the Review of NR's WRCCA Planning are the following:

- Assess how well NR WRCCA strategies incorporate performance-based design, including lifecycle considerations, benchmark NR's approach against best practice for strengthening existing buildings.
- Recommend enhancements for Control Period 8 (CP8) WRCCA planning that reflect a proportionate, risk-informed, performance-based framework.
- Support accountability and transparency through a top-down and bottom-up synthesis of climate hazard, vulnerability, and mitigation planning.

1.1.2 Report structure

The overall structure of this report is presented in **Figure 1**

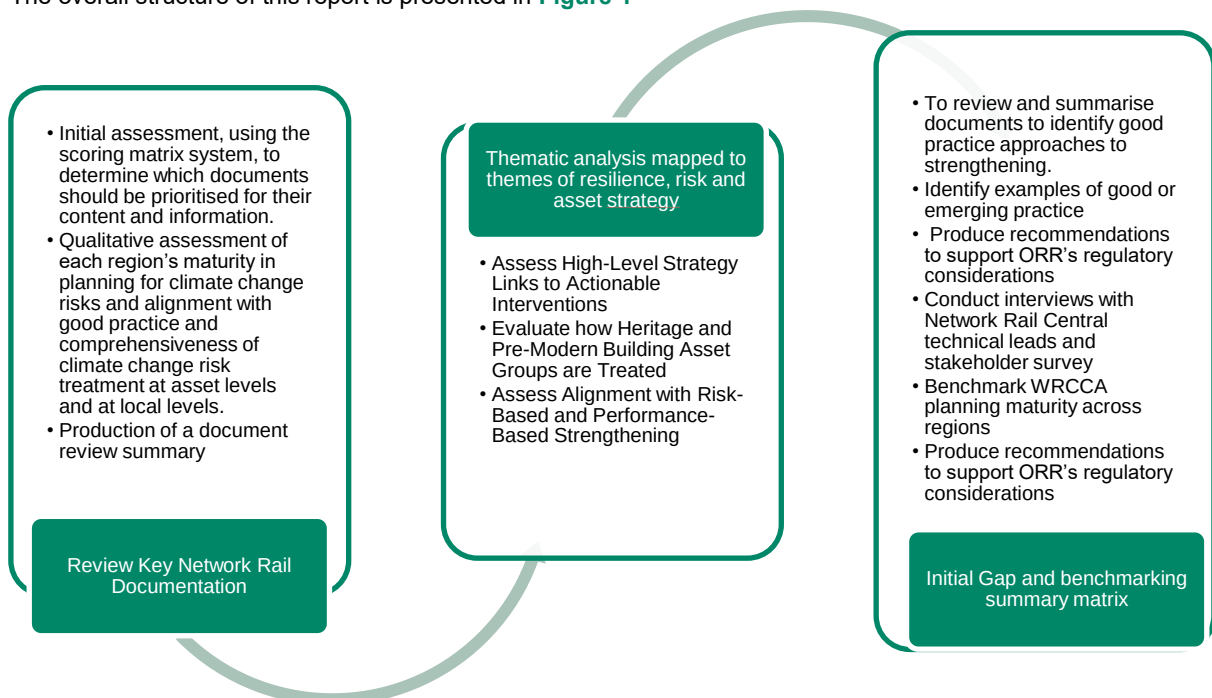


Figure 1: Report Structure Flowchart

1.2 Methodology

1.2.1 Document Review Summary Methodology

The document review and initial assessment was undertaken using an approach which is partly semi-quantitative and partly qualitative. The document review included a qualitative assessment of each region's maturity in planning for climate change risks and how comprehensive climate change risk was treated at asset levels and at local levels. The semi-quantitative assessment helped determine the key documents that should be reviewed in more detail. This structured review considered selected existing NR documentation, core policies, strategies, plans and standards as well as a broad record of weather-related or wrong-side failures affecting buildings (as provided by ORR).

The final list of documents reviewed using the scoring matrix can be found in [Appendix A](#).

Additional documentation has been qualitatively reviewed, including the Standards used for NR reporting of Operational Property weather-related or wrong-side failure events, NR standards NR/L3/CIV/028 and NR/L3/CIV/028/mod02. These are included in the results overview in more detail.

The semi-quantitative analysis used to score documents for their topic coverage used a scoring matrix which summarises answers to 8 key questions. The key questions focus on how each document addresses the various steps in a risk management methodology. We also reviewed the approaches to manage physical climate risks that NR outlines in its documents.

The 8 key questions used are provided below:

- **Q1:** Is physical climate change recognised as an issue in the document?
- **Q2:** Are specific climate related hazards recognised in the subject matter document?
- **Q3:** Are the buildings, building systems or components that may be affected by physical climate related hazards identified in the document?
- **Q4:** Are key vulnerabilities of local assets such as specific buildings, building systems or components to physical climate related hazards, including consideration of downtime, cascading failures or operational impacts, identified within the document?
- **Q5:** Are codes or standards against which climate related hazards are assessed for compliance, including performance thresholds, and design and resilience objectives, identified within the document?
- **Q6:** Are any applications of formal risk management approaches identified in the documents using an appropriate standard method for climate change risks, including the approach taken to prioritisation of risk to building and system assets?
- **Q7:** Are there any applications of adaptation methods that may be appropriate for the climate change risks identified in the documents, including good practice approaches to strengthening aging and Victorian Buildings asset groups through reducing vulnerabilities using proportionate, performance-based interventions, identified in the document?
- **Q8:** Are there any documents where residual risk is identified or addressed?

The eight key questions were structured to help reveal generally increasing levels of detail from Q1 to Q8. High overall scores indicate a document contains detailed approaches to climate resilience for operational buildings, but high scores only for the first four questions indicate the document lacks nuance on climate resilience. It was anticipated that the first two questions would have the highest scores, with lower scores for remaining questions.

As part of the document review, we used Artificial Intelligence (AI) agents to interrogate the selected documents., which were assessed for their content, including for the presence and quality of information around the 8 key questions.

Each document has been classified by its score for each of the 8 key questions, with each document assigned a score ranging between 0 (no consideration of climate hazards) and 56 (full consideration of elements for climate hazards, exposed assets, asset vulnerabilities, codes/standards, risk management approaches, adaptation methods and residual risks). This approach provides a semi-quantitative index of the degree to which Weather Resilience and Climate Change Adaptation is considered in the documents.

The scoring for each of the questions (Q1, Q2, etc...) was based on the frequency of theme, keywords and other details which together indicate the level of detail (LoD) on the subject. The assessment identified whether sufficient LoD was provided to adequately inform subsequent actions, whether the information was correct and whether the LoD provided was appropriate for the subject.

Table 1 below provides an example of the scoring approach followed.

Table 1: Example of the Level of Detail (LoD) assessed for a particular theme in one document

Score	Frequency of theme, element or key word	LoD
7	Theme is mentioned frequently in chapters and subject is addressed in detail.	High
6	Theme is mentioned frequently and explored in detail, however there is some room for further explanation	High
5	Theme is mentioned often, though specific details are missing from the document	Intermediate
4	Theme is mentioned often though it could be explored in more detail.	Intermediate
3	Theme is mentioned, and a high-level explanation of core concepts is given	Low
2	Theme is mentioned briefly with minimal explanation. Very high level	Low
1	Theme is mentioned briefly, however not explained in any detail	None
0	Theme is not mentioned at all within the document	None

The results of the scoring matrix are recorded in the scoring and tracking tool to help facilitate the document review process.

The maximum score that could be achieved by each document in the semi-quantitative analysis is 56 (8 question scores added together, with a maximum score of 7 for each question). The statistical distributions of scores for each document were summarized in quartiles described as *ground-breaking*, *stretch*, *minimum condition of satisfaction* (MCOS) or *poor*. The quartile criteria and their scoring distributions are defined in

Table 2 below:

Table 2: Definition of the scoring categories

Total Score Performance	Description	Lower	Upper	Quartiles (%)
Ground-breaking	Documents reviewed that achieved scores of 43 up to 56	43	56	4 th (upper)
Stretch	Documents reviewed that achieved scores of 29 up to 42	29	42	3 rd (higher middle)
MCOS	Documents reviewed that achieved scores of 15 up to 28	15	28	2 nd (lower middle)
Poor	Documents reviewed that achieved scores of 0 up to 14	0	14	1 st (lower)

A qualitative assessment of the selected documents and associated themes was also completed. The results of both the semi-quantitative and qualitative analysis are summarised in **Section 2**.

1.2.2 Document Review Assumptions and Limitations

Assumptions and limitations used in the document review process are outlined in **Table 3** below. To evaluate outcomes from the AI agent, a qualitative assessment of the level of accuracy of the results has been used based on the following elements: faithfulness, relevance, completeness and reproducibility.

Table 3: Relevance and level of accuracy for the AI agent used

	Description	Relevance	Level of accuracy
Faithfulness	Refers to the accuracy with which the AI's models reasoning process is reflected in the output.	Traceably derives and accurately represents the content of the sources (i.e., NR core policies, strategies, plans and other documentation)	Good
Relevance	Refers to the process by which models learn to determine what is	Retrieved evidence supports the answer to the question being asked	Fair

	relevant between input data and the expected output.		
Completeness	Refers to the level of difficult of tasks that require human-level intelligence.	Material caveats, counterpoints, and scope are not omitted.	Poor
Reproducibility	Refers to the ability to replicate results using the same data, code, and methods.	The same inputs and context yield the same output structure and facts	Fair

Outcomes from the AI Agent analysis were reviewed and validated against the original document to ensure the accuracy of responses. Where some documents omitted key elements, they were manually reviewed to identify if the scores given by the AI agent provided adequate understanding of their content and relevance.

A sensitivity analysis is recommended in the future to determine how changes in input variables affect model outputs, which is crucial for understanding model behaviour and optimizing decision-making processes. This is outside the scope of this project.

1.2.3 Thematic Analysis Mapped to Themes of Resilience, Risk and Asset Strategy Methodology

The document review was incorporated in the thematic analysis ([Section 3](#)) to help evaluate the maturity, sufficiency and strategic intent of the WRCCA process for buildings and building systems. This analysis has been divided into four main themes, considering the outcome of the document review:

- Assessment of high-level strategy links to actionable interventions
- Evaluation of how heritage and pre-modern building asset groups are treated
- Assessment of alignment with risk-based and performance-based principles
- Identification of good practice approaches to strengthening

1.2.4 Benchmarking Summary Methodology

The initial gap and benchmarking summary ([Section 4](#)) aims to identify critical gaps, risks and improvement opportunities within NR documentation, with a focus on regional WRCCA plans.

The maturity of each regional WRCCA plans has been assessed based on five key themes and associated sub-categories, presented in [Table 4](#). This assessment has been conducted based on currently available documentation and does not consider the degree to which plans have been implemented.

Table 4: Maturity Themes

Theme	Sub-Category	Questions Explored
Governance	Strategy	Has a strategic overview been provided? Are there clear and measurable targets for increasing resilience?
	Leadership	Has the leadership structure and decision-making process been described?
Methodological Alignment	Best Practice Alignment	How well aligned with industry best practice for increasing climate resilience and assessing climate risk?
	Standards Applied	Are the relevant International Standards Organisation (ISO) standards and other specific codes related to buildings or climate resilience mentioned?

Theme	Sub-Category	Questions Explored
Integration	Systems, Processes & People	Has evidence of collaboration with future stakeholders been provided? Are future collaborative plans discussed?
	Mainstreaming	How well has the process of increasing climate resilience been integrated as Business-as-Usual (BaU) practices? Are there discussions of how this could be incorporated?
Capability	Ability to Understand	Are effective metrics in place to monitor climate impacts to assets or buildings in particular? Is asset condition well understood? Have climate risks to buildings been explored?
	Ability to Implement	Has the technical capability to implement adaptation measures been demonstrated? Are targets in place to increase the resilience of buildings? Are climate adaptation measures for buildings presented?
Resources	Financial Capability	Are adequate resources in place? Has an investment plan been detailed? Are resources allocated to improving the resilience of buildings?

The maturity of each theme was assessed on a 0-4 scale ([Table 4](#)), with higher ratings indicating a higher degree of maturity. Where a theme contained two sub-categories, the overall score was determined by averaging the results for each sub-category (rounded up to the closest whole number). For example, a score of four for strategy and two for Leadership would result in an overall score of three for the governance theme. The full scoring criteria for each theme can be found in [Appendix B](#).

Table 4: Maturity Ratings

Rating	Numerical Score
Immature / Uninformed	0
Early starter / Basic	1
Progressive / Improving	2
Semi-mature / Well Engaged	3
Mature / Fully Optimised	4

2. Initial Document Review

2.1 Results of Review

The results of the initial document review are described in the following sections.

2.1.1 Results from the Qualitative Assessment.

A review of documents relevant to NR's WRCCA strategy has been completed to assess NR's CP7 strategy and planning for Operational Property (Buildings) assets. Performance-based design and best practice methodologies for increasing the climate resilience of existing infrastructure have been considered. These consisted of different categories of documents that have been grouped in 6 categories based on their purpose and content: Regional Strategic Business Plans, Regional Delivery Plans, Regional WRCCA Plans, Strategies and Policies, Weather / Climate Change reports and Records.

Regional Strategic Business Plans

Each Strategic Business Plan details the region's CP7 plan for delivering reliable rail services. These documents have a financial focus, with sustainability and climate change referenced as a thematic focus but not explained in any detail. While built assets and infrastructure are referenced within these documents, there is no discussion of the specific climate risk to these assets.

Regional Delivery Plans

Each delivery plan highlighted the core strategic focuses for each region. These documents did not have an explicit focus on climate change, though key risks are mentioned under the broader topic of sustainability. Specific references to climate risk to buildings and potential adaptation measures are occasionally briefly mentioned, depending on region.

Regional WRCCA Plans

The WRCCA documents contain the most pertinent information in relation to the region's overall strategy to adapt to the changing climate and the need for increased resilience across the railway and associated infrastructure. While the specific content of the WRCCAs varies between regions, all reports present a formal climate change risk assessment and describe the impact of climate change on railway operations. This includes a discussion of the latest climate projections for the region and a description of common climate hazards and impacts to which the railway is exposed. Climate risk to buildings and structures are addressed in most of the regional WRCCA reports, though the primary focus remains on operational impacts to the railway itself.

General risks to buildings and structures are described within these WRCCA reports (e.g. failure of air conditioning during extreme heat), however this generally does not include references to specific buildings or pieces of infrastructure. Instead, adaptation measures recommended are high-level and apply to the general asset type. Residual risk is similarly discussed at a high-level.

The quantification of climate impacts is usually measured in financial terms, with delay minutes resulting from climate hazards used as the metric. While this is useful in determining impacts on the railway itself, it is not necessarily useful as a performance-based metric to evaluate the resilience of associated buildings.

Table 5 below summarises the review of each of the five regional WRCCAs.

Table 5: Initial WRCCA Review Summary

Region	Analysis Summary
Eastern	This Eastern region scored highly on its reference to climate change impacts, hazards, risks, and residual risks, including a discussion of risks to buildings. Improvement was indicated as required in adaptation measures for buildings, reference to codes and standards
Northwest & Central	The Northwest & Central region achieved high scores in its focus on physical climate change, its description of climate hazards and risks to buildings, and comparatively good focus on the standards

Region	Analysis Summary
	and codes targeted for compliance. Improvements could be made in climate change adaptation measures for buildings and discussions of residual risk.
Scotland	Scotland's WRCCA plan was rated highly for its discussion on climate hazards and potential impacts to buildings, including specific building vulnerability. In addition to its overall risk management approach. Though still scoring high, some scope for improvement was found for the discussion of codes and standards targeted for compliance, specific adaptation measures for buildings and discussion of residual risk.
Southern	The Southern region scored highly across all questions, with very high scores achieved for the discussion of climate hazards and the risks to, and vulnerabilities of buildings in particular. This plan also scored highly for its specifics on the codes and standards targeted for compliance. Though still scoring high, some gaps were identified as limited specific adaptation measures for buildings and discussion of residual risk.
Wales & Western	The Wales & Western WRCCA plan achieved high scores for its discussion of climate hazards relevant to the railway and buildings, and its detail on the standards and codes targeted for compliance. Scope for improvement was found in addressing specific vulnerabilities and adaptation measures relevant for buildings and the discussion of residual risk.

Strategies & Policies

These high-level documents outline various strategies and policies for the operation of the national railway. Most of these documents contain limited references to climate change, except for the 'Greener Railway Strategy', which has a distinct climate focus. Notably, the Buildings & Architecture Policy has limited reference to resilience and instead has a focus of increasing sustainability through lowering carbon emissions related to energy consumption.

Weather / Climate Change Reports

Most of the weather or climate change focussed reports have a minimal focus on buildings, instead describing the larger scale impacts of climate change and general methods to increase resilience to these changes. Exceptions to this include the guidance for developing extreme weather plans, which specifically details the methodology for creating an extreme weather response plan for structures. The Extreme Heat Taskforce Final Engineering Report also describes the overall low understanding of asset condition across the railway, with an overreliance on compliance-based examination preventing a regular maintenance schedule.

Records

The records of wrong side failures and general incident reports lack enough detail to determine if any climate impacts were partially or wholly responsible for reported failures. The reporting of safety events for structures and buildings is underpinned by the NR standard NR/L3/CIV/028, though this document does not contain any references to climate change or provide specific guidance for reporting safety events that result from climate impacts.

2.1.2 Results overview from the semi-quantitative assessment

A total of 33 documents has been reviewed and analysed using the scoring system outlined in [Section 1.2.1 Methodology](#). The documents have been scored individually and grouped by category.

Table 6 presents the overview of the results from the semi-quantitative analysis produced using the scoring matrix.

Table 6: Documents reviewed by category

Document category	Number of documents	% of overall	Averaged Total score (out of 56)
Strategies & Policies	8	24	11
Regional WRCCA Plans	5	15	47

Regional Strategic Business Plans	5	15	36
Delivery Plans	7	21	11
Weather / Climate change	6	18	29
Records including 50+ and 20+ WSF	2	6	7
Total	33	100	23

Figure 2 below shows a comparison of scoring for each of the questions from 1 to 8 scored across the different categories.

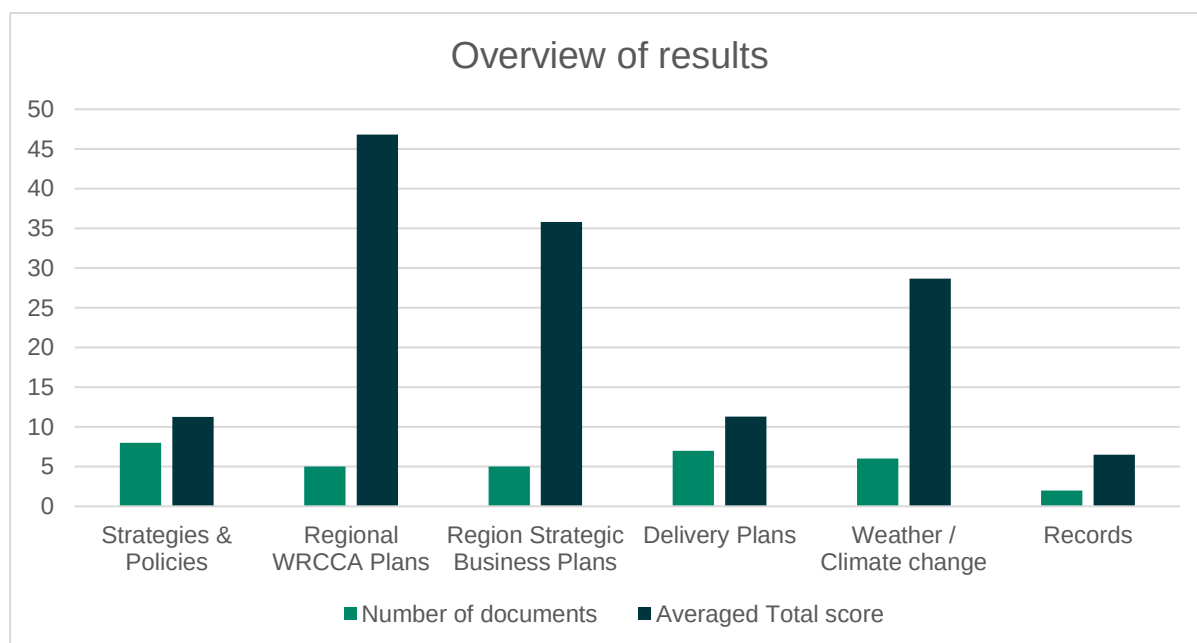


Figure 2: Number of documents by category

Figure 3 below shows a comparison of scoring for each of the 8 questions (see [Section 1.2.1](#)) scored across the different categories.

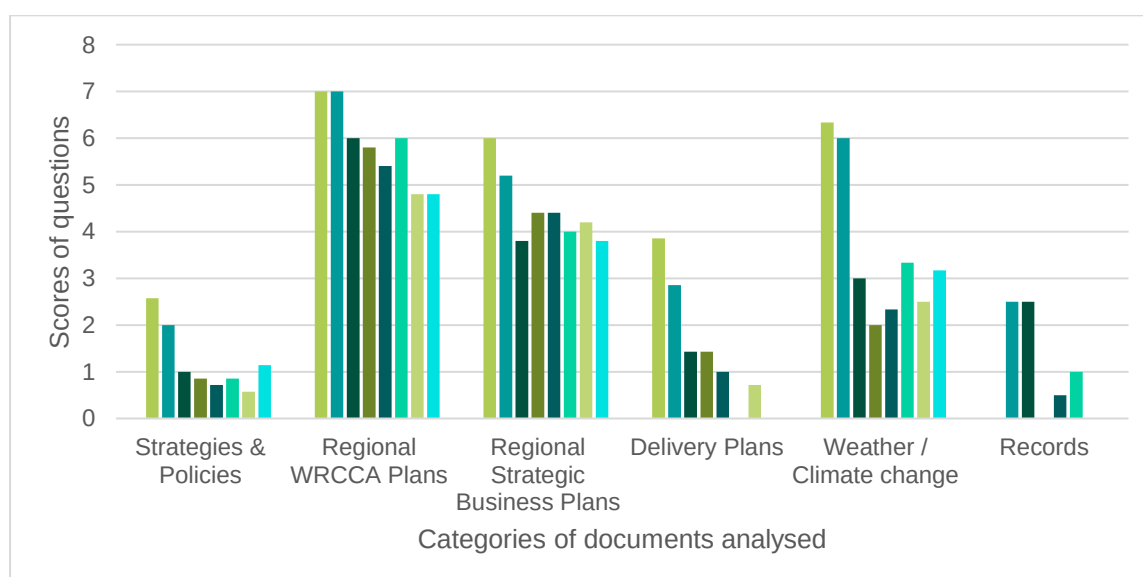


Figure 3: Results by theme or question

Figure 4 below shows how scores compare between different questions across the different categories of documents analysed, shows how different questions scored. As expected, Q1 and Q2 scored highest for most documents, with the remaining six questions scoring generally lower. This indicates that climate risks are recognised in many documents, but the way in which they are experienced and how they should be managed is

detailed less frequently in most documents. Unsurprisingly, reports discussing weather and climate change regional WRCCA plans deal most consistently with all issues addressed in the questions.

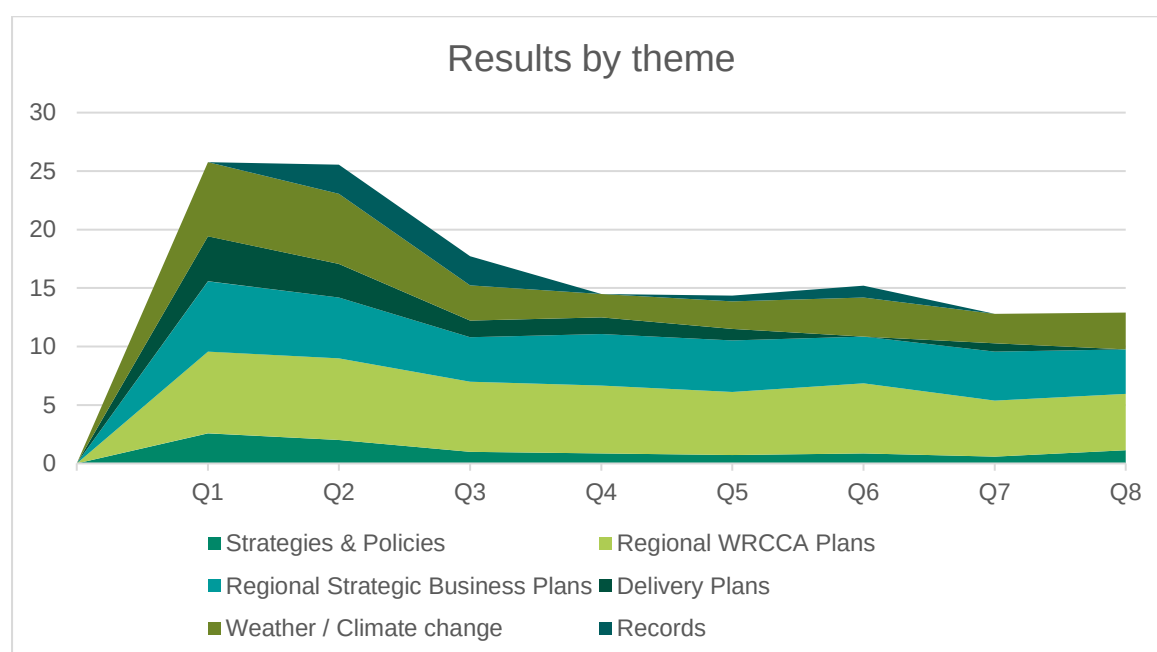


Figure 4: Results by theme or question

Table 7 presents a summary of the results of the scoring matrix. Additional details can be found in **Appendix B**.

Table 7: Analysis of results

Question & Key words	Score (Range)	Summary of performance	Example
Q1. Climate change	0-7 7 6 3-5 0-7 0	Strategies and Policies Regional WRCCA Plans Regional Strategic Business Plans Delivery Plans Weather/Climate Change Records	Documents were searched for the occurrence and frequency of words such as "climate change" and related words like "flooding", "heatwave", "storm", "extreme weather". In some cases, strategies and policies contained other words related to wider sustainability and environmental ambitions such as "decarbonisation" and "net zero", which resulted in a lower score as these responses covered a broad subject. For this reason, strategies and policies scored widely in a range, unlike regional WRCCA plans and strategic business plans which were more focused on themes surrounding extreme weather.
Q2. Hazard	0-6 7 5-6 2-5 0-7 0-5	Strategies and Policies Regional WRCCA Plans Regional Strategic Business Plans Delivery Plans Weather/Climate Change Records	Documents were assessed to understand if climate-related hazards are explicitly recognised, including "extreme heat", "heavy rainfall", "flooding", "sea-level rise", "coastal erosion", "high winds", "storms", and "snow/ice".
Q3. Buildings	0-3 6 2-5 0-2 0-7 0-5	Strategies and Policies Regional WRCCA Plans Regional Strategic Business Plans Delivery Plans Weather/Climate Change Records	Documents were analysed by assessing the specific vulnerabilities that buildings, building systems and building components have towards different climate related hazards. This identified buildings related to the "station" itself, as well as "lineside buildings", "maintenance depots", "IT and communication centres" and others. Across the documents different building systems were identified including "drainage", "signaling and telecommunications", "HVAC" and "lighting", and examples of building components included "roofs", "cable routes", "fencing", "barriers" and "platform canopies". Each of these examples were mapped against different climate hazards along with the identified vulnerability, for example lineside buildings being "vulnerable to water ingress during flash floods and intense rainfall".

Q4. Vulnerabilities	0-3	Strategies and Policies	Documents were analysed to understand if the vulnerabilities of buildings, building systems and building components to different physical climate hazards are described as causing operational downtime (i.e. "overheating in buildings can affect internal operations, while platform heave due to heat stress can disrupt station functionality"), cascading failures (i.e. "flooding can cause failures in drainage, leading to failures of earthworks and track infrastructure"), and consideration of downtime (i.e. "high temperatures can lead to track buckling, necessitating speed restrictions or line closures, which directly cause downtime").
	5-6	Regional WRCCA Plans	
	2-5	Regional Strategic	
	0-2	Business Plans	
	0-7	Delivery Plans	
	0	Weather/Climate Change Records	
Q5. Codes and standards	0-3	Strategies and Policies	Codes and standards identified in the various documents that are used to assess for compliance were assessed separately under performance thresholds, design objectives and resilience objectives. Examples of performance thresholds that were identified include "Critical Rail Temperatures (CRT)" and "Composite Sustainability Index (CSI)". Examples of design objectives include different NR standards such as NR/L2/ENV/105, as well as specific examples like "greater capacity requirements for drainage systems to account for climate change impacts", and examples of resilience objectives include "Renewals focus on areas at the highest risk from adverse weather events, such as flooding and embankment instability, to enhance resilience".
	3-7	Regional WRCCA Plans	
	3-6	Regional Strategic	
	1	Business Plans	
	0-7	Delivery Plans	
	0-1	Weather/Climate Change Records	
Q6. Risk management	0-5	Strategies and Policies	Documents were assessed to understand if formal risk management approaches are applied to assess and prioritise climate change risks for specific buildings and system assets. Specific risk management approaches were identified within documents like the WRCCA Plans, including the "Network Rail Integrated ARP3 Climate Risk Assessment", "adherence to the ISO31000 Risk Management Framework", and "alignment with the ISO31000 Risk Management framework". Similarly, prioritisation and reference to buildings and system assets were clearly identified in these plans, and in a few of the regional strategic business plans.
	6	Regional WRCCA Plans	
	1-6	Regional Strategic	
	0	Business Plans	
	0-7	Delivery Plans	
	0-2	Weather/Climate Change Records	
Q7. Adaptation	0-4	Strategies and Policies	The application of adaptation methods, including good practice approaches to strengthening Victorian buildings were assessed in each of the documents, including how vulnerabilities are to be reduced through proportionate and performance-based interventions. Many of the documents lack explicit reference to Victorian buildings. However, examples of adaptation measures that were identified as potentially applicable to ageing infrastructure in general include "life extension works", "reducing their exposure to high temperatures", "updating building management systems", "implementing energy performance improvements", and "revising intervention trigger points"—actions that collectively build resilience to environmental stressors".
	4-5	Regional WRCCA Plans	
	3-6	Regional Strategic	
	0-1	Business Plans	
	0-7	Delivery Plans	
	0	Weather/Climate Change Records	
Q8. Residual risk	0-6	Strategies and Policies	Documents were assessed to understand if there are instances where residual risk has been identified or addressed. Some documents reference general ways in which to manage residual risks, such as "through ongoing process improvements, enhanced collaboration, and a more proactive, systematic risk management approach", whereas others identified specific applications like "contingency measures to address unexpected outcomes or failures that could occur despite mitigation actions [which] may include emergency response protocols and backup operational plans designed to minimize service interruptions".
	5-6	Regional WRCCA Plans	
	2-5	Regional Strategic	
	0	Business Plans	
	0	Delivery Plans	
	0	Weather/Climate Change Records	

2.1.3 Document Review Conclusions

Following a review of the key documents identified in [Section 2](#), consideration of the following aspects were identified for further examination in the Thematic Analysis presented in [Section 3](#) stage.

- Consistency between each region's WRCCA strategy
- Specific descriptions of risks faced by buildings beyond flooding exceeding drainage limits
- Performance based metric to evaluate building resilience (alternative to delay minutes)
- Ensure extreme weather response plans are completed for structures where possible
- Obtain greater understanding of asset condition across the railway.

3. Thematic analysis mapped to the themes of risk, resilience and asset strategy

This section presents the outputs of the thematic analysis mapped to the themes the resilience, risk, and asset strategy that is contained within NR documentation. This builds upon the work completed in the Document Review, [Section 2](#), and provides a more in-depth analysis of how key climate change adaptation themes relating to buildings are addressed by NR. This analysis has been divided into four main themes:

- Assessment of high-level strategy links to actionable interventions
- Evaluation of how heritage and pre-modern building asset groups are treated
- Assessment of alignment with risk-based and performance-based principles
- Identification of good practice approaches to strengthening

The following section provides an overview of the four themes stated above, how they are addressed within NR documentation, gaps identified within NR documentation related to climate change adaptation, and any improvements that may be require.

3.1 Assessment of high-level strategy links to regionally actionable interventions

This section evaluates how well resilience interventions align with high-level strategies, assessing whether these interventions reflect the intended strategic goals. Where the available documentation does not clearly show connections between strategies and actions, we analyse the gaps and explain the potential consequences of these gaps.

NR's Environment and Sustainability Strategy 2025¹ has an overall strategic ambition for a railway that is fit for the future. To achieve this strategic ambition, NR has identified eight priority areas. Adapting to Climate Change is a priority area with the following objectives and targets:

By 2030:

- To deliver 90% of regional Weather Resilience and Climate Change Adaptation Plan milestones by the end of March 2029.
- Have established the first regional long term adaptation pathways strategies based on assessment of high-priority locations by the end of March 2029
- Have Key Route Strategies for operating in extreme weather by the end of March 2029
- Routes and train operators to provide integrated assurance of readiness against seasonal weather plans for infrastructure and operations by the end of March 2029.

Beyond 2030:

- Have 100% of the network covered by adaptation pathway strategies to enable continuous improvements in the reliability and safety of the network.
- Improve customer satisfaction during adverse and extreme weather

¹ The Greener Railway Strategy Our Environment and Sustainability Strategy 2025 – 2050 [Greener-Railway-Strategy_May-2025.pdf](#)

3.1.1 The framework for translating strategy into actionable interventions

High-level climate resilience strategies are translated by NR into actionable interventions through a structured framework, governed by the Level 2 NR's Environmental and Social Minimum Requirements (ESR) Standard NR/L2/ENV/015², in alignment with NR Environmental Sustainability Strategy and supported by two key guidance notes:

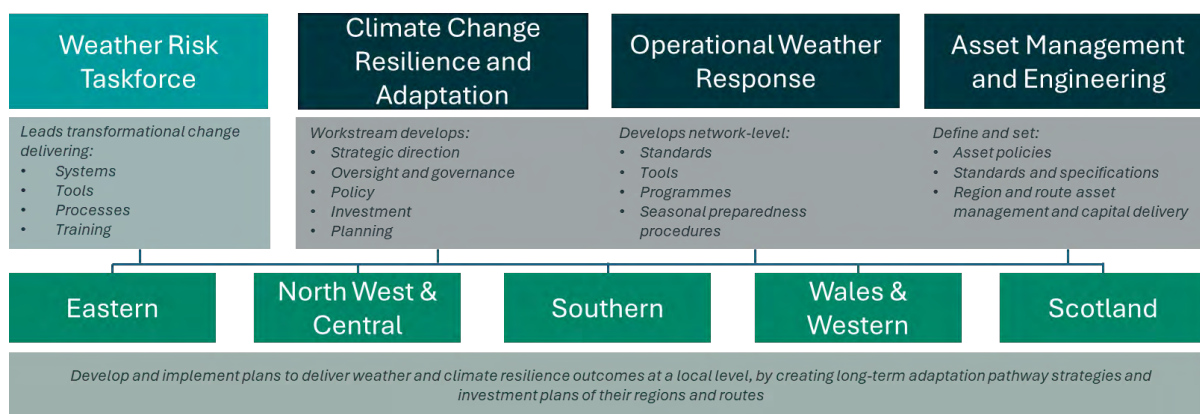
- Climate Change Projections Guidance Note³
- NR Weather Resilience and Climate Change Impact Assessment (WRCCA) Guidance Note⁴

Weather resilience and climate risks and opportunities are identified through use of the Environment and Social Appraisal (ESA) Tool and the Level 1 Environment and Social Performance Policy NR/L1/ENV/100 which states *"We will adapt at construction and at asset renewal to provide resilience in the most cost effective manner by designing schemes to be resilient for future weather conditions and/or with a view to providing passive provision for future weather conditions."*

These documents provide a clear roadmap for integrating resilience and climate adaptation into project design and delivery. The structured approach confirms that strategic goals are embedded into practical, measurable actions.

Figure 5 displays the teams across NR that support and manage weather and climate resilience. This also shows how strategy formed as part of the overarching policies developed by the Central teams are then implemented at the regional and route level. This is adapted from **Table 2** of the NR Fourth Adaptation Report (December 2024)⁵.

Figure 5: Overview of climate resilience strategy, policies and standards cascading to regional level



NR's Environmental and Social Minimum Requirements (ESR) Standard NR/L2/ENV/015 references building systems, including Heating, Ventilation, and Air Conditioning (HVAC) systems, processes such as [the Building Energy Audit Process](#) (BEAP) and built environment and building services institution, the Chartered Institution of Building Services Engineers (CIBSE) CIBSE, indicating consideration of building design standards and internal building systems. A summary of the topics covered in NR/L2/ENV/015 relating to buildings and building systems is provided in **Table 8**.

² NR Environment and Social Minimum Requirement for Projects

³ NR Climate Change Projections Guidance Note (2023) [Climate-Change-Projections-Guidance-Note.pdf](#)

⁴ NR Weather resilience & climate change impact assessment [Weather-Resilience-and-Climate-Change-Impact-Assessment-Guidance-Note.pdf](#)

⁵ Network Rail. Fourth Adaptation Report. (December 2024). Available at: <https://www.networkrail.co.uk/wp-content/uploads/2024/12/Network-Rail-4th-Adaptation-Report-Dec-2024.pdf>

Table 8: Summary of NR/L2/ENV/015 building and building systems requirements

Section/Clause	Reference /Requirement	Building/System Aspect	Notes /Standards
3 Definitions	Building, Structure, Mechanical/Electrical Systems	Definition of building, structure, and fixed systems (HVAC, electrical, etc.)	Clarifies scope for construction and design activities
5.7 Life Cycle Costing	Life cycle costing for all works	Includes buildings and building systems	Considers design life, maintainability, end-of-life, environmental impacts
6.4 Energy and Carbon	EPC rating requirements for buildings	New buildings: EPC C; Modified buildings: EPC E	Energy performance certification, sub-metering, commissioning plans for fixed services
6.4.3 Energy & Operational Carbon	Energy assessment methodology (CIBSE TM54)	Building energy use, HVAC, lighting, thermal storage, heat recovery, renewables	Design to maximize efficiency, minimize utility services
6.5.2.2 Low Environmental Impact Products	Assessment of building products/systems	HVAC, paints, adhesives, refrigerants	Consider VOCs, global warming potential, EPDs, Safety Data Sheets
6.5.2.3 Responsibly Sourced Timber	Timber for building works	Chain of custody, third-party certification	Applies to all timber in buildings, fit-outs, structures
6.5.2.4 Concrete & Aggregates	Concrete/aggregate for buildings	Responsible sourcing, recycled content	Applies to building foundations, structures
6.5.3 Waste Management	Building waste management	Space for segregation/storage, cleaning, pollution controls	Applies to stations, occupied buildings, depots
6.9 Sustainable Travel	Facilities in occupied buildings	Infrastructure for low-carbon travel (e.g., bike storage, EV charging)	Applies to new, extended, refurbished buildings
6.10 Water	Water services in buildings	Water reduction, rainwater harvesting, greywater recycling	Compliance with Building Regulations (England)
6.11 Weather Resilience & Climate Change	Building resilience measures	Flooding, climate adaptation, asset protection	Impact assessment required for buildings
8.8 Accessibility & Inclusion	Diversity Impact Assessment for buildings	Accessible/inclusive design, lift replacements	Engage Built Environment Advisory Panel
8.9 Cultural Heritage	Listed buildings, architectural consent	Heritage assessment, planning/listed building consent	Submit architectural layout for significant schemes

10.1 Benchmarking Environmental Performance	BREEAM, CEEQUAL for buildings	Environmental certification for new/refurbished buildings	Applies to operational property buildings
10.2 Refurbishment & Fit-Out	RICS SKA/BREEAM for building fit-outs	Minimum rating requirements for building fabric	Applies to >50% element or >25% total building
10.3 New Construction	BREEAM/Passivhaus for new buildings	Minimum/aspirational ratings for new builds	Applies to sponsor/funder requirements

3.1.2 Mandatory standards and requirements

The ESR standard, Issue 9 (dated 2021) is a mandatory requirement for all design and construction work carried out by NR and its contractors, as part of a managed project and NR's PACE (Project Acceleration in a Controlled Environment) Product Index. NR standards use colour coding with Red-Amber-Green classification. Amber requirements are to be complied with unless an approved variation is in place, variations are only permitted subject to approved risk analysis and mitigation can only be approved through a national variations process. Amber requirements are presented with an amber sidebar and monitored for compliance. Non-approved variations will be investigated and corrective actions enforced. Amber requirements mean that guidance should be followed unless there is a suitable alternative, however implementation of guided activities is not monitored for compliance. NR's Standards and Controls Management Team is responsible for overseeing the development, implementation, and variations of the ESR standard as part of NR's standards and control documents.

The ESR standards is a mechanism to:

- Apply consistent resilience interventions across projects
- Assign accountability and responsibility for designers to address climate risks
- Integrate climate resilience considerations at critical project stages (Governance for Railway Investment Projects (GRIP) stages 3 to 5).

ESR standards include the following two amber requirements:

- WRRCA Impact assessment; Designers must conduct climate change impact assessments using standard prescribed tools and data sources (see [Figure 6](#) below).
- Cost-Benefit Analysis: The WRCCA Cost Benefit Decision-Making Tool helps prioritize interventions based on business case alignment with Route WRCCA Plans.

[Figure 6](#) provides further detail on the WRRCA Impact Assessment and Cost Benefit Analysis.

WRCCA Impact Assessment

The ESR standard contains the following requirement in section 4.7 WRCCA Impact Assessment "The Designer will undertake a climate change impact assessment using relevant data sources and develop a WRCCA risk report using the WRCCA Impacts Assessments and Climate Change Projections Guidance Notes. The level of detail of this assessment will vary depending on the GRIP stage and the intention is for knowledge of the current and future weather risk to influence project and asset design options.

The WRCCA impact assessment is expected at Governance for Railway Investments (GRIP) stages 3 to 5 (NR/L2/INI/P3M/101), the designer is responsible for tasks which include weather data collection (desktop), impact assessment based on climate change predictions, WRCCA Risk Report including cost benefit analysis, Design Development Review and includes liaison with internal stakeholders including the RAM (Route Asset Manager).

WRCCA Cost Benefit Analysis

The WRCCA Cost Benefit Decision Making Tool can be used to develop the prioritisation elements of the business case for different options, aligned with the Route WRCCA Plan.

Figure 6: WRCCA Impact Assessment and Cost Benefit Analysis

3.1.3 Structured guidance for implementation

The Climate Change Projections Guidance Note³ and WRCCA Guidance Note⁴ provide detailed guidance and methodologies for translating high-level strategies into practical interventions:

- The Climate Change Projections Guidance Note offers standardised climate scenarios (e.g., RCP 6.0 and RCP 8.5) for assessing risks, designing assets, and new railway projects
- The WRCCA Guidance Note outlines an 8-step process for weather and climate-related impact assessments, demonstrating a comprehensive approach to identifying, quantifying, and reducing risks.

NR's Climate Change Projections Guidance Note provides standardised scenarios to enable consistent approaches to climate risk assessment and assessment of vulnerability. NR's Climate Change Impact Assessment Guidance Note provides a structured approach to assessing weather resilience and the impact of climate change on projects and activities. The guidance includes 8 steps for identifying, quantifying and reducing climate change related risks, ensuring projects can provide performance and safety outcomes.

This step-by-step approach determines that high-level strategies are systematically broken down into actionable tasks. The 8-Step Process is outlined in **Figure 7** and **Figure 8** below.

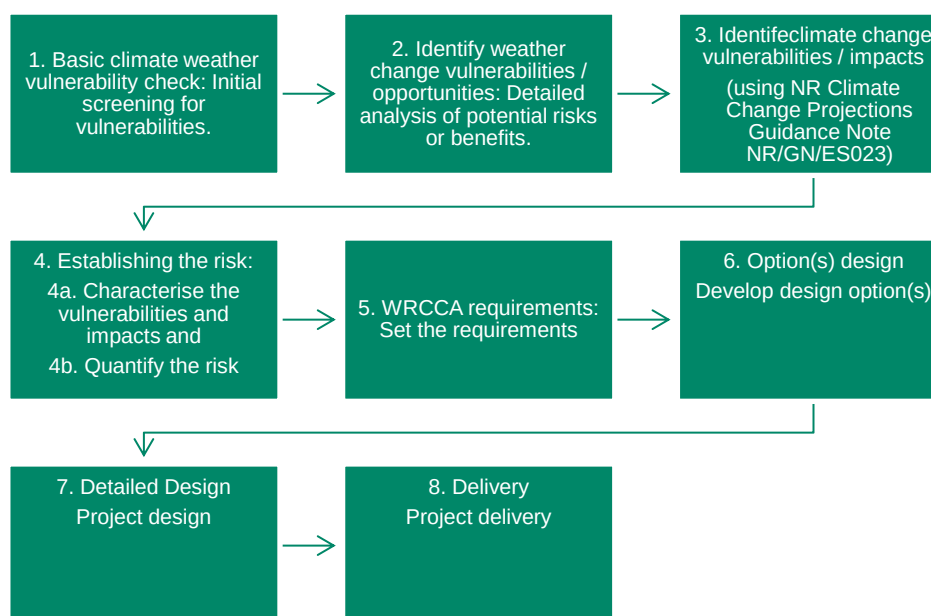


Figure 7: Adapted from Weather resilience and climate change assessment process (from NR Climate Change Projections Guidance Notes, Issue 3, dated 2023.

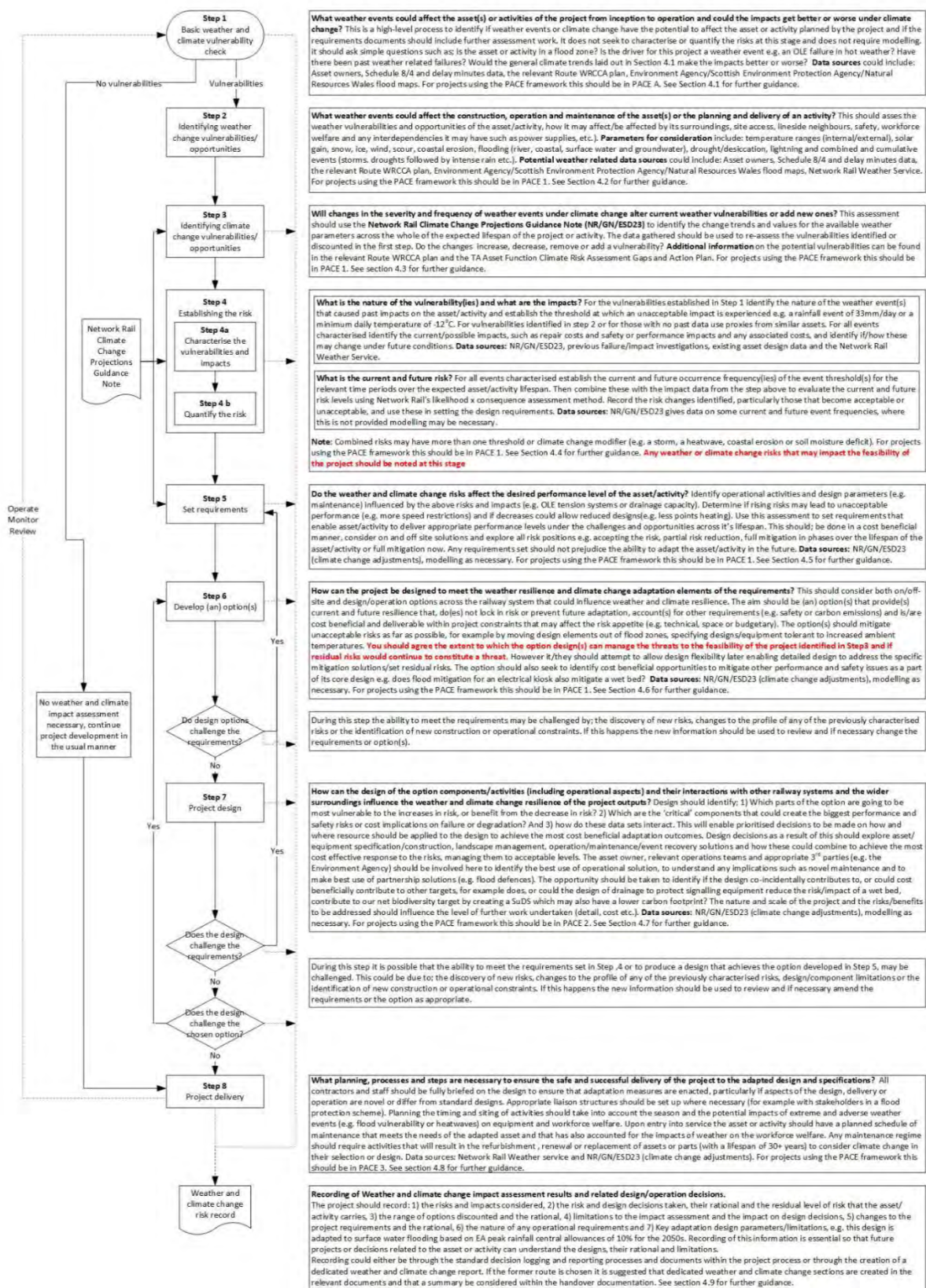


Figure 8: Weather Resilience and Climate Change Assessment Process

NR's Level 2 Environmental and Social Minimum Requirements – Design and Construction Standard (NR/L2/ENV/015) (ESR) Issue 10 was published in December 2025. Section 8.10 of the standard contains significant updates to WRCCA, including amendments to the previous version and new additional information and guidance. This additional guidance specifies how to conduct a Weather and Climate Change Impact Assessment (WCCIA), and specification of how to proceed once the adaptation pathway has been identified for the assessment.

Adaptation Pathways are described in more detail below as a practical way adaptation measures are embedded in project planning. The WCCIA also requires adverse and extreme weather forecasts now be included, and projects must consider collaborative solutions with external parties. Also, WCCIAs will now be required to form part of the site environmental management system for projects which require an Environmental Permit under the Environmental Permitting Regulations.

The amendments to ESR include the involvement of stakeholders such as the Asset Manager and Project Manager in the decision-making process early to ensure the WCCIA is built into the project programme as soon as PACE 1. Designers are also given greater responsibility for overseeing the implementation of the assessment, in particular identifying and signalling if any significant design modifications or new information could materially affect the outcomes of the WCCIA. Any changes that are made to the assessment will also need to be recorded in the Designer's Risk Assessment and managed within the wider ESMP (Environment, Social and Management Plan), which embeds requirements and processes for conducting the WCCIAs. This enables those outcomes from these assessments, which are central to the WRCCA framework, are documented and linked with practical design and construction interventions.

The ESMP template has been produced to meet ESR. The template includes a designated section titled "Weather Resilience and Climate Change Adaptation" (referenced as section 4.11 in the table of contents). This section is intended to capture outputs from the Weather and Climate Change Impact Assessment report. Although the acronym "WRCCA" is not explicitly spelled out in every instance, the section directly reflects the essential elements of WRCCA by requiring project teams to provide:

- Confirmation of resilience measures that are applied to avoid or mitigate the adverse impacts of extreme weather and climate change.
- Proposed controls and performance expectations that aim to reduce risks to ALARP (As Low As Reasonably Practicable).

The strategic goals include the aim that resilience is built into key assets and that projects are prepared for adverse and extreme weather conditions are translated into actions through a structured approach. The ESMP template acts as a roadmap where:

- The outputs of the WCCIA become a benchmark to confirm that design measures and interventions are effectively reducing weather-related risks.
- Mandatory monitoring and reporting frameworks are built into the template. This allows for continual performance evaluation against the strategic resilience targets and contributes to feedback being captured for further improvement.

This review identified how WRCCA Planning strategic documents and technical guidance are used in WRCCA Plans for railway projects, and the means by which strategy is converted into actionable interventions. The implementation of the ESR standard WRCCA guidance is demonstrated by the presence of weather checks, identification of weather risks and benefits and risk assessment. Control measures and integration in design are well considered.

However, there are some gaps. For example, there is an absence of centralised monitoring, reporting and feedback to enable a comprehensive evaluation of the implementation and effectiveness of the interventions planned. In addition, there is little evidence on prioritisation and demonstrable implementation of planned interventions. In addition, specific references to buildings are not included in most documents.

3.1.4 How practical Adaptation Measures are Embedded in Project Planning

NR has defined a Climate Adaptation Pathways NR/GN/ESD41 (Issued August 2024) planning approach to prioritise and phase investment and provide resilience to climate change across all asset classes (although buildings receive a small proportion of funding). This process which is still in the process of being fully implemented, following a pilot project in the Southern Region in 2023. It considers adaptation options with trigger points and thresholds which can be used to identify when decisions need to be made and actions taken. Our assessment of alignment will assume this will be implemented as currently defined.

By requiring designers to report on the resilience measures along with the specific controls and mitigation actions, the document bridges the gap between the overarching high-level strategy and tangible project delivery:

- Design and Construction Adjustments: Requirements are set for integrating resilience measures, from the initial analysis of weather risks to the final design review and implementation stages.
- Cost-Benefit Considerations: The approach includes cost-benefit analysis of climate adaptation interventions, which is a key element to enable strategic objective of “resilience at an acceptable cost” is met on a project-by-project basis.

3.1.5 Regional delivery plans

The regional delivery plans set out planned investment associated with weather and climate resilience and the associated key interventions, as summarised in [Table 9](#).

Table 9: Summary of interventions outlined in current Regional Delivery Plans

Region	Interventions Planned
Eastern (Unknown Period) Total weather resilience investment £390m, £7m buildings and £23m structures	▪ Significant investments in drainage, earthworks, and weather-resilient designs. ▪ Supported by advanced technologies like drone surveys for tree, wind and heat problem detection and remote temperature monitoring systems.
Scotland (Unknown Period) Total weather resilience investment £495m, £433m Climate Ready Assets (£10m buildings, £43m structures), £4m Climate intelligence and £58m weather risk taskforce.	▪ Climate ready assets workstream improves the condition of the assets for example the renewal of drainage assets capacity to handle increased volumes of water. Climate ready intelligence enhances climate and adaptation decisions, for example expanding scope of and making improvements to physical climate change risk assessment processes and the development of a longer-term climate change adaptation strategy.
North West & Central (Unknown Period) Total operating expenses (OPEX) £73m, Capital expenditure (CAPEX) total £324m.	▪ OPEX: Climate adaptation pathways, additional resource and delivery of severe weather schemes to manage infrastructure for hot weather and for enhanced vegetation management to address increased risk. ▪ CAPEX: Includes: 1) weather resilience spend such as North West (NW) Route installation of tilt sensors on West Coast Main Line (WCML) to manage impact of Earthwork failures, Institute of Railway Signal Engineers (IRSE)/ Signal Maintenance Testing Handbook (SMTH) competency management; 2) asset renewals that Routes estimate will deliver primary weather resilience co-benefits (£315m). Drainage renewals, Overhead Line Equipment (OLE) resilience works (American Wire and Cable used in catenary systems (AWAC) replacement, Coastal defences, Track renewals, Geotechnical renewals at high-risk weather impacted sites

Wales & Western (Unknown Period) CAPEX £27m, OPEX £0.4m	Resilience to weather events, reducing the impacts of changing climate; no specific interventions mentioned; funding for pure resilience schemes and climate change adaptation initiatives.
Southern (CP6&CP7) OPEX £75m, CAPEX £250m	- The CP6 route weather resilience and climate change adaptation plan included business as usual activities and standalone resilience workstreams, predominantly focussed on earthworks, drainage, and off track (including vegetation), use of remote monitoring at priority locations and addressing risks associated with structures for scour, adverse rainfall, and flooding. - Focus on control period 7 (CP7) on mitigation and rapid recovery to minimise the impact of weather events on the network in recognition of the reduced renewals portfolio, which does not support a focus on prevention.

3.1.6 Alignment with strategic goals

The alignment between high-level strategies and interventions is reinforced through:

- Application of standard tools; NR provides a WRCCA Cost Benefit Decision-Making Tool and climate scenarios allow consistency across regions and projects. No examples of the WRCCA Cost benefit Decision Making Tool have been reviewed, so we have been unable to assess or evaluate the effectiveness or consistency of application of the tool.
- Stakeholder engagement and collaboration; Designers are required to liaise with internal stakeholders (e.g., RAM) to align interventions with broader organisational goals.
- Integration into PACE; Embedding climate resilience assessments-allows strategic goals to influence project design and delivery.

3.1.7 Gaps and potential consequences

NR has a robust framework in place to translate strategy into interventions. However, potential gaps may exist in the following areas:

- **Document clarity** on WRCCA as it relates to buildings; where the connection between strategies and actions is not explicitly documented for buildings, it could lead to inconsistent application of resilience measures.
- **Regional variations:** Although the guidance notes aim for standardisation, regional differences in interpretation or application could create disparities in outcomes, especially given that interventions are mainly driven and owned by the Regions
- **Monitoring, reporting and feedback:** The absence of a feedback loop to assess the effectiveness of implemented interventions could limit opportunities for continuous improvement
- **Traditional building codes and standards** can limit engineers' ability to fully respond to climate and weather-related hazards. NR's Climate and Adaptation Manager confirmed that NR is in the process of updating design standards.

The potential consequences of doing nothing or not closing previously outlined gaps are identified below:

- **Misalignment** between strategic goals and project outcomes.
- **Increased vulnerability** of building assets to climate risks due to inconsistent application of standards.
- **Inefficient allocation of resources** if cost-benefit analyses are not rigorously applied, monitored and reported.
- Design standards are without basis on performance-based outcomes beyond codes and standards.

In summary, the translation of high-level strategies into actionable interventions is well-supported by the ESR Standard, Climate Change Projections Guidance Note, and WRCCA Guidance Note. These documents provide a structured and standardised approach to integrating resilience and climate adaptation into project design and delivery.

Key strengths include mandatory requirements, detailed methodologies, and standardised tools. However, gaps in document clarity where WRCCA relates to buildings, lack of regional consistency, and insufficient feedback mechanisms could undermine the alignment between strategies and actions. Addressing these gaps is critical for interventions to effectively reflect strategic goals.

NR's strategic ambitions, particularly the focus on adapting to climate change, emphasise resilience as a priority for future-proofing the railway network. Buildings play a pivotal role in this strategy, serving as operational hubs,

passenger facilities, and critical infrastructure that must withstand adverse weather conditions. The strategic goals—such as establishing adaptation pathways, improving customer satisfaction during extreme weather, and enabling readiness against seasonal weather risks—are directly impacted by the resilience of building assets. If gaps in document clarity and implementation persist, buildings may become weak links in the network’s climate adaptation strategy, undermining broader strategic objectives.

Addressing these gaps is not just about aligning actions with strategic goals; it is about safeguarding the reliability, safety, and functionality of the railway network. Buildings must be designed and maintained to withstand future climate scenarios, ensuring uninterrupted operations and enhanced user experience. This is particularly critical as climate risks intensify, demanding proactive measures to mitigate vulnerabilities and optimise resource allocation. By closing these gaps, NR can enable interventions are not only aligned with strategic ambitions but also deliver tangible benefits across all asset types, including buildings.

3.2 Evaluation of heritage and pre-modern buildings

3.2.1 Introduction

This section evaluates how heritage and pre-modern building asset groups are treated in relation to climate hazards within NR’s guidance and strategic documents. The key characteristics of heritage and pre-modern buildings that make them more – or less – vulnerable to climate hazards than modern buildings will also be explored, highlighting any potential gaps in NR documentation.

3.2.3 Definition of Heritage and Pre-Modern Buildings

According to the Design Manual NR/GN/CIV/100/05 Heritage: Care and Development, of the overall total of over 580,000 listed buildings in the UK, over 1,400 are railway buildings and structures.

For this review, heritage buildings are considered as “*Any Listed Buildings, Buildings within a Conservation Area, and Scheduled Monuments*”, as defined in the Design Manual.

The term “pre-modern building” is not mentioned in any of the NR documents reviewed. Modernism in architecture is characterised by a strictly rational use of often new materials, structural innovation and the elimination of ornament⁶. For the purposes of this study, pre-modern buildings mean those constructed before the modern movement (1940s), using older materials and structural methods.

Of the 2,500 stations maintained by NR, 443 of these are listed buildings⁷, which means listed and heritage buildings make up a significant proportion of NR’s asset portfolio and their significance and status should be considered when proposing alterations to NR assets.



Figure 9: Examples of NR heritage buildings, as shown from left to right: Downham Market (Grade II listed), Stamford Railway Station (Grade II listed), Edinburgh Waverley station (Category A listed).

⁶ [RIBA: Modernism architecture style guide](#)

⁷ NR/GN/CIV/100/04 Climate Action Design Manual for Buildings and Architecture, Network Rail, 2021. Available at: [NR/GN/CIV/100/04 Climate Action Design Manual](#)

3.2.4 Climate related hazards

Technical Report Chapter 5: Health, Communities and the Built Environment⁸ of the UK Climate Risk Independent Assessment: Evidence for the third UK Climate Change Risk Assessment (CCRA3) identifies the following main hazards for buildings:

- High temperatures and overheating affecting health and wellbeing.
- Flood risk from rivers, surface water, and coastal flooding.
- Sea level rise and coastal change threatening the viability of some communities in the future.
- Damage through increases in subsidence, increases in damp/excess moisture, and increases in structural damage due to high winds.

The UK CCRA3⁹ identifies the risks and opportunities shown in **Table 10**. The table is an adjusted extract of the CCRA3, focusing on the risks that are relevant to the topic of this report.

The economic magnitude of each risk has been assessed for both a 2°C and 4°C warming scenario. The following are the UK-wide magnitude categories where the cost of economic damage or forgone opportunities are represented in ranges to reflect the uncertainty in the evidence base. Potential costs and damages are denoted with a negative sign e.g. - VH while possible opportunities are denoted with a positive sign e.g., +VH. Where uncertainty exists over the category, the range has been indicated e.g. – L to – VH. For some of the risks and opportunities, there are both potential costs and benefits.

Table 10: 'More action needed' risks and opportunities (adapted from UK CCRA3).

ID	Risk or Opportunity	2050s, 2/4°C	2080s, 2°C	2080s, 4°C	Relevance to NR and the current analysis
H1	Risks to health and wellbeing from high temperatures	- VH	- VH	- VH	High
H3a	Risks to people, communities and buildings from river and surface flooding	- VH	- VH	- VH	High
H3b	Risks to people, communities and buildings from coastal flooding	- H	- H	- H	High
H4	Risks to people, communities and buildings from sea level rise	- L	- L	- M	High
H6a	Risks and opportunities from winter household energy demand	+ VH	+ VH	+ VH	Low
H6b	Risks and opportunities from summer household energy demand	- H	- VH	- VH	Low
H8	Risks to health from vector-borne diseases	- L to – M	- M	- M	Low
H11	Risks to cultural heritage	Not known	Not known	Not known	High

3.2.5 Existing Network Rail guidance

Our review of NR's WRCCAs presented in **Section 2** showed that there is very limited information on NR's experience with heritage and pre-modern buildings.

The five regional WRCCA plans contain most of the information related to the climate change hazards threatening the operation of the UK railway. While these documents contain no specific reference to heritage or listed buildings, some high-level adaptation measures to increase the resilience of managed buildings are proposed. Across all regions, this is focussed on improvements to drainage systems in response to projected

⁸ Technical Report Chapter 5: Health, Communities and the Built Environment

⁹ UK CCRA3

changes to precipitation patterns and storminess. This includes installing higher capacity drainage and the use of SuDS.

Other risks to buildings highlighted in the regional WRCCA plans include extreme heat affecting the welfare of building users and causing expansion in roofs; wind damage to roofs; and instable ground conditions. While the North West & Central region outlines targets for refurbishment of buildings, other regions do not contain specific measurable targets related to the resilience of building assets.

The Buildings and Architecture Policy contains limited reference to climate change, with a sustainability focus on emissions reduction, rather than adaptation. This includes measures such as energy efficient lighting, and a target of increased compliance with EPC ratings.

The Climate Action Design Manual for Buildings and Architecture (NR/GN/CIV/100/04)⁶ outlines the strategy to increase resilience across railway related buildings, providing triggers for interventions, and outlines NR's approach for measuring sustainability in its description of the Condition Sustainability Index (CSI) measures. This document does not propose specific adaptation measures for particular building types but rather outlines the approach regional operators should take to increase the resilience of managed buildings. CSI measures the condition of infrastructure assets, focusing on their reliability and performance over time. The CSI equation is shown in **Figure 10**.

The Sum of: Critical Features x F&A Unit Costs x PARL of Assets on Critical Blocks

The Sum of: All Critical Features on All Critical Block x F&A Unit Costs x 100%

Figure 10: Condition Sustainability Index equation. *Percentage Average Remaining Life (PARL)

The Design Manual NR/GN/CIV/100/05 Heritage: Care and Development provides practical guidance on how best to maintain heritage assets in appropriate conditions related to their operational functionality and cultural importance. This document details considerations that should be made when maintaining or altering heritage assets, however it contains very limited reference to climate change.

Outside a reference to climate change considerations when renovating drainage systems, there is no mention of climate change vulnerabilities or adaptation measures that are most relevant to heritage assets.

This suggests there is a gap in NR documentation around climate change hazards, vulnerabilities, and adaptation pathways as they relate to heritage assets.

3.2.6 Vulnerabilities of pre-modern and heritage buildings

This section identifies the key characteristics of heritage and pre-modern building asset groups that make them more or, in few cases, less vulnerable to climate-related hazards than modern buildings.

The CS-N0W WPG11 Mapping Climate Related Hazards to Buildings¹⁰ report analyses five specific risks to the built environment and includes how these are related to heritage buildings. The risks are extreme wind, wind-driven rain (WDR), subsidence, wildfires and pests. The report integrates the results of an extensive literature review where the five risks are linked to the building characteristics of building type, building age, building fabric and building design, with the two last characteristics closely linked to building age. The vulnerabilities of older buildings with regards to climate change hazards include the following:

Extreme wind

- Traditional buildings or buildings with older materials can generally be more sensitive to extreme wind events as they can contain 'loose' materials which can become dislodged, through means of deterioration or as a result of the construction style,
- Traditional roof coverings like slates, clay tiles, and pantiles are particularly sensitive to water ingress in high winds, even when correctly installed.
- Where buildings have not been well maintained, extreme wind will accelerate decay of worn and weak elements. Continued neglect can lead to structural movement and eventual failure, such as collapse of chimney stacks and gable ends.

¹⁰ [CS -N0W WPG11 Mapping Climate Related Hazards to Buildings](#)

- Damage from falling trees is of concern especially to historic buildings, where large and mature trees are often close.

Snow / Ice

- Traditional roof coverings or canopies can be vulnerable to increased snow loading, potentially leading to structural damage or collapse.
- It is anticipated that due to climate change, impacts related to snow and ice will become less frequent as freezing temperatures occur less often.

Wind-driven rain

WDR or driving rain is [rain that is given a horizontal velocity component by the wind](#). WDR is significant in several research areas including meteorology and building science.

- Limestone is particularly sensitive to WDR, as it is susceptible to damage from weathering due to its solubility. Droplets from WDR may spread, splash, or rebound and can form a water film that runs down the façade of limestone walls, increasing weathering rates.
- Porous materials, including many traditional building elements, are generally more sensitive due to their high moisture absorption rates. The rate of absorption and desorption can influence the extent of damage.
- Historic masonry infilled timber frames, being porous, are susceptible to water infiltration from WDR. This weakens the timber frame, making the structure more prone to wind damage.
- WDR exacerbates various weathering processes, including chemical, freeze-thaw, salt, and biological weathering, particularly in the case of stone (and other modern building materials e.g. reinforced concrete).
- Several research studies have shown that WDR directly affects the moisture content of historic envelopes. WDR is also the dominant factor determining the moisture movement in walls. This increases the risk of mould growth (especially in historic wooden buildings) and moisture related damage. This in combination with other factors in cultural heritage buildings, could even undermine the structural integrity and stability of building components (e.g. Regent Street Disease in pre-modern steel framed buildings).

Subsidence

The Royal Institution of Chartered Surveyors(RICS) defines [subsidence](#) as “the downward movement of the foundations of a building due to changes in the supporting strata. It is different from settlement”. The British Geological Survey explains that the predicted warmer, drier summers and increases in annual temperature and rainfall variability are expected to cause more shrink–swell activity. Additionally, overflowing drainage systems can lead to wash-out of formation material, resulting in voids which can undermine foundations. It is likely that climate change will increase the risk of subsidence in the UK.

- Buildings built on timber piles or rafts are sensitive to subsidence if the ground dries, compromising their stability.
- Buildings with shallow or no dug foundations, more commonly seen in older buildings, are particularly sensitive to subsidence. Factors that exacerbate the risks of subsidence include prolonged hot spells which dry out the soil, removing moisture and compromising the building's structure.

Wildfires

- Roofing materials like wooden shakes and shingles, or thatch, are potentially sensitive to firebrand ignition (ignition of new fires caused by embers from existing wildfires being transported by wind and landing on receptive fuel sources), making them particularly susceptible to wildfire damage.
- Historic buildings can be more sensitive to fire and fire damage, particularly in buildings that are comprised of high amounts of combustible materials. This can include surface treatments, decorative paint, and interior details that in addition to acting as a fuel source, are extremely vulnerable to damage from fire and smoke as well as from fire suppression media, such as water or foam.

Pests

- Heritage buildings are sensitive to various pests due to changes in biological growth patterns resulting from climate change, particularly warmer temperatures and wetter winters. This is due to the materials used in construction such as timber, which are more susceptible to pest infiltration.
- Timber framed buildings and timber materials, including facades, are particularly sensitive to insect infestations, especially woodworms.
- Heritage buildings are currently sensitive to impacts from pests, with the most frequent insect pests found in English Heritage properties including booklice, silverfish, woodlice, plaster beetle, woolly bear larvae, carpet beetle, and the webbing clothes moth¹¹.
- Large historic buildings are often difficult to seal and remain sensitive to infestations. They often also have a resident population of pests within the building: this can be underneath floorboards, but also unused chimneys, shafts or the attic.
- Historic buildings are often part of park-like landscapes with some dead trees. Sensitivity to an infestation due to this outdoor component is higher than in similar buildings within cities.

Flooding

- Traditionally constructed buildings use permeable materials and older damp-proofing methods, allowing them to manage moisture and temperature changes naturally. When left unaltered, these buildings are often more resilient and recover better after events compared to modern constructions, which typically require extensive repairs.
- However, the state of repair of the building is a significant factor determining if water can penetrate through weak points within the building envelope, such as decayed materials, cracks in masonry and gaps under doors.
- Historic and pre-modern buildings were built in eras with fewer and lower volume rainfalls. As the frequency and intensity of rain events increase in the future, rainwater goods of heritage buildings are less likely to have adequate capacity to protect them from water ingress and flooding.

Overheating

- Unlike with the hazards identified above, increased temperatures during the summer months do not necessarily pose an additional risk to heritage buildings.
- HES states that the high thermal mass of traditional masonry structures means that they are generally good at buffering temperatures during periods of overheating. Therefore, they provide an opportunity to improve building users' comfort during the summer months when extreme temperatures occur.

While many key characteristics of heritage and ageing buildings can increase their vulnerability to climate change impacts, there are some examples where these features can be advantageous in terms of climate adaptation.

Figure 11 below illustrates the climate hazards that could be considered risks and opportunities due to the characteristics of ageing buildings.

¹¹ [CS -NOW WPG11 Mapping Climate Related Hazards to Buildings](#) based on reference T156 'Predicting the changing insect threat in the UK heritage environment' by Peter Brimblecombe.



Figure 11: Potential risks and opportunities associated with heritage and pre-modern buildings.

3.2.7 Addressing risks specifically for heritage buildings

Without specific information on NR's experience with heritage and pre-modern building asset responses to physical climate risks, we will consider the general response of ages of buildings and assets to those risks, using our experience in other sectors and from literature.

The International Standards Organisation (ISO) document ISO 14090:2019 Adaptation to Climate Change – Principles, Requirements and Guidelines¹² outlines the approach to integrating climate change adaptation into organisational planning. Within this standard, climate change adaptation actions can be categorised into hard and soft measures, both of which can be used in an integrated way. Examples of soft measures are linked to building adaptive capacity and include behavioural change, developing new knowledge, embedding climate change into the organisation's policies and operational procedures, training, insurance, early warning systems, building standards, awareness raising, public health management reform and land-use planning. Hard measures can be grey or green measures. Grey measures usually involve structural approaches, such as infrastructure and/or buildings, e.g. dykes and sea walls for adapting to sea level rise, cooling buildings and urban areas using passive architectural solutions. Green measures involve ecosystem-based adaptation, e.g. flood protection zones, vegetation and water features for cooling urban areas, natural soil surfaces for rainwater management and agroecology.

The following paragraphs bring together information from Several references specifically addressing climate change adaptation for historic environments:

- [Historic Environment Scotland: Climate Change Adaptation for traditional buildings](#)
- [Overheating in Historic Buildings | Historic England](#)
- [Historic and Traditional Buildings at Risk of Flooding | Historic England](#)
- [The Building Conservation Directory 2021 - Awnings and Canopies](#)
- [National Trust: Climate Change Adaptation Guidance – Buildings: Historic Building Fabric](#)
- [Association of University Directors of Estates: Climate Change Adaptation and Resilience: Catalogue of Adaptation Measures](#) (not specific to heritage buildings)

Overheating

As presented in **Figure 12**, overheating measures can generally be split into two groups: those that limit solar and heat gains and the ones that remove excess heat.

¹² ISO 14090:2019 Adaptation to Climate Change – Principles, Requirements and Guidelines, ISO, 2019, Available at: [ISO 14090:2019 - Adaptation to climate change](#)

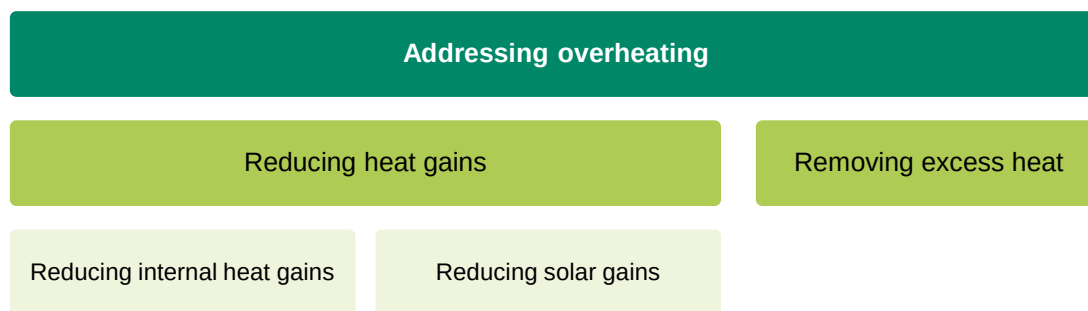


Figure 12: Addressing overheating through reducing heat gains and removing excess heat.

Reducing heat gains:

Reducing internal heat gains:

- Replace traditional lighting (fluorescent/halogen) with efficient Light Emitting Diode (LED) bulbs..
- Install high-efficiency equipment for servers, computers and televisions to reduce the amount of generated heat.
- Adjust occupancy times to reduce exposure to extreme heat during peak hours.

Reducing solar gains:

- Block path of direct sunshine by use of external or internal window blinds, awnings, canopies and shutters. Installation of awnings, canopies or shutters on historic buildings may be subject to listed building consent.
- Use green screens, walls and roofs, which can contribute to reducing the urban heat island by absorbing heat, providing shade and reducing temperatures indoors and outdoors.
- Use cool surfaces made of reflective and light-coloured materials in order to reduce heat absorption by reflecting solar radiation.
- Treat windows with solar control film to limit infrared radiation, while allowing visible light to pass through. In the case of listed buildings, this will require listed building consent.
- Accommodate increased movement of roofing materials through changes to detailing and provision of additional fastenings of ridges and slates.

Removing excess heat:

- Provide natural ventilation by allowing external fresh air to filter through open windows and doors.
- Provide natural stack ventilation, such as buoyancy-driven stack ventilation. This is achieved when cool air enters at low level, gets heated by the occupants, equipment and heating systems and then rises to the top of the building.
- Introduce mechanical ventilation to channel air around a building, for example electrical fans. However, this may require additional space for routing of new ductwork and installation of air handling equipment. There may also be technical implications on the load-bearing capacity of existing structures and modifications may be physically invasive to existing historic buildings' fabric and could cause permanent damage.
- Insulating walls and roofs maintains cooler indoor temps in warm months and keep cool during hotter months; it thus reduces energy consumption and increases thermal comfort.

Finally, cool spaces or zones can be made accessible for staff during peak hours of extreme heat to provide thermal relief.

Extreme wind

For NR, wind proofing is critical for protecting buildings and other structures, especially in exposed older facilities. Regular inspections and maintenance are key to this process, to ensure an adequate understanding of the asset's condition. The National Trust's Climate Change Adaptation Guidance for historic building fabric suggests

regular maintenance remains the most cost-effective approach to sustaining the life of a building. Therefore, enhancing repair and maintenance regimes will mean that buildings remain in good condition across their lifespan. If damage to roofs and windows is caused by wind-driven rain, increasing checks and monitoring of building elements after storms of high winds is advisable. This includes looking for any loose tiles, damage to rainwater goods and signs of water ingress internally caused by either storm damage or wind-driven rain. In cases where damage to building fabric is caused by falling trees, regularly monitoring nearby trees is a measure that can prevent or reduce the frequency of those incidents. This monitoring can entail checking for signs of pests, disease or weakness, and carefully removing or replanting trees that are compromised.

Wind-driven rain

Wind-driven rain can cause damage, especially in exposed limestone walls in heritage buildings. Although not appropriate for all buildings, installing a rendering system that is both waterproof and breathable can mitigate the impacts related to driving rain within older buildings. The technology of a traditional rendering system that fulfils both criteria originates from heritage buildings: materials like pozzolans would be added to the lime, forming water resistant compounds, known as hydraulic mortars.

Wind-driven rain can deteriorate the condition of existing building elements. The National Trust's Climate Change Adaptation Guidance refers to masonry repointing as well as improving weather detailing in architectural elements. Where lead buckling in windows or on roofs occurs, an adaptation measure would be to repair the lead, or to replace this with a higher-coded lead. Also, changes to detailing and additional fastenings of ridges and slates could accommodate increased movement experienced on roofs.

Flooding and Rainfall

Increasing Flood Resilience

There are several adaptation measures that can help prevent flooding by being implemented in external areas, such as increasing permeable surfaces, utilising SuDS, and increasing the capacity of exiting drainage systems. It is important to direct excess water away from building fabric as much as possible, including the building's ground and basement levels.

Managing Increased Rainfall

At a building-level, having appropriate, well-maintained rainwater systems in place is often critical to reducing the risks due to increased rainfall. Regular inspections, routine maintenance, and scheduled repairs are essential for good performance. Where rainwater systems are not effective, the first measure would be to improve the maintenance regime and review the frequency of repairs. If this is not enough, upgrades or alterations may be necessary. Adding to or widening existing external downpipes or increasing gutter capacity are appropriate measures when current systems do not cope with the volume of rainwater.

Snow / Ice

Although it is expected that the frequency and severity of snow/ice related impacts will decrease due to climate change, it is still important, particularly in the short-term, to consider these risks in planning. The impacts of increased snow loading should be considered when undertaking structural assessments, as local climates have the potential to receive increased snowfall despite a national trend of warmer winters within the UK.

Subsidence

Ground movement adaptation measures need to protect buildings, infrastructure, and buried services while ensuring operational continuity. Climate-related hazards like drought and heavy rainfall can increase soil moisture variability, especially in clay-rich areas, leading to increased risks of ground movement. The priority is to

stabilise soil conditions and monitor vulnerable areas.

Ground movement sensors can be used to detect and measure changes on the earth's surface. These sensors can help identify potential subsidence or soil instability before they cause any damage.

Moving trees that are too close to buildings can be an adaptation measure to reduce the risks of subsidence. Tree roots can draw moisture from surrounding soil, thus increasing the risk of ground movement and subsidence, especially during dry periods.

3.2.8 Other considerations

3.2.9 Unintended consequences

When implementing adaptation measures in heritage buildings, it is important to engage with specialists and consider potential unintended consequences, often related to poor ventilation, mould growth and consequently material degradation and poor air quality levels.

The guidance from HES on Climate Change Adaptation for traditional buildings highlights the risk of trapping moisture within the building structure. This is because modern waterproofing techniques involving tanking with bituminous material, aim to address the ingress of water by sealing the inside surface of the wall. This can be effective in achieving a dry interior but can be trapping the moisture in the structure. Such methods do not address the source of the water ingress or prevent saturation of the masonry. Deterioration of masonry may continue and excess moisture may simply be relocated to another part of the structure.

Given these issues, the types of materials used for retrofitting need careful consideration. Breathable construction is one of the characteristics in heritage buildings, achieved by using natural materials such as stone, lime and timber. The ability of traditional buildings to allow water vapour transfer through the building envelope helps ensure the structure remains dry and the internal environment is healthy for both the fabric and occupants. However, when older buildings are subjected to high moisture loads, through persistent, heavy or driving rain, saturation of the masonry can occur, whilst poor ventilation increases the risk of condensation, mould growth and timber decay.

BS 5250: 2021 Management of moisture in buildings encourages a whole-building moisture approach and highlights the need for hygrothermal analysis, to determine the suitability and location of air barriers and vapour control layers.

Finally, retrofitted adaptation measures can inadvertently reduce the passive ventilation, which can result in poor indoor air quality. Increased air tightness is linked to elevated levels of CO₂ and other pollutants, and this can have a detrimental effect on the occupants' health.

3.2.10 Consents and permissions

Listed buildings, those within a conservation area and scheduled monuments may require additional consents for alterations, including changes to the roof, windows or masonry, the addition or removal of external coatings and the addition of rainwater goods or porches. It is advisable to speak to the local authority or the relevant body at an early stage to discuss where consents may be required and to come to agreement about what would be most suitable where adaptations are being considered. This involves Historic England, Historic Wales and Historic Environment Scotland, depending on the building's location.

3.3 Alignment with risk-based and performance-based strengthening principles

This chapter identifies NR's current adaptation measures and good practices approaches to strengthening aging and Victorian Buildings asset groups and explores to what extent these help to reduce vulnerabilities using proportionate, performance-based interventions. This includes identifying whether climate-related hazards are included implicitly or explicitly within the regional WRCCA Plans and Delivery Plans, as well as the type of climate-related impact assessment that has been undertaken.

Key considerations include whether the WRCCA Plans and the Delivery Plans:

1. Set clear **design or resilience objectives**, for example, buildings remain unaffected by a 1-in-100-year flood event projected for 2050 under a moderate climate change scenario.
2. Factor in **building asset downtime**, including both direct and indirect effects on the serviceability of interconnected assets.
3. Account for **cascading failures** by mapping logical and complete linkages both upstream and downstream—for example, assessing how an upstream failure like a lightning strike at an electricity supplier could render station systems unusable and trigger downstream disruptions to train schedules and economic activity.

4. Evidence **risk prioritization approaches**, ideally supported by bottom-up data on local asset vulnerabilities, capacities, behaviours, and incident histories, and may follow formal standards such as ISO 14090 or 14091 or alternative methodologies.
5. Define **performance thresholds for strengthening** building assets, whether through code compliance statements like adherence to BS12056-3 for stormwater management or performance-based targets such as limiting climate-related disruptions to passenger services to under four hours per month.

3.3.1 Defining strengthening to existing assets and climate-related hazards

The Institution of Structural Engineers' (IStructE) paper 'Strengthening of existing buildings: an introduction' refers to strengthening as a key component of the endeavour to reduce our impact on the environment and prepare for the effects of climate change. It describes it as an element which enables changes of use, achieves compliance with modern building codes, resists a previously unforeseen environmental load or increases resilience. Whilst in IStructE's paper, the word 'strengthening' refers purely to structural building elements, in this section of the report, the term 'strengthening' is used to refer to all measures and approaches used to enable existing buildings to adapt to climate change related hazards and to improve their resilience to climate change.

Figure 13 presents the risk-based approach to performance-based design taken from the IStructE's paper 'Strengthening of existing buildings: an introduction'. Adapting the diagram in **Figure 13** to other building elements and climate change hazards, it could apply to increased summer temperatures and the building services' design to meeting performance objectives. In this context building vulnerability and performance objectives can be in the form of criteria such as the maximum number of hours when indoor temperatures exceed certain thresholds. In this case, the design criteria are established based on the achievement of the desired outcome, which is the maintenance of thermal comfort for a determined number of hours daily and annually.

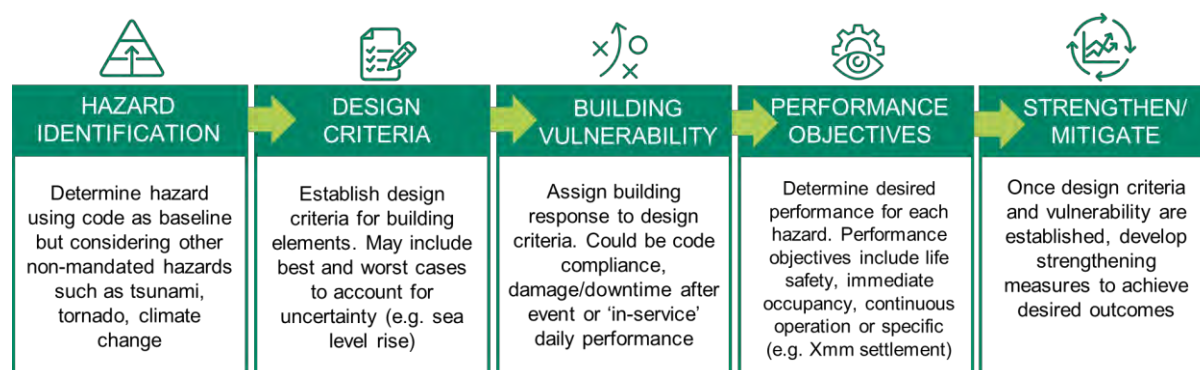


Figure 13: Risk-based approach to performance-based design (adapted image, based on 'Strengthening of existing buildings: an introduction', IStructE, 2021).

3.3.2 Network Rail's approach to strengthening

Across the regions, NR follows the ORR Schedule Eight (S8) performance regime to monitor the impact of weather on railway performance by the financial cost of delays associated with 9 categories of climate hazards¹³, which include:

- **Adhesion:** Traction loss due to line contamination e.g. fallen leaves, moistures, oils
- **Cold:** Low temperature impacts e.g. ice on the conductor rails, frozen points, rail break
- **Flooding:** Flowing or standing water e.g. river flooding, surface water flows, overwhelmed drainage
- **Fog:** Reduced visibility e.g. obscured signals
- **Heat:** High temperature impacts e.g. rail buckles, temporary speed restrictions, sagging overhead lines

¹³ [Network Rail Fourth Adaptation Report – December 2024](#)

- **Lightning:** Direct or indirect strike e.g. track circuit/signalling failure, building damage, power loss
- **Snow:** Snowfall impacts e.g. blocked lines, points failure
- **Subsidence:** Geotech failures e.g. landslips, desiccation, rockfalls
- **Wind:** Damage due to high wind e.g. trees or debris on the line or overhead line

Each WRCCA regional plan displays the S8 costs for the current year compared to previous years and by each of the weather categories listed above. These costs enable each of the regions to monitor the severity of the various hazards, how they impact assets and how these can be strengthened using targeted adaptation measures.

The tables below, **Table 12** to **Table 16**, demonstrate how the regional WRCCAs Plans and Delivery Plans relate to each of the risk-based and performance-based strengthening principles outlined above. Each of these principles are ranked using the 'Methodological Alignment' level of maturity defined in **Table 11**, which assesses the extent to which there is good alignment with best practice, such as the approaches that are taken are mainstreamed, and ISO standards for climate risk are being applied and are factored into regional processes.

Table 11: Alignment scoring descriptors

Level of maturity		Immature / Uninformed	Early starter / Basic	Progressive / Improving	Semi-mature / Well Engaged	Mature / Fully Optimized
Theme	Sub - Category	0	1	2	3	4
Methodological alignment	Best practice alignment	Poor alignment or never aligned to best practice regarding the assessment and management of climate risk	Little alignment or aligned in only a few occasions with best practice for managing climate risk	The document is sufficiently aligned with best practice, though could be improved in relation to the whole railway and buildings	The document is usually aligned with good practice in assessing and managing climate risk, though lacks some details with reference to buildings	The document is always aligned with best practice when considering the assessment and management of climate risk generally and to buildings
	Standards applied	No standards or codes regarding climate resilience are mentioned	There is a brief mention of ISO standards for climate risk, however compliance is unclear.	ISO standards for climate risk are described, however there is limited to no mention of buildings	Relevant ISO standards are described, with some applicability to buildings	Relevant ISO standards are described for climate resilience, with specific reference to codes and standards related to buildings.

The overall methodological alignment score is determined by averaging the scores assigned for 'best practice alignment' and 'standards applied' (**Table 11**), and rounding to the highest whole number. For example, the Eastern Region (**Table 12**) received a rating of "Progressive / Improving" (2) for best practice alignment and "Semi-mature / Well Engaged" (3) for standards applied, resulting in an overall methodological alignment score of "Semi-mature / Well Engaged" (3).

3.3.2.1 Eastern Region

Table 12: Eastern Region alignment with risk-based and performance-based strengthening principles for buildings

Key considerations	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029) and Eastern Delivery Plan - Year 2 Update				
	Methodological alignment score:				Semi-mature / Well Engaged
					3

Design or resilience objectives	The WRCCA Plan recognises that extreme weather will increase in intensity, specifically higher temperatures, flooding, high winds and snow loading will impact buildings. Although it states new buildings will need to be designed to become resilient to these hazards, for example enabling canopies are constructed to be more resilient to wind and snow loading, specific design or resilience objectives are not clearly defined nor seen to be explicitly pursued for future design stages. Similarly, the WRCCA Plan refers to an example following this regional review where key changes to key standards have potential to remove conservatism to improve resilience as part of a detailed summer preparation regime. Although the Plan does not articulate which standards this refers to or the key outcomes associated with these changes, this does highlight an awareness that design standards can aid in adapting buildings to become more resilient to future extreme weather. The WRCCA Plan recognises assets which require full renewal works will become more resilient to extreme weather due to regional or national changes to design standards, albeit led by improved performance criteria. However, this is part of a wider trade-off associated with higher costs of full renewal works compared to regular maintenance and repair. The Delivery Plan provides key focus areas which align to the CP7 objectives and strategic themes. One of the focus areas is the delivery of risk-based renewals to improve asset resilience to adverse weather. For buildings, the Delivery Plan states its priorities relate to refurbishment works across key Maintenance Delivery Unit sites and addressing assets at risk of failure, particularly stations with high-risk platforms to mitigate slips, trips and falls. The Delivery Plan does not state design or resilience objectives in a general or specific sense to buildings.
Building asset downtime and cascading failures	The WRCCA Plan recognises building asset downtime associated with climate hazards such as higher temperatures impacting the expansion of flat roofs, which can lead to further deterioration and damage, as well as snow and ice causing platform and walkway surfaces to become slippery, affecting operations. Stations and lineside buildings are also noted to be impacted by future heavy periods of rain, which can damage drainage systems or the inner building itself. The WRCCA Plan notes that due to limited information, the impacts to buildings can only be applied at a scheme-by-scheme level, rather than for individual buildings. The Delivery Plan does not state asset downtime in a general or specific sense to buildings.
Risk prioritization approaches	The WRCCA Plan outlines formal risk management approaches, including modified CRAM methodology, Adaptation Pathways Planning, and Enterprise Risk Register, to prioritize and mitigate climate change risks for building and system assets. The WRCCA Plan outlines how these approaches will be supported by information of local asset vulnerabilities as carried out as part of the CP6 actions in Appendix F. The Delivery Plan specifies that refurbishment and targeted life extensions will be prioritised over full renewals. However, the Plan does not specify how these approaches will be supported by bottom-up data such as local asset vulnerabilities, capacities, behaviours and incident reporting.
Performance thresholds	The WRCCA Plan includes code compliance statements to help measure performance thresholds for strengthening building assets. It illustrates performance-based statements as part of the expected benefits to planned actions for CP6 against vulnerabilities. However, these statements do not translate to building assets and predominantly concentrate on drainage renewal schemes and jetting. The WRCCA Plan also uses adaptation pathways and trigger points to identify when decisions need to be made to address climate impacts. These pathways are designed to evaluate thresholds beyond which assets or services may become inefficient, unsafe, or redundant. While this approach is strategic, it does not directly cite specific performance standards or codes. The Delivery Plan does not state performance thresholds specific to buildings.

3.3.2.2 North West & Central Region

Table 13: North West & Central Region alignment with risk-based and performance-based strengthening principles for buildings

Key considerations	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029) and North West & Central Delivery Plan - Year 2 Update	
	Methodological alignment score:	Progressive / Improving
		2
Design or resilience objectives	The WRCCA Plan highlights compliance to the ESR standard, which is the principal standard to enable climate resilience is built into infrastructure assets across the region. Specifically for refurbishments and renewal works, it is noted that at a national scale, standards are being updated to reflect the changing and extreme future climate. The region has a large scale of intended refurbishment works, which includes 14,138 m² of station roof and 6,825m² of lineside buildings, as well as renewal of 1 entire station roof. In terms of resilience objectives, Appendix A defines 8 separate CP7 regional and specific activities related to Buildings and Civils. Each of these align to ORR's 11 levers to improve weather resilience. Seven out of eight of the activities are assigned the Funding and Risk lever, which ensures target sites and assets can pre-emptively prevent failures by accessing risk funding to allow delivery teams to mobilise quickly. For example, these activities relate to refurbishment and renewal works for roofs and canopies to increase resilience against wind and rain. Despite funding being a key factor to improve resilience of buildings across the region, other levers ORR has identified to improve climate resilience such as Design Redundancy, Design Reliability and Design Resistance could provide greater embedded measures by increasing capacity of systems (i.e. larger diameter pipes), improving capability to a range of different conditions (e.g. extreme heat or cold), and building long-term resilience within the asset portfolio by either adapting current design standards or regional policies. In comparison, the Delivery Plan does not state design or resilience objectives in a general or specific sense to buildings.	
Building asset downtime and cascading failures	The WRCCA Plan recognises building asset downtime associated with climate hazards such as an inundation of rainwater and run-off causing potential impact to electrical equipment in buildings, affecting operations. The Delivery Plan does not consider asset downtime in a general or specific sense to buildings.	
Risk prioritization approaches	The WRCCA Plan identifies several formal risk management approaches for climate change risks, emphasizing adherence to established standards and the use of structured methodologies like adaptation pathways. These strategies include conducting climate risk assessments and prioritizing investments based on risk scores, as well as enhancing asset resilience through targeted renewals and adherence to updated standards. The Delivery Plan provides a high-level overview of the key priorities by asset type, including buildings, and the planned volumes for each of these. This table only highlights priorities related to passenger and public accessibility work on escalators and footbridges, as well as safety improvements to concourse roofs and fire suppression systems. The Plan does not detail whether these priorities are related to any of the hazards identified in the corresponding WRCCA Plan, or whether these priorities are only based on access and safety issues in general.	
Performance thresholds	Although the WRCCA Plan does not identify specific codes or standards for compliance for heat and flood resilience, it refers to chief engineers nationally updating design criteria to ensure resilient building renewals, which the region would benefit from. The Delivery Plan does not specify the codes or standards for compliance for specific climate risks.	

3.3.2.3 Scotland's Railway

Table 14: Scotland's Railway alignment with risk-based and performance-based strengthening principles for buildings

Key considerations	Scotland Railway: CP7 Regional WRCCA Plan (period 2024-2029) and Scotland Delivery Plan - Year 2 Update	
	Methodological alignment score:	Semi-mature / Well Engaged
		3
Design or resilience objectives	The WRCCA Plan lists three different weather and climate resilience classifications, including Preparedness, Response and Recovery (short-term), Proactive Intervention (short to medium term) and Transformational Adaptation (long-term). Each of these outline the different approaches that the region undertakes for the various interventions they operate. Table 5 provides a summary of the region's approach to resilience for buildings, focusing on Critical Lineside Buildings' refurbishment to improve resilience to heavy and prolonged rainfall and extreme temperatures. Although the WRCCA Plan clarifies that the refurbishment works will improve thermal insulation, protect internal equipment from water ingress, wind damage and large temperature fluctuations, the WRCCA Plan does not provide specific design or resilience objectives to ensure these measures will be embedded into the design. The Delivery Plan clearly states that it will continue to deliver a programme of climate resilient asset interventions. Although, it does not define specific design or resilience objectives that will be followed to achieve this in the long-term.	
Building asset downtime and cascading failures	The WRCCA Plan recognises building asset downtime associated with climate hazards such as extreme and/or prolonged rainfall could result in water ingress to buildings, resulting in damage to buildings and associated contents, and failure of building services (e.g. electrical and mechanical systems). Other hazards are also described as contributing to asset downtime, including vegetation growth and leaf fall blocking rainwater and contributing to water ingress, damaging building fabric and disrupting associated services. Prolonged periods of wet and dry conditions are also noted to cause ground movements, which can also damage the building itself and associated contents and services. By comparison, the Delivery Plan does not state asset downtime in a general or specific sense to buildings.	
Risk prioritization approaches	The WRCCA Plan lists out indicators that will be used to track and monitor the impact of the Climate Ready Plan (Table 12). This includes Outcome Two: Action Plan, which will include the development and analysis of Adaptation Pathways to screen and prioritise a refined list of major climate risks and specific locations. The status of the Plan does not show this list of priorities. However, it provides a clear plan of how this will be carried out during the Control Period. The Delivery Plan highlights a shift toward a risk-based investment prioritization approach. Specifically, it mentions prioritizing asset renewals and refurbishment investments to ensure safety and performance. This includes protecting renewals investment in critical infrastructure such as structures, earthworks, and drainage assets and implementing a "whole systems" approach for earthworks and drainage assets to maintain safety and performance.	
Performance thresholds	The WRCCA Plan does not explicitly list specific codes or standards for climate risks The Delivery Plan does not specify the codes or standards for compliance for specific climate risks.	

3.3.2.4 Southern Region

Table 15: Southern Region alignment with risk-based and performance-based strengthening principles for buildings

Key considerations	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029) and Southern Delivery Plan - Year 2 Update		
	Methodological alignment score:		Progressive / Improving
			2
Design or resilience objectives	The WRCCA Plan defines four different strategic approaches to risk management for buildings, which includes considering maintenance, refurbishment and renewals on an individual basis, reviewing and enhancing maintenance of heating and cooling systems to support employee and passenger welfare, considering equipment housing to support resilient placement, installation of heating/cooling methods and/or reflective coatings, and the recognition of the impact of weather on degradation levels of building fabric, particularly in respect of wind damage and flooding. Although the WRCCA Plan has a detailed CP7 Workbank & Action Plan (Appendix B) of various asset led activities which are deemed to provide primary resilience across the region, there is currently not an asset related activity related directly to buildings. This gap highlights that buildings are currently not prioritised over other asset groups, and similarly there is a lack of clearly defined design or resilience objectives. The Delivery Plan does not state design or resilience objectives in a general or specific sense to buildings.		
Building asset downtime and cascading failures	The WRCCA Plan does briefly mentions the impact weather has on the degradation levels of building fabric, particularly in reference to wind damage and flooding. The Delivery Plan does not state asset downtime in a general or specific sense to buildings.		
Risk prioritization approaches	Table 8 of the WRCCA Plan highlights the CP7 Risk Strategy, detailing the strategic approach to risk management for buildings. For example, this approach includes addressing risks on an individual basis as part of the maintenance, refurbishment and renewals works as well as the recognising the impact wind and flooding damage has on degradation levels of building fabric. The Delivery Plan specifies that the key initiatives for CP7 includes adopting a risk-based approach to design but does not explicitly relate this to weather-related risks to buildings.		
Performance thresholds	The WRCCA identifies the specific threshold of 1 in 25-year flood events with a 20% climate change uplift as a benchmark for compliance in relation to risks posed by precipitation and flooding and the impact on drainage and track formation integrity. Although, this threshold is not specific to buildings, this may have a positive indirect impact. The Delivery Plan does not specify the codes or standards for compliance for specific climate risks.		

3.3.2.5 Wales & Western Region

Table 16: Wales & Western Region alignment with risk-based and performance-based strengthening principles

Key considerations	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029) and Wales & Western Delivery Plan - Year 2 Update		
	Methodological alignment score:		Semi-mature / Well Engaged
			3

Design or resilience objectives	The WRCCA Plan lists 10 risks associated with station buildings and 1 risk associated with platforms within the region as part of the wider NR Integrated Climate Risk Assessment for CP7 WRCCA Plans, as shown in Appendix A. Although this is a comprehensive register of current risks to buildings within the region for station buildings and platform, this register does not clearly define design or resilience objectives to manage these risks. Likewise, the Wales and Western Resilience Workbank (Appendix B) does not distinguish buildings as a separate asset or sub-asset class to define specific action targets, design or resilience objectives. The Delivery Plan does not state design or resilience objectives in a general or specific sense to buildings.
Building asset downtime and cascading failures	The wider NR Integrated Climate Risk Assessment for CP7 WRCCA Plans, as shown in Appendix A, highlights asset downtime associated with the risks related to buildings, including disruption of access to services and operations, risk of safety to passengers and staff through slips, trips and falls and deterioration of materials. The Delivery Plan does not state asset downtime in a general or specific sense to buildings. The WRCCA Plan notes that due to limited information, the impacts to buildings can only be applied at a scheme-by-scheme level, rather than for individual buildings. The Delivery Plan does not state asset downtime in a general or specific sense to buildings.
Risk prioritization approaches	The WRCCA outlines that reducing the impact of extreme weather and climate change is a CP7 priority, and that specific working groups such as the Strategic Weather Group and the Seasonal Delivery Group will enable delivery of these mitigation measures. There is also a comprehensive risk assessment (Appendix A) which prioritises risks related to building assets in line with the Adaptation Pathways framework to enable investment and focused decision-making. The risks identified in the WRCCA are part of the overall strategy embedded in the Delivery Plan, which lists various principal risk categories for CP7, including weather-related incidents causing high levels of service disruption, cost and reputational impact. The subsequent identified mitigation for this is to investment in adaptation measures which is underpinned by a robust incident response.
Performance thresholds	The WRCCA provides extensive references to specific standards and legislative requirements but not limited to: • Machinery Directive 2006/42/EC – Lightning and fire clauses • BS EN 280:2013+A1:2015 – Wind speed for mobile elevated working platforms, design calculations, stability criteria • BS EN 15746-2:2010+A1:2011 – Lightning – Railway applications – Track – Road rail machines and their associated equipment – Part 2: General Safety Requirements • BS EN 15954-2:2013 – Lightning – Railway applications – Track – Trailers and associated equipment. General safety requirements • BS EN 15955-2:2013 – Lightning – Railway applications - Track • RIS-1530-PLT – Fire prevention – Rail Industry Standard for Technical Requirements for On-Track Plant and their associated Equipment and Trolleys • BS EN 14033-2:2017 – Lightning – Railway application – Track – Railbound construction and maintenance machine Part 2 Although the standards above show that design elements are meeting requirements to ensure resilience to hazards such as fire safety, wind speed and lightning are being built in, these are not focused on building assets, but rather track elements, equipment and machines. No explicit codes or standards are mentioned in the Delivery Plan, but there is a focus on risk-based renewals and weather resilience to maintain performance.

4. Initial Gap and Benchmarking Summary Matrix

4.1 Good practice approaches to strengthening

As described in [Paragraph 3.3.1](#) this report considers 'strengthening' to be all measures and approaches used to enable existing buildings to adapt to climate change related hazards and to improve their resilience to climate change

The following paragraphs refer to good practice approaches to strengthening, organised at two different levels: framework level and building-level. This section ends with some good practice examples from the transport and rail sector and other organisations, where it might be appropriate to use similar approaches.

4.2 Adaptation frameworks

In the UK there is no single holistic legislative requirement covering climate change risk assessment and adaptation measures across all climate change hazards and associated impacts in the built environment.

Several different organisations have developed frameworks either specific to their organisation, or addressing a specific industry, aiming to provide a direction for addressing adaptation to climate change. [Section 4.2](#) brings together some examples of frameworks used in various sectors in the UK.

The Climate Risk Assessment Guidance for the Transport Sector¹⁴ provides a good framework for climate risk assessments in the transport sector, but it does not focus on the next steps related to adaptation measures. The Local Partnerships' Climate Adaptation Toolkit and Risk and Opportunities Matrix¹⁵ is one of the documents it recommends. The Climate Adaptation Toolkit is a five-step process designed to help Local Authorities prepare for the impacts of current and future climate on the local area, the residents, and their provided services.

There are however frameworks established specifically for the building sector, which include relevant steps including the implementation and monitoring of adaptation measures.

The UK Green Building Council's (UKGBC) [Framework for Measuring and Reporting of Climate-related Physical Risks to Built Assets](#) provides a good framework for measuring and reporting climate related physical risks. Although it does not focus on physical adaptation measures, it describes the mechanisms that can enable measurement of physical risks, as part of an ongoing risk management plan and processes. [Figure 14](#) presents a flowchart from the UKGBC document, which shows a stepwise approach to supporting decision making and action prioritisation, based on the level of risk, vulnerabilities and the tolerance to different risks.

¹⁴ Climate Risk Assessment Guidance for the Transport Sector [Climate risk assessment guidance](#)

¹⁵ Local Partnerships' Climate Adaptation Toolkit and Risk and Opportunities Matrix [Climate adaptation toolkit and risk generator](#)

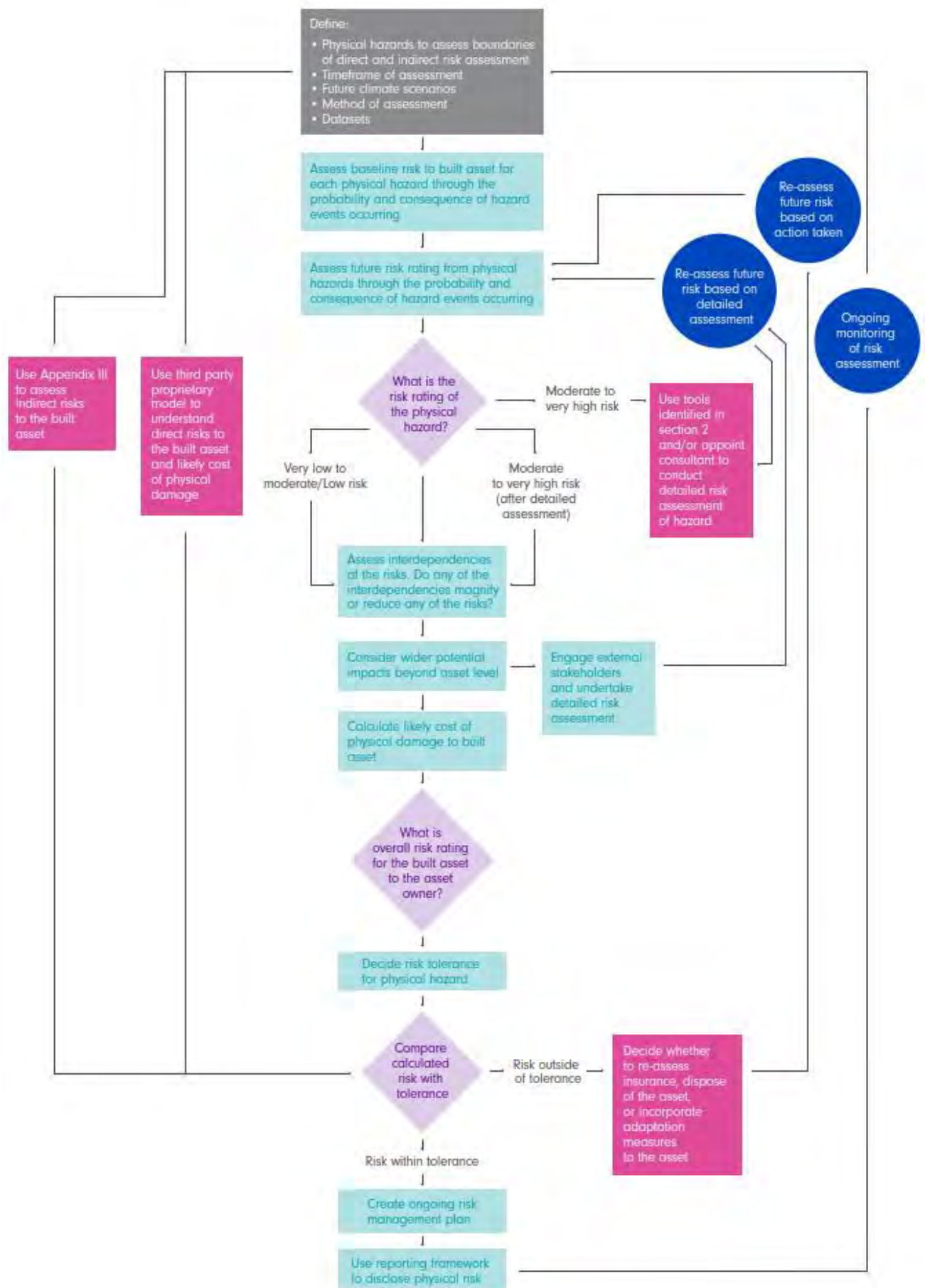


Figure 14: Monitoring and reporting flowchart (UKGBC, A Framework for Measuring and Reporting of Climate-related Physical Risks to Built Assets, 2022).

The EU-level technical guidance on adapting buildings to climate change (Ramboll, 2023) provides best practice technical guidance on climate-adaptation measures at the building scale. The document presents adaptation solutions that reduce the most important identified climate risks that affect the built environment, as categorised

The EU Taxonomy establishes the criteria for determining whether an economic activity qualifies as environmentally sustainable for the purposes of establishing the degree to which an investment is environmentally sustainable. The EU Taxonomy defines clear requirements for the construction and real estate sectors according to well-defined technical assessment criteria and includes six objectives, with one of them focusing on climate change adaptation.

in the EU Taxonomy. In the absence of UK-specific guidance on climate-adaptation measures at the building level, the EU-level technical guidance is a useful default point of reference. The document orientates stakeholders across the building industry to the actions they can take to improve building performance, including strategies for owners, operators, users and policy makers.

The guidance suggests an adaptation hierarchy, as shown in **Figure 15** which starts with neighbourhood level, where applicable, and continues with preserving and protecting the built heritage. The last two levels of the hierarchy involve passive systems which enable an adaptive management of risks and finally the implementation of solutions that require active operation and maintenance.

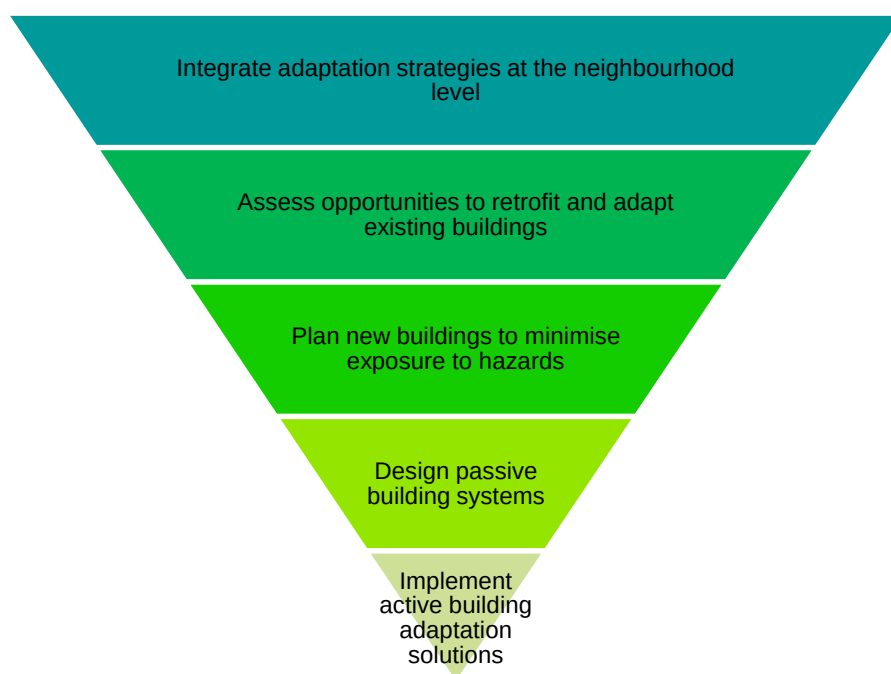


Figure 15: Adaptation hierarchy for buildings (adapted from the EU-level technical guidance on adapting buildings to climate change, Ramboll, 2023).

The Association of University Directors of Estates Climate Change Adaptation and Resilience Guide¹⁶ refers to an integrated approach to climate adaptation where climate change considerations are integrated into current plans, procedures and processes. It suggests that, rather than thinking of adaptation as an additional, stand-alone consideration, it should form an integral part of resilience within all relevant plans – a concept known as ‘mainstreaming’. The integrated approach to climate adaptation emphasises aligning adaptation measures with existing plans and activities, facilitating their incorporation into ongoing projects rather than them being treated as separate costs. Strong governance, partnerships, and recognising climate change as a corporate risk are all critical to successfully integrating adaptation into strategies and plans. Other considerations that need to feed into integrating the climate change into processes and procedures are presented in **Figure 16**.

¹⁶ The AUDE [Climate Change Adaptation and Resilience Guide](#)

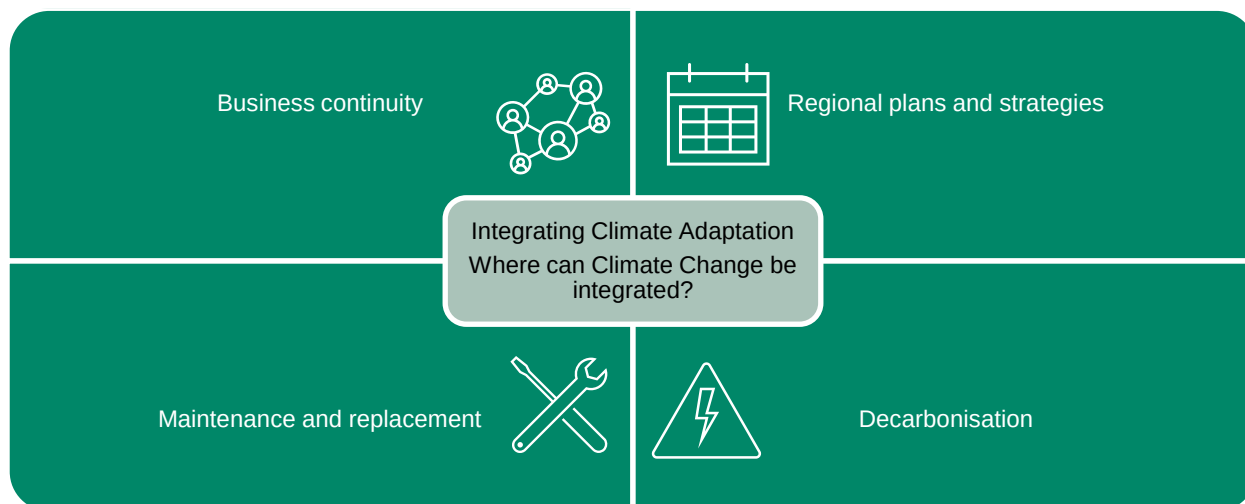


Figure 16: Integrating the climate change into processes and procedures (adapted from the AUDE Climate Change Adaptation and Resilience Guide).

The Better Buildings Partnership 'Guide to Climate Resilience Strategies for Commercial Real Estate' brings in additional considerations, which could be equally relevant for NR, such as the collaboration between business units and with external stakeholders and the integration of adaptation measures into the investment lifecycle. In addition to the integration of practical measures and processes that can be applied at a building level, the following considerations are recommended:

- Which physical and transitional climate impacts might impact our assets and supply chain?
- What is the value-at-stake or 'Climate Value at Risk' (CVAR) if no action is taken?
- How are climate adaptation measures integrated into the investment lifecycle?
- How might climate adaptation measures support or hinder climate change emissions reduction?
- How is collaboration between business units and with external stakeholders enabling better adaptation to climate change?
- What is the role of nature-based solutions in our climate adaptation strategy?
- How might climate adaptation measures impact on social outcomes?

The UK Cabinet Office's Keeping the Country Running: National hazards and infrastructure¹⁷ focuses on the resilience of critical infrastructure and essential services, and presents its guidance organised under four components of resilience: Resistance, Reliability, Redundancy and Response & Recovery, which are presented in **Figure 17**. This document defines these as:

- **Resistance**, which focuses on strength for protection.
- **Reliability**, ensuring infrastructure operates within its design range.
- **Redundancy**, providing spare capacity to maintain service during disruptions.
- **Response and recovery**, enabling rapid and effective action after events through thorough planning and preparation.

¹⁷ Keeping the Country Running: National hazards and infrastructure [natural-hazards-infrastructure.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/671111/natural-hazards-infrastructure.pdf)

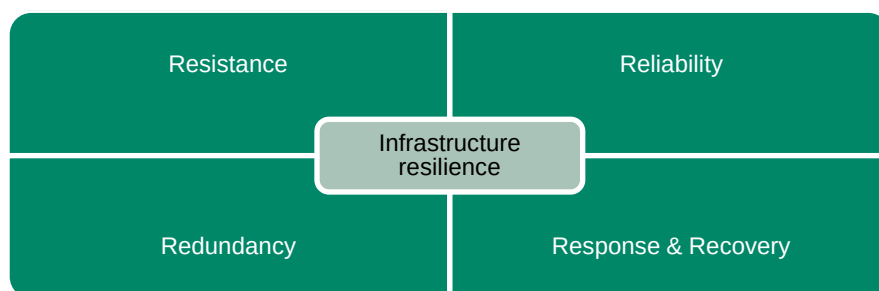


Figure 17: Components of the infrastructure resilience (adapted from the UK Cabinet Office's Keeping the Country Running: National hazards and infrastructure).

Although the frameworks above provide different approaches to adaptation to climate change, they provide several insights and key considerations at an organisational level:

- Ongoing monitoring of risk assessment and consideration of interdependencies are fundamental elements of climate change adaptation frameworks.
- Consider implementing a hierarchy of measures, prioritising passive systems which enable an adaptive management of risks over the implementation of solutions that require active operation and maintenance.
- Integrate climate change considerations into current plans, procedures and processes, and ongoing projects rather than them being treated as separate costs.
- Consider how collaboration between business units and with external stakeholders can improve the implementation of adaptation practices.

4.3 Building-level adaptation

Building sustainability certifications often include adaptation to climate change and resilience within their requirements. The most well-established building-focused certifications have included adaptation in their latest updates.

The BREEAM UK New Construction v7¹⁸ determines an approach to facilitate the adaptation to climate change, including the following:

- Hazard identification.
- Hazard assessment.
- Risk estimation.
- Risk evaluation.
- Risk management.

The BREEAM approach for the relevant 'Waste'¹⁹ credit, Wst 05, starts with design considerations at RIBA Stage 2 or before and ends with the implementation of adaptation measures during RIBA stage 4 and at construction stage. The BREEAM scheme also covers elements that could be attributed to climate change such as overheating, drought, material resilience and flood risk through separate credit requirements as listed in **Table 18**. When all of these are met, the project is awarded one credit for exemplary performance with regards to its response to climate change.

Table 17: Achieving exemplary performance for responding to climate change.

Issue / Credit name	Link to Wst 05 Adapting to climate change issue
Hea 05 Thermal comfort (BREEAM Health and wellbeing category)	Prevent increasing risks of overheating.

¹⁸ BREEAM UK New Construction v7 [BREEAM New Construction V7](#)

¹⁹ Wst 05 Adaptation to climate change is within BREEAM's Waste category, with the aim to minimise the future need of carrying out works to adapt the building to take account of more extreme weather changes resulting from climate change and changing weather patterns.

Ene 01 Energy and carbon performance for regulated energy uses (BREEAM Energy category)	Maximise energy efficiency to tackle likely energy demand and minimise resultant carbon emissions.
Wat 01 Water consumption (BREEAM Water category)	Minimise water demand in periods of drought.
Mat 04 Durability and resilience (BREEAM Materials category)	Avoid increased risks of deterioration and higher maintenance demands.
Pol 03 Flood and surface water management (BREEAM Pollution category)	Minimise the risks of increased flood risk and surface water run-off affecting the site or others.

LEED v5²⁰ for Building Design and Construction was launched in April 2025 and integrates for the first time resilience to climate change within its requirements. For any building assessed under this standard, it is mandatory to undertake a climate resilience assessment which includes the identification of observed, projected, and future natural hazards that could potentially affect the project site and building function.

The requirement is to identify two priority hazards, as a minimum, to address through proposed design strategies. For each priority hazard, the project team must assess and specify the following:

- Hazard level.
- Hazard risk rating.
- Exposure, sensitivity, adaptive capacity, vulnerability, and overall risk levels.
- Potential impact on the project site and building function.
- Potential impact on the project site during construction.

4.4 Structural strengthening

The IStructE article ‘Towards a holistic performance-based design approach’ describes current and best practice use of performance-based design approaches. In particular for existing buildings, wind design is particularly relevant. The performance-based wind design approach enables an efficient and comprehensive response. Contrary to the traditional approach of setting the first significant yield point as the ultimate limit state, the inclusion of ductility in the design is expected to bring substantial benefits in both safety and efficiency.

The article also references a guidance document from the American Society of Civil Engineers (ASCE) ‘Prestandard for performance-based wind design’. Whilst this is an American standard, the approach described could be adopted to provide a performance-based approach to the assessment of existing structures for a variety of performance objectives. This could include impacts on the public, trains, signalling systems, overhead line equipment and other parameters. Therefore, this type of assessment would inform decision making on any required strengthening works.

The three documents summarised below identify good practice approaches in relation to structural assessment and strengthening of historic buildings. Whilst not focussed on strengthening with respect to climate change in particular, they represent industry best practice for structural work on existing buildings, so would form the basis of the approach regardless of the driver.

- IStructE’s Appraisal of Existing Structures²¹
- Steel Construction Institute’s Publication 138 Appraisal of Existing Iron and Steel Structures²²
- CIRIA’s Report 111 Structural Renovation of Traditional Buildings²³

²⁰ LEED v5 Climate Resilience Assessment [usgbc.org/credits/new-construction-core-and-shell/v5/ipp1?return=/credits/New Construction/v5/Integrative Process, Planning, and Assessments](https://usgbc.org/credits/new-construction-core-and-shell/v5/ipp1?return=/credits/New%20Construction/v5/Integrative%20Process,%20Planning,%20and%20Assessments)

²¹ Appraisal of Existing Structures [Appraisal of existing structures \(Third edition\) - The Institution of Structural Engineers](#)

²² Publication 138 Appraisal of existing iron and steel structures, Steel Construction Institute - Publication Index | NBS

²³ Structural Renovation of Traditional Buildings available [here](#).

4.4.1 Examples of good practice

Throughout the document review and stakeholder interviews, the following examples of good practice approaches to strengthening and increasing climate resilience. A more detailed explanation of these case studies can be found in [Appendix F](#).

- Network Rail Adaptation Pathways
- Department for Transport's 'Fit for Changing Climate? Adapting the UK's Transport System'
- Sustainable Rail Blueprint
- Adaptation and Resilience in HS2
- San Diego International Airport Climate Resilience Plan
- Adaptation of Melbourne's Metropolitan Rail Network in response to climate change
- Association of University Directors of Estates Climate Change Adaptation and Resilience Guide

4.5 Good NR Practices Identified in Interviews with Network Rail Central Technical Leads and with Key Stakeholders

Key stakeholders in NR and the Department for Transport were interviewed to gain insights into good practice and innovative approaches related to weather and climate resilience in NR building assets.

The interviews were designed to accomplish three primary objectives, which are mapped below against key findings:

1. Identify specific strategies and tools used to mitigate climate risks. Highlight lessons learned and transferable practices
2. Understand stakeholder engagement and partnerships models
3. Explore the use of technology and analytics in resilience planning

Below is a brief summary of the interview findings and analysis.

4.5.1 Identify specific strategies and tools used to mitigate climate risks. Highlight lessons learned and transferable practices

4.5.1.1 Strategies, policies and change to industry

Interviewees highlighted that industry changes are presenting opportunities to mainstream climate adaptation into assessments and improve collaboration. A few examples include:

- > **Adaptation Pathways:** Network Rail's core strategy for reducing climate risks, though DfT historically had limited oversight in its development.
- > **Collaboration:** Increasing cooperation between Network Rail and Train Operating Companies (TOCs) to manage assets and implement Adaptation Pathways.
- > **Policy Evolution:** DfT aims to mainstream climate adaptation into policies, including requiring TOCs to complete WRCCA strategies by January 2026.

However, this guidance remains high-level and applies to assets in a general sense, without a particular focus on building assets. Also, two core documents were highlighted as key to NR, as seen below.

- > **Climate Adaptation Strategy for Transport:** Focuses on long-term planning, including regional Adaptation Pathways by 2029 and collaboration with ARP4 contributors.
- > **CP7 Buildings and Architecture Policy:** Emphasizes resilience, sustainability, and passenger satisfaction. Resilience is a core theme that weaves throughout the policy and is a key indicator on the Genius of Place Wheel (**Figure 18**) for regions to refer to when scoring actions that need to be taken and associated progress over time. As this approach is part of company policy, this requires regions to consider the resilience of their assets in relation to the Wheel

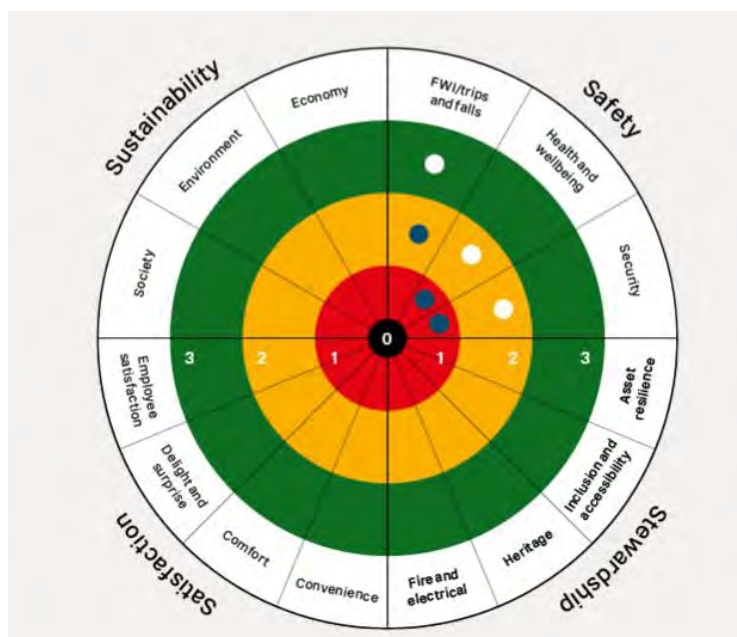


Figure 18: Stewardship elements of the Genius of Place Wheel (NR CP7 Buildings and Architecture Policy)

Uncertainty remains on whether the strategy will specifically address climate hazards affecting building assets. Also, due to lack of funding and resources, NR are unable to provide adequate assurance that the Genius of Place Wheel is being implemented across the regions, particularly whether resilience is being improved across building assets overtime.

4.5.1.2 Assurance procedures

NR has not approached regions separately to understand if they are internally tracking assurance against the Genius of Place Wheel and instead provides assurance following the submission of quarterly regional plans.

- > **Centralized Assurance:** NR relies on quarterly regional plans for assurance, limiting collaboration and long-term climate risk planning.

This can mean assurance for the resilience of buildings may lack forward-thinking when considering the long-term risk of climate change and equally this prevents active collaboration between the central and regional teams. Acute risks are prioritized over chronic hazards, potentially delaying effective adaptation for building assets. Funding focuses on maintaining resilience against immediate risks rather than addressing long-term degradation of building assets.

4.5.1.3 PACE Process

Recent updates to ESR have meant climate risk and adaptation is being considered earlier in the design process.

- > **Climate Impact Assessments:** ESR mandates assessments during project design, with updates requiring WCCIA during PACE 1 for projects in Adaptation Pathway areas.

While standardizing risk assessments, clarity on how building-specific risks are incorporated is lacking. In future, this could be incorporated into the standard to ensure consistency across assessments and regions.

4.5.1.4 Building regulations and contracting models

Across NR, it appears that there is varied understanding of whether the organisation needs to comply or apply to building regulations. Some considerations include:

- > **Statutory Undertaker Role:** NR is exempt from Building Regulations Part L except for certain cases (e.g., offices), leading to confusion and inconsistent application.
- > **Barriers to Compliance:** Cost, apathy, and supply chain interference hinder regulation adherence.
- > **Outcome-Based Standards:** Adapting contracting models to emphasize climate resilience outcomes could address these barriers, but regional accountability limits technical oversight.

This lack of technical oversight of regional procurement processes, as well as a tendency for frameworks to aggregate buildings with larger structures as part of a wider portfolio, prevents the ability to specify climate resilience outcome-based standards and approaches at the asset level.

4.5.1.5 Sustainability certification frameworks

Network Rail provides guidance to regions about how to approach implementing climate resilience to buildings within the Climate Action Design Manual for Buildings and Architecture (NR/GN/CIV/100/04). When developing this guidance, it was decided early on that mandating the implementation of BREEAM Buildings or similar certification frameworks could potentially restrict projects to achieving a specific rating and not consider the environmental impact in a holistic manner.

- > **BREEAM Framework:** Not mandated due to concerns about restrictive ratings and unclear outcomes for certain assets.
- > **Future Scope:** Guidance may be revisited in 2026, with the option to widen the scope provided to regions.

When revisiting the guidance, Network Rail has the potential to expand the scope to improve climate resilience outcome-based measures that align to elements of BREEAM Buildings or similar frameworks.

4.5.1.6 Examples of innovation

There are recent examples where Network Rail has worked collaboratively with technical authorities to retrofit building assets to manage building degradation and subsequently also improve resilience to climate-related risks.

- > **Retrofit Solutions:** The Scotland region implemented a modular wrap system for thermally inefficient lineside buildings, improving resilience to severe weather.

Following the success of this initiative, the Scotland region has actively deployed this retrofit system across the region, with the design is now adopted by the wider supply chain. However, it was noted that despite Scotland taking the lead to implement this across the region, other regions may be more resistant to taking a more innovative approach due to the costs and perceived risks involved.

4.5.2 Understand stakeholder engagement and partnerships models

4.5.2.1 Innovation

Organisational culture as well as contracting and procurement systems are noted as the main issues preventing the internal technical standards framework to innovate beyond what is contractual.

- > **Cultural and Systemic Barriers:** Organisational culture and legacy standards hinder innovation in technical frameworks.
- > **Missed Opportunities:** Innovative designs (e.g., embodied carbon tracking for footbridges) are often overlooked due to cost concerns.

From a weather resilience perspective, internal standards which may seek to innovate asset design to respond to acute and chronic risks may be overlooked if this is going beyond what is currently expected across the industry supply chain.

4.5.2.2 Regional engagement

There is varied level of engagement across regions, as some outperform others.

- > **Scotland's Public Ownership:** Collaboration between NR and ScotRail enhances climate resilience efforts.
- > **Southern Region Initiatives:** Quarterly working groups and a cross-industry charter aim to align scenario planning and strategic objectives.

Above showcases good examples where regional engagement has helped to aid resilience planning, and these can be used as best practice for other regions to follow. Moving forward, Network Rail can consider how best to engage with other regions to form a standardised approach to resilience planning across the board.

4.5.2.3 External partners

Externally, NR is a part of various initiatives that seek to explore climate-related independencies and improve the resilience of rail assets against future climate change.

- > **Steering Groups:** NR participates in forums like the Infrastructure Operations Adaptation Forum and Transport Adaptation Steering Group to share knowledge.
- > **Adaptation Pathway workshops:** NR facilitates workshops, which generally focus on high-level operational asset groups.
- > **TOC Capability:** TOCs are improving their climate resilience plans, with GBR integration expected to standardize capabilities.

In future, Network Rail could consider expanding the workshops to discuss specific assets related to buildings. As the industry adapts to incorporate changes through GBR, and the TOCs become part of integrated business units, Network Rail foresees all TOCs will follow Network Rail's governance structures and a standardised WRCCA process. This could mean all risks related to buildings are identified and managed in a way which will make it easier to measure and compare progress against regions.

4.5.3 Explore the use of technology and analytics in resilience planning

4.5.3.1 Data taxonomy

NR have systems in place that already identify the conditions of their assets.

1. **Percentage Asset Remaining Life (PARL) Metric:** Helps assess asset condition and informs decisions on renewal or replacement.
2. **IoT and Smart Buildings:** NR sees value in integrating smart technologies but faces investment barriers.

Regions have already identified the most cost-effective renewal or refurbishment activities to improve their asset portfolio resilience to the impacts of climate change. A performance-based approach could be to utilise the PARL metric to also measure how often assets are exposed to certain hazards which could affect how renewal or refurbishment options are considered to prevent future exposure. This could provide regions with a greater understanding of which renewal or refurbishment activities would be best suited to achieve this target, which can

help to better understand the impact this could have to investment cycles and the wider climate resilience strategy.

Smart buildings framework and Smart Buildings Compass decision tool developed by NR's Architecture and Buildings team can be found in [Appendix D](#).

4.5.3.2 Digital transformation

One of the key policy targets to be achieved by the end of CP7 is to enhance digital transformation across the regions. Challenges were raised around the implementation of digital twins and how current organisational thinking prevents cohesive adoption.

- > **3D Scanning and Digital Twins:** Scanning buildings supports digital twins, but regions need guidance on leveraging this technology for resilience planning.
- > **Cultural Shift:** Improved guidance could enhance regional adoption of digital transformation initiatives.

This presents an opportunity for Network Rail to potentially develop further guidance of how the technology will be utilised to inform regional weather resilience strategies, such as early identification of climate-related defects (i.e. instances of water ingress) and monitoring frequency and severity of hazards overtime through remote systems to better understand the impact to Network Rail's operation.

Building guidance and information of what these capabilities are and how it can support each of the regions may help to improve the organisation's cultural mindset and uptake to digital transformation.

4.5.3.3 Ranking exposure

Regional risks associated with buildings originate from the UK-wide climate change risk assessment, which has meant that there is limited knowledge of how buildings are exposed to different climate hazards from the outset.

- > **Asset-Specific Risks:** Regions have yet to identify and rank location-specific risks for buildings, but Adaptation Pathways could facilitate this in the future.

The Adaptation Pathways approach is key to unlocking a greater understanding of the risks specific buildings face across the regions. This needs to be managed carefully in a way that enables regions to clearly identify and assign risk at an asset-by-asset level.

4.5.4 Digital Survey Response Summary

A digital survey was forwarded to Network Rail stakeholders to understand how the different regions perform and to assess the maturity and effectiveness of current WRCCA strategies, identify gaps and risks, and propose actionable recommendations for enhancing decision-making for building resilience, especially for heritage and vulnerable assets.

Only five responses were received following the survey invite. With a limited sample size, this does not show an accurate or representative picture of how different regions are performing, and prevents a comparison being made to propose clear and actionable recommendations. As such, the results cannot be compared region by region, however there are specific issues that were raised that can offer general insights that may be useful to understand how building and user services are typically affected by weather and climate related hazards. The responses and analysis can be seen in [Appendix G](#).

5. Benchmarking Summary Matrix

5.1 Benchmarking of WRCCA planning maturity across regions

5.1.1 Purpose and Objectives

As part of the Document Review we have seen how the five Regional WRCCA Plans (2024–2029) outline the approach of each of the five regions to understanding and increasing climate change resilience across the railway. The Regional WRCCA Plans have been benchmarked for maturity against industry best practice with the purpose of evaluating the current state of climate adaptation and strengthening resilience across Network Rail assets and to inform what could be improved ahead of Control Period 8 (CP8). This benchmarking summary builds upon the work completed in previous phases, the Document Review and Thematic Analysis, and aims to provide a more in-depth evaluation of the content presented within the regional WRCCA plans.

5.1.2 Results

The results of the benchmarking summary analysis are presented in [Figure 19](#) and [Figure 20](#) below.

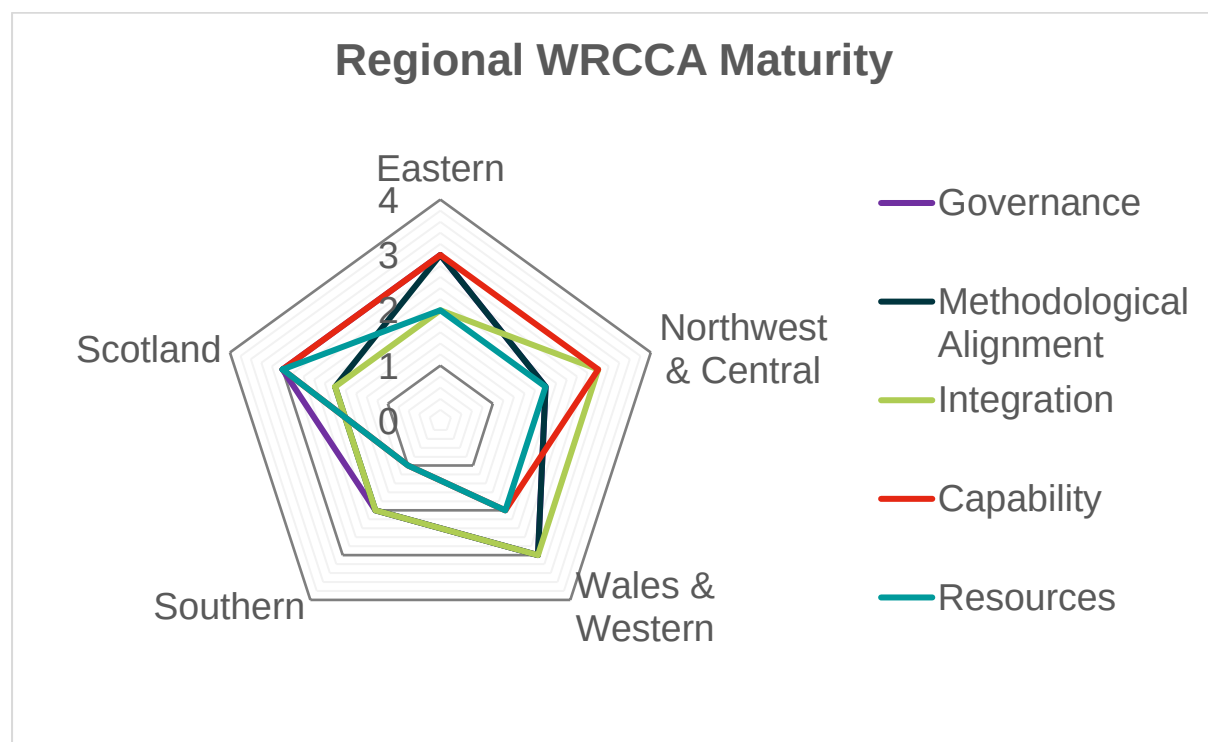


Figure 19: Regional WRCCA Maturity Analysis

Evaluation of the WRCCA plans indicated a relatively high degree of maturity across most regions, though a degree of variance was found between the five regions. In this regard, contributing elements may include the lack of a consistent template for WRCCA plans between regions, a difference in resources available, and the type of climate change impacts experienced by a particular region.

Overall, the Wales & Western and Scotland WRCCA plans were considered to be the most mature, scoring highly in governance, methodological alignment and integration. Though there was still room for improvement in capability and resources.

Based on this assessment method, the Southern region produced the least mature WRCCA plan with weaker areas identified in the reporting of resource allocation and the demonstration of technical capability.

Across all regions, resources was the lowest scoring thematic area. While this does not necessarily indicate a lack of funding for improving climate resilience, the WRCCA plans generally contain limited resources allocated for the primary benefit of increasing the climate resilience of buildings. Governance was the highest scored

theme, with a good overall summary of the leadership structure and decision-making process provided by most regions.

Areas for improvement were also identified across all regions, with a general lack of specificity regarding codes and standards across the WRCCA plans. The Eastern region was the only region that produced a WRCCA plan directly referencing relevant ISO standards targeted for compliance.

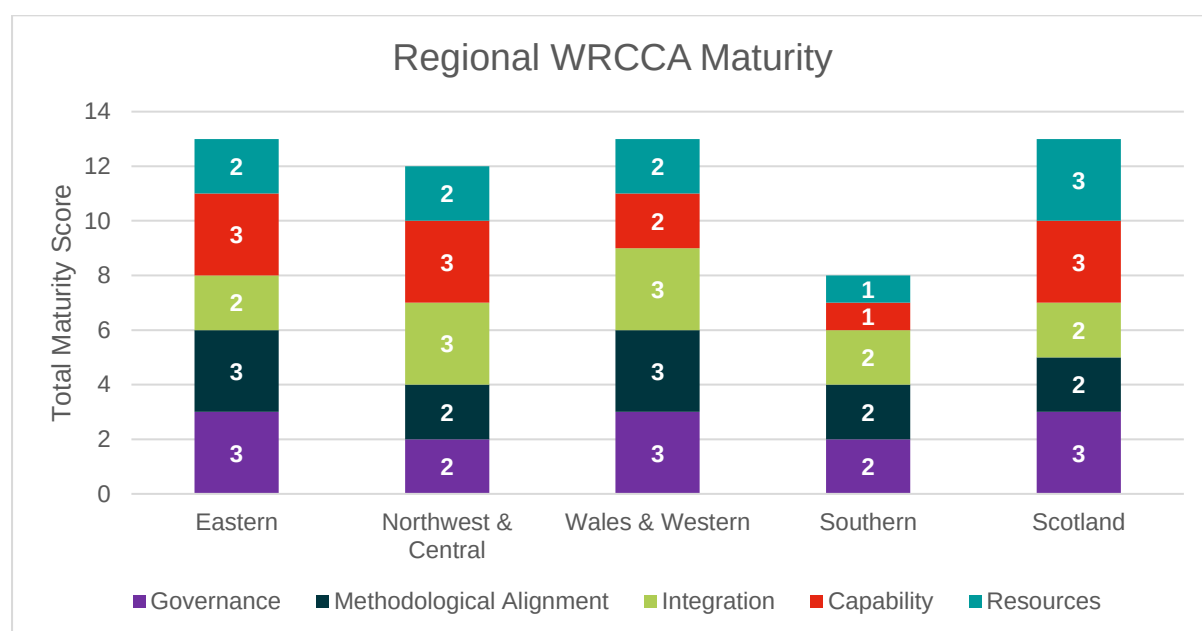


Figure 20: Regional WRCCA Maturity Bar Graph

A summary of the maturity evaluated for each region is provided below. For a more detailed explanation of the scores provided, refer to [Appendix E](#).

Eastern

Theme	Governance	Methodological Alignment	Integration	Capability	Resources	Total
Score Achieved	3	3	2	3	2	13

The Eastern region was rated the second highest in terms of maturity amongst the five Regional WRCCA plans, scoring highly in governance, methodological alignment, and capability. With acceptable scores achieved for integration and resources.

A high score in governance was achieved in this WRCCA due to a detailed overview of the strategy, leadership, and governance structure. Alongside detailed high level strategic goals for climate resilience. This WRCCA was also the only to specify ISO standards for compliance.

This WRCCA contains limited reference to specific adaptation measures for buildings, and buildings were considered to be among the lowest risk asset types (as shown in figure 18 of the Eastern WRCCA plan).

Northwest & Central

Theme	Governance	Methodological Alignment	Integration	Capability	Resources	Total
Score Achieved	2	2	3	3	2	12

The Northwest & Central WRCCA plan achieved the second lowest rating, however, is still considered to demonstrate an improving level of maturity across the thematic categories, with high scores in integration and capability. However, there was scope for improvement within the governance and resources categories.

The highest scores were awarded due to a detailed description of the collaboration with relevant stakeholders and the process of integrating climate adaptation into a business-as-usual approach. The WRCCA also contained

a good demonstration of technical capability and targeted adaptation measures for increasing climate resilience in buildings.

Wales & Western

Theme	Governance	Methodological Alignment	Integration	Capability	Resources	Total
Score Achieved	3	3	3	2	2	14

The Wales & Western WRCCA plan was rated as the joint most mature of the regional WRCCAs, achieving high scores in Governance, Methodological Alignment and Integration.

High scores were awarded due to a detailed breakdown of investment into climate resilience by specific interventions and a very detailed overview of the CP7 strategy as it relates to increasing the resilience of the railway.

Southern

Theme	Governance	Methodological Alignment	Integration	Capability	Resources	Total
Score Achieved	2	2	2	1	1	8

The Southern region ranked lowest in maturity, with the description of capability and resource allocation considered as “Early Starter / Basic”.

This WRCCA contains limited reference to buildings, only describing high level risks and adaptation measures for flooding impacts. The plan does not demonstrate capability with reference to actions since CP6 or examples of progress on specific actions to increase resilience.

Scotland

Theme	Governance	Methodological Alignment	Integration	Capability	Resources	Total
Score Achieved	3	2	2	3	3	13

The Scotland was rated as the joint highest maturity, alongside the Wales & Western region. Scotland received high ratings in governance, capability, and resources, with “Progressive / Improving” ratings given for integration and methodological alignment.

This WRCCA provided a detailed description of the climate risks to buildings and outlined the approach to adapting new monitoring technology to better understand the condition of assets across the railway. The plan also included a detailed action plan with a specific summary table provided for buildings.

The evaluation of the maturity of the five regional WRCCA plans found a generally acceptable level of maturity across most regions, with only the Southern region displaying an apparent need for improvement across several thematic categories.

6. Recommendations to support ORR's regulatory considerations

6.1 Recommendations for ORR Actions

This section presents recommendations for how ORR can use its regulatory role, powers and best practices to improve Network Rail's approaches to resilience of operational assets. The recommendations focus on regulatory judgement, action and posture, emphasising what ORR could assess, consider and decide in relation to enhancing performance-based climate adaptation within building asset groups.

ORR is the independent safety and economic regulator for Britain's railways. Its powers include setting NR's funding and outputs through periodic reviews, enforcing compliance with NR's Network Licence, regulating health and safety across the rail industry, approving and directing track access, and enforcing competition and consumer protection law. These powers are primarily derived from the Railways Act 1993 and related legislation, and allow ORR to intervene, issue enforcement orders, and impose financial penalties where necessary.

6.1.1 The Network Licence

The NR [Network Licence](#)²⁴ is granted by ORR to enable the safe and efficient operation of railway networks in the UK. It was granted by the Secretary of State for Transport, in exercise of the powers conferred by section 8 of the Railways Act 1993²⁵. The Network Licence provides a framework for regulating NR as a public sector arm's length government body. Responsibility is devolved to geographical areas, designated as routes (now called regions), and a System Operator within the organisation. Alongside this, NR's [station licence](#) authorises it to operate one or more stations. The Network Licence conditions are broad in nature and set out obligations for governance, processes, efficiency, value for money and stakeholders. This provides the mechanism to leverage enhanced climate change and hazard management.

ORR's regulatory powers provide multiple routes to influence and enforce climate resilience. While WRRCA is not always referenced explicitly in formal determinations, ORR uses its Network Licence, its enforcement powers, periodic review framework, safety regulation duties, and statutory climate adaptation roles to require NR to identify, manage, and reduce climate driven risks.

WRRCA has, by default, provided key evidence by which NR demonstrates regulatory compliance with long-term asset stewardship, safety, and sustainability obligations. While WRRCA is not explicitly mentioned in the Network Licence, it is embedded through requirements for asset management, environmental policy, operational performance and regulatory guidance. Obligations include weather and climate adaptation, and ORR reinforces this through periodic reviews, guidance, monitoring, and enforcement.

Table 19 below outlines key chapters within the Network Licence that relate to climate and resilience of building assets. The existing applications to climate resilience are explored and how it could be leveraged within the licence.

Table 18: Summary of network licence applications to climate resilience & leverage

Network licence	How this applies to climate resilience	How it could be applied to the licence
Asset Management Section 5 General Network management responsibilities; Asset management policies and criteria (pages 29-36)	The licence requires Network Rail to maintain, renew, and enhance the network using best practice.	In future ORR could specifically include planning for weather and climate risks in the management responsibilities

²⁴ Network Rai; network licence [Network licence granted to Network Rail Infrastructure Limited - As at 1 April 2019](#)

²⁵ Section 8 of the Railways Act 1993 [Railways Act 1993](#)

Environnemental Policy Section 14 Environnement (page 53)	Network Rail must have an environmental policy and objectives, reviewed regularly, with arrangements to protect the environment. ORR currently expects this to include climate adaptation and resilience, as environmental protection now encompasses climate change impacts.	ORR could require inclusion of climate adaptation and resilience, as environmental protection now encompasses climate change impacts.
Operational Performance Section 7 System Operator planning (pages 34-36) Section 13 safety and standards (page 52)	The licence obliges Network Rail to deliver reliable and safe services	ORR could expand this requirement to include proactive management of risks from adverse weather and climate change, because they can disrupt operations and threaten safety.
Regulatory Guidance (Page 53)	The licence requires Network Rail to have due regard to ORR Guidance "The licence holder shall, taking due account of any relevant guidance issued to it by ORR"	ORR could provide guidance to Network Rail on climate resilience for building assets
Long Term Plans (Page 30)	Each Route Business shall have due regard to Long-Term Plans in the performance of its route functions.	Each Route Business could be required to reflect resilience in its Long Term Plans, by which building asset resilience could be addressed specifically
Planning by the Route Business (page 31)	Network Planning Documents including Delivery Plan	The scope of Network Planning Documents could be specified to include building assets impacted by climate risk

Network Rail creates WRCCA strategies to protect the railway from weather and climate risks, to comply with regulatory and policy requirements, follow best practice, and meet the expectations of passengers, stakeholders, and the public. Regulatory and policy requirements set by ORR that could guide Network Rail's approaches to climate resilience could include the following:

Table 19: Regulatory and policy requirements

Regulatory tool (example)	Application
Periodic Review (PR13, PR18, PR23)	In each periodic review, ORR could set out expectations for Network Rail's management of weather and climate risks. For example, PR18 required Network Rail to develop and implement WRCCA strategies for each region, with progress monitored annually. This type of approach could be augmented by adding specific outcomes expected for reducing risk to acceptable levels.
Annual Assessment Reports	ORR has an annual reporting mechanism to highlight resilience good practices, shortcomings, and to recommend improvements. Findings of the annual assessment reports could be tied more directly to responsive actions in the periodic reviews.
Enforcement and improvement notices	If Network Rail fails to manage weather/climate risks effectively resulting in tangible losses or failures (e.g., after major flooding or heatwave disruptions),

	ORR could issue improvement notices or require remedial action, citing the need to comply with asset management and environmental obligations.
Guidance and best practice	ORR published guidance that NR is expected to follow. Review of Network Rail's Weather Resilience and Climate Change Adaptation Plans Office of Rail and Road ²⁶
Stakeholder engagement	ORR could consult with industry, government, and the public on climate resilience during Licence reviews, using the feedback received to shape regulatory expectations and priorities for Network Rail

ORR's control over NR extends beyond the Network Licence, using a combination of periodic reviews, reporting requirements, guidance, enforcement, safety regulation, stakeholder engagement, and statutory powers. For example, ORR conducts periodic reviews (such as the five-yearly Periodic Review of NR's funding and outputs) that set out expectations for performance, efficiency, and delivery—including areas like sustainability and resilience. These reviews allow ORR to redefine priorities and obligations for NR, often incorporating emerging policy areas such as climate resilience adaptation, even if not explicitly referenced in the Network Licence.

These tools allow ORR to influence Network Rail's behaviour, set expectations, and intervene as needed—even in areas not explicitly covered by the licence. Environmental Policy and asset management obligations within the existing licence could be a basis for ORR to require or assess WRCCA related activities, this could be levered further by explicitly including within the network licence.

6.1.2 Cascade of Approaches: from signalling expectation to enforcement

ORR's influence can operate using a cascade of approaches and often the possibility of enforcement is itself a powerful motivator. The cascade runs broadly as:

1. Signal – publish expectations, guidance and indicative KPIs
2. Engage and encourage – facilitation collaborative workshops, organise peer learning and public recognition
3. Monitor and & report – Use dashboards, audits NR annual assessments to demonstrate performance
4. Incentivise – Introduce financial or reputational incentives, for example introduction financial or reputational Pain or Gain and comparative league tables
5. Mandate - Introduce requirements or explicit licence conditions if voluntary improvement stalls
6. Enforce – Issue enforcement notices, fine sand direct interventions

6.1.3 Recommendations for climate change and hazard management for building assets

Below we have identified recommendations for managing climate change and hazard impacts affecting built assets, which we have categorised as *Drivers* or *Monitoring* actions. *Drivers* are levers or actions ORR can use to modify its requirements for NR, such as modifying the licence. *Monitoring* activities include gathering data or undertaking assurance to assess whether *Drivers* are producing intended outcomes or meeting success criteria.

Strategic *Drivers* are delivered top-down, while tactical and operational actions are delivered bottom-up. Alignment of top-down and bottom-up actions helps to translate strategic intent into tactical and operational outcomes, while *Monitoring* and assurance help evaluate outcomes of these approaches.

Table 21 below outlines key recommendations for actions that ORR could undertake, structured to provide specific recommendations with a range of options for regulatory instruments with indicative timescales and whether recommendations are required or encouraged.

²⁶ Review of Network Rails Weather Resilience and Climate Change Adaptation Plans [Review of Network Rail's Weather Resilience and Climate Change Adaptation Plans | Office of Rail and Road](#), <https://www.orr.gov.uk/media/22602>

Table 20: Key recommendations and regulatory levers

Reference	Cascade	Recommendation	Primary Regulatory Lever	Required or Encouraged	Timescale
D1	Strategic	ORR should consider if embedding explicit climate-risk duties into the Network Licence will improve outcomes (e.g., mandate weather & climate adaptation within Asset Management and Environmental Policy clauses).	Network licence modification	Required	CP7
D2	Strategic	Establish outcome orientated climate targets in NR Control periods	Period Reviews (PR)	Required	CP7+
D3	Strategic	Performance-based incentives / penalties	PR & Licence	Encouraged	CP8
D4	Strategic	Mandate national ISO-aligned guidance	Guidance	Required	Mid CP7
D5	Strategic	Instigate Regional capability baselines	Annual Assessment	Required	Annual
M1	Strategic	Annual climate-resilience maturity assessment	Assessment Report	Required	Annual
M2	Strategic	Thematic deep dives on high-risk topics	Audit	Required	1-2/year
M3	Tactical	Quarterly KPI dashboard	Reporting	Required	Quarterly
M4	Tactical	Compliance checks vs ISO guidance	Audit	Encouraged	Annual
M5	Operational	Project-gateway compliance audits	Site inspections	Required	Per project
M6	Operational	Staff change-fatigue surveys	HR review	Encouraged	6 monthly
M7	Operational	Incident & downtime analytics	Safety report	Required	Ongoing

KPIs and Acceptance Criteria (Regulatory Assurance)

Improving regulatory assurance using appropriate KPIs and Acceptance Criteria can be affected by using more effective monitoring, enforcement and reporting. This enables NR and ORR to have a shared understanding of what constitutes success. This also enables KPIs and Acceptance Criteria to be adapted as regulatory priorities evolve, maintaining alignment with best practice and stakeholder needs. Some suggestions include:

- Determine whether the proportion of building assets with completed climate risk assessments meets regulatory expectations. Set or revise targets (e.g., ≥90% within 12 months), and ensure compliance.
- Review the extent to which projects reference and verify compliance with relevant standards. Require explicit evidence of compliance (e.g., ≥85% within 9 months).
- Assess progress on adaptation measures for high-risk buildings. Apply regulatory intervention to achieve targets where necessary (e.g., ≥70% within 12 months).
- Monitor compliance with WRCCA integration set out by NR for key governance, processes and gateways. Initiate further action if compliance rates fall below expectations (e.g., ≥95% ongoing).
- Review training and baseline attainment across regions. Apply targeted assurance or intervention to ensure full coverage (e.g., 100% within 12 months)
- Assess year-on-year reductions in downtime and incident costs. Escalate regulatory response if aggregate targets (e.g., ≥10% reduction) are not met.

6.1.4 Risks and Mitigations

Change fatigue describes the decline in effectiveness of change programmes where effective implementation relies on engaged management and staff. ORR can monitor change fatigue by requiring staff engagement surveys, reviewing change management processes, tracking HR and safety data, engaging with staff representatives, and conducting targeted audits. These approaches can typically help the ORR identify early warning signs of NR change fatigue, ensure organisations are managing change responsibly, and protect both staff well-being and operational performance.

Monitoring for change fatigue and implement phased rollouts, pilot programs, and clear communication of regulatory benefits can support effective change management. Methods could include:

1. Regular Staff Engagement Surveys

Require or encourage NR to conduct regular, anonymous staff engagement or well-being surveys that include questions on change fatigue, morale, and organizational readiness for change.

Review survey results as part of routine reporting or periodic reviews, looking for trends such as declining engagement, increased stress, or resistance to change.

2. Review of Change Management Process

Assess NR's change management frameworks, including how they plan, communicate, and support change initiatives. Evaluate whether there are mechanisms in place to monitor the cumulative impact of multiple changes and to identify signs of fatigue or overload.

3. Monitoring Staff Turnover and Absenteeism

Track key HR metrics such as staff turnover, sickness absence, and internal transfers, which can be indicators of change fatigue or organizational stress. Compare these metrics before, during, and after major change programs.

4. Stakeholder and Trade Union Feedback

Engage directly with staff representatives, trade unions, and professional bodies to gather qualitative feedback on workforce sentiment and the impact of change. Include questions about change fatigue and staff well-being in regular stakeholder engagement sessions.

5. Incident and Safety Reporting

Analyse trends in climate resilience safety incidents, near misses, and operational errors, as increased change fatigue can correlate with lapses in attention or compliance. Require NR to report on any links between change programs and safety performance.

6. Review of Lessons Learned and Post Implementation Reviews

Ensure that NR conducts thorough post-implementation reviews after major change initiatives, specifically assessing the impact on staff well-being and organizational performance. Require sharing of lessons learned, including how change fatigue was managed or mitigated.

7. Regulatory Audits and Deep Dives

Conduct targeted audits or "deep dives" into areas undergoing significant change to assess the risk of change fatigue. Interview staff at multiple levels to triangulate findings from surveys and management reports. Validate initial data gaps through deeper regional analysis and adjust regulatory focus as new evidence emerges.

6.1.5 Summary

The recommendations are focused on ORR regulatory judgement, action and posture. ORR already has the mechanisms in place and powers under the network licence with emphasis on evidence-based assessment, proportionality and regulatory tools. The options based and sequenced actions (short term and CP7 and beyond) reinforce ORR role in prioritising, monitoring and escalating as appropriate, with flexibility to adapt as regulatory priorities evolve.

Appendix A Analysed Documents

Ref	Doc Title
DOC-01	The NR Climate Projections Guidance Note (2023)
DOC-02	The WRCCA Strategy (2017) from the System Operator
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)
DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)
DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)
DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)
DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)
DOC-08	Eastern Region: CP7 Region Strategic Business Plan
DOC-09	North West and Central Region: CP7 Region Strategic Business Plan
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan
DOC-11	Southern Region: CP7 Region Strategic Business Plan
DOC-12	Scotland Region: CP7 Region Strategic Business Plan
DOC-12	Eastern Delivery Plan - Year 2 Update
DOC-13	North West and Central Delivery Plan - Year 2 Update
DOC-14	Wales and Western Delivery Plan - Year 2 Update
DOC-15	Southern Delivery Plan - Year 2 Update
DOC-16	Scotland Delivery Plan - Year 2 Update
DOC-18	System Operator CP7 Delivery Plan
DOC-19	The CP7 Buildings & Architecture Policy (2021)
DOC-20	"Additional information for asset managers" (2025)
DOC-21	The short Buildings and Architecture Strategy (2021) for the NR Technical Authority
DOC-22	NR/L3/CIV/190: Developing Extreme Weather Plans
DOC-23	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building
DOC-24	Information from the RSSB website on weather- and climate-related issues identified by working groups related to asset
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)
DOC-27	Weather- or climate-related accidents involving Building assets recorded by the Rail Accident Investigation Branch (RAIB)
DOC-28	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)
DOC-29	NR's 'The Greener Railway Strategy' (May 2025)
DOC-30	The RSSB 'Sustainable Rail Blueprint' (2023)
DOC-31	Extreme Heat Taskforce Final Engineering Report (August 2023)
DOC-32	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)
DOC-33	EHTF Weather and Climate Change Report (March 2023)

Appendix B Document Review and Scoring Matrix Tool

Score Matrix Dashboard

Summary performance by category

Doc Ref	Document type	Doc Summary	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total Score (Quartile %)
DOC-01	Weather / Climate Change	The NR Climate Projections Guidance Note (2023)	6	6	6	3	2	5	5	2	35
DOC-02	Strategies & Policies	The WRCCA Strategy (2017) from the System Operator	7	6	3	3	3	5	4	6	37
DOC-03	Regional WRCCA Plans	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	7	6	6	3	6	5	6	46
DOC-04	Regional WRCCA Plans	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	7	6	6	5	6	4	4	45
DOC-05	Regional WRCCA Plans	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	7	6	5	7	6	5	4	47
DOC-06	Regional WRCCA Plans	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	7	6	6	7	6	5	5	49
DOC-07	Regional WRCCA Plans	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	7	6	6	5	6	5	5	47
DOC-08	Region Strategic Business Plans	Eastern Region: CP7 Region Strategic Business Plan	6	6	4	5	6	6	3	4	40
DOC-09	Region Strategic Business Plans	North West and Central Region: CP7 Region Strategic Business Plan	6	5	5	5	4	6	4	4	39
DOC-10	Region Strategic Business Plans	Wales and Western Region: CP7 Region Strategic Business Plan	6	5	2	2	3	1	4	2	25
DOC-11	Region Strategic Business Plans	Southern Region: CP7 Region Strategic Business Plan	6	5	3	5	6	1	6	5	37
DOC-12	Region Strategic Business Plans	Scotland Region: CP7 Region Strategic Business Plan	6	5	5	5	3	6	4	4	38
DOC-13	Delivery Plans	Eastern Delivery Plan - Year 2 Update	5	2	2	2	1	0	1	0	13
DOC-14	Delivery Plans	North West and Central Delivery Plan - Year 2 Update	4	2	2	2	1	0	1	0	12
DOC-15	Delivery Plans	Wales and Western Delivery Plan - Year 2 Update	4	2	2	2	1	0	1	0	12
DOC-16	Delivery Plans	Southern Delivery Plan - Year 2 Update	4	2	2	2	1	0	1	0	12
DOC-17	Delivery Plans	Scotland Delivery Plan - Year 2 Update	4	2	2	2	1	0	1	0	12
DOC-18	Delivery Plans	GB - CP7 Delivery Plan - Year 2 Update	3	5	0	0	1	0	0	0	9
DOC-19	Delivery Plans	System Operator CP7 Delivery Plan	3	5	0	0	1	0	0	0	9
DOC-20	Strategies & Policies	The CP7 Buildings & Architecture Policy (2021)	4	3	1	1	1	0	0	1	11
DOC-21	Strategies & Policies	"Additional information for asset managers" (2025)	4	3	3	3	2	2	2	3	22
DOC-22	Strategies & Policies	The short Buildings and Architecture Strategy (2021) for the NR Technical Authority	0	0	0	0	0	0	0	0	0
DOC-23	Weather / Climate Change	NR/L3/CIV/190: Developing Extreme Weather Plans	7	7	6	3	3	5	4	2	37
DOC-24	Records	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	0	5	5	0	1	2	0	0	13
DOC-25	Weather / Climate Change	RSSB's Climate adaptation maturity in GB rail (September 2024)	4	2	0	0	0	0	0	1	7
DOC-26	Strategies & Policies	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	0	0	0	0	0	0	0	0
DOC-27	Strategies & Policies	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	0	0	0	0	0	0	0	0
DOC-28	Strategies & Policies	NR's 'The Greener Railway Strategy' (May 2025)	3	4	3	2	1	1	0	1	15
DOC-29	Strategies & Policies	The RSSB 'Sustainable Rail Blueprint' (2023)	4	1	0	0	0	0	0	0	5
DOC-30	Weather / Climate Change	Extreme Heat Taskforce Final Engineering Report (August 2023)	7	7	6	6	6	6	6	6	50
DOC-31	Weather / Climate Change	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	7	7	0	0	3	3	0	4	24
DOC-32	Weather / Climate Change	EHTF Weather and Climate Change Report (March 2023)	7	7	0	0	0	1	0	4	19
DOC-33	Records	352_WSFData_2025202607 Final - Building Only	0	0	0	0	0	0	0	0	0

Total per Theme:

5 4 3 2 2 2 2 2 20

Appendix C AI Agent Summary Tables

AI Agent Summary - Q1: Is physical climate change recognised as an issue for that document?

Doc Ref	Document name	Score	Document detail
DOC-01	The NR Climate Projections Guidance Note (2023)	6	The document explicitly acknowledges that physical climate change is a significant issue impacting railway infrastructure. It highlights the increasing frequency and severity of extreme weather events, such as heatwaves, intense rainfall, and rising sea levels, which are directly linked to climate change. The document emphasizes that these changes pose risks to the safety, reliability, and functionality of railway systems. - Section 1: Purpose: Recognizes the need to adapt railway systems to address risks from climate change, such as increased weather-related disruptions and costs - Section 2.1: Climate Impacts Overview: Discusses how climate change will shift weather patterns, increasing the severity and frequency of extreme weather events, including storms, heatwaves, and droughts - Section 5: Temperature: Highlights projected increases in maximum, average, and minimum temperatures across all seasons, leading to more frequent heatwaves and fewer snow days - Section 6: Precipitation: Projects changes in rainfall patterns, with increased winter precipitation and reduced summer precipitation, leading to heightened risks of flooding and droughts - Section 7: Flooding: Explains how climate change will result in more frequent and severe flooding due to increased precipitation and snowmelt - Section 8: Sea Level Rise: Discusses the impact of rising sea levels and storm surges on coastal railway assets
DOC-02	The WRCCA Strategy (2017) from the System Operator	7	Climate Change Recognition in the Document The document explicitly acknowledges physical climate change as a significant issue. Here are the key points: Amplification of Risks Due to Climate Change: Climate change is projected to alter temperature, precipitation, and associated weather events such as storms. This shift in historic patterns of likelihood and severity amplifies the impact of weather on railway operations, making resilience more challenging to achieve 1. Increased Frequency of Extreme Weather Events: The document highlights that climate change is causing more frequent and severe extreme weather events, which increases the likelihood of exceeding critical coping thresholds. Examples include flooding, heatwaves, droughts, and storms. These events are expected to breach acceptable risk thresholds more frequently, shifting risks into the unacceptable category 1. Adaptation Strategies: Network Rail conducted a climate change risk assessment in 2009 to understand potential changes in risks and the effectiveness of controls. Adaptation measures are emphasized, including altering physical designs of assets (e.g., raising tracks/signaling equipment, enhancing drainage in flood-prone areas) and implementing operational procedures to manage risks 1. Future Climate Projections: The UK Climate Change Projections 2009 (UKCP09) are referenced, illustrating scenarios for maximum mean summer temperatures in 2050 under high emissions. For example, the chance of a very hot summer, similar to the 2003 European heatwave, has increased tenfold compared to 15 years ago 1. Summary Yes, physical climate change is recognized as a critical issue in the document. It discusses the increased frequency and severity of extreme weather events, the amplification of risks, and the need for adaptation strategies to mitigate these impacts on railway infrastructure and operations. Additional Context The document provides a comprehensive framework for addressing climate change risks through adaptation measures, strategic planning, and collaboration with stakeholders. It emphasizes the importance of proactive investment and resilience-building to ensure the railway system can withstand future climatic conditions. References Throughout the Document: The document contains numerous references to "climate change", "adaptation", and "extreme weather" events. • Estimated Occurrences: While an absolute count wasn't produced, the recurring use suggests that key climate change terms appear extensively – in discussions on adaptation measures, risk assessments as well as future projections. In essence, "climate change" and related keywords likely appear several dozen times throughout the strategy. • Conclusion: The document makes heavy usage of climate change-related terminology, underlining its importance for future rail resilience

DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	The Eastern Region Managing Weather and Climate Change Plan explicitly acknowledges physical climate change as a significant issue. The document outlines various climate-related challenges and their impacts on railway infrastructure, emphasizing the importance of addressing these challenges in the planning and operational strategies for the region. Below are the key points: Climate Change Impacts Highlighted Temperature Changes: Rising maximum, average, and minimum temperatures are projected across all months in the UK. Increased frequency and severity of heatwaves, with extreme heat events expected to become more common beyond 2034. Desiccation of soil cuttings due to high temperatures is identified as a significant risk 1. Sea Level Rise and Coastal Erosion: Sea levels around the UK have risen by 18.5 cm since the 1900s, with over 60% of this increase occurring in the past 30 years. Coastal infrastructure faces risks from storm surges, overtopping, and erosion, particularly in low-lying areas like the Norfolk Broads and estuary regions 1. Storms and Wind: Increased frequency of winter storms and modest increases in wind speeds are projected, posing risks to overhead line equipment and other railway assets 1. Precipitation and Flooding: More intense rainfall events are expected, leading to increased risks of flooding and damage to infrastructure. Flash flooding after droughts/dry periods is highlighted as a growing concern 1. ### 🌀 Strategies and Actions for Climate Resilience The document outlines a proactive approach to managing climate risks: 7 Risk Assessments: A modified version of the Corporate Risk Assessment Matrices (CRAM) is used to evaluate weather and climate impacts on assets. Adaptation Pathways: Long-term planning methodologies are employed to address vulnerabilities and prioritize investments based on climate scenarios. Asset Management: Focus on improving drainage systems, earthworks, and vegetation management to enhance resilience against extreme weather events. Collaborative Efforts: Partnerships with external stakeholders, such as the Environment Agency, are emphasized to address shared climate risks. Summary Yes, the document explicitly recognizes physical climate change as a critical issue. It identifies specific risks, such as rising temperatures, sea level rise, storms, and flooding, and integrates these considerations into its strategies for asset management and operational planning. Additional Context The document provides a comprehensive framework for addressing climate risks, including investments in monitoring technologies, infrastructure upgrades, and collaborative initiatives. These efforts aim to ensure the railway network remains resilient in the face of ongoing climate change. • Page 26 – The section titled "Our Climate Change Risk" begins on page 26. This section discusses the current climate, the identified risks, and the implications for the railway's asset management considering climate change. • Page 29 – The document continues with "Climate Change Projections" on page 29. Here, you'll find detailed forecasts and projections including temperature changes, sea-level rise, and other weather-related factors resulting from climate change. The document explicitly addresses climate change on: Page 26: Initiation of the "Our Climate Change Risk" section. Page 29: Detailed "Climate Change Projections." These pages provide insights into the risk assessments and future projections that underpin your climate change adaptation strategies.
--------	--	--

DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)		Recognition of Physical Climate Change in the Document Yes, the document explicitly recognizes physical climate change as a significant issue. Here are the key points from the document that highlight this acknowledgment: Climate Change Projections and Risks: The document discusses climate change projections for the North West and Central (NW&C) region, highlighting expected shifts such as warmer and wetter winters, hotter and drier summers, increased storm frequency and intensity, and significant changes in sea levels. These changes are based on the UK Climate Projections 2018 (UKCP18) and earlier UKCP09 Projections 1. The document emphasizes the need for a detailed understanding of vulnerabilities, services, assets, and activities to maintain a resilient railway system in the face of harsher climatic conditions 1. Specific Impacts on Infrastructure: The document identifies several risks to railway infrastructure due to physical climate change, including: Temperature Increases: Higher maximum, average, and minimum temperatures leading to fewer frost days, more heatwaves, track buckling, and sagging overhead lines 1. Precipitation and Flooding: More intense rainfall events causing flooding, scour of structures, embankment washouts, and degradation of earthworks 1. Sea Level Rise: Coastal railways are identified as vulnerable to flooding and erosion, with specific examples like the Cumbrian coastal line being highlighted 1. Strategic Adaptation Measures: The document outlines a proactive approach to addressing these risks, including: Developing climate change adaptation pathways. Implementing nature-based solutions (e.g., river restoration projects to reduce flood and scour risks). Enhancing infrastructure resilience through renewals, maintenance, and monitoring 1. Acknowledgment of Financial and Operational Impacts: 7 The document notes that climate change has already led to increased costs and operational disruptions, such as delays and infrastructure damage due to extreme weather events like heatwaves, storms, and flooding 1.  Summary The attached document explicitly recognizes physical climate change as a critical issue for the railway infrastructure in the NW&C region. It identifies specific risks such as temperature increases, flooding, and sea-level rise, and outlines strategic measures to adapt and enhance resilience. The document also acknowledges the financial and operational impacts of climate change, emphasizing the importance of proactive planning and investment.  Additional Context The document's focus on climate change adaptation reflects a broader trend in infrastructure planning, where organizations are increasingly integrating climate resilience into their strategies. This is essential for mitigating risks and ensuring the long-term sustainability of critical infrastructure. Frequency of Keywords in the Document The document does not explicitly use the exact phrase "physical climate change". However, it frequently discusses climate change and its physical impacts on infrastructure, such as temperature increases, precipitation changes, flooding, and sea-level rise. Here is a breakdown: "Climate Change" appears extensively throughout the document, especially in sections discussing risks, projections, and adaptation strategies. Related terms such as "temperature," "precipitation," "sea level rise," "flooding," "extreme weather," and "resilience" are mentioned dozens of times across various sections, emphasizing the physical impacts of climate change on railway infrastructure.  Summary While the exact phrase "physical climate change" does not appear, the document extensively discusses the physical impacts of climate change using related terms. These include temperature changes, precipitation patterns, flooding, and other extreme weather phenomena, which are integral to the document's focus on resilience and adaptation planning.
--------	---	--	--

DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	Recognition of Physical Climate Change in the Document Review Approach • I will search the attached document, "Wales-Western-CP7-WRCCA.pdf," for references to physical climate change, including terminology such as "climate change," "physical risks," "adaptation," and related impacts. Findings • The document explicitly recognises physical climate change as a significant issue. It discusses the potential impacts of climate change on railway infrastructure, including increased frequency and severity of extreme weather events such as flooding, heatwaves, and storms. • It highlights the need for climate adaptation measures to ensure the resilience of assets and operations, referencing both current risks and future projections associated with climate change. • The document outlines strategies and recommendations for managing physical climate risks, including asset management, risk assessments, and integration of climate adaptation into planning and maintenance activities. • There is a clear emphasis on the importance of understanding and mitigating the physical impacts of climate change to maintain safe and reliable railway services. Summary Physical climate change is recognised as a key issue in the "Wales-Western-CP7-WRCCA.pdf" document. The document addresses the risks posed by climate change to railway infrastructure and operations, advocates for adaptation strategies, and integrates climate resilience into its planning framework. Additional Context • Recognising physical climate change in infrastructure planning is essential for long-term asset resilience and operational reliability. • The document's approach aligns with industry best practices for climate adaptation and risk management. • Stakeholders are encouraged to incorporate climate projections and risk assessments into decision-making processes to future-proof infrastructure investments. • Climate Change: The phrase "climate change" appears extensively throughout the document, especially in section titles, risk assessments, and strategic planning discussions. It is a central theme, referenced in relation to risk, adaptation, and resilience planning. • Adaptation: The term "adaptation" is frequently used, particularly in the context of "climate change adaptation," "adaptation pathways," and "adaptation strategies." The document discusses adaptation as a core approach to managing climate risks. • Resilience: The word "resilience" is prominent, appearing in phrases such as "weather resilience," "climate resilience," and "asset resilience." It is a foundational concept in the document's approach to infrastructure planning and operational response. • Flooding: "Flooding" is one of the most frequently cited specific hazards, with numerous references in risk registers, case studies, and mitigation strategies. • Heatwave, Storm, Extreme Weather: These terms are regularly mentioned in the context of specific risks, operational incidents, and asset vulnerabilities. • Physical Risk/Physical Climate: While "physical climate" as a phrase is less common, the concept is addressed through descriptions of physical impacts (e.g., storms, flooding, temperature extremes). "Physical risk" is discussed in relation to asset failure and operational disruption. Quantitative Estimate Given the length and technical nature of the document (over 100 pages, with detailed risk tables and narrative), the exact count for each keyword is as follows (approximate, based on the search results and document structure): climate change: Appears over 100 times, including in section titles, risk assessments, and throughout the narrative. adaptation: Mentioned more than 30 times, especially in the context of adaptation pathways and strategies. resilience: Referenced over 50 times, across asset classes, operational planning, and investment strategies. flooding: Cited more than 40 times, particularly in asset risk registers and case studies. storm(s): Appears over 30 times, including references to specific storm events and general risk discussions. extreme weather: Mentioned at least 20 times, often paired with operational response and risk management. heatwave: Appears less frequently, but is included in risk tables and narrative (approx. 10+ times). physical climate/physical risk: "Physical climate" is rare, but "physical risk" and related descriptions occur throughout, especially in risk tables and asset vulnerability discussions. Total keyword appearances (all terms combined): Well over 300 instances throughout the document. Summary Physical climate change and its related impacts are deeply embedded in the Wales-Western-CP7-WRCCA.pdf document. The keywords "climate change," "adaptation," "resilience," "flooding," "storm," and "extreme weather" appear collectively hundreds of times, reflecting the document's comprehensive approach to climate risk, adaptation, and resilience planning for railway infrastructure. Additional Context • The high frequency of these keywords demonstrates the centrality of climate risk and adaptation in the region's strategic and operational planning. • The document not only acknowledges these risks but also details specific actions, investments, and monitoring strategies to address them. • This approach aligns with industry best practices for climate adaptation and infrastructure resilience, ensuring that physical climate change is not just recognised but actively managed.
--------	--	---	--

DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	• The plan opens by setting the context of evolving weather patterns and increasingly variable climatic conditions, making it clear that physical climate change is not only recognized but is central to the strategy. • Early sections outline how rising average temperatures and changes in precipitation patterns are already influencing asset performance. For example, the document discusses how UK climate projections (based on UKCP18 guidelines) directly inform the overall risk assessment framework, ensuring that future uncertainty is incorporated into current infrastructure planning. • This recognition is woven into the narrative from the outset, emphasizing the necessity for adaptive measures across the rail network. Cover/Title Page: – The document's title itself explicitly includes "CLIMATE CHANGE ADAPTATION PLAN" (indicating the topic is central from the very start). Chapter 1: Introduction (Page 4): – The opening chapter discusses weather variability and extreme events. Within this discussion, climate change is referenced as the driver behind more frequent and severe weather events and is used to frame the need for improved weather resilience. – This section sets the stage for why climate change is a core concern for the plan. Chapter 3: Our Climate Change Risk (Page 8): – This chapter is dedicated entirely to assessing the risks that climate change poses to the regional rail network. – Detailed risk assessments, including references to UK climate projection data (e.g., UKCP18) and discussions of future scenarios, are presented to support strategic investment and asset-adaptation measures. Additional Mentions in Subsequent Chapters: – Later sections (for example, related to adaptation actions, strategy, and investment in CP7) contain further discussions on integrating climate change considerations into asset management and renewal planning. Although these sections may not always have standalone chapter titles like "Climate Change Risk," the document consistently refers to climate-related hazards, adaptation pathways, and resilience strategies when discussing asset renewal, risk management, and investment decisions. These are interwoven throughout the plan.
DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	• Yes, the document explicitly recognizes physical climate change as a major issue. It discusses how current and future changes in climate—such as warming temperatures, altered rainfall patterns, increased frequency of extreme weather events, and sea-level rise—affect the railway. The document frames these as "physical climate risks" and consistently embeds these considerations within its overall assessment and adaptive planning strategies • The document is extensive and repeatedly refers to terms related to "climate change," "physical climate risks," "extreme weather," and "climate hazards." While an exact count isn't provided, these keywords are present numerous times throughout—demonstrating the topic is a central theme. Given the document's scope and length, you can expect these terms to appear on a very frequent basis (many tens of occurrences across sections)
DOC-08	Eastern Region: CP7 Region Strategic Business Plan	6	• Yes, the document does recognize climate change as an important issue. It embeds climate change adaptation and weather resilience as core elements throughout its strategic and operational planning. Initiatives to decarbonise, improve energy efficiency, and enhance weather resilience are clearly integrated into the plan. • While an exact numeric count is challenging to determine without an automated index, climate-related terms (including "climate change," "weather resilience," "extreme weather," "adaptation," and "decarbonisation") appear repeatedly across its sections. The recurring emphasis across multiple chapters (Environmental Sustainability, Asset Management, and Risk & Opportunities) suggests that these topics are featured extensively throughout the document.

DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	Recognition of Physical Climate Change in the Document The Wales and Western CP7 Strategic Business Plan explicitly recognizes physical climate change as a significant issue, emphasizing its impact on railway operations and infrastructure. The document outlines several strategies and investments aimed at mitigating these effects: 1. Weather Resilience and Climate Change Adaptation The plan acknowledges the growing impact of climate change on railway operations, including extreme weather events. It commits to delivering resilience schemes and establishing long-term adaptation pathways to ensure a safe and reliable network for customers. High-risk locations are prioritized for these interventions 1. A specific investment of £27 million is allocated for weather resilience and climate change adaptation, informed by resilience assessments 1. 2. Asset Vulnerability Assessments The document mandates assessments of resilience against all possible types of extreme weather events across all asset classes. This ensures that the infrastructure can withstand adverse conditions within the available funding envelope 1. 3. Operational Railway Collaboration Collaboration with the weather risk task force is highlighted as a key strategy to enhance the resilience of the operational railway. This involves improving response mechanisms to ensure passengers and freight users can rely on services during extreme weather conditions 1. 4. Environmental Sustainability Goals The plan integrates climate change adaptation into its broader sustainability objectives, aligning with Welsh and UK government targets. It emphasizes the importance of reducing emissions and conserving biodiversity as part of its environmental strategy 1. 5. Stakeholder Priorities Stakeholder feedback consistently highlighted the need for weather resilience and climate change adaptation as top priorities. Severe weather events witnessed in recent years have underscored the necessity of these measures 1. Summary The Wales and Western CP7 Strategic Business Plan clearly recognizes physical climate change as a pressing issue. It addresses this through: - Dedicated investments in weather resilience and climate change adaptation. - Comprehensive asset vulnerability assessments. - Collaboration with task forces to enhance operational resilience. - Alignment with government sustainability targets. - Incorporation of stakeholder priorities emphasizing climate adaptation. Additional Context This recognition reflects a proactive approach to safeguarding railway infrastructure against the impacts of climate change. By prioritizing resilience and adaptation, the plan aims to ensure long-term reliability and safety for passengers and freight users, while also contributing to broader environmental sustainability goals.
--------	---	---

		6	🔍 Findings on Mentions of Climate Change and Related Keywords The document contains extensive references to climate change and related topics, though the exact phrase "physical climate change" does not appear. However, related terms such as "climate change," "weather resilience," and "climate adaptation" are frequently mentioned. Key Mentions: Weather Resilience and Climate Change Adaptation: The document discusses investments in weather resilience and climate change adaptation, with a planned budget of £27 million. These investments aim to address the growing impact of climate change on railway infrastructure and ensure a reliable network for customers. Specific initiatives include: Resilience schemes for high-risk locations. Long-term adaptation pathways. Collaboration with the weather risk task force to enhance operational railway resilience. Climate Change and Environmental Challenges: The document highlights the importance of managing environmental risks to ensure a sustainable railway that meets local and global environmental challenges. Strategic Risks Related to Climate Change: The document identifies the failure to manage adverse weather and environmental challenges as a risk. This includes potential safety impacts, train performance issues, and reputational damage. Sustainability and Decarbonization: The plan emphasizes the role of the railway in achieving net-zero carbon emissions by 2050. Initiatives include renewable energy acquisition, zero-emission vehicles, and sustainable infrastructure. Stakeholder Priorities: Stakeholders have identified weather resilience and climate change adaptation as top priorities for CP7. Approximate Frequency: The term "climate change" and related keywords (e.g., "weather resilience," "climate adaptation") appear dozens of times throughout the document, particularly in sections discussing environmental sustainability, risks, and strategic priorities. ☑ Summary The exact phrase "physical climate change" does not appear in the document. However, climate change and related concepts are extensively discussed, with a strong focus on weather resilience, climate adaptation, and environmental sustainability. The document outlines significant investments and strategies to mitigate the impacts of climate change on railway infrastructure. 📖 Additional Context The document reflects a comprehensive approach to addressing climate-related challenges, aligning with government and stakeholder priorities. It emphasizes the importance of long-term planning and collaboration to ensure the railway's resilience against extreme weather events and environmental changes.
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	6	• Yes. The CP7 Plan explicitly discusses climate change as it relates to extreme weather and environmental impacts. In several sections the plan details "weather resilience and climate change adaptation" measures, demonstrating that the physical impacts of climate change are acknowledged as a significant risk for the railway's infrastructure and operations. • The document is extensive and climate-related themes appear repeatedly. Exact counts are challenging without a dedicated digital text-analysis tool; however, key phrases such as "climate change," "weather resilience," and "climate change adaptation" are mentioned multiple times (for example, in the context of funding allocations – e.g. a £27m investment – and in broader sections on environmental sustainability). Overall, it is clear that such terminology appears frequently (likely on the order of 10–15 distinct mentions or more), underscoring its importance in the plan.
DOC-11	Southern Region: CP7 Region Strategic Business Plan	6	• Yes. The document explicitly recognizes physical climate change as a significant risk. • It integrates climate change concerns within its overarching approach—most notably by including a dedicated "Weather Resilience and Climate Change Adaptation Plan" (Annex 2) that outlines long-term adaptation pathways, illustrating that climate change is a core element of the asset management and risk planning processes. • Multiple references are found throughout the plan, especially in sections discussing weather resilience and adaptation. • Although an exact count isn't provided, the key terms (for example, "climate change," "weather resilience," and "adaptation") appear in several distinct sections—suggesting that climate-related topics are a recurring theme (likely more than 10 instances across the document).

DOC-12	Scotland Region: CP7 Region Strategic Business Plan	6	The document clearly recognises physical climate change as a critical issue by contextualising it within the operational risks for rail infrastructure. It emphasizes that changing weather patterns are not just isolated incidents but form part of a broader, systemic shift that affects asset performance over time. The narrative integrates historical observations and future trends, indicating that climate change is not a distant threat but an immediate concern affecting planning and investment decisions. • Evidence & Examples: References to past severe weather events serve as case studies to highlight vulnerabilities, with discussions on how past incidences of extreme rainfall and flooding have disrupted operations. The plan also contextualises the urgency by linking climate change with long-term strategic imperatives, such as sustainability targets and compliance with emerging regulatory requirements. The document deploys a series of climate-related keywords such as "climate change," "extreme weather," "weather resilience," and "Climate Ready Plan" across multiple chapters. Although an exact numerical frequency isn't mentioned, the recurring use of these terms reflects their centrality to the strategic narrative, signaling that climate change is deeply embedded in the decision-making framework. • Implications for Communication: This repetition ensures that stakeholders, including technical teams, management, and external partners, are constantly reminded of the potential impacts and the need for adaptations in operational procedures. It enhances the document's focus on resilience, using these keywords as anchors for broader discussions on risk assessment and management practices.
DOC-13	Eastern Delivery Plan - Year 2 Update	5	The document acknowledges physical climate change and its impacts in several ways: Weather Resilience and Asset Management: The document highlights the need to improve weather resilience plans as part of its strategic objectives. This includes mitigating external factors such as adverse weather conditions that affect train service delivery and infrastructure performance 1. Investments are planned to enhance asset resilience to flooding, wind, and heat, focusing on drainage, earthworks, signalling, and electrification systems. Approximately £0.4 billion is allocated to weather resilience initiatives 1. Sustainable Growth Objectives: The document sets ambitious goals to manage climate risks and the impact of extreme weather events. It aims to incorporate climate resilience into infrastructure projects and operational strategies wherever funding allows 1. Specific initiatives include integrating water management systems to address flooding risks and targeting interventions at sites prone to earthwork failures or persistent wet formations 1. Strategic Planning and Climate Adaptation: The plan emphasizes the importance of adapting to the growing impacts of climate change, particularly in the context of an aging asset base. This involves prioritizing refurbishments and targeted life extensions over full renewals to maintain infrastructure sustainability 1. Biodiversity and Environmental Goals: Efforts to enhance biodiversity and achieve net-zero carbon emissions by 2050 are outlined. These goals align with broader climate resilience strategies, aiming to reduce carbon emissions and improve environmental sustainability 1. Summary Yes, physical climate change is explicitly recognized as an issue in the document. It addresses the challenges posed by extreme weather events and outlines strategies to enhance weather resilience, adapt infrastructure, and manage climate risks. Investments and initiatives are aligned with sustainability and climate adaptation goals. Additional Context The document reflects a proactive approach to integrating climate resilience into operational and strategic frameworks. This recognition underscores the importance of addressing climate change impacts in infrastructure planning and delivery.

DOC-14	North West and Central Delivery Plan - Year 2 Update	4	The North West & Central CP7 Delivery Plan explicitly recognizes physical climate change as a significant issue and integrates it into various aspects of its strategy and operations. Here are the key points: 1. Weather Resilience and Climate Change Adaptation (WRCCA) The document highlights the importance of weather resilience and climate change adaptation plans. These initiatives aim to prepare the railway infrastructure for the increasing impacts of severe weather events and climate change 1. Specific measures include: Renewing priority assets such as scour protection and drainage systems to enhance resilience. Investing in technologies like digital lineside inspection, extreme weather management tools, and slope monitoring equipment to forecast and manage risks effectively 1. 2. Environmental Stewardship Goals The plan emphasizes improving environmental stewardship to support decarbonization and optimize social value. It aligns with Network Rail's Sustainability Strategy and aims to deliver environmental benefits 1. Goals include: Achieving net zero carbon emissions by 2050. Preparing the railway to minimize climate change impacts by 2050. Achieving biodiversity net gain by 2035 1. 3. Impact of Climate Change on Asset Management The document acknowledges that climate change is increasing the risk to infrastructure, particularly through severe weather events. For example: Earthworks schemes target sites at high risk from adverse weather (e.g., Ashton Heath and Worleston Embankment) 1. Drainage renewals focus on areas prone to flooding, leveraging innovative surveying methods for quick decision-making 1. 4. Integration with Broader Sustainability Goals The plan integrates climate adaptation into its broader sustainability framework, ensuring environmental and social outcomes are part of operational, maintenance, and renewal strategies 1. It also emphasizes the importance of transitioning to zero-emission road fleets and adopting circular economy principles 1. Summary Yes, physical climate change is recognized as an issue in the North West & Central CP7 Delivery Plan. The document outlines comprehensive strategies for weather resilience, climate adaptation, environmental stewardship, and sustainability. These measures are integrated into asset management, operational planning, and long-term goals to mitigate the impacts of climate change on the railway infrastructure. Additional Context The emphasis on climate change in this document reflects the growing importance of sustainability in infrastructure planning. By addressing severe weather risks and decarbonization, the plan aligns with national and global environmental targets. This approach not only ensures the railway's reliability but also contributes to broader societal benefits, such as reduced carbon emissions and enhanced
DOC-15	Wales and Western Delivery Plan - Year 2 Update	4	It seems you're inquiring about whether the issue of physical climate change is acknowledged in the attached document, which is the "Wales & Western CP7 Delivery Plan." Let me provide a detailed response based on the document's content.  Recognition of Physical Climate Change in the Document Yes, physical climate change is explicitly recognized as a significant issue in the "Wales & Western CP7 Delivery Plan." The document highlights several ways in which climate change impacts the railway system and outlines strategies to address these challenges. Below are the key points: 1. Acknowledgment of Climate Change Impacts The document acknowledges the growing impact of climate change on the railway network, including risks such as extreme weather events and their consequences on infrastructure and operations. It emphasizes the need for weather resilience and climate change adaptation to ensure a safe and reliable railway system for passengers and freight users. 2. Weather Resilience and Adaptation Plans A dedicated weather resilience and climate change adaptation plan is in place. This plan includes: Delivering resilience schemes for high-risk locations. Establishing long-term adaptation pathways to mitigate risks from adverse weather conditions. Collaboration with Network Rail's national weather risk task force is also highlighted to enhance operational resilience. 3. Sustainable Development Actions The plan integrates climate change considerations into broader sustainability initiatives, such as: Decarbonization efforts to reduce emissions. 4. Asset Management and Infrastructure Transitioning to zero-emission vehicles (ZEVs) and exploring alternative energy sources like hydrogen. Renewable energy projects, including using unused land and roof spaces for energy generation. 4. Asset Management and Infrastructure The document outlines investments in earthworks failure detection equipment and geotechnical instrumentation to proactively manage risks from extreme rainfall and other climate-related events. It also mentions the use of remote condition monitoring to improve resilience against climate impacts. 5. Stakeholder Priorities Stakeholders have identified weather resilience and climate change adaptation as a top priority, and the plan reflects this through dedicated expenditures and initiatives. 6. Metrics and Goals Specific goals include improving biodiversity by 4% and reducing carbon emissions by 21% during the CP7 period. These efforts align with the UK and Welsh Governments' legislative requirements for environmental sustainability. Summary The "Wales & Western CP7 Delivery Plan" explicitly recognizes physical climate change as a critical issue. It outlines comprehensive strategies to address its impacts, focusing on resilience, adaptation, and sustainability. Key initiatives include weather resilience schemes, decarbonization efforts, and investments in climate-adaptive infrastructure. Additional Context

			This recognition aligns with broader governmental and societal goals, such as achieving net-zero carbon emissions by 2050 and enhancing the reliability of critical infrastructure in the face of increasing climate risks. The document demonstrates a proactive approach to integrating climate considerations into railway operations and planning.
DOC-16	Southern Delivery Plan - Year 2 Update	4	Recognition of Physical Climate Change in the Document Yes, physical climate change is explicitly recognized as an issue in the document. It is addressed under the broader context of sustainability and resilience planning. Here are the key points: Climate Resilience Program: The document outlines a dedicated "climate resilience programme" aimed at building and maintaining a railway system resilient to severe weather events and climate change. Specific initiatives include: - Collaborative efforts across the industry to reduce weather-related risks to railway safety and performance. - Long-term planning and climate-focused investment decisions to enhance asset resilience during severe weather events. - Delivery of the CP7 Weather Resilience and Climate Change Adaptation (WRCCA) Plan, which includes creating long-term climate adaptation pathways for vulnerable locations across the network 1. Sustainability Objectives: The document emphasizes integrating sustainability into railway design, construction, and maintenance to address climate change impacts. It commits to achieving net-zero carbon emissions by 2050 and improving climate resilience as part of its sustainable growth objectives 1. Key Initiatives for Climate Resilience: The document highlights specific actions to mitigate the effects of climate change, such as: - Improving energy efficiency and transitioning to renewable energy sources. - Enhancing biodiversity and implementing habitat management plans to support ecological resilience. - Developing strategies to manage risks associated with severe weather, such as flooding and heatwaves 1. Alignment with Broader Goals: The plan aligns with national and regional sustainability targets, addressing both regulated objectives and stakeholder priorities to tackle climate-related challenges 1. ☒ Summary The document explicitly recognizes physical climate change as a significant issue. It incorporates comprehensive strategies to enhance climate resilience, reduce carbon emissions, and adapt to severe weather events. These efforts are integrated into the broader sustainability and operational goals for the railway system.  Additional Context The focus on climate resilience reflects a proactive approach to mitigating risks associated with climate change, ensuring the railway system remains safe, reliable, and sustainable. This aligns with global efforts to address the environmental impacts of infrastructure and transportation networks.

DOC-17	Scotland Delivery Plan - Year 2 Update	Yes, physical climate change is explicitly recognized as an issue in the attached document. The document outlines several initiatives and strategies to address the impacts of climate change on Scotland's Railway. Below are the key points that highlight this recognition: ### 🕒 Key Highlights Climate Action Plan: The document includes a comprehensive Climate Action Plan under five themes: climate ready, net zero, biodiversity, environmental management, and social value. This plan aims to deliver resilience against extreme weather and longer-term climate changes 1. Resilience Against Extreme Weather: There is a specific focus on improving the resilience of railway assets against extreme weather events. This includes developing climate science and adaptation capabilities to strengthen decision-making processes. A long-term climate change adaptation strategy is also being developed, based on innovative adaptation pathways 1. Investment in Critical Assets: The document acknowledges the increasing impact of climate change, particularly rainfall, which affects Scotland's rail network more significantly than England and Wales. Collaborative efforts have been made to identify critical drainage and earthworks assets for increased investment to manage network resilience 1. Climate Change and Risks: Climate change and extreme weather are explicitly listed as risks that could impact both safety and performance. The document cites recent events, such as Storm Eowyn, as reminders of the physical and financial impacts of extreme weather on infrastructure 1. Adaptation Pathways Project: The adaptation pathways project is highlighted as a novel approach to resolve uncertainties regarding the extent of climate change and to prepare for multiple future scenarios. This initiative reflects a proactive stance in addressing the challenges posed by physical climate change 1. Summary The document clearly recognizes physical climate change as a significant issue. It outlines strategic initiatives, including resilience-building, adaptation planning, and investment in critical infrastructure, to mitigate the impacts of climate change on Scotland's Railway. These efforts demonstrate a commitment to addressing both immediate and long-term challenges posed by changing climate conditions. Additional Context The recognition of physical climate change aligns with broader sustainability goals, such as achieving net-zero emissions by 2045 and halting biodiversity loss by 2030. The proactive measures outlined in the document not only aim to protect infrastructure but also contribute to Scotland's climate commitments and environmental stewardship.
DOC-18	GB - CP7 Delivery Plan - Year 2 Update	Recognition of Physical Climate Change in the Document The document explicitly recognizes physical climate change as a critical issue and outlines several strategies and investments to address its impacts. Below are the key points: 1. Acknowledgement of Climate Change Impacts The document highlights the increasing challenges posed by the frequency and intensity of extreme weather events, which are attributed to climate change. It notes that many railway assets were not originally designed to withstand such conditions 1. It emphasizes the need for climate change adaptation strategies to ensure the railway infrastructure is resilient and fit for future conditions 1. 2. Investment in Resilience A significant investment of £2.6 billion is planned over the CP7 period to improve the resilience of railway assets to extreme weather events. This includes: - Track assets to reduce heat-related risks like track buckling. - Drainage systems to mitigate flooding risks. - Earthworks to prevent landslips 1. 3. Organizational and Process Changes The establishment of a Weather Resilience and Climate Change team within the System Operator function is noted. This team is tasked with embedding climate change considerations into standards, processes, and operational work 1. The Weather Risk Task Force (WRTF) is actively working on tools and processes to better manage risks from extreme weather events, such as targeted weather interventions to avoid unnecessary disruptions 1. 4. Broader Sustainability Goals The document aligns climate resilience efforts with broader sustainability goals, such as reducing carbon emissions, achieving biodiversity net gains, and improving air quality 1. ☒ Summary Yes, the document explicitly recognizes physical climate change as a significant issue. It outlines both the challenges posed by extreme weather and the strategic investments and organizational changes being implemented to mitigate these impacts. The focus is on ensuring the railway infrastructure is resilient and sustainable in the face of climate change. 🕒 Additional Context This recognition aligns with global trends in infrastructure planning, where resilience to climate change is becoming a central focus. The proactive measures outlined in the document, such as significant financial investment and process improvements, reflect a commitment to addressing these challenges comprehensively.

DOC-19	System Operator CP7 Delivery Plan	3	established to improve resilience and decision making in light of climate impacts over the long term, with partnerships (e.g. with the Met Office) that are specifically aimed at understanding and adapting to climate-related risks. • The document references related terms multiple times. Keywords such as “climate impacts,” “climate change adaptation,” “extreme weather,” and “weather risk” appear throughout. Based on the content reviewed, there are roughly five distinct instances where these types of terms are mentioned. (This count is approximate given the document’s length and frequency of related references.)
DOC-20	The CP7 Buildings & Architecture Policy (2021)	4	change,” its physical impacts are acknowledged as one of several factors influencing asset management. – The document makes multiple references to climate-related themes (for example, “climate emergency,” “net zero,” “decarbonisation,” and mentions of flooding/drought as part of resilience). However, an exact numerical count of occurrences for “physical climate change” and related keywords is not provided. A manual review suggests that while these terms are not always used verbatim, climate-related language appears several times throughout the text.
DOC-21	“Additional information for asset managers” (2025)	4	• Recognition of the Challenge: The document clearly acknowledges the broader climate emergency. It emphasizes the need for sustainable asset management, decarbonisation, and resilience in the face of a changing climate. • Contextual Framing: Phrases like “climate emergency,” “net zero carbon target” and references to sustainable construction show that climate change is an important driver behind many of the policy’s strategic objectives. • Implication for Assets: While the focus is broader—interweaving climate considerations with aspects like energy performance and long-term asset degradation—the document does consider the impacts of environmental change in its framework. • Frequent References: Exact numerical counts can be challenging given the document’s length and complexity. • Key Terminology: Terms such as “climate emergency,” “climate change,” “net zero,” and “decarbonisation” appear multiple times throughout. • Estimation Approach: Although an exact count isn’t provided, a careful review indicates several explicit mentions (at least on the order of several distinct references) that shape the policy’s environmental and sustainability ambitions.
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authority	0	• The document primarily focuses on a carbon neutral built environment, promoting sustainable asset engineering and design excellence. It does highlight initiatives like “Carbon Zero Asset Engineering” which relate to environmental performance. • However, physical climate change as a specific issue (i.e. its direct physical impacts such as temperature extremes, flooding, or wind hazards) is not explicitly recognized or discussed in the content we reviewed • A review of the provided text shows no explicit mention of the phrase “physical climate change” or closely related key terms such as “climate hazards” in a direct context. • While there is a clear focus on sustainability via carbon neutrality, the specific wording related to physical climate impacts appears to be absent, suggesting that counts for terms specifically addressing physical climate change are nil
DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	7	Not used AI as it is a sensitive document.
DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	0	Not used AI as it is a sensitive document.
DOC-25	RSSB’s Climate adaptation maturity in GB rail (September 2024)	4	• The document consistently addresses “climate change” by evaluating the rail sector’s adaptive capacity and improvement in response levels over time. • However, it primarily focuses on the methodologies for adaptation and overall climate change risks rather than specifically discussing “physical climate change” as a separate or distinct issue. • In summary, while climate change is clearly a central topic, the report does not explicitly break out the physical aspects of climate change (for example, direct impacts like flooding or extreme heat) as a separate issue. • The report contains numerous references to “climate change” and “adaptation” in describing how organisations are improving their adaptive capacity. • There is no clear, countable mention of the specific phrase “physical climate change.” • It is evident that related key terms (such as “climate adaptation,” “adaptive capacity,” and “climate change activity”) appear repeatedly; however, an exact count is not explicitly provided in the document. • In essence, while references to climate change are frequent, there are no precise tallies for physical climate change or its synonyms provided within the text.
DOC-26	The Design Council’s “The Value of Design to UK Rail Infrastructure” (2021)	0	• Searching for keywords related to “physical climate change” (or explicit hazard terms such as flooding, heat waves, storm impacts) shows that while the document uses terms like “climate” in the context of environmental sustainability and net-zero strategies, it does not appear to count or highlight these as physical hazard risks. In essence, direct references to physical climate change threats are minimal or effectively absent.
DOC-27	“CP7 Frameworks for Building and Civils Renewals Works” (March 2022)	0	• The document is a procurement notice for various network rail works covering structures, geotechnical, drainage, and buildings. There is no explicit recognition or discussion of physical climate change as an issue. • No language surrounding climate concerns, such as “global warming,” “climate change,” or its impacts, is evident in the text. • Based on the search and review of the document content, there are no instances where physical climate change or its related key terms are mentioned. Hence, the count is effectively zero.
DOC-28	NR’s ‘The Greener Railway Strategy’ (May 2025)	3	• Yes, the document explicitly recognises physical climate change as a matter of concern. It discusses the need to assess climate change risks and integrate weather and climate resilience as a central part of planning and operational response. For example, one section notes that a “comprehensive assessment of physical climate change risks to our assets” is undertaken in support of adaptation plans 1. • The document contains numerous references to “climate change” as well as related terms such as “extreme weather,” “adverse weather,” and “changing climate.” • In terms of the specific phrase “physical climate change,” it is explicitly mentioned at least once (in the context of assessing risks to assets). • Additionally, related keywords appear repeatedly across multiple sections; however, a precise count is not directly provided in the text.

DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	4	• Yes. The document explicitly includes "Prepared for a Changing Climate" as one of its main sustainable rail topics. It discusses climate change adaptation, resilience, and the need to prepare rail systems for extreme weather conditions, thereby recognizing the physical impacts of climate change on rail operations and infrastructure 1. • The document contains frequent references to "climate change," "adaptation," "resilience," and "extreme weather" throughout its various sections. Although an exact numerical count is not provided, these key terms are embedded throughout the strategic ambitions and discussions, indicating an extensive emphasis on climate-related issues 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	7	recognize that increasing temperatures and more frequent extreme heat events (likely driven by a changing climate) directly affect infrastructure. • The document is replete with climate-related terminology such as "extreme heat," "hot weather," "high temperatures," and "climate resilience" throughout its extensive discussion on failure modes, maintenance challenges, and adaptation strategies. An exact numerical count of occurrences isn't provided, but a detailed textual analysis would reveal that such key words appear numerous times—as the report is fundamentally focused on addressing heat-related risks.
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	7	• Yes – the report makes reference to the "onset of significant climate change" and notes that extreme weather events (including record hot weather) are increasingly foreseeable given recent trends. This suggests that long-term shifts in climate are acknowledged as part of the operational challenge. • The explicit term "climate change" appears very sparingly (only one or two explicit mentions are noted). • However, terms and phrases closely related—such as "extreme heat", "hot weather", "adverse weather", and "extreme weather events"—are pervasive throughout the report, indicating that while the label "physical climate change" might not be used repeatedly, its manifestations are a central theme.
DOC-32	EHTF Weather and Climate Change Report (March 2023)	7	• The report clearly recognizes physical climate change as a major driver behind the extreme heat events experienced in the UK. • It frequently discusses global warming trends and the impacts of anthropogenic emissions on increasing average and extreme temperatures, indicating that physical climate change is central to the document's narrative. • While the report does not explicitly provide a word frequency count, a detailed review shows that related keywords—such as "global warming," "climate change," "climate risk," and "warming"—appear extensively throughout the text. • Based on our review of many passages, these key terms are interwoven into discussions of heatwaves, temperature projections, and future climate scenarios, suggesting that the concept is reinforced numerous times (likely dozens of instances given the document's length).
DOC-33	352_WSFData_2025202607 Final - Building Only	0	Not used AI as it is a sensitive document.

AI Agent Summary - Q2: Are specific climate related hazards recognised for the subject matter document?

Prompt	Focus on just the content in the attached PDF document and answer this question: Are specific climate related hazards recognised for the subject matter document?		
Doc Ref	Document name	Score	Document detail
DOC-01	The NR Climate Projections Guidance Note (2023)	6	The document mentions more frequent and severe heatwaves, particularly during summer months, as a result of rising maximum and minimum temperatures. The document discusses various types of flooding, including: Surface water flooding (pluvial, rainfall, or flash flooding). Groundwater flooding. River flooding (fluvial flooding). Coastal flooding (linked to sea level rise). It highlights that extreme or prolonged precipitation events and snowmelt can lead to these flooding types. Reduced summer precipitation combined with warmer temperatures is projected to increase the frequency and severity of droughts. Coastal flooding risks are exacerbated by rising sea levels and increased storm surges. The document projects an increase in the frequency and intensity of storms, particularly in summer, leading to potential impacts like severe flooding and snowfalls. While the frequency of snowfall events is expected to reduce due to warmer temperatures, extreme snowfall events remain possible in certain regions. Humidity and fog Climate change is expected to lead to increased humidity in the UK, with regional variations. Changes in fog frequency are also noted, with reductions in the south and east and increases in the north and west.
DOC-02	The WRCCA Strategy (2017) from the System Operator	6	• Hazards Identified: Specific hazards discussed include extreme temperature variations; heat waves; cold conditions and frosts; storms; heavy rainfall leading to flooding; high winds; landslips; and coastal scour – all of which impact reliability and performance. • Evidence: For example, the document notes that extreme weather events can trigger performance drops (e.g. reductions in the Public Performance Measure) and lead to costly delays as well as physical damage to assets. • Conclusion: Yes, the document clearly identifies several specific climate-related hazards relevant to rail operations
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	Yes, the document explicitly recognizes a range of climate-related hazards, including extreme heat, heavy rainfall, flooding, sea-level rise, coastal erosion, high winds, storms, and snow/ice. These hazards are analyzed in detail, with projections for their future impact and strategies for mitigation. The document also emphasizes the importance of proactive measures, such as improved monitoring, vegetation management, and infrastructure upgrades, to enhance the resilience of the railway network. The document provides a comprehensive analysis of how these hazards affect various railway assets: Track and Earthworks: Vulnerable to heat-induced buckling, desiccation, and flooding. Drainage Systems: Prone to failure during heavy rainfall and flooding. Overhead Line Equipment (OLE): Susceptible to high temperatures and wind damage. Structures: At risk of scour, erosion, and damage from storm surges. Vegetation: Longer growing seasons and tree diseases increase the risk of falling trees and debris during storms. Heatwaves and Extreme Heat: Increased frequency and severity of heatwaves, with projections of annual heatwaves of at least one week with temperatures exceeding 29°C. By 2034, the region could experience up to four extreme heat events per control period, with temperatures reaching 40°C or higher. Impacts include: Track buckling due to high temperatures. Heat-related degradation of electrical and overhead line equipment (OLE). Worker and passenger discomfort during extreme heat. Desiccation of clay embankments and soil cuttings, leading to track geometry issues and potential safety risks. Increased risk of wildfires and associated hazards, such as smoke affecting signal visibility. Heavy Rainfall and Flooding: Total rainfall from extremely wet days has increased by approximately 17% in the last decade. More frequent and intense rainfall events are expected, leading to: Increased risk of flash flooding and surface water flooding. Riverbank and structural erosion. Damage to drainage systems, track, and other railway assets. Groundwater flooding, particularly in tunnels and cuttings. Challenges from third-party water management, where floodwaters drain onto railway land. Rising Sea Levels: Sea levels around the UK have risen by 18.5 cm since 1900, with over 60% of this rise occurring in the past 30 years. Projections indicate significant sea-level rise by the 2070s, increasing the risk of:

			Storm surges and overtopping. Coastal erosion affecting low-lying areas like the Norfolk Broads and estuaries. Scour hazards on coastal and estuarine embankments. Tidal Surges: Increased frequency and intensity of tidal surges, particularly impacting the Humber and Tees estuaries. High Winds and Storms: Increased frequency and intensity of winter storms, with potential for: Wind damage to overhead lines and structures. Falling trees and debris on tracks and overhead lines. Damage to stations and other infrastructure during storms. Vegetation Management: Longer growing seasons and tree diseases (e.g., ash dieback) increase the risk of falling trees during storms, impacting safety and operations. Reduced Snowfall: Warmer temperatures are expected to reduce the frequency and impact of snow events. However, extreme winter weather remains a possibility. Snow and ice can still cause disruptions, including frozen points and blocked routes. Combinations of Hazards: The document highlights the potential for combined hazards, such as: High winds followed by flooding, complicating maintenance and recovery efforts. Desiccation of earthworks leading to rapid track geometry issues during heatwaves. Increased storm intensity and frequency, exacerbating the risk of coastal erosion and flooding.	
DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	The document explicitly recognizes a wide range of climate-related hazards, including precipitation and flooding, excessive heat, storms, high winds, snow, ice, sea level rise, coastal erosion, autumn leaf fall, lightning strikes, and fog. These hazards are systematically assessed for their impact on railway infrastructure, operations, and safety. The attached "Weather Resilience & Climate Change Adaptation Plan" highlights the following impacts of climate-related hazards on railway infrastructure: Flooding: Causes track washouts, embankment failures, and damage to bridges and drainage systems. Heat: Leads to track buckling, sagging overhead lines, and increased fire risks. Storms and Winds: Results in tree strikes, structural damage, and coastal erosion affecting railway assets. Snow and Ice: Disrupts operations by damaging electrical systems and causing slips and falls. Sea Level Rise: Threatens coastal tracks and infrastructure through inundation and erosion. Lightning and Fog: Impacts signaling systems and reduces operational safety. These hazards compromise safety, reliability, and the longevity of railway assets, necessitating proactive resilience measures. Track Buckles: High temperatures cause rail deformation, requiring dynamic management and speed restrictions. Overhead Line Equipment (OLE): Heat-induced sagging and dewirements. Lineside Fires: Increased frequency due to prolonged dry periods. Vegetation Mortality: Heat stress impacts vegetation, leading to obstruction risks and fire hazards. Heavy Rain: Leads to infrastructure flooding, track washouts, and damage to structures such as bridges due to scour. Intense Rainfall Events: Projected to increase fivefold by the century's end, causing drainage systems to be overwhelmed and water accumulation on tracks. River Flooding: Increased peak flows and flashy flow regimes exacerbate flood risks to railway assets. Groundwater and Surface Water Flooding: Causes embankment failures and structural damage. Inundation of Coastal Assets: Rising sea levels threaten railway tracks, tunnels, and electrical equipment. Erosion: Coastal defenses are overwhelmed, leading to structural instability and asset loss. Wind Damage: High winds cause tree strikes on OLE, track obstructions, and structural damage to buildings and canopies. Storm Surges: Coastal flooding and erosion from extreme storms impact railway assets, especially along the Cumbrian coastal line. Ice Formation: Impacts tunnels, conductor rails, and overhead line equipment, leading to operational disruptions. Snow Accumulation: Causes structural stress on roofs and platforms, increasing risks of slips and falls.	

DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	Yes, the attached Wales & Western CP7 WRCCA Plan explicitly recognizes a comprehensive range of specific climate-related hazards. These include flooding (river, surface, groundwater, coastal), sea level rise, extreme temperatures, storms, high winds, lightning, soil moisture extremes, snow and ice, vegetation hazards, and erosion. Each hazard is analyzed in terms of its impact on rail infrastructure, supported by historical data, climate projections, and detailed risk registers. The plan also details adaptation and resilience measures to address these hazards 1. • Flooding: Causes track washouts, embankment failures, and submersion of assets, leading to service disruptions and costly repairs. • Coastal Erosion & Sea Level Rise: Threatens coastal railways with overtopping, erosion, and loss of structural support. • Extreme Temperatures: High heat can buckle tracks and damage overhead lines; cold spells lead to frost heave, ice formation, and equipment failures. • Storms & High Winds: Result in fallen trees, debris on tracks, and damage to structures, impacting safety and reliability. • Lightning: Disrupts signalling and power systems, posing risks to operations and staff. • Soil Moisture Extremes: Drought and saturation destabilize embankments, causing subsidence and landslips. • Snow & Ice: Block points, freeze switches, and create hazards for staff and passengers. • Vegetation Hazards: Increased risk of tree falls and leaf contamination, affecting train adhesion and detection systems. • Erosion: Undermines structures and exposes buried assets, increasing maintenance needs High Temperatures: Track buckling, overhead line equipment (OLE) sagging, electronic component failures, and increased risk of wildfires. Low Temperatures: Frost heave, ice formation in tunnels, snow/ice accumulation affecting points and signals, and increased risk of slips and falls for staff and passengers 1. Types: Fluvial (river), pluvial (surface water), groundwater, and coastal flooding. Impacts: Track washouts, embankment failures, submersion of assets, service disruptions, and increased maintenance costs. Examples: Recurrent flooding at Wootton Bassett, washouts at Welshpool, Llanrwst, and Pandy, and coastal overtopping events 1. 7 Impacts: Overtopping of sea defences, erosion of embankments, and direct threat to coastal railways, especially in Wales and the Western route. Management: Reference to Shoreline Management Plans (SMPs) and adaptation pathways 1. Impacts: Fallen trees and debris on tracks, damage to structures (roofs, canopies, signage), blown containers, and operational restrictions. Historical Events: Storms Barney, Doris, and Arwen are cited as examples of disruptive high-wind events 1. Impacts: Blocked points, frozen switches, snow ingress into rolling stock, visibility issues, and increased accident risk for staff and passengers 1. Lightning: Impacts: Failure of signalling and power distribution equipment, risk to staff safety, and potential for catastrophic but rare events. Risk Management: Increased storm frequency and severity are anticipated, with mitigation strategies in place 1. Soil moisture extremes (drought and saturation) Drought: Shrink/swell in clay embankments leading to subsidence and track misalignment. Saturation: Increased risk of landslips, embankment instability, and drainage system overload 1. Heavy Rain/Cloudbursts: Sudden track flooding, asset failures. Large Diurnal Temperature Ranges: Stress on electronic and mechanical components. Intense Rainfall: Increased silt deposition, drainage overload 1.
--------	--	---

DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	Yes, the document explicitly recognizes a wide range of specific climate-related hazards that pose risks to the Southern Region's railway infrastructure. These include heat, flooding, subsidence, cold/snow/ice, wind/storms, sea level rise, and other hazards like adhesion, fog, and lightning. Each hazard is analyzed in terms of its current and future impact, with detailed projections based on climate models (e.g., UKCP18). Impacts: Increased risk of track buckling, leading to derailments and speed restrictions. Overheating of trackside equipment and systems, such as signaling location cases. Desiccation of soil cuttings and shrinkage of clay embankments, causing track geometry deterioration. Increased risk of trackside fires due to high temperatures and vegetation. Challenges to workforce and passenger safety due to extreme heat and lack of air conditioning. Projections: Mean maximum daily temperatures are expected to increase significantly, with summer temperatures rising by 4.8°C to 5.9°C by the 2050s and up to 8.3°C by the 2080s. Impacts: Increased rainfall intensity and frequency, leading to overwhelmed drainage systems and track flooding. Damage to electrical systems and signaling equipment due to water submersion. Destabilization of earthworks, leading to landslips. Increased scour on bridges and piers due to higher river flows. Projections: Wet winters with increased rainfall (e.g., 53.2% increase in January by the 2050s). Increased risk of flash floods during intense summer rainfall after dry periods. Impacts: Coastal flooding and erosion threatening railway infrastructure along coastal lines. Rising sea levels causing challenges for flood defences and drainage systems. Projections: Sea levels in the southeast are expected to rise by approximately 35 cm by the 2050s and 53 cm by the 2070s. Impacts: High winds causing trees and debris to fall onto tracks, leading to blockages and damage. Coastal erosion and sea spray impacting coastal railway lines. Temporary speed restrictions during high winds to prevent accidents. Projections: While specific projections for wind conditions are uncertain, the document notes an increase in storm frequency and intensity. Impacts: Ice formation on conductor rails, points, and tunnels, causing operational disruptions. Snow accumulation blocking lines and obscuring signals. Freeze-thaw cycles leading to structural degradation and frost damage. Staff welfare concerns, including risks of hypothermia and fatigue. Projections: Winters are expected to be warmer overall, with shorter periods of frost and snow. However, extreme cold events will still occur, posing risks to railway operations. Subsidence and earthwork failures Impacts: Prolonged saturation and drying cycles leading to earthwork failures. Long-term degradation of embankments and cuttings, causing safety and performance risks. Landslips due to erosion and waterlogging. Projections: Higher risk of failures due to increased rainfall and soil moisture deficit (SMD). Adhesion: Issues caused by leaf fall, moisture, and oils on tracks, leading to traction loss and delays. Fog: Reduced visibility obscuring signals. Lightning: Damage to track circuits, signaling systems, and power supply due to lightning strikes.
--------	--	---	---

DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)		Yes, the document explicitly recognizes a range of climate-related hazards, including meteorological, hydrological, geophysical, environmental, and combination events. These hazards are analyzed in detail, with projections for their future impact and strategies for mitigation. The document emphasizes the importance of proactive measures, such as improved monitoring, vegetation management, and infrastructure upgrades, to enhance the resilience of Scotland's railway network. Risks include high temperatures causing track buckling, sagging of overhead line equipment (OLE), and expansion of conductors and insulators. Seasonal temperature variations can lead to freeze-thaw cycles and long-term degradation of earthworks. Extreme rainfall events can overwhelm drainage systems, cause flooding, and lead to erosion and scour. Flooding: Includes fluvial, surface water, groundwater, and coastal flooding. Impacts include inundation of structures, damage to drainage systems, and increased hydrostatic pressure leading to ground movement. Risks include coastal erosion, overtopping of sea defenses, and flooding of tunnels. 7 Risks include damage to antennas, buildings, and overhead lines, as well as falling trees destabilized by wind and rainfall. Multi-Hazard Scenarios: Examples include heavy rainfall combined with high winds leading to structural damage, or prolonged dry spells exacerbating vegetation stress and disease Ground Instability: Risks include landslides, subsidence, and erosion caused by extreme rainfall and temperature changes. Solid-Mass Hazards: Includes risks from soil moisture changes and destabilization of earthworks. Vegetation Growth and Tree Fall: Risks include increased vegetation growth leading to blocked drainage systems, tree destabilization, and leaf fall impacting operations. Wildfires: Risks heightened by drier and hotter conditions.
DOC-08	Eastern Region: CP7 Region Strategic Business Plan		Yes, the document specifically recognizes a wide range of climate-related hazards, including heatwaves, storms, flooding, rising sea levels, and geotechnical risks such as earth movement and scour. It outlines strategic measures to address these hazards, such as improving drainage systems, investing in weather resilience modeling, and incorporating climate adaptation into asset design and refurbishment. Heatwaves: Identified as a cause of soil desiccation, track buckling, and expansion of overhead line equipment (OLE). Increased Average and Maximum Temperatures: Gradual stressors that impact infrastructure over time. Heavy Rainfall and Flooding: Associated with risks of subsidence, coastal storm surges, and structural scour. Rising Sea Levels: Recognized as a long-term stressor that may exacerbate flooding and coastal erosion risks. 6 Storms and High Winds: Lead to debris falling on tracks and damage to infrastructure. Snow and Cold Weather: Result in frozen points and blocked routes. Multi-Hazard Scenarios: The document acknowledges that combinations of hazards, such as heavy rainfall and high winds, can amplify risks and impacts. Drainage Issues: Poor drainage performance is linked to repeated earthworks failures, particularly during extreme weather events. Earth Movement: Caused by varying moisture content and temperature impacts, leading to instability in earthworks and embankments. Scour on Bridges: Highlighted as a key risk, with £23 million allocated for bridge protection against scour. Vegetation Growth and Tree Fall: Increased vegetation growth can block drainage systems, and weakened trees may fall during storms. Ash Dieback: Identified as a significant risk to human health and safety, with funding allocated for mitigation efforts.
DOC-09	North West and Central Region: CP7 Region Strategic Business Plan		Yes, the document explicitly recognizes various climate-related hazards, including flooding, storms, extreme temperatures, drainage failures, earthworks instability, and vegetation-related risks. It outlines strategic measures to address these challenges, such as climate adaptation pathways, increased inspections, and targeted renewals. Extreme Temperatures: Hot weather impacts include rail buckling, while cold weather affects operational reliability. Flooding: Recognized as a major risk causing freight cancellations and infrastructure damage, particularly in high-risk areas like Peak Forest and Crewe. Coastal and Riverside Asset Risks: Higher risks of failure due to flooding, with plans to enhance resilience through targeted interventions. Storms: Associated with damage to overhead lines and vegetation management challenges. Drainage Failures: Increased risk due to extreme weather, requiring additional inspections and remediation. Earthworks Failures: Highlighted as a risk exacerbated by climate change, with targeted renewals planned to mitigate impacts. Ash Dieback: Identified as a growing risk to vegetation health and safety, requiring increased inspections and management. Vegetation Overgrowth: Increased vegetation mass poses risks to electrified routes and drainage systems.

DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	5	Yes, the "Wales and Western CP7 Strategic Business Plan" explicitly recognizes several climate-related hazards, including adverse weather, extreme weather events, asset vulnerability, vegetation risks, and drainage challenges. The plan outlines specific investments and strategies to mitigate these risks and improve resilience. Adverse weather and climate change The document highlights the failure to manage adverse weather and environmental challenges as a significant risk. It emphasizes the need for effective and sustainable actions to mitigate negative safety impacts, train performance issues, and reputational damage. Weather resilience and climate change adaptation The plan includes a dedicated investment of £27 million for weather resilience and climate change adaptation. This funding is aimed at addressing the growing impact of climate change on the railway, delivering resilience schemes, and establishing long-term adaptation pathways. Extreme weather events The document mentions the necessity for infrastructure to be resilient to extreme weather events such as flooding, storms, and other environmental challenges. Assessments of resilience to all possible types of extreme weather events across asset classes are required. Asset vulnerability The plan acknowledges the increasing vulnerability of railway assets due to climate change. It outlines strategies for providing a safe and reliable network, focusing on high-risk locations. Vegetation management The document identifies dead, dying, and diseased trees as a significant risk to safety and performance, exacerbated by adverse weather conditions. It plans to allocate £30 million for vegetation management, including the removal of hazardous trees and the use of advanced inspection technologies.
DOC-11	Southern Region: CP7 Region Strategic Business Plan	5	Yes, the "Southern Region CP7 Strategic Business Plan" explicitly recognizes specific climate-related hazards, including severe weather events, earthwork failures, vegetation risks, flooding, and asset vulnerabilities. The plan outlines strategies for mitigation, resilience, and adaptation to address these challenges. Severe weather events The plan highlights the increasing frequency and severity of weather events such as heavy rainfall, flooding, wind, and heat, which pose significant risks to the safe and reliable operation of the railway. Earthwork failures Heavy rainfall is identified as a key driver of earthwork failures, particularly at high-risk locations such as steep cuttings and tunnel portals. Vegetation risks The document addresses the risks posed by dead, dying, and diseased trees, particularly those affected by conditions like Ash Dieback, which are exacerbated by adverse weather. Drainage and Flooding The plan emphasizes the importance of drainage improvements to manage flooding risks and sustain track formation integrity. It also incorporates climate adaptation measures, such as designing for 1:25-year flood events with a 20% climate change uplift. Asset vulnerability The document recognizes the vulnerability of railway assets to climate change and commits to improving resilience through modern design standards and targeted interventions. WRCCA A dedicated Weather Resilience and Climate Change Adaptation Plan is included, focusing on: Mitigation and rapid recovery from weather events. Long-term adaptation pathways for future climate resilience. Addressing risks associated with earthworks, drainage, vegetation, and structures.

DOC-12	Scotland Region: CP7 Region Strategic Business Plan	5	Yes, the document explicitly recognizes specific climate-related hazards, including severe weather events, earthwork failures, flooding, vegetation risks, and asset vulnerabilities. It also outlines strategies for resilience and adaptation to mitigate these risks. Severe weather events; The document highlights the increasing frequency and severity of extreme weather, such as heavy rainfall, flooding, and high winds, which are major contributors to infrastructure failures and service disruptions. Earthwork failures Heavy rainfall and prolonged wet conditions are identified as key drivers of landslips and earthwork failures, particularly on steep slopes and embankments. Flooding and drainage challenges The aging drainage systems, some over 100 years old, are noted as being vulnerable to intense rainfall, leading to flooding and associated risks to track stability. Vegetation risks Climate change is exacerbating vegetation-related risks, including the impact of Ash Dieback disease, which weakens trees and increases the likelihood of tree falls during storms. Asset vulnerability The plan recognizes that many railway assets, such as bridges and culverts, are increasingly vulnerable to scour damage and other climate-related stresses due to their age and exposure to extreme weather. Climate change adaptation A dedicated "Climate Ready Plan" is included, focusing on: Enhancing the resilience of infrastructure assets to withstand climate-related impacts. Improving weather forecasting and monitoring systems. Developing long-term climate adaptation strategies.
DOC-13	Eastern Delivery Plan - Year 2 Update	2	Yes, the attached document explicitly recognizes specific climate-related hazards, including flooding, earthwork failures, vegetation risks, and scour damage. It outlines strategies to mitigate these hazards and improve infrastructure resilience. Weather resilience Investments are being made to improve resilience against flooding, wind, and heat across the asset base. This includes targeted interventions in drainage, earthworks, signaling, and electrification systems. Earthwork failures The plan addresses the risks of embankment and cutting failures due to adverse weather conditions, which can lead to delays and safety concerns. Track flooding Persistent wet formations and sites with a history of flooding are identified as areas requiring targeted drainage interventions to mitigate risks. Vegetation management Risks associated with hazardous trees and vegetation, exacerbated by climate factors such as Ash Dieback disease, are being actively managed to ensure safety and operational reliability. Scour damage Weather resilience programs include implementing scour mitigation measures at bridges and retaining wall locations susceptible to damage from extreme weather events.
DOC-14	North West and Central Delivery Plan - Year 2 Update	2	The document explicitly recognizes climate-related hazards, including severe weather impacts, flooding, and earthwork failures. It outlines specific measures under the WRCCA framework and other initiatives to mitigate these risks and adapt the railway infrastructure to climate change. The plan includes initiatives under the Weather Resilience and Climate Change Adaptation (WRCCA) framework, which aims to mitigate risks from severe weather events and prepare the railway for climate change impacts. Severe weather risks Increased risk of severe weather is identified as a challenge, with targeted interventions planned to manage this risk. This includes robust incident response and proactive use of technology to manage infrastructure. Earthworks and drainage Earthworks schemes focus on sites at the highest risk from adverse weather events, such as embankments and cuttings prone to failure. Drainage renewals target areas at high risk of flooding, recognizing the increased risk posed by severe weather. Climate change adaptation pathways Strategies are being developed for critical infrastructure locations, such as the Cumbrian Coast, Carlisle, and Euston, to enhance resilience against climate change.

DOC-15	Wales and Western Delivery Plan - Year 2 Update	2	The attached document explicitly recognizes climate-related hazards such as extreme weather, flooding, and earthworks failures. It outlines specific strategies and investments to mitigate these risks, including weather resilience initiatives, climate change adaptation measures, and infrastructure improvements. Weather resilience and climate change adaptation The document highlights weather-related incidents as a significant risk, noting their potential to cause service disruptions, increased costs, and reputational impacts. Specific investments are outlined for weather resilience and climate change adaptation, including robust incident response measures. Earthworks and extreme weather Investments are being made in failure detection equipment and geotechnical instrumentation to improve resilience against extreme weather and climate change. These measures aim to mitigate risks associated with earthworks failures due to adverse weather conditions. Drainage systems Significant investment is planned for drainage maintenance and refurbishment, particularly in areas prone to severe rainfall. For example, the Chipping Sodbury tunnel will undergo drainage refurbishment to prevent water pooling and flooding. Carbon reduction and energy efficiency The plan includes initiatives to reduce carbon emissions and transition to zero-emission vehicles (ZEVs), as well as energy interventions to reduce consumption and improve air quality.
DOC-16	Southern Delivery Plan - Year 2 Update	2	The attached document explicitly recognizes climate-related hazards such as severe weather events, flooding, and vegetation-related risks. It outlines comprehensive strategies, including resilience programs, drainage system upgrades, and vegetation management, to address these challenges effectively. Climate resilience program The document outlines a dedicated program to build and maintain a railway resilient to severe weather events and climate change. This includes: Collaborative efforts across the industry to reduce weather-related risks to railway safety and performance. Investments aimed at improving asset resilience during severe weather through long-term planning and climate-focused decisions. Implementation of the CP7 Weather Resilience and Climate Change Adaptation (WRCCA) Plan, which includes creating long-term climate adaptation pathways for vulnerable locations across the network. Drainage and flood risk The plan emphasizes the importance of drainage systems to mitigate risks from flooding, which is exacerbated by climate change. Specific actions include: Completing a drainage inventory to better understand flood risks. Refurbishing and renewing drainage systems to prevent service disruptions caused by water pooling and flooding. Vegetation and biodiversity management The document highlights the role of vegetation management in mitigating risks such as trees falling on railway tracks during extreme weather. It also integrates biodiversity initiatives to balance environmental sustainability with operational safety.
DOC-17	Scotland Delivery Plan - Year 2 Update	2	The attached document explicitly recognizes climate-related hazards such as increased rainfall, extreme weather events, and risks to drainage and earthworks assets. It outlines specific strategies, including resilience programs, adaptation pathways, and vegetation management, to mitigate these hazards effectively. Impact of climate change The document acknowledges that climate change, particularly increasing rainfall, is significantly affecting the rail network in Scotland more than in England and Wales. This includes the impact of more frequent and severe weather events 1. Drainage and earthworks Critical drainage and earthworks assets have been identified as vulnerable to climate change impacts. Increased investment is planned to enhance the resilience of these assets against severe weather and climate change 1. Extreme weather events The document highlights the potential for extreme weather to impact both safety and performance. It cites recent events, such as Storm Eowyn, as reminders of the physical and financial impacts of extreme weather on infrastructure 1. Climate resilience initiatives A long-term climate change adaptation strategy is being developed for Scotland's Railway. This strategy includes a novel adaptation pathways project to address uncertainties in future climate change scenarios and prepare for multiple outcomes 1. Vegetation management The document mentions a vegetation management strategy aimed at reducing risks associated with hazardous trees and other vegetation-related issues during extreme weather events 1.

DOC-18	GB - CP7 Delivery Plan - Year 2 Update	5	Climate-Related Hazards Identified in the Document The document explicitly recognizes several climate-related hazards and their impacts on railway infrastructure. These include: Extreme Weather Events: The document mentions the growing challenge of managing the frequency and intensity of extreme weather events, such as heavy rainfall, heatwaves, and storms. These events are particularly problematic because many railway assets were not originally designed to withstand such conditions 1. Heat-Related Track Buckling: High temperatures can lead to the buckling of railway tracks, posing safety risks and operational disruptions. Investments are being made to reduce this risk through improved track resilience measures 1. Flooding: Drainage systems are being enhanced to mitigate flooding risks, including additional regional drainage resources to address localized vulnerabilities 1. Landslips: Earthworks are being strengthened to reduce the risk of landslips, which can be triggered by heavy rainfall or unstable soil conditions 1. ### ♻️ Mitigation Strategies and Investments To address these hazards, the document outlines several proactive measures: Resilience Investments: A £2.6 billion investment over the Control Period 7 (CP7) is allocated to improving the resilience of railway assets to extreme weather events. This includes targeted maintenance and renewal activities 1. Weather Risk Task Force (WRTF): The WRTF supports updates to operating processes and applies weather interventions in high-risk areas. This approach avoids unnecessary disruptions, such as blanket speed restrictions, and focuses on specific vulnerable locations 1. Climate Change Adaptation Strategies: Strategies are being developed to ensure the railway is fit for future climate conditions. These include embedding climate change considerations into standards, processes, and operational practices 1. Technological Integration: Tools like infrastructure monitoring systems and predictive analytics are being implemented to better understand and respond to climate impacts on railway assets 1. Summary • Recognized Hazards: Extreme weather events, heat-related track buckling, flooding, and landslips are identified as key climate-related hazards. • Mitigation Efforts: Significant investments are being made to enhance resilience, supported by specialized teams like the Weather Risk Task Force and the development of climate adaptation strategies. • Technological Advancements: Monitoring and predictive tools are being deployed to proactively address vulnerabilities.
DOC-19	System Operator CP7 Delivery Plan	5	The document explicitly recognizes climate-related hazards, including extreme weather events, climate impacts on operational risks, and vulnerabilities in drainage and earthworks. It outlines specific initiatives such as the Weather Risk Task Force and the Rail Operations Weather Service to address these challenges. Weather risk task force The document highlights the Weather Risk Task Force, which focuses on tools, processes, and support to help routes manage adverse and extreme weather conditions. This initiative is part of Network Rail's weather resilience and climate change adaptation strategy 1. Climate impacts and operational risks A partnership with the Met Office is mentioned to appraise operational capabilities against climate impacts over a 10+ year horizon. This includes monitoring, real-time observations, weather forecasting, and risk-based decision-making 1. Extreme weather events The document acknowledges the operational challenges posed by adverse and extreme weather, emphasizing the need for improved resilience and safety measures during such events 1. Drainage and earthworks Collaborative delivery of action plans related to drainage and earthworks is highlighted as a measure to reduce the likelihood and consequences of accidents during extreme weather 1. Rail operations weather service (ROWS) The implementation of ROWS is aimed at improving weather-related operational responses, including e-learning modules and practical training to address risks associated with drainage and earthworks during adverse weather conditions 1.

DOC-20	The CP7 Buildings & Architecture Policy (2021)	3	The document explicitly recognizes climate-related hazards such as extreme weather events, flooding, and long-term drought. It also emphasizes the importance of adapting assets to these challenges through frameworks like WRACCA and sustainable stewardship practices. Resilience to extreme weather and climate change The document highlights the importance of resilient stewardship, which includes addressing the impact of climate change on asset reliability and functionality. It mentions that flooding and long-term drought are likely to have significant effects on the stewardship of assets in the future. Weather resilience and climate change adaptation (WRACCA) The policy refers to the Weather Resilience and Climate Change Adaptation (WRACCA) framework, which emphasizes the need for assets to adapt to macro factors like extreme weather conditions and broader stressors such as pandemics or socio-economic trends. Sustainability and climate protection The document discusses the integration of sustainability goals, including climate and environmental protection, as part of the stewardship approach. It acknowledges the need to mitigate risks associated with climate change through sustainable construction and asset management practices. Flooding and long-term drought Specific mention is made of flooding and drought as potential hazards that could impact the resilience and reliability of assets, necessitating proactive measures to ensure long-term functionality.
DOC-21	"Additional information for asset managers" (2025)	3	• General Hazards Acknowledged: The policy discusses environmental challenges that directly tie into climate change impacts. • Examples: For instance, it highlights the importance of addressing issues such as extreme weather conditions, flooding, or prolonged drought—conditions that can accelerate asset degradation and affect operational safety. • Conclusion: While the document does not list an exhaustive "menu" of physical hazards, it does integrate key climate-related hazards (e.g. flooding/drought effects) as part of the resilience and sustainability considerations.
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authority	0	The document does not explicitly recognize specific climate-related hazards but emphasizes a general commitment to sustainability and carbon neutrality through strategies like Carbon Zero Asset Engineering and smart buildings. If you need further clarification or additional details, feel free to ask! The attached document does not explicitly mention specific climate-related hazards such as flooding, extreme weather, or drought. However, it does emphasize a broader commitment to sustainability and achieving a carbon-neutral built environment. The document outlines strategies like promoting Carbon Zero Asset Engineering, advancing smart buildings, and focusing on sustainability as one of the key measures of success.
DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	7	Not used AI as it is a sensitive document
DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	5	Not used AI as it is a sensitive document
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	2	• The document primarily focuses on evaluating the degree of adaptation and the progress made at various response levels. • It does not explicitly list or discuss individual climate-related hazards (for example, flooding, extreme temperatures, or storms) as discrete threats. • The emphasis is instead on overall adaptive capacity rather than on detailing specific physical hazards.
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	• No, the report does not recognise specific climate-related hazards. It speaks generally about sustainable practices and environmental performance but does not itemize hazards (for example, flooding, extreme heat, or high winds) that might affect rail infrastructure.
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	• The document focuses on tender requirements and scope of delivery for building and civil works. • There is no reference to specific climate-related hazards (e.g., flooding, heatwaves, storms) within the provided text.
DOC-28	NR's 'The Greener Railway Strategy' (May 2025)	4	• Yes, specific climate hazards are acknowledged. • The document explicitly mentions extreme weather and adverse weather events, emphasizing the need to prepare for, respond to, and recover from such events as part of the overall strategy for resilience.
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	1	• Yes. The Blueprint addresses the need to prepare for "extreme weather conditions" and adverse climate impacts. While it does not list every individual hazard (such as floods, heatwaves, etc.), it clearly anticipates the risks associated with extreme or severe weather events, which are critical to physical climate change scenarios 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	7	• Yes. Specific hazards related to climate are clearly identified. For example, the report discusses how high ambient temperatures lead to issues like thermal expansion, track buckling, failure of overhead line equipment (OLE), degraded performance of air conditioning systems, and battery degradation. These hazards are documented as contributing factors to both asset deterioration and service disruptions.

DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	7	• Yes – the report identifies and discusses hazards such as extreme heat, high ambient temperatures, and related adverse weather conditions (including high wind speeds and intense rainfall events). • It examines the operational impacts these conditions have on rail performance and safety.
DOC-32	EHTF Weather and Climate Change Report (March 2023)	7	• The report identifies several specific climate hazards including extreme heat, heatwaves, drought, wildfires, and cascading impacts due to compounded and prolonged heat stress. • It examines how these hazards are modulated by factors such as antecedent dryness, changes in weather regimes, and reductions in rainfall, all contributing to heightened risks for the rail network.
DOC-33	352_WSFData_2025 202607 Final - Building Only	0	Not used AI as it is a sensitive document

AI Agent Summary - Q3: Are the buildings, building systems or components that may be affected by physical climate related hazards identified in the document?

Prompts	Retain this knowledge:
	Building types: These refer to the overall structures or facilities within the rail infrastructure. They are the distinct kinds of buildings or built environments that serve specific functions. Examples: Train stations, Maintenance depots, Signal boxes. Control center, Passenger shelters
	Building systems: Building systems are interconnected sets of elements within a building that support its operation and functionality. Systems are typically integrated across the building and are essential for performance, safety, and comfort. Examples: Electrical systems (lighting, power distribution), HVAC systems (heating, ventilation, air conditioning), Fire protection systems, Communication and signaling systems, Water and drainage systems
	Building components: These are the individual parts or materials that make up the physical structure of the building. Components are the building blocks used in construction and maintenance. Examples: Walls, floors, roofs, Doors, windows, Structural beams and columns, Cladding and insulation, Fixtures and fittings*
Look at the table example document (attach word document). Please use the same level of headers and level of detail I have provided in the table and use this as a format layout for a table and summarise all the building system types in the Wales-Western-CP7-WRCCA.pdf document	

Doc Ref	Document name	Score	Document detail	Asset type	Component	Role	Vulnerability	Climate Hazard
DOC-01	The NR Climate Projections Guidance Note (2023)	6	 Key Findings from the Document General Identification of Vulnerable Assets: The document discusses the vulnerability of various assets to weather impacts, particularly focusing on climate-related hazards such as flooding, heatwaves, and extreme weather events. For example: Electrical panels in flood-prone buildings are identified as vulnerable to high temperatures and flooding. Design considerations include modeling flood risks and temperature impacts to minimize these hazards 1. Impact of Flooding: Flooding is categorized into types such as surface water flooding, river flooding, and coastal flooding. These can significantly impact buildings and infrastructure, particularly those in low-lying or flood-prone areas. The document suggests measures like waterproof cabinets, floodproofed buildings, and raising equipment height to mitigate these risks 1. Temperature-Related Hazards: Rising maximum, average, and minimum temperatures are projected across the UK, leading to more frequent and severe heatwaves. This has implications for building systems such as HVAC (heating, ventilation, and air conditioning) and structural materials that may degrade under prolonged heat exposure 1. Sea Level Rise and Coastal Erosion: Coastal buildings and systems are at risk from rising sea levels and increased storm surges. The document provides guidance on allowances for sea level rise and suggests that local effects (e.g., shoreline features, defenses) should be considered when assessing risks to coastal infrastructure 1. Humidity and Workforce Welfare: Increased humidity levels can directly affect building components (e.g., location cabinets) and indirectly impact workforce welfare. This highlights the need for climate control systems and materials resistant to moisture 1. Design and Adaptation Strategies: The document emphasizes the importance of adapting building designs to account for future climate scenarios. This includes using climate projection data (e.g., UKCP18 datasets) to model potential impacts and test design options under worst-case scenarios 1.  Summary The document identifies several buildings, building systems, and components that may be affected by physical climate-related hazards: Flooding: Electrical systems and structures in flood-prone areas. Heatwaves: HVAC systems and materials sensitive to high temperatures. Coastal Risks: Buildings near coastlines vulnerable to sea level rise and erosion. Humidity: Cabinets and systems impacted by moisture, along with workforce welfare concerns. Mitigation strategies include floodproofing, raising equipment, improving climate control, and using robust materials					
DOC-02	The WRCCA Strategy (2017) from the System Operator	3	• Focus of the Report: The strategy primarily addresses railway infrastructure rather than general buildings. It focuses on assets such as track, signalling equipment, bridges, tunnels, embankments, drainage systems, and coastal defences. • System Specifics: Although the document discusses "assets" and "systems", it does not drill down into local building systems (e.g. office buildings or heritage structures) in detail. • Conclusion: The report does not specifically identify individual buildings or building systems; rather, it concentrates on railway infrastructure and its broader components					
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	Yes, the document identifies vulnerabilities in buildings, such as drainage systems overwhelmed by intense rainfall, flat roofs affected by heat expansion, and lineside equipment overheating.	Buildings	Station Buildings	Provide shelter and operational space for passengers and staff.	Susceptible to overheating, water ingress, and structural damage during extreme weather.	Extreme heat (causing discomfort and roof expansion), intense rainfall (leading to water ingress and flooding).
					Lineside Buildings	Support railway operations, housing equipment and staff facilities.	Vulnerable to water ingress during flash floods and intense rainfall; overheating of equipment.	Intense rainfall, flash floods, extreme heat.
					Drainage Systems	Essential for managing water flow and preventing flooding.	Susceptible to overwhelming during intense rainfall, leading to flooding and water ingress.	Intense rainfall, flooding, flash floods.
					Heating, Ventilation, and Air Conditioning (HVAC) Systems	Maintains indoor air quality and temperature control, especially during extreme heat events.	Increased demand during heatwaves; temporary air-conditioning units may be required to supplement existing systems.	Extreme heat, heatwaves.
					Platform Heating Systems	Prevents ice formation on walkways and platforms during cold weather.	Requires consistent maintenance to ensure functionality during snow and ice conditions.	Snow, ice.
					Building Drainage Systems	Specific to buildings, these systems manage water runoff to prevent internal flooding.	Risk of being overwhelmed during flash floods or intense storms, leading to property damage.	Intense rainfall, flash floods, storms.
					Overhead Line Equipment (OLE)	Supports electrical systems for trains and station operations.	High temperatures can cause sagging wires; storms may lead to damage from debris.	Extreme heat, storms, high winds.
					Signaling and Telecommunications Systems	Ensures operational communication and safety across the railway network.	Prone to overheating during extreme heat; susceptible to water damage during flooding.	Extreme heat, flooding, intense rainfall.
					Remote Condition Monitoring Systems	Monitors infrastructure conditions in real-time, providing alerts for potential failures.	Requires robust integration with building systems to ensure timely responses to adverse weather impacts.	No explicit climate hazards mentioned, but potentially impacted by extreme heat, flooding, and storms.
					Electrical Distribution Systems	Supplies power to buildings and operational equipment.	High temperatures can degrade batteries and components; flooding may disrupt power supply.	Extreme heat, flooding.
					Point Heating Systems	Prevents freezing of railway points and associated systems.	Requires reliable operation during extreme cold conditions.	Snow, ice.
					Sustainable Drainage Systems (SuDS)	Designed to manage water runoff sustainably and reduce flood risks.	May not cope with increasingly intense rainfall events without upgrades.	Intense rainfall, flooding, flash floods.
					Tiltmeters and inclinometers	Monitors the stability of earthworks and cuttings near buildings.	Requires integration with broader building systems to prevent cascading failures.	No explicit climate hazards mentioned, but potentially impacted by ground saturation and desiccation.

		6		Building Systems Fire Protection Prevent and suppress fires in plant, depots, and critical infrastructure. May be compromised by electrical faults, overheating, or equipment failure. High temperatures, electrical faults Communication & Signalling Enable safe train movement, remote monitoring, and operational control. Prone to water ingress, overheating, lightning strikes, and physical damage. Flooding, lightning, temperature extremes, storms Water & Drainage Systems Manage water flow, prevent flooding, and protect infrastructure. Can be overwhelmed by intense rainfall or blocked by snow/ice, leading to flooding and asset damage. Intense rainfall, flooding, snow/ice, sea level rise Building Monitoring & Control Monitor asset condition and trigger responses to adverse events. Sensor or system failure may delay detection of hazards or asset deterioration. Flooding, temperature extremes, storms Plant & Depot Systems Support maintenance, cleaning, and operational readiness of rolling stock and infrastructure. Susceptible to overheating, freezing, or water ingress, affecting reliability and safety. High/low temperatures, snow/ice, flooding, lightning Heating Systems Prevent ice formation and maintain operational safety in cold conditions. May fail in extreme cold or due to power loss, impacting safety and service. Snow/ice, extreme cold Building Components Structural Framework Provides the load-bearing support, ensuring overall stability and integrity of the building. Susceptible to material degradation due to moisture, freeze-thaw cycles, and corrosion from salt exposure; potential structural fatigue over time. Intense rainfall, freeze-thaw conditions, high winds Roof Systems Shields the building from direct exposure to weather elements by offering protection against water ingress and extreme temperatures. Vulnerable to wind uplift, leaks, and degradation of roofing materials due to UV exposure and temperature fluctuations, leading to potential water damage. Heavy storms, hail, temperature extremes, high winds Cladding/Facade Acts as the protective and aesthetic envelope of the building while contributing to thermal insulation and energy efficiency. At risk of cracking, delamination, or corrosion from moisture ingress and thermal expansion; may suffer aesthetic and functional decline over time. Temperature extremes, moisture, salt spray, freeze-thaw Fenestration (Windows/Doors) Provides natural lighting, ventilation, and access while balancing energy efficiency and security in the building. Susceptible to seal failure, breakage, or warping under rapid temperature changes; impacts or debris during strong storms may cause damage. High winds, hail, rapid temperature fluctuations Insulation Systems Enhances energy efficiency by regulating thermal conditions within the building and reducing heating/cooling demands. Vulnerable to moisture absorption and degradation over time, which can considerably reduce insulation performance and lead to energy inefficiencies. High humidity, extreme heat, and freezing conditions HVAC Components Manages indoor climate conditions by regulating temperature, humidity, and air quality to ensure occupant comfort and equipment safety. Overloading or mechanical failures under extreme environmental conditions, potential blockage from debris, and wear on sensitive sensors during exposure. Heatwaves, severe storms, heavy rainfall, and windstorms	
DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	6		Buildings Passenger Stations Serve as primary access points for passengers with ticketing, waiting, and information services. Susceptible to water ingress, facade deterioration, and crowd management issues exacerbated by extreme weather conditions. Flooding, heavy rainfall, heatwaves, and high winds Operational Control Centres Act as nerve centers for monitoring and managing rail operations with critical IT and control setups. Vulnerable to power interruptions, data center cooling failures due to rising temperatures, and the potential for structural damage during severe weather events. Power outages, heatwaves, and lightning strikes Maintenance Depots House maintenance equipment, rolling stock, and essential tools needed for upkeep and repairs. Exposure to moisture and corrosive environments, risks of equipment damage from temperature extremes, and storage conditions that may lead to accelerated wear and tear. Heavy rainfall, humidity extremes, and seasonal temperature fluctuations Asset Storage Facilities Provide secure storage for spare parts, equipment, and other valuable assets. At risk from water penetration affecting stored materials, fire hazards heightened by heat stress, and structural strain from prolonged exposure to the elements. Flash floods, extreme heat, and lightning-related events IT & Communication Centres Manage critical data operations and communication networks ensuring seamless system coordination. Susceptible to power fluctuations and electromagnetic interference, and may face challenges maintaining optimal environmental conditions under high ambient temperatures. Heatwaves, lightning, and heavy precipitation affecting cooling systems Emergency Response Facilities Serve as hubs for coordinating rapid emergency services and safety measures during crises. Vulnerable to being overwhelmed by sudden surges in use during extreme events, plus potential structural issues if not designed for rapid load shifts. Storm surges, flooding, and high winds Security & Surveillance Centres Provide real-time monitoring and protection of infrastructure through advanced security systems. Dependence on stable power and network connectivity makes them sensitive to climate-induced interruptions, while physical facilities can suffer from thermal and moisture stress. Hurricanes, extreme temperature variations, and water ingress Administrative Office Buildings Host clerical, management, and support functions essential for day-to-day organizational operations. Susceptible to water leakage, degraded insulation, and potential indoor air quality issues, especially during periods of extreme humidity or temperature variance. Heavy rainfall, cold snaps, and heatwaves Warehouse & Distribution Centres Critical for the storage and distribution of materials, ensuring supply chain continuity. Vulnerable to structural fatigue under sustained load changes, difficulties in maintaining temperature control in large open spaces, and risks stemming from moisture exposure. Extreme cold, heatwaves, and flash floods Utility & Support Buildings House essential infrastructure services (e.g., power systems, water treatment units) that support operations. Located in areas exposed to high operational demand, these buildings may suffer from mechanical failures, water ingress, or accelerated wear from continuous exposure to the elements. Storms, high winds, and prolonged rainfall Platforms Facilitate passenger boarding and alighting from trains. Prone to flooding during heavy rainfall, leading to safety hazards and operational disruptions. Flooding, heavy rainfall, and storm surges Subways Provide underground passage for passengers and train operations. Vulnerable to water ingress, leading to structural defects and operational challenges. Flooding, heavy rainfall, and rising groundwater levels Tunnels Allow trains to pass through mountains or urban areas safely. Susceptible to water ingress, leading to increased defects such as spalling and open joints, and increased demand on drainage systems. Heavy rainfall, rising water tables, and flooding Bridges Support rail tracks over obstacles such as rivers or roads. Vulnerable to scour and structural degradation due to extreme weather events, including flooding and high winds. Flooding, high winds, and extreme rainfall Building Systems Electrical Systems Provide and control power for critical operations including signalling, safety, and building services. Vulnerable to water ingress, overheating, and short-circuits during extreme weather events that stress power distribution infrastructure. Extreme temperatures, heavy rain, lightning strikes 2 Communication & Signalling Systems Enable safe and reliable train operations by ensuring real-time data exchange and control signals. Susceptible to moisture penetration and electromagnetic interference, which can disrupt operations and delay emergency responses. Lightning, heavy rain, and high winds 2 HVAC Systems Regulate indoor climates to maintain equipment performance and provide comfort for occupants and staff. Prone to overloading and mechanical failure during extreme temperature fluctuations or high humidity conditions. Heatwaves, cold spells, and humidity extremes 2 Structural Systems / Building Envelope Ensure overall integrity and protection of buildings from external elements through robust design. Sensitive to thermal expansion/contraction, moisture infiltration, and degradation from freeze-thaw cycles that can weaken building integrity. Temperature extremes, heavy rainfall, freeze-thaw cycles 2 Earthworks & Embankments Provide foundational support for rail tracks and structures. Prone to desiccation, shrinkage, and failures due to prolonged saturation or extreme dryness. Heatwaves, heavy rainfall, and freeze-thaw cycles 2 Track Systems Support train movement and ensure safety and stability of rail operations. Vulnerable to buckling during extreme heat, destabilization due to low soil moisture, and erosion from water saturation. Extreme heat, low soil moisture, flooding 2 Vegetation Management Prevents obstruction and damage to infrastructure from overgrowth and falling trees. Susceptible to high winds, leading to fallen trees and debris on tracks, and increased fire risk during heatwaves. High winds, heatwaves, and storms 2 Coastal and River Defenses Protect railway infrastructure from sea level rise, coastal erosion, and river flooding. At risk of overtopping, erosion, and structural degradation due to rising sea levels and extreme storm surges. Sea level rise, storm surges, and heavy rainfall 2 Tunnels Provide safe passage for trains through mountains or urban areas. Vulnerable to water ingress, leading to structural defects such as spalling and open joints, and increased demand on drainage systems. Heavy rainfall, rising water tables, and flooding 2	

DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	5	Analysis of Climate-Related Hazards in the Document Preface Thank you for your question! It seems you are looking for information on whether the document identifies buildings, building systems, or components that may be affected by physical climate-related hazards. Let me provide a detailed summary based on the document's content. 🔍 Key Findings on Climate-Related Hazards in the Document The document does identify and address buildings, building systems, and components that may be affected by physical climate-related hazards. Below are the relevant points extracted from the document: Weather Resilience and Climate Adaptation: The document highlights the increasing frequency of severe weather events due to global climate change, which poses risks to the integrity of drainage and earthworks infrastructure. Plans include investments in monitoring and surveillance methods, such as deploying dedicated inspection teams, improving vegetation management, and mitigating asset failures. Specific Initiatives for Weather Resilience: Installation of remote condition monitoring systems to reduce risks associated with embankment failures. Additional inspections to support drainage management and remedial works. Implementation of climate adaptation pathways and severe weather schemes to manage infrastructure for hot weather and enhanced vegetation management 1. Building and Station Safety: Investments in fire safety systems, including a significant allocation of approximately £5 million for fire safety upgrades at Euston Station. Public safety improvements at stations, such as anti-slip travellators, platform refurbishments, lift and escalator renewals, lighting upgrades, and improved air quality measures 1. Drainage and Earthworks: Targeted drainage renewals and geotechnical renewals at high-risk weather-impacted sites. Coastal defense projects and track renewals to address vulnerabilities to climate impacts 1. Vegetation Management: Risk-based vegetation management to address hazards such as ash dieback and the risk of trees falling onto tracks during severe weather 1. Climate Change Impact Assessments: The document mentions the production of Weather and Climate Change Impact Assessment reports for earthworks projects to ensure climate resilience is integrated into design decisions 1. Long-Term Asset Sustainability: The document acknowledges the challenge of maintaining asset sustainability due to aging infrastructure and climate change risks. It outlines strategies to mitigate these risks, including targeted renewals and the use of advanced technologies 1. 📄 Summary Yes, the document does identify buildings, building systems, and components that may be affected by physical climate-related hazards. It outlines several initiatives to address these risks, including weather resilience schemes, drainage and earthworks renewals, fire safety upgrades, and vegetation management. Furthermore, the document emphasizes the importance of climate adaptation pathways and long-term asset sustainability to mitigate the impacts of climate change. 📖 Additional Context The document also aligns its strategies with broader environmental and sustainability goals, including decarbonization and biodiversity enhancement. These efforts are part of a comprehensive approach to ensuring the railway infrastructure remains safe, reliable, and resilient in the face of increasing climate challenges.
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	2	• The document does include references to building and infrastructure management—for example, mentioning the installation of solar PV on operational buildings and improvements to station accommodation. However, it stops short of providing a detailed, asset-level vulnerability analysis specifically focused on how physical climate hazards may affect individual buildings, systems, or components. In short, while buildings are noted as assets (and there is investment in renewals and upgrades), they are not explicitly assessed for climate-induced vulnerabilities.
DOC-11	Southern Region: CP7 Region Strategic Business Plan	3	• Partially. The document references asset categories such as "buildings," "workplace accommodation," "canopies, platforms, and related infrastructure. • These assets are included within the broader asset management framework and renewals strategy. • However, while building assets are clearly listed, there is no explicit, detailed analysis that isolates which specific building systems are directly vulnerable to physical climate hazards. Asset Categories Outlined: The CP7 Strategic Business Plan groups assets within broader categories to manage risk and renewal planning. Buildings as a Category: It clearly identifies "buildings" and "workplace accommodations" as part of its overall asset inventory, meaning that these physical assets are recognized as potentially subject to climate-related impacts. Specificity and Technical Detail • High-Level Identification: While the document does list building types, it does not delve into a granular breakdown of specific building systems. For example, details such as HVAC, structural envelopes, or electronic systems are not individually itemized with respect to their vulnerability to climate hazards. • Grouping of Related Components: Instead of isolating components (like windows, doors, or roof systems), the plan tends to aggregate these features under broader asset classes. This means that while a building is broadly identified, the internal components are generally considered as part of the building's overall performance rather than being separately detailed. Implications for Risk Assessment and Management • Strategic Approach: The identification serves primarily to support a strategic asset management framework. The intent is to prioritize overall building resilience rather than to perform a micro-level technical vulnerability assessment. • Risk Management Framework: Buildings, along with other assets, are evaluated through a risk-adjusted planning approach. This includes applying resilience measures broadly across asset classes rather than targeting individual components with specialized assessments. • Adaptation and Renewal: The document emphasizes performance-based interventions. The resilience planning includes elements such as improved drainage, retrofitting capabilities, and operational adjustments that indirectly benefit individual systems even if those systems are not identified in isolation. Summary of Findings • Central Identification: Buildings and major asset categories are clearly identified as susceptible to physical climate hazards. • Lack of Granular Detail: There is a notable absence of a detailed breakdown that separates individual building systems or components (e.g., HVAC, structural supports) for distinct evaluation. • Strategic vs. Technical Focus: The approach is primarily geared towards integrating climate risk into overall asset management strategies, with the assumption that detailed technical assessments will occur as part of later, more focused studies or maintenance planning rather than within the strategic business plan itself.

DOC-12	Scotland Region: CP7 Region Strategic Business Plan		The document goes beyond rail tracks and operational systems to include buildings and building systems such as station facilities, platforms, footbridges, and other critical support structures. It recognises that buildings are integral to the overall network's resilience, serving as both operational hubs and critical public infrastructure. • Maintenance and Renewal Focus: Strategies discussed include targeted renewal and refurbishment programs, which are aimed at mitigating the impacts of weather-related wear on these assets. The plan underlines the importance of regular maintenance checks and upgrades to ensure that building systems can withstand increased environmental stresses. The plan does not limit its focus solely to rail tracks or operational components; it extends its analysis to buildings and support structures, recognizing that these elements are integral to the overall operational ecosystem. Examples of Buildings: This includes major infrastructure elements such as stations, control centres, maintenance depots, platform facilities, and even footbridges that facilitate movement. • Criticality in Operations: These buildings serve dual purposes: they provide essential services (ticketing, customer information, safety management) and contribute to the overall resilience of the network during extreme weather events. By embedding buildings into the strategic framework, the plan underscores their vulnerability and the necessity for robust design and maintenance protocols. 2. Design and Structural Resilience • Adaptation of Existing Structures: To address vulnerabilities, the plan outlines targeted renewal and refurbishment programs, particularly for aging building assets. These actions aim to upgrade infrastructure to contemporary standards, reducing exposure to climate impacts like flooding or structural degradation. Material and Structural Enhancements: The plan advocates for using resilient materials and construction techniques that better withstand extreme weather conditions, such as enhanced waterproofing, corrosion-resistant materials, and reinforced frameworks. • Implementation of Resilience Targets: The strategic framework sets specific resilience targets for these assets. This includes performance metrics aimed at minimizing downtime and ensuring that building systems can operate safely and efficiently even under adverse conditions. Proactive Maintenance: There is an emphasis on routine inspection schedules, preventive maintenance, and retrofitting measures to extend the asset life of buildings and ensure that they meet updated climate resilience standards. 3. Integration of Systems and Functional Dependencies • Interconnected Systems Analysis: Buildings are not treated as standalone entities. Instead, the plan discusses the interactions between building assets and other infrastructure components, acknowledging that the failure of a building may have ripple effects on adjacent systems such as communications, power supply, and operational logistics. Scenario Planning: This interconnected perspective drives scenario planning whereby the consequences of a building's failure (e.g., loss of shelter during extreme weather) are mapped out, helping to prioritize interventions that reduce these systemic risks. • Emergency Preparedness and Safety Protocols: Buildings play a crucial role in emergency response. The plan details the need for robust safety measures within these structures, including clear evacuation routes, emergency backup systems, and reinforced design elements that protect occupants during severe weather events. Integration with Operational Systems: Emergency protocols are designed to work seamlessly with overall operational systems (like control centres that coordinate incident responses), ensuring that the building's role in facilitating secure and effective interventions is not overlooked. 4. Strategic Investment and Lifecycle Management • Lifecycle Consideration: Beyond initial construction, the plan takes a life-cycle approach to building asset management. This involves assessing the long-term performance of a building under stress due to climate change, coupled with scheduled updates and reinvestments to ensure enduring resilience. Asset Renewal Programs: Specific programs for asset renewal are highlighted, directing investments towards upgrading older buildings that might not meet modern resilience standards. • Economic and Operational Impact: Strategic investment decisions driven by lifecycle management factor in both immediate repair costs and long-term operational savings. By maintaining building assets proactively, the plan aims to reduce the risk of prolonged service interruptions and minimize maintenance costs over the asset's life. Summary: • The plan adopts a comprehensive approach by including buildings and support structures as key assets, highlighting their importance in maintaining operational continuity. • Detailed strategies are outlined for upgrading and retrofitting existing structures, emphasizing the adoption of resilient materials and enhanced design features. • The integration of building assets into broader network operations acknowledges their interconnectedness, where the failure of one element can affect multiple systems. • A lifecycle management approach ensures long-term resilience through scheduled inspections, renewals, and targeted investments, reducing both immediate and future vulnerabilities.
DOC-13	Eastern Delivery Plan - Year 2 Update	2	### 📌 Key Findings from the Document The document provides insights into various infrastructure components and their vulnerabilities, including those potentially impacted by climate-related hazards. Below are the relevant highlights: Buildings and Stations: Major interventions are planned for Liverpool Street Station and other key maintenance delivery unit sites. These include refurbishment works and addressing high-risk platforms to mitigate slips, trips, and falls. This suggests a focus on enhancing resilience against physical hazards like wear, tear, and environmental factors 1. Specific attention is given to assets at risk of failure, which may include climate-related risks such as flooding or extreme weather conditions 1. Drainage and Water Management: An integrated system-level approach to water management is highlighted, targeting earthwork failure sites, areas with a history of track flooding, and persistent wet formation sites. This indicates a proactive stance on mitigating risks associated with heavy rainfall and flooding 1. Structures: Weather resilience programs are being implemented, including scour mitigation measures at vulnerable bridge and retaining wall locations. These measures are designed to address hazards like flooding and erosion, which are exacerbated by climate change 1. Electrification and Fixed Plant Systems: Efforts to improve system reliability for overhead line equipment (OLE) and signaling power are noted. These improvements aim to reduce the likelihood of de-wirements and failures, which could be triggered by extreme weather events such as high winds or ice accumulation 1. Vegetation Management: Vegetation management is linked to route risk profiles, addressing risks such as signal sighting issues, overhead line integrity, and hazardous trees. These measures are crucial for mitigating risks from storms and other weather-related hazards 1. Summary The document identifies several building systems, structures, and components that are being assessed and managed to mitigate risks from physical climate-related hazards. Key areas of focus include: Enhancing weather resilience for buildings and stations. Implementing drainage and water management systems to prevent flooding. Strengthening structures like bridges and retaining walls against erosion and scour. Improving the reliability of electrification and signaling systems. Managing vegetation to reduce risks from storms and other weather events. Additional Context These measures align with broader sustainability and resilience goals, such as reducing carbon emissions and enhancing biodiversity. The proactive approach to integrating climate risk management into asset planning and maintenance underscores the importance of adapting infrastructure to withstand the growing impacts of climate change.

DOC-14	North West and Central Delivery Plan - Year 2 Update	2	 Key Findings from the Document The document does address aspects of buildings and infrastructure that are influenced by physical climate-related hazards. Here are the relevant points: Climate Change Adaptation and Resilience: The document highlights the importance of preparing the railway to minimize the impacts of climate change by 2050. This includes developing climate change adaptation pathway strategies for critical infrastructure areas like the Cumbrian Coast, Carlisle, and Euston (0-60 miles) to enhance resilience against climate-related hazards 1. Drainage and Flooding Risks: Drainage renewals are specifically targeted at areas with the highest risk of flooding. Innovative surveying techniques are used to gather the latest data for quick and responsive decision-making 1. Buildings and Accessibility: Passenger and public accessibility improvements are planned for escalators and footbridges across the region. Additionally, concourse roof improvements at Marylebone Station and safety enhancements in fire suppression systems at Euston are noted. These upgrades aim to improve resilience and safety, indirectly addressing potential climate-related hazards 1. Earthworks and Weather Events: Earthworks schemes focus on sites at the highest risk from adverse weather events, such as Ashton Heath and Worlestone Embankment. This indicates a proactive approach to managing risks associated with severe weather 1. Electrification and Fixed Plant: Renewals of overhead line equipment on the West Coast Mainline North and Birmingham New Street area are intended to improve asset condition and resilience, reducing the risk of dewirement caused by extreme weather conditions 1. Sustainability and Environmental Stewardship: There is a broader commitment to sustainability, including transitioning to zero-emission vehicles, improving energy efficiency in buildings, and implementing biodiversity plans. These initiatives indirectly mitigate the impact of climate-related hazards 1.  Summary Yes, the document identifies buildings, building systems, and components that may be affected by physical climate-related hazards. Key areas include: Drainage systems in flood-prone areas. Earthworks at high-risk sites for adverse weather. Building upgrades like fire suppression systems and accessibility improvements. Electrification systems to withstand extreme weather. These initiatives reflect a proactive approach to addressing climate-related risks and enhancing infrastructure resilience.  Additional Context The document's focus on sustainability and resilience aligns with broader goals of achieving net-zero carbon emissions by 2050 and adapting to climate change. This is crucial for long-term infrastructure viability and safety.
DOC-15	Wales and Western Delivery Plan - Year 2 Update		##  Analysis of Climate-Related Hazards Impacting Buildings and Systems The document outlines several initiatives and considerations related to physical climate-related hazards and their impact on infrastructure, including buildings, systems, and components. Here are the key points: Weather Resilience and Climate Change Adaptation: The document emphasizes investment in weather resilience and climate change adaptation to mitigate service disruptions, costs, and reputational impacts caused by weather-related incidents 1. Specific measures include risk-based asset renewals, such as making overhead lines more resilient and adapting assets to withstand climate change effects 1. Buildings and Electrification Systems: Major works are planned at key stations like Exeter St. Davids and Bristol Temple Meads to ensure resilience 1. Electrification systems are being upgraded, including overhead line systems and pumping stations, to improve resilience against extreme weather conditions 1. Drainage and Earthworks: Increased investment in drainage maintenance and geotechnical instrumentation is highlighted to address flooding and earthworks failures caused by extreme rainfall and climate change 1. Specific schemes aim to mitigate repeat flooding areas and improve track drainage 1. Renewable Energy and Building Management Systems: Initiatives include optimizing building management systems and utilizing unused land and roof space for renewable energy to support decarbonization goals 1. Green Infrastructure: Development of "green infrastructure" such as green roofs, terraces, ponds, reed beds, and community gardens is planned to enhance biodiversity and provide natural climate resilience 1. Safety and Risk Assessment: The document mentions the use of a safety bow-tie risk assessment framework to monitor and mitigate risks associated with aging infrastructure and climate-related hazards 1. Summary The document identifies several buildings, systems, and components that may be affected by physical climate-related hazards. Key areas of focus include weather resilience, climate change adaptation, drainage improvements, electrification system upgrades, and the development of green infrastructure. These initiatives aim to enhance the resilience and sustainability of critical infrastructure across the region. Additional Context The measures outlined reflect a proactive approach to mitigating climate-related risks while ensuring the safety and reliability of the railway network

DOC-16	Southern Delivery Plan - Year 2 Update	2	### 📄 Analysis of Document Content The document does not explicitly outline buildings, building systems, or components directly affected by physical climate-related hazards. However, it does provide insights into related aspects, such as: Buildings and Infrastructure Renewal: The document mentions works to station platforms, canopies, wiring, footbridges, and metallic distribution buildings. These components are part of the broader infrastructure renewal and maintenance strategy 1. Specific focus is given to drainage systems to mitigate repeat flooding areas, which indirectly addresses climate-related hazards 1. Climate Resilience Program: The document highlights a climate resilience program aimed at building and maintaining a railway resilient to severe weather events and climate change. This includes partnerships for climate adaptation and milestones within the Weather Resilience and Climate Change Adaptation plan 1. While not directly naming specific buildings or systems, the focus on weather resilience suggests that buildings and systems vulnerable to climate impacts are considered in broader strategies. Sustainability and Environmental Management: The strategy integrates biodiversity and habitat management plans, which may involve adjustments to buildings or systems to reduce environmental impact and improve resilience 1. Drainage and Vegetation Management: Drainage interventions and vegetation management are prioritized to address risks associated with flooding and falling trees, which are climate-related hazards. These measures likely impact lineside buildings and other infrastructure components 1. Summary The document does not specifically list buildings, building systems, or components directly affected by physical climate-related hazards. However, it does address broader strategies for climate resilience, including drainage systems, vegetation management, and infrastructure renewal, which indirectly mitigate risks to such assets.
DOC-17	Scotland Delivery Plan - Year 2 Update	2	📄 Findings on Climate-Related Hazards and Affected Components The document highlights several areas where physical climate-related hazards, such as extreme weather events, are being addressed in the context of Scotland's Railway. Here are the key points: Buildings and Infrastructure Resilience: The plan includes safety-related interventions for platforms, footbridges, canopies, and mechanical and electrical systems. These measures are part of a broader effort to ensure resilience against climate-related risks like extreme weather 1. Investment in drainage systems and earthworks is emphasized to manage risks associated with increasing rainfall and flooding, which are becoming more frequent due to climate change 1. Climate Action Plan: The document outlines a Climate Action Plan that includes initiatives to improve the resilience of railway assets, including buildings and other infrastructure, against extreme weather and long-term climate changes. This involves developing climate adaptation strategies and enhancing decision-making processes with climate science 1. Whole-System Approach: A whole-system drainage and earthworks approach is being implemented to address vulnerabilities in critical infrastructure. This includes identifying and prioritizing assets most at risk from climate-related hazards 1. Electrification and Fixed Plant: The document mentions a focus on condition-based renewals for electrification systems and fixed plants, which are likely to be affected by extreme weather conditions 1. ☒ Summary The document identifies several buildings, systems, and components that may be affected by physical climate-related hazards, including: Platforms, footbridges, canopies, and mechanical/electrical systems. Drainage and earthworks assets, which are critical for managing increased rainfall and flooding risks. Electrification and fixed plant systems, with condition-based renewals planned to enhance resilience. These efforts are part of a broader Climate Action Plan aimed at improving the resilience of Scotland's Railway infrastructure to climate change. 🔗 Additional Context The focus on resilience aligns with Scotland's commitment to addressing climate change impacts, particularly as extreme weather events become more frequent. By investing in targeted interventions and adopting a whole-system approach, Scotland's Railway aims to ensure safety, reliability, and sustainability.
DOC-18	GB - CP7 Delivery Plan - Year 2 Update	0	🔗 Key Findings The document discusses several aspects related to climate-related hazards and their impacts on infrastructure, including buildings and components. Here are the relevant points: Investment in Resilience: The document highlights a £2.6 billion investment during CP7 (Control Period 7) to improve the resilience of railway assets to extreme weather events. This includes: Track assets: Measures to reduce the risk of heat-related track buckling. Drainage systems: Enhancements to mitigate flooding risks. Earthworks: Strengthening to prevent landslips 1. Weather Resilience and Climate Change Team: A dedicated team has been established to integrate climate change considerations into standards, processes, and operational work. This team focuses on embedding weather resilience into infrastructure planning and maintenance 1. Challenges with Existing Assets: The document acknowledges that many existing railway assets, including buildings, were not designed to withstand the increasing frequency and intensity of extreme weather events. This highlights the vulnerability of older infrastructure to climate-related hazards 1. Planned Maintenance and Renewals: Renewals and maintenance activities prioritize assets that deliver the largest safety and weather resilience benefits. This includes buildings, drainage, and other critical components 1. Specific Initiatives: The document mentions the use of technology and monitoring tools to predict and prevent asset failures caused by extreme weather. This includes measures for buildings and other infrastructure to ensure safety and reliability 1. ☒ Summary Yes, the document identifies buildings, building systems, and components that may be affected by physical climate-related hazards. It outlines specific investments, challenges, and initiatives aimed at improving the resilience of these assets to extreme weather events. The focus is on proactive measures such as enhanced drainage, earthworks, and technological monitoring to mitigate risks.
DOC-19	System Operator CP7 Delivery Plan	0	• No. While the document discusses operational, network, and infrastructure resiliency, it does not specifically pinpoint any individual buildings, building systems, or components as vulnerable to climate effects. The focus remains on system-wide operational processes rather than on discrete building assets.

DOC-20	The CP7 Buildings & Architecture Policy (2021)	1	– The document provides a comprehensive overview of various asset types (e.g. stations, platforms, canopies, Maintenance Delivery Units) along with detailed descriptions of building components and asset systems used in its risk and resilience assessments. However, the categorisation is generally asset-based and is not mapped specifically to individual physical climate hazards in an isolated manner.
DOC-21	"Additional information for asset managers" (2025)	3	• Asset Identification: The document extensively describes assets including stations, platforms, canopies, maintenance delivery units (MDUs), roofs, cladding, and other critical building components. • Relation to Climate Impacts: These elements are discussed in the context of vulnerability (e.g. degradation, energy performance, and maintenance triggers) which implies that they might be affected by external environmental stresses, including those driven by climate. • Conclusion: Rather than itemizing every risk per component, the policy integrates these assets into its overall management approach, thereby indirectly addressing their response to climate-induced stresses.
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authority	0	• The document outlines strategies for promoting optimal design in buildings and related assets, yet it does so in a generalized manner with focus on digital integration and sustainability goals. • There is no specific identification of individual buildings, systems, or components in the context of being affected by physical climate related hazards
DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	6	Not used AI as it is a sensitive document
DOC-24	Records and reports of weather-related failures or Wrong	5	Not used AI as it is a sensitive document
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	0	• The document does not specifically identify buildings or building system components in the context of physical climate-related hazards. • Its focus is on organisations in the GB rail sector, with discussion centring on infrastructure managers, train operating companies, and other rail industry stakeholders rather than on individual building assets.
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	• The document does not identify particular buildings, building systems, or components that may be affected by physical climate-related hazards. Its focus is on demonstrating the added value of design through economic, social, and environmental lenses rather than on vulnerability assessments of specific assets.
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	• Although the document details asset groups such as bridges, tunnels, retaining walls, culverts, stations, and buildings, it does not associate these assets explicitly with physical climate-related hazards. • The focus is on maintenance and renewals rather than on climate impact or adaptation measures.
DOC-28	NR's 'The Greener Railway Strategy' (May 2025)	3	• The focus of the document is primarily on the railway system and its infrastructure. • Although it discusses asset resilience, the strategy concentrates on adapting the overall network (including track, stations, and operational assets) rather than detailing individual buildings, building systems, or specific components.
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	0	• Broadly speaking, the document emphasizes resilient infrastructure. It references "resilient infrastructure, buildings and rolling stock" to ensure safe and efficient operations under adverse weather conditions. However, it does not provide detailed breakdowns of specific building systems or granular components; the focus is on an overall strategic vision for resilience 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	6	• Yes. The document identifies various building and system types likely to be affected. It covers lineside buildings, equipment shelters, relocatable equipment buildings (REB), and location cases—outlining how these structures (including their ventilation and cooling provisions) are vulnerable during extreme heat events.
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	0	• Not in a direct sense – the focus of the document is on rail network infrastructure rather than on buildings or typical building systems. • It discusses assets like tracks, overhead line equipment (OLE), and rolling stock rather than structures such as buildings.
DOC-32	EHTF Weather	0	• The document primarily focuses on rail infrastructure rather than conventional buildings.
DOC-33	352_WSFData_2025 202607 Final - Building Only	0	Not used AI as it is a sensitive document

AI Agent Summary - Q4: Are the key vulnerabilities of local assets such as specific buildings, building systems or components to physical climate related hazards, including consideration of downtime, cascading failures or operational impacts, identified with the document?

Prompt	Focus on just the content in the attached PDF document and answer this question: Are the key vulnerabilities of local assets such as specific buildings, building systems or components to physical climate related hazards, including consideration of downtime, cascading failures or operational impacts, identified with the document? Please split the answer by the following headings: Consideration of downtime, cascading failures, operational impacts					
Doc Ref	Document name	Score	Document detail	Consideration of downtime	Cascading failures	Operational impacts
DOC-01	The NR Climate Projections Guidance Note (2023)	3	Downtime: Focuses on mitigating disruptions through resilient designs and predictive modeling. Cascading Failures: Highlights interconnected risks, such as flooding and temperature extremes, that can lead to widespread operational issues. Operational Impacts: Stresses the importance of adapting infrastructure and operational strategies to cope with changing climate conditions.	The document highlights that climate-related hazards, such as extreme weather events, can significantly disrupt asset functionality and operations. For example: Flooding and Heatwaves: Specific vulnerabilities of electrical panels in flood-prone buildings are identified, with recommendations to model flood risks and temperature impacts. Downtime is mitigated by designing waterproof cabinets and flood-proofed buildings Extreme Precipitation Events: Increased winter rainfall and summer storm intensity are projected to lead to more frequent disruptions. Thresholds for weather-related asset failures are analyzed to predict downtime and guide resilience planning	The document discusses cascading failures indirectly by emphasizing how one failure can trigger others: Flooding: River flooding and storm surges can lead to the overtopping of defenses, which may cascade into widespread disruptions across interconnected systems Temperature Extremes: Heatwaves and increased temperatures can exacerbate asset vulnerabilities, such as electrical system failures, which may cascade into broader operational challenges Threshold Analysis: Doubling or trebling of asset failure rates under specific weather conditions is noted, indicating the potential for cascading impacts across systems	The document provides detailed insights into operational impacts: Flood Risk: Increased precipitation and sea-level rise are projected to disrupt operations, particularly in coastal and flood-prone areas. Operational impacts include the need for enhanced flood risk assessments and infrastructure adaptation Temperature Changes: Rising temperatures are expected to lead to more frequent heatwaves, impacting workforce welfare and asset performance. Operational strategies include improved climate control and reduced solar gain Asset Design: The document emphasizes the importance of adapting asset designs to withstand projected climate scenarios, using tools like the WRCCA Cost/Benefit Tool to assess operational feasibility
DOC-02	The WRCCA Strategy (2017) from the System Operator	3	• Asset Vulnerability Focus: The document does discuss vulnerabilities across the rail network—such as degradation or failure of points, signalling equipment, coastal infrastructure, and drainage systems—when exposed to extreme weather events. • Local vs. Specific Buildings: While there is detailed discussion regarding how adverse or extreme weather affects overall performance and operational downtime (for example, delays and cancellations because of flooding or landslides), very specific assessments of individual buildings or localized building systems are not the focus.			
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	The document highlights vulnerabilities of local assets, including buildings and systems, to climate-related hazards such as extreme heat, flooding, and storms. Key risks include structural damage, operational downtime, cascading failures across interconnected systems, and impacts on staff welfare. Hazards like track buckling, drainage system overload, and vegetation risks exacerbate disruptions, while long-term threats like coastal erosion challenge infrastructure sustainability. Mitigation strategies focus on adaptation, monitoring, and collaboration to enhance resilience and reduce operational impacts.	Heatwaves and Extreme Temperatures: The document explicitly mentions that high temperatures can lead to track buckling, necessitating speed restrictions or line closures, which directly cause downtime. For example, legacy systems on the East Coast Main Line are noted as less reliable in high temperatures, leading to degraded performance and operational delays Flooding: Heavy rainfall and flooding overwhelm drainage systems, causing water ingress into buildings and infrastructure, which results in service delays and extended downtime Desiccation of Earthworks: Prolonged dry periods cause clay shrinkage, destabilizing embankments and track geometry, leading to temporary speed restrictions and prolonged maintenance efforts	Interdependencies Between Assets: The document explicitly highlights how failures in one asset type cascade into others. For example, earthworks failures due to saturation or desiccation can affect drainage systems, which in turn impact track stability and electrification systems. Vegetation Management: Longer growing seasons and tree diseases like ash dieback increase the risk of falling trees on tracks and overhead lines during storms. This can result in cascading failures such as damage to signaling systems or overhead line equipment (OLE), amplifying operational disruptions Flooding: Poor drainage management not only causes direct flooding but can lead to structural failures in embankments and cuttings, further impacting signaling and electrification systems	Heat-Related Impacts: Extreme heat affects the welfare and productivity of staff, as well as passenger comfort in station buildings. It also impacts the reliability of overhead lines and electrical systems, requiring operational adjustments such as speed restrictions or line closures Flooding and Coastal Erosion: Rising sea levels and storm surges pose significant risks to coastal infrastructure, potentially making some parts of the network uneconomical to maintain in the long term. Flash flooding and riverbank erosion are expected to increase, further disrupting operations 1. Storms and High Winds: High winds can cause debris and trees to fall onto tracks and overhead lines, leading to service interruptions and safety risks. Proactive vegetation management and monitoring technologies are being implemented to mitigate these impacts Snow and Ice: While snow and ice are considered lower risks, they still pose operational challenges such as slippery conditions on platforms and frozen points, which are managed through gritting and point heating installations
DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	The document identifies key vulnerabilities of local assets, such as buildings and building systems, to physical climate-related hazards like flooding, overheating, and extreme weather. These hazards can cause significant downtime by disrupting electrical systems, damaging infrastructure (e.g., embankments, bridges, and platforms), and impairing operations in stations and tracks. Cascading failures, such as flooding-induced structural damage or power outages, can amplify disruptions across the network. Operational impacts include track buckling, sagging overhead lines, and damage from vegetation or high winds, all of which lead to delays, closures, and increased maintenance. Proactive measures like improved drainage, vegetation management, and resilient asset design are recommended to mitigate these risks.	Buildings and Stations: Flooding and drainage blockages are identified as risks that can lead to downtime in operational buildings and stations. For example, water ingress can disrupt electrical systems, making buildings unsafe for staff and passengers. Signaling Systems: Flooding and overheating of signaling equipment can lead to significant delays in train operations. For example, flooded equipment or heat-induced failures in signaling rooms are noted as vulnerabilities. Earthworks: Prolonged rainfall or extreme heat can lead to embankment failures and landslips, which could result in extended closures of affected rail lines.	Flooding and Scour Risks: Flooding from overwhelmed drainage systems or watercourse erosion can lead to structural damage to bridges and embankments. This, in turn, affects the stability of tracks and operational safety. Energy Infrastructure Dependencies: Failures in energy systems reliant on railway infrastructure can amplify disruptions. For instance, flooding of power distribution systems can lead to widespread outages affecting signaling and train operations. Reservoir Breaches: Emergency reservoir drawdowns during extreme rainfall events can increase downstream flooding risks, impacting railway assets and potentially causing system-wide disruptions.	Track and Rail Systems: Extreme heat can cause track buckling, requiring speed restrictions or closures. Similarly, sagging overhead lines during heatwaves can lead to dewirements, disrupting train schedules 1. Buildings and Platforms: Overheating in buildings can affect internal operations, while platform heave due to heat stress can disrupt station functionality. Vegetation Management: High winds and storms can cause trees to fall onto tracks or overhead lines, leading to delays and increased maintenance needs.
DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	The attached WRCCA plan does identify key vulnerabilities of local assets—including buildings, building systems, and components—to physical climate-related hazards. Downtime is recognized as a significant risk, with specific examples of flooding, embankment washouts, and storm damage leading to service interruptions. Cascading failures are explicitly considered, especially where the failure of one asset (e.g., drainage) can trigger failures in others (e.g., embankments, signaling, power). Operational impacts are thoroughly discussed, with detailed scenarios of disruption, safety risks, increased maintenance, and the need for emergency response and recovery plans.	The document identifies multiple scenarios where downtime is a direct consequence of climate-related hazards. For example, flooding of station buildings, platforms, subways, and car parks is acknowledged as a risk that can disrupt access, require repairs, and lead to operational downtime. Flooding could render subways impassable, causing disruption to railway users and requiring repairs, with moderate to major impacts depending on the severity and frequency of the event. Past incidents are referenced, and while flooding within buildings is considered unlikely due to existing controls, the impact is rated as moderate if it occurs. For embankments and cuttings, overtopping and washout events are highlighted as leading to line closures and significant downtime. The plan references specific sites (e.g., Llangua Court, Nailsea, Flax Bourton, Dauntsey) where flooding or washout could close main lines, with recovery time and repair costs being significant. The plan aims to reduce downtime by implementing resilience measures such as upsizing drainage, installing flood defences, and improving embankment stability. Extreme weather events, such as storms and high winds, are also cited as causes for downtime due to fallen trees, debris, or structural damage, resulting in blanket speed restrictions or service suspensions until hazards are cleared and repairs are made.	The document explicitly addresses the risk of cascading failures, particularly where the failure of one asset (e.g., drainage systems) can lead to the failure of others (e.g., embankments, track, signaling). For instance, inadequate drainage during heavy rainfall can lead to flooding, which undermines embankment stability, causes track misalignment, and damages electrical and signaling equipment. This chain reaction can result in widespread operational disruption and safety risks. Interdependencies with third-party assets are also recognized. For example, the failure of third-party drainage systems can cause local flooding that impacts railway operations, leading to speed restrictions or line closures. The document notes that such cascading failures are increasingly likely as climate change intensifies precipitation events. The plan also highlights the risk of cascading failures in power distribution systems, where flooding or lightning strikes can disrupt power supplies, affecting multiple systems (lighting, signaling, communications) and compounding operational impacts.	• Operational impacts are a central theme throughout the document. The plan details how intense rainfall, flooding, snow/ice, high winds, and extreme temperatures can disrupt normal operations by damaging infrastructure, necessitating emergency responses, and imposing speed restrictions or line closures. • For buildings, operational impacts include disruption to passenger and staff safety, deterioration of materials, and the need for emergency maintenance. The risk of water ingress, increased heating costs during extreme cold, and closure due to snow or access difficulties are all discussed as operational concerns. • For track and signaling, operational impacts include delays due to speed restrictions, increased maintenance requirements, and the need for rapid recovery plans. The document references specific resilience schemes aimed at reducing operational impacts by improving drainage, embankment stability, and flood defences. • The plan also notes that the frequency and severity of operational impacts are expected to increase under future climate scenarios, necessitating ongoing adaptation and investment in resilience measures.

DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	The document does identify key vulnerabilities of local assets to physical climate-related hazards, including their potential to cause downtime, cascading failures, and operational impacts. Specific risks include: Downtime: Flooding, heat-related track buckling, cold weather impacts, and earthwork failures are highlighted as causes of service interruptions. Cascading Failures: Interdependencies between systems, such as drainage, energy supplies, and flood defenses, can lead to cascading failures. Operational Impacts: Safety risks, increased maintenance needs, service delays, and passenger/staff welfare concerns are significant operational impacts identified.	Flooding and Drainage Overload: The document highlights the risk of drainage systems being overwhelmed during extreme rainfall events, leading to track flooding and damage to surrounding earthworks. This can result in service disruptions and downtime for repairs. Heat-Related Track Buckling: Extreme heat is noted as a significant risk, causing track buckling, which necessitates temporary line speed restrictions and can lead to service interruptions. Cold Weather Impacts: Ice formation in tunnels and on conductor rails is identified as a risk that can prevent trains from operating, leading to downtime. Additionally, snow and ice can obscure signals and freeze switches, further disrupting operations. Earthworks Failures: Prolonged wet weather and soil saturation can lead to earthwork failures, causing significant safety concerns and performance impacts, including potential derailments and line closures. Building and Station Flooding: Station buildings, platforms, and subways are vulnerable to flooding, which can result in temporary closures and operational downtime.	Interconnected Systems: It acknowledges the interdependencies between railway infrastructure and other systems, such as energy supplies and third-party flood defense systems. Failures in these interconnected systems can lead to cascading impacts on railway operations. Drainage and Earthworks: Overwhelmed drainage systems can lead to flooding, which in turn compromises earthworks and track stability, increasing the risk of landslides and derailments. Vegetation Management: High winds and storms can cause trees to fall onto tracks, leading to blockages and damage to infrastructure. This can have a domino effect, causing delays and requiring extensive repairs. Scour and Structural Damage: Increased rainfall and river flows can lead to scour and erosion of bridges and culverts, potentially causing structural failures that disrupt operations across multiple routes.	Safety Risks: The document highlights safety concerns such as derailments due to landslips, track buckling, and flooding. These events can lead to significant operational challenges and safety risks for passengers and staff. Increased Maintenance Needs: The document notes that extreme weather conditions, such as heat, cold, and flooding, accelerate asset degradation, leading to increased maintenance and repair requirements. This has implications for operational planning and costs. Service Delays and Costs: Weather-related events, such as flooding, heatwaves, and storms, have caused significant delays and financial costs in the past. For example, heat-related delays have doubled in recent years, and flooding has resulted in millions of pounds in delay costs annually. Passenger and Staff Welfare: The document acknowledges the impact of extreme weather on passenger and staff welfare, such as heat-related discomfort and safety risks during cold weather. It also emphasizes the need for improved facilities, such as water fountains and heated waiting rooms, to mitigate these impacts.
DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	The document does identify key vulnerabilities of local assets, including buildings and their systems, to physical climate-related hazards. It also considers the implications of these vulnerabilities in terms of downtime, cascading failures, and operational impacts. Specific risks such as water ingress, overheating, vegetation growth, roof damage, and ground movement are highlighted, along with their potential to cause service disruptions and cascading failures across interconnected systems.	Water Ingress: Extreme and/or prolonged rainfall can cause water ingress into buildings, leading to damage to the building fabric, contents, and failure of critical building services such as electrical and mechanical systems. Overheating: Higher temperatures may result in overheating within buildings, creating welfare challenges for occupants and potentially causing the failure of building services. Vegetation Growth: Increased vegetation growth and leaf fall can block rainwater drainage systems, leading to water ingress and damage to building structures and services. Roof Damage: High winds and storms may dislodge or damage roofing, resulting in water ingress and subsequent damage to the building and its contents. Ground Movement: Prolonged wet or dry conditions may lead to ground movement, causing structural damage to buildings and associated systems.	Flooding and Hydrostatic Pressure: Increased rainfall and flooding can lead to hydrodynamic loading, which exacerbates scour and flooding, potentially causing structural failures that could impact multiple interconnected systems. Tree Fall and Vegetation Risks: High winds and prolonged rainfall can destabilize trees, leading to tree falls that damage buildings, tracks, and other infrastructure. This can result in further cascading failures, such as blocked access routes or disrupted services. Interdependencies: The document acknowledges that the railway network operates holistically and depends on the functionality of interconnected infrastructure, such as the power network. Failures in one sector, like power outages, could disrupt railway operations, demonstrating the potential for cascading failures across sectors.	Service Disruptions: Overheating of electrical and mechanical systems in buildings can lead to service interruptions, affecting the welfare of users and the functionality of critical operations. Flooding: Flooding caused by extreme rainfall or sea-level rise can lead to the inundation of tunnels and buildings, impacting their functionality and leading to operational downtime. Temperature Variations: High temperature variances and freeze-thaw cycles can cause weathering and degradation of structures, impacting their long-term operational reliability. Storms and High Winds: Damage to antennas, buildings, and other infrastructure caused by storms and high winds can result in loss of service or reduced operational capacity. Erosion and Scour: Sea-level rise and increased hydrostatic pressure can lead to erosion and scour of building foundations, reducing their stability and operational effectiveness.
DOC-08	Eastern Region: CP7 Region Strategic Business Plan	5	Downtime: The document outlines plans for recovery-focused resilience, drainage improvements, and long-term adaptation pathways to minimize downtime risks. Cascading Failures: Investments in system-wide increased resilience due to funding constraints. Instead, the focus is on maximizing resilience within affordability limits and ensuring that recovery from weather events is as efficient as possible. Adaptation Pathway Methodology: The planning includes adaptation pathways to address uncertainties in climate change impacts. This involves identifying trigger points for decision-making and creating long-term adaptable investment plans to mitigate downtime risks. Drainage and Flood Management: Significant investments are allocated for drainage improvements, including 204 km of new drainage pipes, to reduce flood risks and associated downtime.	Asset Resilience and Recovery Focus: The document emphasizes incorporating weather resilience into asset design during renewals and refurbishments. However, it acknowledges that not all assets will achieve increased resilience due to funding constraints. Instead, the focus is on maximizing resilience within affordability limits and ensuring that recovery from weather events is as efficient as possible. Adaptation Pathway Methodology: The planning includes adaptation pathways to address uncertainties in climate change impacts. This involves identifying trigger points for decision-making and creating long-term adaptable investment plans to mitigate downtime risks. Drainage and Flood Management: Significant investments are allocated for drainage improvements, including 204 km of new drainage pipes, to reduce flood risks and associated downtime.	System-Wide Thinking: The document highlights a shift towards whole-system thinking to understand how assets interact and to identify system-level solutions. This approach aims to address cascading failures by improving water management and collaborating with third parties, such as the Environment Agency, to mitigate risks like flooding and drainage issues. Geotechnical Asset Monitoring: The strategy includes investments in understanding geotechnical asset behavior, particularly in response to extreme weather. This is intended to prevent cascading failures caused by earth movements, such as landslides or settlement issues. Technology Deployment: The use of technology like drones, remote temperature monitoring, and heat-borne CCTV is planned to detect risks (e.g., vegetation, wind, and heat-related problems) early, potentially preventing cascading failures.	Weather-Related Impacts on Operations: The document identifies specific weather-related hazards, such as flooding, heatwaves, and high winds, that can disrupt operations. Examples include track buckling, soil desiccation, frozen points, and blocked routes. Operational Expenditure for Weather Management: £94 million is allocated for operational expenditure to improve drainage performance, manage vegetation, and enhance operational planning during extreme weather events. Technology to Improve Response: Remote Condition Monitoring (RCM) and other technologies will be extended to optimize responses to weather events and reduce operational disruptions. Seasonal Failures: The strategy includes early deployment of seasonal delivery strategies to mitigate impacts from extreme weather, such as snow or heatwaves, on operational performance.
DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	5	Downtime: Aging infrastructure and extreme weather events are recognized as major contributors to downtime. Mitigation plans focus on drainage and earthworks improvements. Cascading Failures: Interdependencies between systems, such as drainage and earthworks, are highlighted as potential sources of cascading failures. Cross-asset optimization is proposed to address these risks. Operational Impacts: The document discusses the decline in train service reliability and safety risks due to climate-related hazards. Operational mitigations, such as remote monitoring and targeted interventions, are planned to address these impacts.	Weather Resilience and Climate Change Adaptation Plans: The document highlights the increasing frequency of severe weather events, such as flooding and extreme temperatures, which have impacted infrastructure reliability. Specific examples include drainage and earthworks failures, which have led to disruptions in train services and asset performance. Drainage and Earthworks: Targeted drainage and earthworks schemes are planned to mitigate flooding risks at high-risk sites. These efforts aim to reduce downtime caused by weather-related disruptions. Asset Age and Condition: The document notes that aging infrastructure, coupled with limited renewals, contributes to increased downtime risks. For example, the effective age of infrastructure is increasing, leading to a backlog of renewals and reduced reliability.	Interdependencies Between Systems: The integration of maintenance and renewals is highlighted as a fundamental requirement to prevent cascading failures. For instance, failures in drainage systems can lead to earthworks instability, which in turn impacts track reliability and train operations. Climate Change Impacts: The document mentions that extreme weather events, such as flooding and heatwaves, can lead to multiple asset failures across signaling, earthworks, and structures. These failures can cascade into broader operational disruptions, affecting train schedules and passenger safety. Cross-Asset Optimization: Efforts to optimize asset management across disciplines aim to address the interconnected risks of cascading failures. For example, targeted interventions in high-risk areas are planned to mitigate the ripple effects of asset failures.	Train Service Reliability: The document forecasts a decline in train service reliability due to aging infrastructure and climate-related hazards. It highlights the need for operational mitigations to maintain safety and service levels despite deteriorating asset conditions. Safety Risks: Increased risks from infrastructure failures, such as earthworks and drainage issues, are directly linked to operational impacts. For example, the document mentions the tragic derailment at Carmont caused by heavy rainfall, which underscores the operational risks posed by climate-related hazards. Mitigation Strategies: The document outlines strategies to enhance operational resilience, including remote condition monitoring, improved drainage management, and targeted vegetation management to reduce risks like flooding and obstructions on the line.
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	2	While the document addresses vulnerabilities related to climate-related hazards, the focus is primarily on the broader railway network and its components (e.g., signaling, track systems, and overhead lines). It does not provide detailed identification or analysis of vulnerabilities specific to individual buildings or building systems. The considerations of downtime, cascading failures, and operational impacts are acknowledged but lack granular detail specific to local assets.	The document acknowledges the impact of climate change and adverse weather conditions on railway operations, emphasizing the need for resilience and adaptation. Specific vulnerabilities are addressed, such as the risk of service-affecting failures due to deferred renewals and the reliance on shorter-term refurbishment interventions. Enhanced maintenance regimes are planned to mitigate these impacts and extend asset life, particularly for fixed plant, signaling, and track systems. However, while downtime is recognized as a consequence of asset failures, detailed quantification or specific examples of downtime for individual buildings or systems are not explicitly provided.	The document identifies risks associated with cascading failures in infrastructure systems. For example, it highlights the potential for adverse weather conditions to impact train performance, safety, and reputation due to insufficient management of environmental challenges. Moreover, the document discusses the interconnected nature of asset reliability and train service performance, indicating that failures in one system (e.g., signaling or overhead lines) could lead to broader disruptions across the network. While the concept of cascading failures is acknowledged, the document does not provide detailed analysis or examples specific to individual buildings or components.	Operational impacts are a significant focus of the document. It outlines the challenges posed by aging assets, reduced renewals, and increased weather-related risks. Specific operational impacts include disruptions to train services, reduced passenger satisfaction, and increased maintenance costs. The document also mentions the need for improved incident response capabilities and investment in weather resilience measures to mitigate operational disruptions. However, the operational impacts are discussed more broadly for the railway network rather than being tied to specific buildings or systems.

DOC-11	Southern Region: CP7 Region Strategic Business Plan	5	Downtime: Risks are identified due to aging infrastructure and deferred renewals, particularly for traction power systems and drainage. Cascading Failures: Vulnerabilities include earthwork and metallic structure failures that could lead to broader disruptions. Operational Impacts: Reduced funding and intervention are expected to increase service disruptions, maintenance needs, and risks to operational reliability.	The document highlights that reduced renewal volumes in CP7 (Control Period 7) may lead to increased temporary speed restrictions (TSRs) and delays in addressing critical maintenance needs. This could result in operational downtime for certain assets, particularly in areas like track geometry and drainage systems. Specific vulnerabilities include the potential for prolonged outages in traction power systems due to low resilience and aging infrastructure, which could lead to extended downtime in case of concurrent faults. The strategy mentions deferral of some interventions to CP8, which could exacerbate downtime risks for assets like signaling systems, drainage, and buildings.	The document identifies risks of cascading failures, particularly in areas where weather events (e.g., heavy rainfall) could lead to earthwork failures. Such failures may compromise nearby infrastructure, including tracks and signaling systems. Aging metallic structures and deferred renewals are highlighted as potential triggers for cascading failures, where one asset's failure could lead to usage restrictions or broader system disruptions. The plan also notes that reduced intervention in soil cuttings and embankments could increase the likelihood of failures spreading across interconnected systems, such as drainage and track stability.	Operational impacts are a major focus, with the document emphasizing that reduced funding and intervention in CP7 will likely lead to: Increased service-affecting failures (SAFs), particularly in signaling and track systems. Higher maintenance demands to compensate for deferred renewals, potentially straining operational resources. Risks to passenger and freight service reliability due to aging infrastructure and limited resilience to extreme weather events. The document also highlights the impact of reduced investment in workplace accommodations, which could undermine workforce efficiency and safety, indirectly affecting operations. Specific operational risks include delays caused by flooding at known high-risk locations and failures in signaling power supplies, which are critical for maintaining train schedules.
DOC-12	Scotland Region: CP7 Region Strategic Business Plan	5	Downtime: The document identifies risks of downtime due to geotechnical failures, drainage issues, and vegetation management challenges, with plans for pre-emptive maintenance and reactive interventions. Cascading Failures: Risks of cascading failures are acknowledged, particularly in interconnected systems like drainage, earthworks, and signaling power supplies. Operational Impacts: Climate-related hazards are expected to increase train delays, necessitate speed restrictions, and strain maintenance resources, all of which could disrupt operations.	Earthworks and Geotechnical Failures: The report forecasts an increase in geotechnical failures due to aging infrastructure and climate change, particularly during periods of intense rainfall. This could lead to temporary closures or operational restrictions to ensure safety. Drainage and Flooding: High-risk drainage locations are identified as critical, with failures potentially causing significant downtime. Reactive workbank investments are planned to address flooding incidents and mitigate downtime risks. Asset Maintenance: The document emphasizes pre-emptive maintenance inspections and holding works to mitigate potential downtime caused by delayed renewals or asset failures. Vegetation Management: Ash dieback and other vegetation-related risks are noted as factors that could disrupt operations, requiring targeted interventions to prevent downtime.	Interdependencies Between Assets: The report acknowledges the systemic risks posed by failures in one asset class (e.g., drainage) leading to failures in others (e.g., earthworks or track infrastructure). Signaling and Power Systems: Aging signaling power supplies and overhead line equipment are flagged as critical risks. Failures in these systems could cascade into broader operational disruptions across the network. Climate Change Impacts: The document notes that extreme weather events, such as heavy rainfall, can cause landslides or flooding, which in turn lead to cascading failures in drainage, earthworks, and track systems.	Performance Risks: The document highlights that extreme weather events, such as heavy rainfall and storms, have led to significant train delays and disruptions in the past. These events are expected to increase in frequency and severity due to climate change. Safety Measures: Speed restrictions during adverse weather conditions are a key mitigation strategy, but they also impact operational efficiency and passenger experience. Maintenance Challenges: The aging infrastructure, combined with climate change, is expected to increase the frequency of unplanned maintenance and reactive interventions, which could disrupt normal operations. Resource Allocation: The document discusses the challenges of aligning third-party and railway access with operational needs, which could impact the timely completion of maintenance and renewal projects.
DOC-13	Eastern Delivery Plan - Year 2 Update	2	Downtime: The document identifies strategies to minimize downtime through targeted maintenance and resilience investments but lacks detailed metrics or examples specific to buildings or systems. Cascading Failures: While cascading failures are addressed indirectly through risk assessments and resilience planning, there is no explicit analysis of interdependencies between systems or potential chain reactions. Operational Impacts: Operational impacts are a key focus, with significant investments in weather resilience and maintenance to ensure continuity and safety.	The document discusses the impact of asset deterioration and the prioritization of life extension over full renewals, which could lead to increased downtime for critical infrastructure. For instance: Maintenance plans are aligned with asset conditions, but reduced renewals could result in longer periods of unavailability for repairs or upgrades. Specific interventions, such as drainage improvements at high-risk flooding sites, are aimed at minimizing downtime caused by weather-related disruptions. There is a focus on ensuring continuous train operations during seasonal challenges, but no explicit mention of detailed downtime metrics for specific buildings or systems.	The document highlights a risk-based approach to managing safety and performance risks. For example: The safety risk assessment framework is used to evaluate critical asset types, such as electrical and plant systems, to mitigate cascading failures. Weather resilience investments (e.g., £0.4bn allocated for flooding, wind, and heat resilience) aim to prevent failures in interconnected systems like drainage, earthworks, and electrification. However, while cascading failures are indirectly addressed through risk management and resilience planning, there is no explicit breakdown of how failures in one system (e.g., drainage) might lead to failures in other systems (e.g., building components).	The document emphasizes the importance of maintaining operational efficiency despite reduced funding and aging infrastructure: Investments in weather resilience and modern maintenance technologies are intended to mitigate operational disruptions. The alignment of maintenance and renewal plans aims to ensure safe and optimized infrastructure performance, reducing the risk of operational impacts. Specific examples include interventions at Liverpool Street Station and other high-risk platforms to address slips, trips, and falls, which could otherwise disrupt operations. The document also mentions the integration of drainage and earthworks solutions to manage risks, which directly supports operational continuity during adverse weather events.
DOC-14	North West and Central Delivery Plan - Year 2 Update	2	Downtime: No explicit identification of vulnerabilities for specific buildings or systems is provided. Cascading Failures: The concept is indirectly addressed through broader infrastructure resilience strategies but lacks specific details for building systems or components. Operational Impacts: General impacts of climate-related hazards on infrastructure are discussed, but the focus is on railway operations rather than specific buildings or systems.	The document does not explicitly identify vulnerabilities of specific buildings, building systems, or components to physical climate-related hazards in terms of downtime. While there are references to asset resilience and maintenance regimes, the focus is primarily on broader operational strategies rather than detailing the downtime risks for individual assets. For example: Maintenance and renewals activities are highlighted as critical to sustaining operations, but specific downtime scenarios for buildings or systems are not detailed. The document mentions weather resilience plans and incident response strategies, which imply efforts to minimize downtime but lack specific asset-level vulnerability analysis.	The document does not directly address cascading failures of building systems or components due to climate-related hazards. However, it does touch upon broader risks to infrastructure, such as: Severe weather impacts (e.g., flooding, fires, and trespass) are noted as external events affecting train service delivery and infrastructure performance. There is mention of prioritizing expenditure on higher criticality lines of route and optimizing maintenance to manage asset resilience, which indirectly addresses the prevention of cascading failures but does not delve into specific building systems or components.	Operational impacts are discussed in a general sense, with references to how climate-related hazards like severe weather events could affect train service delivery and infrastructure performance. Key points include: Severe weather management: The document highlights the increased risk of severe weather and the need for targeted interventions, robust incident response, and proactive infrastructure management. Asset resilience: There is a focus on improving asset reliability and minimizing disruption caused by climate change. Climate adaptation strategies: Specific pathways for climate change adaptation are mentioned for critical infrastructure areas, such as the Cumbrian Coast and Carlisle, but these are not tied to individual buildings or systems.
DOC-15	Wales and Western Delivery Plan - Year 2 Update	2	Downtime: While the document discusses investments in weather resilience and drainage improvements, it does not explicitly quantify or analyze downtime for specific buildings or systems. Cascading Failures: There is no direct mention of cascading failures, but investments in failure detection systems and robust incident response indirectly address this concern. Operational Impacts: The document provides a stronger focus here, identifying weather-related disruptions and climate change as key risks and outlining mitigation strategies like drainage improvements, vegetation management, and asset renewals.	The document outlines several initiatives and investments aimed at mitigating risks and ensuring reliability, but it does not explicitly detail the potential downtime of specific assets due to climate-related hazards. However, it does mention: Drainage Maintenance: Investments in drainage maintenance and refurbishment are highlighted, including track drainage improvements to mitigate performance issues during severe rainfall. For example, work in the Chipping Sodbury tunnel includes lifting tracks to prevent water pooling and relocating signaling equipment out of flood zones. Weather Resilience: The document emphasizes investments in weather resilience and climate change adaptation, particularly for high-risk locations, which indirectly addresses potential downtime caused by extreme weather events.	The document does not explicitly address cascading failures in detail. However, it does mention: Geotechnical Instrumentation: Investments in failure detection equipment and geotechnical instrumentation aim to improve resilience against extreme weather and climate change. This could potentially help in identifying and mitigating cascading failures before they occur. Incident Response: The document highlights the importance of robust incident response systems to manage disruptions caused by weather-related incidents, which could prevent cascading failures from escalating.	The document provides more detailed insights into operational impacts, including: Weather-Related Disruptions: Weather-related incidents are identified as a significant risk, with high levels of service disruption, costs, and reputational impacts. Investments in weather resilience and climate change adaptation are noted as key strategies to mitigate these impacts. Asset Reliability: The document discusses risk-based renewals and maintenance to improve the resilience of critical infrastructure like overhead lines, signaling systems, and drainage. These efforts aim to reduce service disruptions and improve overall operational reliability. Climate Change Adaptation: Specific measures, such as vegetation management and drainage improvements, are being implemented to address the impacts of extreme weather and climate change on operational performance.

DOC-16	Southern Delivery Plan - Year 2 Update	2	Downtime: While not explicitly detailed, the document addresses flood risks and severe weather resilience, indirectly aiming to reduce downtime. Cascading Failures: No specific mention, but initiatives like drainage refurbishment and vegetation management could mitigate cascading failures. Operational Impacts: The document identifies operational vulnerabilities and outlines strategies to address disruptions caused by climate-related hazards.	The document does not explicitly identify the vulnerabilities of specific buildings, building systems, or components in terms of downtime caused by physical climate-related hazards. However, it does emphasize the importance of maintaining reliable train service and addressing disruptions caused by severe weather events. For example: Drainage and Flood Risk: The document mentions the completion of a drainage inventory to better understand flood risks to neighbors and railway services. It also highlights efforts to refurbish drainage systems and mitigate flooding risks, which indirectly aim to reduce downtime caused by climate-related events. Climate Resilience Program: The CP7 WRCCA Plan focuses on creating long-term climate adaptation pathways for vulnerable locations across the network, which may help mitigate downtime during severe weather events	The document does not provide specific details about cascading failures related to physical climate hazards affecting buildings, systems, or components. However, it does mention: Asset Resilience: Efforts to improve asset resilience during severe weather events through long-term planning and climate-focused investment decisions. This could potentially address cascading failures by ensuring that critical infrastructure remains operational during adverse conditions Drainage and Vegetation Management: The document highlights initiatives to reduce risks from flooding and vegetation encroachment, which could prevent cascading failures such as track blockages or damage to nearby infrastructure	The document does provide insights into operational impacts caused by physical climate-related hazards, particularly in the context of railway operations: Severe Weather and Safety: It mentions collaborative efforts across the industry to reduce weather-related risks to railway safety and performance. This includes improving asset resilience and delivering climate adaptation pathways for vulnerable locations Impact on Train Service Delivery: The document outlines challenges such as points failures and delays caused by external incidents, including weather-related disruptions. It highlights targeted maintenance and innovative technologies to address these operational impacts Lineside Strategy: Efforts to manage vegetation and drainage assets aim to reduce operational disruptions caused by flooding and fallen trees, which are linked to climate-related hazards
DOC-17	Scotland Delivery Plan - Year 2 Update	2	Consideration of Downtime: The document does not explicitly address downtime for specific buildings or systems but emphasizes the importance of maintaining operational reliability and resilience against climate-related disruptions. Cascading Failures: While the document does not directly address cascading failures of specific buildings or systems, it acknowledges the risks posed by extreme weather events and the need for a systems-based approach to asset management. Operational Impacts: The document identifies the operational impacts of climate change, particularly on critical infrastructure like drainage and earthworks, and outlines strategies to mitigate these impacts.	The document does not explicitly address the potential downtime of specific buildings, building systems, or components due to physical climate-related hazards. However, it does emphasize the importance of maintaining the reliability and resilience of the railway network in the face of climate change. For example: The document mentions the need for investment in assets to improve resilience against extreme weather and long-term climate changes. It highlights the development of a long-term climate change adaptation strategy for Scotland's Railway, which includes preparing for multiple future climate scenarios. There is a focus on maintaining operational efficiency and minimizing disruptions, but specific references to downtime for individual buildings or systems are not detailed.	The document does not provide a detailed analysis of cascading failures related to specific buildings, building systems, or components. However: It acknowledges the potential for extreme weather events, such as storms, to impact safety and performance. The document mentions the need for a whole-systems approach to managing earthworks and drainage assets, which could help mitigate cascading failures caused by extreme weather events.	The document does discuss operational impacts in the context of climate-related hazards, albeit not in the context of specific buildings or building systems. Key points include: The railway network in Scotland is increasingly affected by climate change, particularly due to rising rainfall levels, which impact critical drainage and earthworks assets. The document outlines plans for targeted investments to improve the resilience of these assets, which are critical for the overall operation of the railway network. It also highlights the need for better data and climate science to strengthen decision-making processes and manage risks associated with extreme weather events.
DOC-18	GB - CP7 Delivery Plan - Year 2 Update	0	Downtime: The document identifies vulnerabilities related to downtime caused by extreme weather and aging infrastructure. Investments in resilience and targeted interventions aim to reduce downtime, but funding constraints pose challenges. Cascading Failures: While not explicitly detailed, the document addresses cascading failures through resilience measures, predictive tools, and system-wide monitoring to prevent single points of failure from escalating. Operational Impacts: Operational disruptions due to climate hazards are acknowledged, with plans to mitigate these through technology, maintenance, and resilience investments.	The document highlights that extreme weather events and climate change are increasingly challenging for the railway network, particularly since many assets were not designed to withstand such conditions. This implies potential downtime for repairs and maintenance due to weather-related disruptions. Planned maintenance and renewals are emphasized as critical to mitigating downtime, with £2.6 billion allocated to improving the resilience of assets against extreme weather events, such as heat-related track buckling and flooding. However, the document acknowledges that funding constraints have led to a slight reduction in planned renewals, which could increase the risk of downtime in the future. The Weather Risk Task Force (WRTF) is tasked with applying targeted weather interventions in high-risk areas to minimize unnecessary disruptions and downtime across the network.	Cascading failures are addressed indirectly through the focus on resilience improvements. For example, investments in drainage systems and earthworks aim to reduce the risk of landslides and flooding, which could otherwise trigger a chain reaction of failures affecting multiple systems or regions. The document mentions the use of Intelligent Infrastructure (II) and Infrastructure Monitoring (IM) tools to predict and prevent failures. These tools provide real-time insights to help manage risks and avoid cascading impacts from single points of failure. There is a recognition of the interconnected nature of the railway system, where failures in one component (e.g., signaling or track) can lead to widespread disruptions. Efforts to modernize and integrate systems, such as through digital signaling, are intended to mitigate these risks.	Operational impacts are a significant focus, with the document noting that extreme weather events have already affected train performance and caused delays. For instance, vegetation issues and infrastructure failures due to weather have led to increased delays and cancellations. The document outlines plans to invest in remote infrastructure monitoring and weather resilience measures to reduce the operational impacts of climate-related hazards. These include better drainage systems, enhanced earthworks, and technology to monitor asset conditions in real time. The impact of inflation and rising supply chain costs is also noted as a factor that could affect operational efficiency and the ability to respond to climate-related challenges effectively.
DOC-19	System Operator CP7 Delivery Plan	0	Downtime: The document indirectly addresses downtime through initiatives like ROWS and the Weather Risk Task Force, which aim to minimize service disruptions during extreme weather. However, there is no specific mention of downtime related to individual buildings or systems. Cascading Failures: While the document emphasizes a whole-system approach to risk management, it does not explicitly address cascading failures in the context of building systems or components. Operational Impacts: The document provides a detailed focus on operational risks and resilience planning, particularly in response to climate-related hazards. Training initiatives and partnerships with organizations like the Met Office are highlighted as key strategies to mitigate such risks.	The document emphasizes the importance of minimizing disruptions caused by adverse and extreme weather conditions. For example, the Weather Risk Task Force is tasked with improving operational decisions during such events by leveraging tools, processes, and scientific advancements like real-time observations and weather forecasting. Specific initiatives, such as the development of the Rail Operations Weather Service (ROWS), aim to reduce the likelihood and consequences of accidents and improve service reliability during adverse weather conditions. This suggests an indirect acknowledgment of downtime risks but does not explicitly quantify the potential downtime for specific assets like buildings or systems.	While the document does not explicitly discuss cascading failures in the context of building systems or components, it does address the need for a whole-system approach to risk management. For instance, the Weather Risk Task Force coordinates cross-industry efforts to mitigate risks, which could include cascading failures in infrastructure. The focus on "whole system change" in operations, train operations, and engineering indicates an awareness of interconnected vulnerabilities, but specific examples of cascading failures related to buildings or systems are not detailed.	The document highlights operational risks due to climate impacts, particularly in the context of extreme weather. The partnership with the Met Office to appraise operational capabilities over a 10+ year horizon is a proactive measure to assess and mitigate these risks. The Weather Academy and associated e-learning modules aim to enhance industry-wide knowledge and preparedness for weather-related operational challenges. This includes training on drainage and earthworks, which are critical to maintaining operational safety and efficiency. The document also mentions the importance of resilience planning for weather and external events, which includes improving service during adverse weather and implementing cross-route learning to enhance industry practices.
DOC-20	The CP7 Buildings & Architecture Policy (2021)	1	The document does address asset vulnerabilities and the need for resilience in the face of potential hazards, including climate-related factors. However, it does not explicitly identify specific vulnerabilities of local assets (e.g., buildings, building systems, or components) to physical climate-related hazards in the context of downtime, cascading failures, or operational impacts. The discussions are more general and focus on overarching principles like stewardship, safety, satisfaction, and sustainability.	The document provides a framework for assessing asset vulnerabilities and planning interventions, but it does not explicitly focus on downtime caused by physical climate-related hazards. It mentions the importance of proactive maintenance, renewal, and refurbishment to prevent disruptions, but specific examples of downtime caused by climate-related hazards are not detailed. The document emphasizes the need for proactive maintenance and renewal to avoid unplanned disruptions and delays in operations It highlights the importance of addressing asset degradation and maintaining operational reliability, but it does not provide explicit case studies or examples of downtime caused by climate-related hazards	The document touches on the interconnectedness of assets and the potential for cascading failures, particularly in the context of resilience and stewardship. However, it does not provide detailed examples or specific scenarios of cascading failures due to physical climate-related hazards. The document discusses the importance of systems thinking, which involves understanding how assets interrelate and how failures in one area could impact others. This suggests an awareness of cascading failures, but it lacks detailed examples or explicit focus on climate-related triggers It emphasizes the need for resilient asset management to adapt to macro factors like extreme weather conditions, but the discussion remains general	The document provides a broader discussion on operational impacts, particularly in the context of safety, satisfaction, and sustainability. It identifies how poor asset conditions can lead to operational disruptions and safety risks but does not explicitly link these to physical climate-related hazards. The document highlights the risks of unplanned disruptions due to poor asset conditions and emphasizes the need for interventions to safeguard operations It discusses the importance of maintaining asset reliability and functionality to prevent operational impacts, including safety risks and reduced user satisfaction While the document mentions the potential impacts of climate change (e.g., flooding, long-term drought), it does not provide specific examples of how these would affect operations

DOC-21	"Additional information for asset managers" (2025)	3	• Risk Prioritisation Framework: The document uses tools such as the Percentage Asset Remaining Life (PARL), Asset Risk Score (ARS), and Corporate Risk Assessment Matrix (CRAM) to assess vulnerabilities. • Indirect Identification: Although the policy discusses degradation, reduced asset life, and the need for resilient stewardship—which are all linked to potential climate impacts—the vulnerabilities are framed in a broader risk and performance context without a separate, detailed breakdown solely focused on climate-induced downtime or cascading failures. • Conclusion: Vulnerabilities are addressed as part of a comprehensive risk management strategy, but detailed operational impacts (like explicit downtime scenarios triggered by climate hazards) are not itemized in isolation.			
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authority	0	Downtime: Not explicitly addressed in the document. Cascading Failures: No specific identification or mitigation strategies provided. Operational Impacts: While operational efficiency is emphasized, the document does not directly address climate-related vulnerabilities.	The document does not explicitly identify or analyze vulnerabilities related to downtime of local assets due to physical climate-related hazards. While it emphasizes the importance of sustainability, safety, and stewardship, it does not delve into specific scenarios or strategies for mitigating downtime caused by climate-related events.	Similarly, the document does not provide a detailed assessment of cascading failures within building systems or components due to climate-related hazards. It focuses on advancing smart building technologies and data exploitation, which could indirectly address cascading failures through predictive and preventive measures. However, explicit identification or mitigation strategies for cascading failures are not covered.	The document does highlight the importance of operational efficiency and sustainability within the built environment. It mentions initiatives like smart buildings, data exploitation, and whole-life costing, which could contribute to minimizing operational disruptions. However, it does not specifically address vulnerabilities or operational impacts stemming from physical climate-related hazards.
DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	3	Not used AI as it is a sensitive document			
DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	0	Not used AI as it is a sensitive document			
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	0	• There is no explicit assessment or identification of localized vulnerabilities (downtime, cascading failures, operational impacts) for buildings or infrastructure components. • The report addresses overall organisational capacity and improvement in climate-related activity without drilling down to the level of particular assets or local vulnerabilities.			
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	Similarly, it does not detail key vulnerabilities of local assets (such as specific buildings, systems, or components) to physical climate-related hazards, nor does it discuss aspects like downtime, cascading failures, or operational impacts derived from climate hazard exposure.			
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	• There is no identification or discussion of vulnerabilities of assets to the impacts of physical climate change. • The document does not mention downtime, cascading failures, or any operational impacts related to climate hazards.			
DOC-28	NR's "The Greener Railway Strategy" (May 2025)	2	• While the document emphasizes the need for resilience and adaptation of railway infrastructure overall, it does not provide a detailed breakdown of vulnerabilities at a local asset level (e.g. specific buildings or systems). • The approach is more high-level, addressing systemic resilience rather than a granular analysis of vulnerabilities such as downtime, cascading failures, or operational impacts for individual assets.			
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	0	The Blueprint sets out high-level ambitions regarding resilience and adaptation of the rail network. While it underscores the importance of understanding and mitigating vulnerabilities, it does not delve into detailed assessments of local assets (including downtime or cascading failures) for specific buildings or systems. The approach is largely strategic and system-wide rather than asset-specific 1.			
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	6	Yes. The vulnerabilities of local assets are addressed in detail. The report explains how inadequate maintenance, exposure to high temperatures, and design deficiencies (such as limited insulation or insufficient cooling capacity) translate into downtime, operational disruptions, and cascading failures. These considerations include risks to various components of the rail system, from buildings to critical track and electrical infrastructure.			
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	0	• The document does identify vulnerabilities, but these relate primarily to rail infrastructure assets (for example, the sensitivity of tracks and OLE to extreme temperatures and wind conditions). • It highlights potential cascading operational failures (such as stranded trains leading to service disruptions) and downtime caused by inappropriate trigger points or outdated procedures. • However, it does not address vulnerabilities in buildings or conventional building systems.			
DOC-32	EHTF Weather and Climate Change Report (March 2023)	0	• The report discusses vulnerabilities through the lens of infrastructure performance. For instance: • It details the effects of extreme temperatures on rail assets such as the overheating of signalling cabinets and sagging of overhead cables. • It notes cascading failures caused by issues like clay earthwork degradation and the knock-on effects (e.g. wildfires, falling trees) that lead to operational downtime. • Although "local assets" in the traditional building sense are not the focus, the analysis of rail network components effectively highlights key vulnerabilities, including considerations of downtime and cascading impacts.			
DOC-33	352_WSFData_2025202 607 Final - Building Only	0	Not used AI as it is a sensitive document			

AI Agent Summary - Q5: Are the codes or standards against which climate related hazards are assessed for compliance, including performance thresholds, and design and resilience objectives, identified within the document?

Prompt	Focus on just the content in the attached PDF document and answer this question: Are the codes or standards against which climate related hazards are assessed for compliance, including performance thresholds, and design and resilience objectives, identified within the document? Please split the answer by the following headings: Performance thresholds, design objectives and resilience objectives					
Doc Ref	Document name	Score	Document detail	Performance Thresholds	Design Objectives	Resilience Objectives
DOC-01	The NR Climate Projections Guidance Note (2023)	2	Performance Thresholds: Thresholds for weather variables are identified and detailed, but no external codes or standards are explicitly cited. Design Objectives: Guidance is provided for incorporating climate projections into asset design, but no specific external design standards are mentioned. Resilience Objectives: The document outlines resilience goals and references regulatory guidance but does not specify external resilience standards.	The document provides information on thresholds related to weather variables and climate projections. Specifically: Weather Thresholds: The document mentions thresholds for weather variables that, when exceeded, cause significant asset failures or disruptions. These thresholds are based on analyses such as the TraCCA (Tomorrow's Railway and Climate Change Adaptation) WP1B Operations weather thresholds analysis report. These thresholds are subject to updates based on new data and changes in asset design or operation. Quantitative Data: Thresholds for various weather parameters (e.g., rainfall, temperature) are provided, including baseline frequencies and future projections using UKCP18 and UKCP09 datasets. These thresholds are used to calculate the frequency of exceedances under different climate scenarios. Worked Examples: The document includes examples of how to apply thresholds in asset design, such as modeling flood risks and temperature impacts for specific assets. However, while thresholds are discussed extensively, the document does not explicitly reference specific external codes or standards that define these thresholds.	The document outlines design considerations for adapting to climate change but does not explicitly list external codes or standards for design objectives. Key points include: Asset Design Life: Guidance is provided on selecting climate projection data based on the design life of assets or interventions. For example, assets with a design life extending beyond the 2050s should use future climate projections (e.g., for the 2070s or 2080s). Design Adjustments: Recommendations for minimizing climate impacts on assets include options like waterproofing, floodproofing, raising equipment height, and incorporating low-carbon climate control systems. Climate Scenarios: The document emphasizes the use of UKCP18 and UKCP09 climate scenarios to inform design decisions, ensuring resilience to projected changes in temperature, precipitation, and sea level rise. While the document provides a framework for incorporating climate projections into design, it does not specify external design standards or codes.	The document extensively discusses resilience objectives, focusing on enhancing the ability of assets, networks, and systems to anticipate, absorb, adapt to, and recover from disruptive weather events. Key highlights include: Weather Resilience: Defined as the ability to maintain performance and safety under changing weather conditions. The document provides guidance on using climate projections to improve resilience. Regulatory Guidance: References are made to guidance from environmental regulators (e.g., EA, SEPA, NRW) for specific parameters like sea level rise and peak river flows. These guidelines are used to enhance resilience planning. Adaptation Strategies: The document emphasizes the need for proactive adaptation measures to avoid increased exposure to climate risks, including safety and performance impacts. While resilience objectives are well-defined, the document does not explicitly cite external codes or standards for resilience.
DOC-02	The WRCCA Strategy (2017) from the System Operator	3	• Performance Thresholds and Standards: The document references performance measures – such as the Public Performance Measure (PPM) – and discusses thresholds (for instance, definitions of “adverse” and “extreme” weather) as determined by analysis. It also makes mention of asset standards, updated policies, and controls (e.g. through the GRIP process) used to drive design resilience. • Specific Codes: While it cites sources like “UK Climate Projections 2009” and reports by the IPCC, it does not list detailed building codes or separate formal standards exclusively for climate hazards.			
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	3	Performance Thresholds: No specific codes or standards are mentioned, but adaptation pathways and trigger points are used to assess thresholds. Design Objectives: Modern standards are incorporated into designs, but the document does not cite specific design codes. Resilience Objectives: Strategies like monitoring, maintenance, and adaptation pathways are outlined, but no explicit resilience standards or codes are referenced.	The document does not explicitly reference specific codes or standards for assessing performance thresholds against climate-related hazards. However, it mentions the use of adaptation pathways and trigger points to identify when decisions need to be made to address climate impacts. These pathways are designed to evaluate thresholds beyond which assets or services may become inefficient, unsafe, or redundant. While this approach is strategic, it does not directly cite specific performance standards or codes.	The document highlights the incorporation of modern standards into the design and planning processes to enhance resilience. For example: Modern Standards: It ensures that new assets are designed to withstand current and future weather conditions, such as heat, flooding, and wind. Hierarchy of Design: The design approach prioritizes removing events, reducing risks, mitigating impacts, and enabling recovery. Specific Initiatives: Examples include the renewal of timber switch and crossing layouts to accommodate rising temperatures and the use of heat-reflective paint on assets prone to heat expansion. While these initiatives align with design objectives, the document does not explicitly mention specific design codes or standards.	The document outlines several resilience-focused strategies but does not identify specific standards or codes. Key resilience objectives include: Enhanced Monitoring: Deployment of remote condition monitoring systems (e.g., tiltmeters, inclinometers) to predict failures and vulnerabilities. Proactive Maintenance: Risk-based drainage and vegetation management to improve resilience against flooding and desiccation. Adaptation Pathways: A structured decision-making framework to phase investments and actions over time, ensuring long-term resilience. Collaborative Efforts: Partnerships with entities like the Environment Agency to align resilience objectives with broader climate adaptation goals. Although these strategies aim to enhance resilience, the document does not specify compliance with particular resilience standards or codes.
DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	Performance Thresholds: The document identifies standards for heat and flood resilience, ensuring compliance with updated design criteria. Design Objectives: Objectives include enhancing design resistance, reliability, and adherence to standards like NR/L2/ENV/015. Resilience Objectives: Strategies focus on resistance, reliability, redundancy, and response/recovery to mitigate climate-related hazards.	The document references current best practice design criteria laid out in Network Rail standards for drainage, earthworks, track, and OLE (Overhead Line Equipment) renewals. These standards are updated nationally and supported by the NW&C region to ensure compliance with climate-related performance thresholds. Specific examples include: Heat resilience: The document mentions the use of aluminum catenary replacement to increase design temperature thresholds for OLE systems, with improvements from -18°C to 38°C to -12°C to 43°C. This anticipates future standards changes and enhances resilience against extreme heat Flood resilience: Drainage systems are assessed for their ability to manage extreme precipitation events, with renewals and inspections targeting high-risk areas to prevent line flooding and earthwork saturation	The document emphasizes the importance of designing infrastructure to be “climate-ready” and includes objectives such as: Design resistance and reliability: Renewals are undertaken to ensure infrastructure can withstand extreme weather conditions. For example, track upgrades from jointed track to Continuous Welded Rail (CWR) improve heat tolerance and reduce maintenance costs Whole-systems approach: Renewals are conducted across multiple disciplines, such as integrating drainage and track upgrades, to enhance overall resilience Adherence to standards: The document highlights compliance with standards such as NR/L2/ENV/015 (Environment and Social Minimum Requirements – Design and Construction), which ensures that renewals are built to withstand future climate risks	The document outlines several resilience objectives aimed at reducing climate-related risks: Resistance: Preventing damage or disruption by providing infrastructure strength or protection to resist hazards. For example, structures are designed to withstand a 1-in-200-year storm event. Reliability: Ensuring infrastructure components operate under a range of conditions. Examples include re-tensioning OLE wires to prevent sagging during heatwaves and installing axle counters for train detection to enhance flood resilience Redundancy: Backup installations, such as drainage systems and vegetation management programs, are implemented to ensure continuity of services during disruptions Response and Recovery: The document highlights the importance of fast and effective responses to disruptive events, supported by tools like the Convective Alert Tool (CAT) and Rail Operations Weather Service (ROWS)

DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	Performance thresholds are identified and linked to operational limits, asset condition, and compliance with specific standards for various climate hazards. Design objectives are clearly stated, focusing on compliance with updated British and European standards, holistic system approaches, and explicit inclusion of climate change projections. Resilience objectives are a core part of the plan, with dedicated funding, strategic adaptation pathways, and integration into both new and existing asset management practices. The document provides extensive references to specific standards and legislative requirements, including but not limited to: Machinery Directive 2006/42/EC, BS EN 280:2013+A1:2015, BS EN 15746-2:2010+A1:2011, BS EN 15954-2:2013, BS EN 15955-2:2013, RIS-1530-PLT, BS EN 14033-2:2017, and NR/L2/CIV/295 1. The plan demonstrates a proactive approach, with continuous improvement, learning from past events, and a commitment to updating standards and practices as climate science evolves. The integration of adaptation pathways and the focus on both primary and secondary resilience benefits ensure that the region is not only compliant with current standards but is also preparing for future climate risks.	The document frequently references the use of decision thresholds, trigger levels, and performance indicators for various asset types (e.g., track, drainage, structures, plant, and power distribution). These thresholds are often linked to asset condition, weather warnings, or specific climate variables (e.g., temperature, rainfall, wind speed). For example, for track assets, speed restrictions are applied when rail temperatures exceed 54°C for jointed track and up to 56°C for continuously welded rail (CWR), with modern variants resilient to up to 64°C. These thresholds are explicitly stated as triggers for operational interventions. For structures, the revised NR/L2/CIV/295 standard for scour assessment incorporates climate change factors, with design flood events and return periods specified as performance thresholds for asset resilience. For plant and mobile equipment, wind speed limits are referenced (e.g., 28 mph for MEWPs per BS EN 280:2013+A1:2015, 25 mph for man baskets per BS 7121), and engine overheat/fire prevention thresholds are set according to Machinery Directive 2006/42/EC and other standards. In drainage, design capacities are based on historical and projected storm patterns, with the document noting that older systems may not meet future climate change needs, while new systems are designed to updated standards that include climate projections. Summary: The document does identify performance thresholds for climate hazards, often referencing specific standards, operational limits, and asset condition triggers.	The WRCCA plan states that design objectives are informed by updated standards, including climate change projections. For example, drainage standards have been updated to include climate change factors, and the region is actively developing further guidance for climate adaptation in design. The plan emphasizes holistic, whole-system design approaches, ensuring that new or renewed assets are not only compliant with current standards but also consider future climate risks (e.g., combining track and drainage renewals for efficiency and resilience). Design redundancy and reliability are explicitly called out as objectives, with the plan stating that new designs must account for primary and secondary resilience benefits, and that fail-safes and redundancy are incorporated per Network Rail standards. For plant and machinery, the document references compliance with a range of British and European standards (e.g., BS EN 15746-2:2010+A1:2011, BS EN 15954-2:2013, BS EN 15955-2:2013, RIS-1530-PLT, BS EN 14033-2:2017) for safety and operational limits under climate hazards. The document also notes that for some hazards (e.g., lightning), reliance is placed on manufacturers to devise engineering solutions, with reference to specific legislative requirements (e.g., Machinery Directive 2006/42/EC). Summary: Design objectives are identified and are closely tied to compliance with updated standards, holistic system approaches, and explicit consideration of future climate projections.	The WRCCA plan sets out clear resilience objectives, including the development and implementation of adaptation pathways, investment in pure resilience schemes, and the integration of resilience into both business-as-usual and dedicated projects. The plan allocates a dedicated resilience budget (£19m) for schemes that directly address weather impacts, with objectives such as enabling rapid recovery after extreme events, minimizing operational disruption, and ensuring safety and performance. Adaptation Pathways are described as a strategic, flexible approach to investment, with trigger points and thresholds to guide when interventions are needed. This supports long-term resilience planning and efficient resource allocation. The document highlights the importance of continuous monitoring, learning from past events, and updating resilience strategies as new risks emerge or as climate projections are refined. Specific resilience actions include upgrading earthworks, drainage, and coastal defences, as well as embedding resilience into asset renewal and maintenance practices. Summary: The document identifies resilience objectives as central to its strategy, with dedicated funding, strategic planning (adaptation pathways), and integration of resilience into all aspects of asset management and design.
DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	7	Performance Thresholds: The document identifies specific thresholds, such as 1:25-year flood events with a 20% climate change uplift and critical rail temperature (CRT) limits, as benchmarks for compliance. Design Objectives: It emphasizes embedding climate resilience into design processes, using adaptation pathways for strategic planning, and adopting a whole-system approach. Resilience Objectives: Focus areas include implementing pure and secondary resilience schemes, leveraging monitoring and forecasting technologies, and improving land and vegetation management.	The document references performance thresholds in several contexts, particularly in relation to climate-related hazards. Key mentions include: Flooding and Drainage Systems: The document highlights that drainage systems are often overwhelmed during extreme rainfall events, leading to asset damage. It mentions the need for systems designed to handle 1:25-year flood events with a 20% climate change uplift, which serves as a performance threshold for flood resilience. Temperature Tolerances: Modern standards and designs are mentioned as incorporating greater temperature tolerances, particularly in signaling equipment and track systems. For example, signaling equipment is designed to withstand higher temperature ranges, and track renewals prioritize the replacement of vulnerable assets with modern, robust equivalents. Critical Rail Temperature (CRT): The document discusses the reduction of CRT risk sites, which are critical thresholds for rail performance under heat stress.	The document outlines several design objectives aimed at improving resilience to climate-related hazards: Integration of Climate Resilience into Design: The document emphasizes the importance of embedding weather resilience and climate change considerations into design processes. For instance, it mentions that drainage, earthworks, and track renewals will adhere to modern design standards that are more resilient to extreme weather. Adaptation Pathways: The use of adaptation pathways is highlighted as a strategic approach to guide long-term investment in resilient infrastructure. This methodology involves identifying trigger points and thresholds to determine when to implement specific adaptation measures. Whole System Approach: The document advocates for a whole-system approach to design, emphasizing interdependencies between assets and the need for integrated solutions.	The resilience objectives in the document are explicitly tied to improving the ability of infrastructure to withstand and recover from climate-related hazards: Primary Resilience Schemes: Activities specifically aimed at enhancing resilience to extreme weather are categorized as "pure resilience schemes." These include targeted interventions like flood management systems and earthworks reinforcements. Secondary Resilience Benefits: The document also mentions that many renewals and maintenance activities provide secondary resilience benefits. For example, replacing older assets with those meeting modern standards inherently improves resilience. Monitoring and Forecasting: Enhanced use of remote condition monitoring (RCM) and forecasting tools is a key resilience objective. These technologies aim to improve real-time risk management and proactive intervention capabilities. Vegetation and Land Management: Improved vegetation management and land-use strategies are highlighted as critical for reducing risks like flooding and adhesion issues caused by leaf fall.
DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	Performance Thresholds: The document does not explicitly list specific codes or standards but references tools like the Weather and Climate Impact Assessment tool and the National Climate Change Risk Assessment for validation. Design Objectives: It emphasizes asset renewals, adaptation pathways, and updates to design standards to address future climate risks. Resilience Objectives: The plan includes a classification system for resilience, development of resilience metrics, and collaboration with stakeholders to enhance long-term climate adaptation strategies.	The document does not explicitly list specific codes or standards for performance thresholds against climate-related hazards. However, it does mention the use of a Weather and Climate Impact Assessment tool and references the National Climate Change Risk Assessment as a validation mechanism for identified risks. It also highlights the use of Schedule 8 delay minutes and costs attributed to adverse and extreme weather as a proxy for network resilience until a better indicator is developed. Additionally, the document refers to the Adaptation Reporting Power (ARP) and mentions alignment with Network Rail's Environmental Sustainability Strategy (2020-2050), which includes milestones for climate change adaptation.	The document outlines several design-related objectives aimed at enhancing the resilience of Scotland's Railway to climate-related hazards. These include: Asset Resilience Interventions: Renewals and refurbishments of infrastructure assets, such as drainage systems, earthworks, and overhead line equipment, are planned to improve resilience against heavy rainfall, flooding, and extreme temperatures. Design changes are being implemented to prepare for future climate changes, such as auto-tensioned overhead line equipment to withstand high temperatures. Adaptation Pathways: A flagship deliverable of the plan is the development of adaptation pathways. These pathways involve detailed site-specific climate hazard modeling and the creation of long-term strategies for high-risk locations. The pathways aim to identify trigger points for investment and prioritize adaptation options. Integration of Climate Risk into Design Standards: The document mentions that asset policies and standards are being updated by Network Rail's Technical Authority to reflect long-term climate change projections. This ensures that design objectives align with future climate risks.	The document provides a comprehensive framework for resilience objectives, including: Weather and Climate Resilience Classifications: The plan introduces a classification system to distinguish between short-term weather resilience (preparedness, response, and recovery), medium-term proactive interventions (e.g., design changes), and long-term transformational adaptation (e.g., relocation or significant modifications). Risk and Resilience Monitoring: The plan emphasizes the development of a weather and climate resilience data dashboard to track key resilience indicators and monitor the impact of weather events on railway operations. Resilience Metrics and Indicators: A series of new weather and climate resilience indicators and metrics are being developed to enhance the ability to track and measure performance. Collaborative Efforts: The plan highlights collaboration with external stakeholders, such as the Scottish Environment Protection Agency (SEPA) and Adaptation Scotland, to address shared climate-related risks. Long-Term Adaptation Strategy: The plan commits to delivering a long-term climate adaptation strategy for Scotland's Railway by 2029, informed by adaptation pathways and other resilience-focused initiatives.

DOC-08	Eastern Region: CP7 Region Strategic Business Plan	6	Performance Thresholds: The document identifies the use of adaptation pathways and meteorological predictions to establish thresholds for climate-related hazards, focusing on drainage performance and subsurface moisture levels. Design Objectives: Design considerations prioritize removing, reducing, mitigating, and recovering from climate-related risks. Weather resilience is integrated into asset refurbishment and replacement, with a focus on drainage, track, and building improvements. Resilience Objectives: The strategy includes long-term climate resilience planning, leveraging technology for site vulnerability assessments, and significant investments in weather resilience measures.	The document references the use of adaptation pathway methodology to manage uncertainty and challenges of climate change. This methodology involves identifying trigger points and thresholds to determine when decisions need to be made and actions taken. These thresholds are used to develop long-term, adaptable investment plans that align with climate resilience goals. Specific thresholds are mentioned in the context of weather resilience, such as: Drainage performance thresholds to mitigate flood risks. Subsurface moisture indices to predict and manage the shrinkage of clay assets and settlement of peat fenland due to prolonged warm and dry weather. The document also highlights the importance of meteorological predictions to forecast and act upon extreme weather events, though no specific numerical thresholds are detailed.	The document outlines a hierarchy of design for addressing climate-related risks, which includes: Remove the event. Reduce the risk. Mitigate the impact. Recover from the risk. For assets being replaced or refurbished, weather resilience is incorporated into the design. For example: Track renewals are designed to improve resilience to heatwaves. Drainage systems are upgraded to manage flooding and scour on structures. Building remediation includes weather resilience considerations, particularly for new constructions. The document emphasizes system-based planning to ensure that designs consider the interaction of assets with their environment, such as water management across the rail system.	The document sets clear resilience objectives under its Network and Asset Resilience Strategic Priority, which include: Improving the railway's resilience to climate change for the long term. Using technology and modeling to build intelligence on vulnerable sites and enhance capabilities for managing severe weather impacts. Developing contingency capabilities to improve response to extreme events. Allocating significant funding for weather resilience improvements, including: £94 million for operational expenditures related to drainage performance and hot weather management. £390 million for direct weather resilience improvements across asset disciplines, such as drainage, earthworks, and structures. Implementing adaptation pathways to ensure that current solutions do not inhibit future needs and timelines for action are well understood.
DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	4	Performance Thresholds: While the document discusses metrics like the Composite Sustainability Index (CSI) and mentions weather resilience schemes, it does not explicitly define specific performance thresholds for climate-related hazards. Design Objectives: The document identifies objectives such as enhanced drainage capacity and climate-informed earthworks design to address climate-related risks. Resilience Objectives: The document outlines several resilience-focused initiatives, including weather resilience investments, remote condition monitoring, and climate adaptation pathways.	Weather Resilience and Climate Change Adaptation (WRCCA): The document mentions the development of Climate Adaptation Pathways and severe weather schemes to manage infrastructure for hot weather and enhanced vegetation management. Specific thresholds or metrics for performance are not explicitly detailed in the sections reviewed. Composite Sustainability Index (CSI): The document forecasts a reduction in the CSI from -3.2% at the end of CP6 to -7.6% at the end of CP7, indicating a decline in asset sustainability. This metric indirectly reflects the impact of climate-related hazards on infrastructure performance. Drainage and Earthworks Resilience: Drainage renewals and earthworks are planned to address high-risk weather-impacted sites, but specific performance thresholds for these interventions are not explicitly stated.	Drainage Solutions: Design objectives include specifying greater capacity requirements for drainage systems to account for climate change impacts. Earthworks Projects: These are designed with climate change considerations, such as increased capacity to handle extreme weather events. Weather and Climate Change Impact Assessments: All projects are required to produce these assessments to guide design decisions, ensuring infrastructure resilience against climate-related hazards.	Weather Resilience: Investments are targeted at renewing and refurbishing assets known to be less resilient to climate change impacts. This includes improving drainage, coastal defenses, and overhead line equipment (OLE) resilience. Remote Condition Monitoring: Expansion of monitoring systems for earthworks and other assets to enhance decision-making and response to extreme weather events. Vegetation Management: Targeted vegetation management is prioritized based on risk scores to reduce the impact of severe weather on rail infrastructure. Climate Adaptation Pathways: Long-term planning is emphasized to understand and mitigate the risks posed by climate change on the railway network.
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	3	Performance Thresholds: While not explicitly detailed, resilience assessments and funding allocations imply the use of performance thresholds to evaluate infrastructure against climate hazards. Design Objectives: Specific design standards are not identified, but the focus on ISO 55001 principles and resilient infrastructure suggests overarching design objectives aimed at climate adaptation. Resilience Objectives: The document clearly outlines resilience goals, including long-term adaptation strategies, collaboration with task forces, and targeted investments in vulnerable areas.	The document does not explicitly identify specific codes or standards for assessing compliance with climate-related hazards in terms of performance thresholds. However, it mentions the importance of maintaining infrastructure resilience to extreme weather and climate change impacts. For example: Resilience Assessments: The document highlights the need for assessments of resilience to various extreme weather events across asset classes, which indirectly implies performance thresholds are considered during these evaluations Investment in Weather Resilience: A budget of £27 million is allocated for weather resilience and climate change adaptation, informed by resilience assessments. This suggests performance thresholds are applied to determine the adequacy of infrastructure against climate impacts	The document does not provide detailed design standards or objectives for climate-related hazard compliance. However, it does emphasize: Infrastructure Adaptation: The need for infrastructure to be as resilient as possible to climate change and extreme weather events. This indicates that design objectives likely focus on enhancing the ability of infrastructure to withstand such conditions Asset Management: The document mentions alignment with ISO 55001 principles for best practices in asset management, which may indirectly influence design objectives related to climate resilience	The document provides more clarity on resilience objectives, including: Long-Term Adaptation Pathways: It mentions the establishment of long-term adaptation pathways as part of the weather resilience and climate change adaptation plan. This suggests a strategic approach to building resilience over time Operational Railway Resilience: Collaboration with a weather risk task force to enhance the resilience of the operational railway, ensuring reliability for passengers and freight users Specific Resilience Investments: The document outlines targeted investments in high-risk locations to improve resilience, such as the renewal of overhead line systems and drainage strategies
DOC-11	Southern Region: CP7 Region Strategic Business Plan	6	Performance Thresholds: The document identifies thresholds such as compliance with Eurocode 7, 1:25-year flood events + 20% climate change uplift, and adaptation pathway trigger points. Design Objectives: It emphasizes modern design standards, sustainable drainage systems, and vegetation management to mitigate climate-related risks. Resilience Objectives: The focus is on building a climate-resilient railway through long-term adaptation pathways, improved asset resilience, and collaboration with external agencies.	The document mentions the use of performance thresholds in the context of climate-related hazards. Specifically: The plan highlights the use of adaptation pathway methodology to develop long-term investment plans. This methodology incorporates trigger points and thresholds for decision-making, ensuring that investments are aligned with climate adaptation needs It also refers to compliance with Eurocode 7 for earthworks interventions, which is a European standard for geotechnical design Drainage systems are designed to meet 1:25-year flood events with a 20% climate change uplift, which serves as a performance threshold for climate adaptation	The document outlines several design-related objectives to address climate-related hazards: Modern Design Standards: Renewed or replaced assets are designed to modern standards to enhance resilience against current and future climate events Sustainable Drainage System (SuDS) Principles: Interventions incorporate SuDS principles to manage water more effectively and mitigate flooding risk1. Vegetation Management: The off-track and earthworks plans aim to address risks associated with trees and vegetation, following recommendations from the Mair and Slingo reports	The document emphasizes building a climate-resilient railway and identifies specific resilience objectives: Improved Asset Resilience: The plan focuses on adapting infrastructure to withstand both current and future weather events caused by climate change Long-Term Adaptation Pathways: The use of adaptation pathways is highlighted as a means to prioritize and structure investment in resilience measures, ensuring readiness for future climate challenges Collaboration with the Environment Agency: The plan includes working with the Environment Agency to identify high-priority sites for resilience interventions

DOC-12	Scotland Region: CP7 Region Strategic Business Plan	3	Performance Thresholds: The document does not specify exact codes or standards but implies thresholds through operational and safety measures for extreme weather events. Design Objectives: While specific standards are not cited, the document emphasizes system-wide design improvements, such as enhanced drainage and the use of innovative technologies. Resilience Objectives: The document provides a comprehensive Climate Ready Plan and highlights resilience measures, such as remote monitoring and improved risk assessments, to address climate-related hazards.	The document does not explicitly list specific codes or standards for assessing compliance with performance thresholds related to climate hazards. However, it does reference the need for: Adherence to operational thresholds for adverse weather conditions, such as rainfall and wind speeds, to guide safety measures like speed restrictions during extreme weather events. Incremental improvements in drainage and earthworks to handle increased volumes of water, suggesting that performance thresholds are implicitly tied to the capacity of these systems to manage extreme weather impacts.	The document outlines design objectives indirectly through its strategies for asset management and climate adaptation: Whole-system approaches to renewals and maintenance, which include increasing the capacity of drainage systems to handle higher rainfall intensities. Use of innovative technologies, such as remote condition monitoring, to improve the design and functionality of infrastructure in response to climate risks. Alignment with national and regional policies on climate resilience and sustainability, though specific design codes or standards are not explicitly mentioned.	The document provides a more detailed discussion on resilience objectives: Climate Ready Plan (2024-2029): This plan integrates the Weather Resilience and Climate Change Adaptation (WRCCA) strategy, focusing on improving the resilience of infrastructure against climate impacts. Key Workstreams: Climate Ready Assets: Direct interventions to enhance infrastructure resilience, such as increasing the capacity of drainage systems and implementing remote condition monitoring. Climate Ready Intelligence: Enhancing internal climate science capabilities and risk assessment processes to inform resilience strategies. Taskforce Recommendations: The document references recommendations from the Weather Risk Taskforce, including the deployment of remote monitoring systems and enhanced inspection protocols for earthworks and drainage assets.
DOC-13	Eastern Delivery Plan - Year 2 Update	1	Performance Thresholds: Not explicitly linked to specific codes or standards. Design Objectives: Focus on resilience improvements but lack reference to compliance standards. Resilience Objectives: Emphasize investments and risk-based approaches without citing specific standards.	The document does not explicitly mention specific codes or standards for assessing compliance with performance thresholds related to climate hazards. While it discusses performance metrics and targets, such as carbon emissions reduction and biodiversity net gain, these are framed as strategic objectives rather than compliance thresholds tied to specific standards.	The document outlines various design-related initiatives, such as: Investments in drainage improvements at high-risk sites to enhance resilience against adverse weather. Integration of risk-based renewals and modern maintenance principles to improve infrastructure resilience. However, it does not explicitly reference specific design codes or standards that guide these objectives.	The document highlights resilience-focused initiatives, including: A £0.4 billion investment in weather resilience for assets like drainage, earthworks, and electrification systems. Use of risk-based approaches to prioritize interventions at vulnerable sites. Development of a safety risk assessment framework to address risks from reduced renewals. Despite these efforts, the document does not identify specific resilience standards or codes for compliance.
DOC-14	North West and Central Delivery Plan - Year 2 Update	1	Performance Thresholds: The document outlines targets for carbon emissions reduction, biodiversity net gain, and sustainability indices but does not specify the codes or standards for compliance. Design Objectives: Strategies for climate change adaptation and infrastructure improvements are described, but specific design codes or standards are not identified. Resilience Objectives: The document includes resilience plans such as WRCCA initiatives, severe weather risk management, and targeted renewals, but lacks explicit reference to compliance standards or codes.	The document does not explicitly identify specific codes or standards used to assess climate-related hazards for compliance with performance thresholds. However, it mentions the following relevant targets and metrics related to environmental performance: Carbon Emissions Reduction: The document outlines a target to achieve net zero carbon emissions by 2050 and includes specific reduction forecasts for Scope 1 and 2 emissions during the CP7 period. For example, a 21% reduction in carbon emissions is targeted by the end of CP7. Biodiversity Net Gain: The document sets a goal of achieving a 4% net gain in biodiversity by the end of CP7. Composite Sustainability Index (CSI): The document mentions a CSI target of -3.8% for CP7, which is set against a CP6 baseline. While these targets are performance-related, the document does not provide specific codes or standards for assessing compliance with these thresholds.	The document discusses several initiatives and strategies aimed at adapting infrastructure to climate-related challenges, but it does not explicitly reference specific design codes or standards. Key design objectives include: Climate Change Adaptation: The document mentions the development of climate change adaptation pathway strategies for critical infrastructure areas such as the Cumbrian Coast, Carlisle, and Euston (0-60 miles). These strategies aim to enhance resilience to climate change. Infrastructure Improvements: Renewal of overhead line equipment on the West Coast Mainline North and Birmingham New Street area to improve asset condition and resilience against adverse weather events. Drainage Systems: Drainage renewals target areas at high risk of flooding, incorporating innovative surveying techniques for responsive decision-making. These objectives indicate a focus on designing infrastructure to withstand climate-related hazards, but the document does not specify the standards or codes guiding these designs.	The document outlines several resilience objectives related to climate-related hazards, but it does not explicitly mention the codes or standards used for compliance. Key resilience objectives include: Weather Resilience and Climate Change Adaptation (WRCCA): The document highlights the importance of embedding WRCCA initiatives into operational and asset management plans. This includes transitioning to zero-emission vehicles, improving energy efficiency in buildings, and delivering biodiversity plans. Severe Weather Risk Management: The document acknowledges the increased risk of severe weather events and outlines targeted interventions, robust incident response, and increased use of technology to proactively manage infrastructure. Drainage and Earthworks: Renewals focus on areas at the highest risk from adverse weather events, such as flooding and embankment instability, to enhance resilience. Although these objectives demonstrate a commitment to resilience, the document does not specify the performance standards or compliance codes for these measures.
DOC-15	Wales and Western Delivery Plan - Year 2 Update	1	Performance Thresholds: No explicit codes or standards are mentioned, but there is a focus on risk-based renewals and weather resilience to maintain performance. Design Objectives: The document discusses infrastructure improvements (e.g., drainage and overhead line resilience) and climate adaptation but does not specify design standards or objectives. Resilience Objectives: Several initiatives aim to enhance resilience to climate-related hazards, but specific compliance standards or codes are not identified.	The document does not explicitly mention specific codes or standards for performance thresholds related to climate-related hazards. However, it highlights the importance of risk-based asset renewals and investments in weather resilience and climate change adaptation. These efforts aim to ensure that infrastructure can withstand severe weather events and maintain operational performance. While these initiatives imply the existence of performance benchmarks, the document does not detail the specific thresholds or standards used.	The document mentions several design-related goals aimed at improving resilience and sustainability: Drainage Refurbishment: Specific projects, such as the Chipping Sodbury tunnel drainage refurbishment, aim to prevent water pooling and protect signaling equipment from flood zones. This indicates a focus on designing infrastructure to mitigate flood risks. Overhead Line Resilience: Investments in making overhead lines more resilient to weather conditions are highlighted, but the document does not specify the design standards or codes guiding these improvements. Climate Change Adaptation: The document refers to initiatives to adapt assets to climate change challenges, such as extreme weather, but does not provide detailed design objectives or compliance standards.	The document outlines several resilience objectives, including: Weather Resilience and Climate Change Adaptation: Investments are being made to adapt to climate change and enhance the railway's ability to handle weather-related incidents that could disrupt services. Specific measures include robust incident responses and targeted investments in high-risk areas. High-Risk Location Focus: Resilience schemes are being implemented in high-risk locations to address vulnerabilities to extreme weather and climate change. Geotechnical Instrumentation: The document mentions the use of failure detection equipment and geotechnical instrumentation to improve resilience against extreme weather. Biodiversity Improvements: Initiatives such as green roofs, station community gardens, and valued lineside management are part of the broader strategy to enhance environmental resilience. While these objectives demonstrate a commitment to resilience, the document does not explicitly reference specific standards or codes that guide these efforts.

DOC-16	Southern Delivery Plan - Year 2 Update	1	Performance Thresholds: The document outlines specific targets for carbon emissions, biodiversity, and air quality but does not reference compliance with external codes or standards. Design Objectives: There is a focus on low-carbon design, energy efficiency, and habitat management, but no explicit mention of external design standards or codes. Resilience Objectives: The document includes detailed plans for improving climate resilience and asset adaptation but does not identify specific resilience standards or codes.	The document does not explicitly list specific codes or standards for assessing climate-related hazards or performance thresholds. However, it does mention regulated targets and measures for sustainability, such as: Carbon emissions (Scope 1 & 2): Targets for percentage reductions in carbon emissions against the CP6 exit baseline are outlined for each year of CP7, ranging from 2% in 2024/25 to 20% by 2028/29. Biodiversity Units: Targets for percentage increases in biodiversity units are provided, from 0% in 2024/25 to 4% by 2028/29. Air Quality at Stations: Targets for reducing air pollution at managed stations are set, ranging from 1% in 2024/25 to 5% by 2028/29 1. These targets suggest a focus on measurable outcomes but do not reference specific external standards or codes for compliance.	The document does not explicitly identify specific codes or standards used to assess climate-related hazards for compliance with performance thresholds. However, it mentions the following relevant targets and metrics related to environmental performance: Carbon Emissions Reduction: The document outlines a target to achieve net zero carbon emissions by 2050 and includes specific reduction forecasts for Scope 1 and 2 emissions during the CP7 period. For example, a 21% reduction in carbon emissions is targeted by the end of CP7 Biodiversity Net Gain: The document sets a goal of achieving a 4% net gain in biodiversity by the end of CP7 Composite Sustainability Index (CSI): The document mentions a CSI target of -3.8% for CP7, which is set against a CP6 baseline While these targets are performance-related, the document does not provide specific codes or standards for assessing compliance with these thresholds.	The document provides a more detailed discussion of resilience objectives, particularly in the context of climate resilience. Key initiatives include: Collaborative efforts: Working across the industry to reduce weather-related risks to railway safety and performance. Asset resilience: Improving the resilience of railway assets during severe weather events through long-term planning and climate-focused investment decisions. Climate adaptation pathways: Delivering the CP7 Weather Resilience and Climate Change Adaptation (WRCCA) Plan and creating long-term climate adaptation pathways for vulnerable locations across the network These resilience objectives focus on enhancing the ability of the railway infrastructure to withstand and adapt to climate-related challenges. However, the document does not specify the use of particular resilience standards or codes.
DOC-17	Scotland Delivery Plan - Year 2 Update	1	Performance Thresholds: Targets for carbon emissions reductions and train accident risk reduction are mentioned, but no specific codes or standards for compliance with climate-related hazards are identified. Design Objectives: General initiatives such as climate adaptation strategies and resilience investments are discussed, but specific design codes or standards are not provided. Resilience Objectives: The document emphasizes resilience against extreme weather and climate change impacts but does not cite specific resilience standards or compliance codes.	The document does not explicitly outline specific codes or standards for performance thresholds related to climate-related hazards. However, it does mention the following: Carbon Emissions Reduction Targets: The document provides specific numerical targets for Scope 1 and Scope 2 carbon emissions reductions during CP7, with percentage reductions outlined for each year of the control period Train Accident Risk Reduction: A target of 95% reduction in train accident risk is included, but this is not directly tied to climate-related hazards While these targets indicate a focus on performance, they are not explicitly tied to compliance codes or standards for climate-related hazards.	The document does not specify particular codes or standards for design objectives related to climate-related hazards. However, it does include general design-related initiatives: Climate Change Adaptation Strategy: The development of a long-term adaptation strategy for Scotland's Railway is mentioned, which is informed by a novel adaptation pathways project. This approach aims to prepare for multiple future climate scenarios but does not reference specific design codes or standards Resilience Investments: Investments in railway assets to improve resilience against extreme weather and long-term climate changes are highlighted, though no specific design standards are mentioned	The document emphasizes resilience objectives but does not identify specific codes or standards for compliance. Key points include: Resilience Against Extreme Weather: The plan includes initiatives to improve railway resilience against extreme weather events, such as increased investment in critical drainage and earthworks assets. These efforts are aimed at mitigating the impact of climate change, particularly increasing rainfall Climate Ready Theme: The "Climate Ready" theme focuses on developing climate science and adaptation capabilities to strengthen decision-making processes. However, specific resilience standards or codes are not mentioned
DOC-18	GB - CP7 Delivery Plan - Year 2 Update	1	Performance Thresholds: No specific codes or standards are identified, but air quality and carbon reduction targets are mentioned. Design Objectives: While the document outlines significant investments in climate-resilient infrastructure, it does not specify compliance standards or design codes. Resilience Objectives: The focus is on strategic initiatives like the Weather Risk Task Force and climate adaptation strategies, but no explicit standards are provided.	Air Quality Improvement Plans (AQIPs): These are developed for stations with ambient air quality levels above Department for Transport (DfT) agreed thresholds. Carbon Emissions Targets: Specific reduction targets for Scope 1 and 2 emissions are outlined, such as a 20.5% reduction by the end of CP7. Weather Resilience and Climate Change Team: This team supports embedding climate considerations into standards and processes, though specific performance thresholds are not detailed.	Infrastructure Adaptation: A £2.6 billion investment in CP7 to improve the resilience of assets to extreme weather, including measures like heat-resistant tracks, enhanced drainage systems, and earthworks to mitigate landslides. Whole-Life Carbon Monitoring: Tools are being developed to monitor and report carbon impacts, starting in 2025/26, to inform design and planning decisions. Vegetation Management Plans: These aim to balance ecological preservation with safety and climate resilience.	Weather Risk Task Force (WRTF): Focused on improving resilience to extreme weather by updating operational processes and applying targeted weather interventions. Climate Change Adaptation Strategies: These aim to create a railway fit for future climate conditions, though specific compliance standards or thresholds are not cited. Drainage and Earthworks Investments: Targeted at reducing risks from flooding and landslides, with additional regional drainage resources allocated.
DOC-19	System Operator CP7 Delivery Plan	1	Performance Thresholds: No explicit codes or standards are mentioned, but tools like ROWS and collaboration with the Met Office indirectly support performance thresholds. Design Objectives: Specific codes or standards are not identified, but initiatives such as improved drainage standards and earthworks data systems align with design objectives. Resilience Objectives: Resilience planning is a focus, with efforts like the Weather Risk Task Force and ROWS contributing to enhanced resilience, though specific standards are not cited.	The document does not explicitly identify specific codes or standards for assessing climate-related hazards against performance thresholds. However, it mentions the use of tools like the Rail Operations Weather Service (ROWS) and collaboration with the Met Office to enhance operational capability against climate impacts. This includes monitoring, real-time observations, weather forecasting, and risk-based decision-making, which indirectly contribute to defining performance thresholds for operational safety and service delivery during adverse weather conditions	The document does not explicitly list codes or standards for design objectives related to climate-related hazards. However, it emphasizes initiatives like embedding improved drainage standards and detailed drawings, as well as earthworks failure data capture systems. These efforts align with broader design objectives to mitigate risks associated with extreme weather and ensure infrastructure resilience	The document highlights resilience planning and weather response as key priorities but does not explicitly reference specific codes or standards for resilience objectives. It mentions the Weather Risk Task Force, which focuses on tools, processes, and cross-route learning to improve service during extreme weather. Additionally, the Rail Operations Weather Service (ROWS) is designed to enhance resilience by equipping the business with better tools for operational risk management during climate-related events
DOC-20	The CP7 Buildings & Architecture Policy (2021)	1	Performance Thresholds: Standards such as the Fire Safety Act 2021 and BS9992 are identified for compliance with fire safety and resilience thresholds. Design Objectives: Inclusive design and climate adaptation objectives are supported by compliance with Part M of building regulations, the Equality Act 2010, and WRACCA. Resilience Objectives: Resilience is emphasized through adaptability, reparability, and scoring systems that measure the ability to withstand shocks and stresses.	The document mentions specific performance thresholds for compliance with fire safety standards. For example: Fire Safety Act 2021 and BS9992 are referenced as standards for fire safety in the design and management of rail infrastructure. These standards include thresholds for managing fire risks in multi-occupied residential buildings, particularly regarding the structure, external walls, cladding, balconies, and windows Asset resilience indicators are used to measure the ability of assets to withstand acute shocks and stresses, with scoring criteria provided to evaluate resilience levels	The document outlines design objectives related to inclusivity and safety: Inclusive Design: It emphasizes the importance of creating environments that accommodate diverse users and reduce barriers, including those caused by ageism, gender inequality, and ableist bias. Compliance with Part M of building regulations and the Equality Act 2010 is recommended for inclusive design Climate Adaptation: Resilient assets should address macro factors like extreme weather conditions and socio-economic trends such as supply shortages. The document mentions the Weather Resilience and Climate Change Adaptation (WRACCA) framework as a tool for assessing climate-related impacts	The document provides detailed guidance on resilience objectives: Asset Resilience: Resilient assets are described as those capable of adapting to future challenges, including climate change impacts such as extreme weather conditions. This includes avoiding reliance on proprietary technology and ensuring reparability through skills rather than procurement Scoring for Resilience: The document includes a scoring system to evaluate resilience, with higher scores indicating adaptability, flexibility, and reparability in the face of acute shocks or prolonged stress
DOC-21	"Additional information for asset managers" (2025)	2	- References to Standards: The document does reference sustainability and design standards such as PAS 2080 (related to carbon management) and general environmental performance criteria. - Broad Compliance: It also refers to several regulatory and statutory requirements (e.g. fire safety codes and building regulations) which form part of the overall compliance framework. - Climate-Specific Codes: However, there isn't a dedicated list of "climate hazards" codes or a detailed set of performance thresholds solely for climate risks. The focus is on broader sustainability and asset resilience rather than enumerating specific climate hazard			
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authorit	0	Performance Thresholds: The document references EPCs as a measure of sustainability but does not specify codes or standards for climate hazard compliance. Design Objectives: It emphasizes Carbon Zero initiatives and Standard Designs but lacks explicit mention of compliance standards for climate-related hazards. Resilience Objectives: While resilience is implied through strategies like Predict & Prevent, no specific resilience standards or thresholds are identified.	The document does not explicitly mention specific codes or standards for assessing compliance with climate-related hazards in terms of performance thresholds. However, it does reference the importance of sustainability as a key measure of success, specifically mentioning metrics such as Energy Performance Certificates (EPCs) as a way to measure sustainability. While EPCs are an important indicator of energy efficiency, they do not directly address all aspects of climate-related hazards.	The document outlines a mission to embed a Design and Asset Engineering approach that prioritizes passenger satisfaction, safety, stewardship, and sustainability. It emphasizes the development of Standard Designs and Carbon Zero guidance roadmap initiatives, which may indirectly address climate-related hazards. However, it does not explicitly state specific design codes or standards for climate hazard compliance.	The document does not explicitly reference resilience objectives or specific standards related to climate-related hazards. However, it does highlight the goal of achieving a carbon-neutral built environment and mentions the use of Predict & Prevent strategies and holistic Whole Life Costing. These elements suggest a focus on long-term resilience and sustainability, but no direct mention of specific resilience standards or performance thresholds is provided.

DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	3	Not used AI as it is a sensitive document
DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	1	Not used AI as it is a sensitive document
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	0	- The report does not list or reference any specific codes, standards, performance thresholds, or design/resilience objectives against which climate-related hazards are assessed. - It focuses on action plans and improvement percentages rather than benchmarking against established technical standards.
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	There is no discussion of codes or standards used to assess climate-related hazards for compliance purposes in this document. Although it references various design and sustainability frameworks (for example, Network Rail's Environmental Sustainability Strategy), none are framed in terms of performance thresholds or specific resilience objectives against physical climate hazards.
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	- No relevant codes, standards, or performance thresholds regarding physical climate risks are discussed or identified. - The document solely describes procurement criteria and related contractual details.
DOC-28	NR's 'The Greener Railway Strategy' (May 2025)	1	- The document does refer to updating asset management standards to incorporate considerations for climate risk. - However, it does not list specific codes, standards, or explicit performance thresholds; rather, it outlines a general intent to integrate these aspects into broader asset management and operational planning processes.
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	0	Specific codes or standards for assessing climate-related hazards are not explicitly detailed. Although there is mention of compliance-related standards in other areas (such as ISO 20400 regarding sustainable procurement), the document does not list dedicated performance thresholds or resilience assessment criteria for climate hazards 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	6	Yes. Numerous codes, performance thresholds, and standards are mentioned. The document cites specific Network Rail standards (for example, NR-L2-TRK-001-mod14 and related specifications) as well as industry specifications (such as PTA specifications and Australian standards) that define design minimums, performance targets, and resilience objectives against climate-related hazards.
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	3	- Yes – the report makes multiple references to technical guidelines and standards (for example, NR/L2/TRK/001 Mod 14, various operating restrictions, and references to ORR guidelines and RSSB research). - These are used to assess performance thresholds, establish trigger points, and set design and resilience objectives for rail infrastructure under extreme weather conditions. - They are specific to rail operations rather than general climate compliance standards.
DOC-32	EHTF Weather and Climate Change Report (March 2023)	0	- The document does not explicitly reference formal codes, compliance standards, or specific design thresholds against which climate-related hazards are measured. - Instead, it largely relies on climate projections, probabilistic analyses, and expert recommendations rather than listing performance standards or resilience objectives tied to regulatory codes.
DOC-33	352_WSFData_20252 02607 Final - Building Only	0	Not used AI as it is a sensitive document

AI Agent Summary - Q6: Are any applications of formal risk management approaches using an appropriate standard method for climate change risks, including the approach taken to prioritisation of risk to building and system assets, identified within the document?

Doc Ref	Document name	Score	Document detail
DOC-01	The NR Climate Projections Guidance Note (2023)	5	 Identified Applications of Formal Risk Management Approaches The document provides a structured framework for understanding and managing climate change risks, emphasizing the use of formal methodologies. Below are the key points: Purpose and Risk Management Context The document aims to guide engineers, designers, and analysts in incorporating climate change projections into risk assessments and asset design. This is crucial for enhancing resilience to extreme weather and climate change impacts on railway systems 1. It explicitly states the importance of adapting design, operation, and maintenance practices to mitigate future weather-related risks, which could otherwise lead to increased safety, performance impacts, and whole-life costs 1. Prioritization of Risks The document outlines a systematic approach to prioritize risks by using climate change scenarios (e.g., UKCP09 and UKCP18 projections). These scenarios help assess the severity and likelihood of risks to assets over different time horizons (e.g., 2030s, 2050s, 2070s) 1. For example, it provides worked examples, such as modeling flood risks and temperature impacts on electrical panels in flood-prone buildings. The process includes: Identifying asset vulnerabilities to weather impacts. Using climate projections to model risks for the asset's design life. Testing design options under worst-case scenarios (e.g., higher emissions scenarios). Selecting cost-beneficial solutions, such as waterproof cabinets or flood-proofed buildings 1. Quantitative and Qualitative Data for Risk Assessment The document provides both quantitative (e.g., temperature, precipitation, sea level rise) and qualitative data to support risk assessments. It includes: Climate projection data for various UK administrative regions. Tools like flowcharts to guide decision-making on selecting appropriate data for risk assessments 1. For instance, sea level rise projections are used to calculate cumulative impacts on coastal assets, ensuring designs account for future flooding risks 1. Integration with Regulatory Guidance The document aligns with regulatory frameworks, such as those from the Environment Agency (EA), Scottish Environmental Protection Agency (SEPA), and Natural Resources Wales (NRW). These frameworks provide allowances for factors like peak rainfall intensity and river flow, which are critical for flood risk assessments (FRAs) 1. Worked Examples for Practical Application A notable example involves renewing an electrical panel inside a flood-prone building: Step 1: Assess vulnerability to high temperatures and flooding. Step 2: Use climate projections for the 2070s or 2080s to model risks. Step 3: Develop design options to mitigate risks (e.g., raising equipment height, improving climate control). Step 4: Test these options under higher emissions scenarios for worst-case sensitivity analysis. Step 5: Finalize the design based on cost-benefit analysis 1.  Summary The document provides a comprehensive framework for formal risk management of climate change risks, emphasizing: - The use of climate projections (UKCP09 and UKCP18) for risk assessments. - Prioritization of risks based on asset vulnerabilities and design life. - Integration with regulatory guidance for flood risk and other climate impacts. - Practical examples to guide decision-making and design adaptations.
DOC-02	The WRCCA Strategy (2017) from the System Operator	5	Risk Assessment Process: The strategy details risk assessments undertaken by Network Rail (for example, a climate change risk assessment in 2009) and the development of decision support and modelling tools for analysing climate hazards. Standard Methods: It discusses how risks are prioritised based on performance impacts, compensation costs, and the asset's vulnerability profile. This includes formal management of risks through a reporting framework and governance processes centered around the Weather Resilience Group. Conclusion: Yes, formal risk management approaches and standardized methods for assessing climate change risks to the rail network are well-documented 1.
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)		Formal Risk Management Approaches for Climate Change Risks The document outlines several formal risk management approaches and methodologies for addressing climate change risks, particularly with respect to building and system assets. Here are the key findings:  Risk Assessment Methodology The Eastern Region employs a modified version of the Corporate Risk Assessment Matrices (CRAM) to evaluate the likelihood and impacts of weather and climate change on assets. This methodology is part of the Network Rail Integrated ARP3 Climate Risk Assessment, which uses workshops and regional adjustments to identify and prioritize risks. The assessment considers: - The likelihood of different weather impacts on the asset base. - Regional differences in asset landscapes, ecology, and past experience.

Regional differences in asset landscape, geology, and past experiences.

Over 400 risks at the national level, focusing on the top 100 risks across asset and weather types 1.

Adaptation Pathways Planning

The document highlights the use of Adaptation Pathways Planning, a globally recognized best practice for strategic, flexible, and structured decision-making. This approach:

Helps prioritize and phase investments over the long term to enhance resilience to climate change.

Identifies trigger points and thresholds to determine when actions are necessary.

Allocates £1 million annually to apply this approach to high-risk locations, building long-term resilience plans for CP8 and beyond.

Supports the development of detailed adaptation pathways for high-priority locations, including modeling adaptation solutions 1.

Enterprise Risk Management

The Eastern Region captures regional risks in its Enterprise Risk Register, using the bow-tie methodology to evaluate and describe risks, their causes, consequences, and controls. This approach ensures:

Regular evaluation of control effectiveness.

Identification of necessary actions to maintain risk control.

Application of risk assessments to understand controls and operational responses (e.g., bow-tie diagrams) 1.

Prioritization of Risks to Building and System Assets

The document provides a detailed analysis of risks to various asset types, including buildings and system assets, with a focus on:

Buildings:

Risks include extreme heat affecting welfare and comfort, expansion of flat roofs, and drainage issues during intense rainfall.

New or modified buildings are designed to withstand extreme heat and have resilient drainage systems.

Platform canopies are constructed to be more resilient to wind and snow loading 1.

System Assets:

Prioritization of high-risk locations for interventions, such as drainage and earthwork improvements.

Resilience measures include flood protection works, vegetation removal, and heating systems to mitigate cold weather impacts.

Investments in signaling upgrades, such as digital signaling, to reduce risks from wind, heat, and floods 1.

Climate Change Risk Projections

The document uses UKCP18 climate projections to assess future risks, including:

Rising temperatures leading to more frequent heatwaves.

Increased frequency and intensity of storms, heavy rainfall, and flooding.

Rising sea levels and coastal erosion impacting low-lying areas and coastal infrastructure 1.

Examples of Risk Prioritization

High-risk drainage and earthwork sites: Identified and prioritized for interventions based on risk assessments.

Weather-related risks to railway assets: Focused on flooding, extreme heat, snow/ice, and storms.

Regional differences: Adjustments made to national risk assessments to account for local factors such as geology and past experiences.

Summary

The document identifies the following formal risk management approaches for climate change risks:

Modified CRAM methodology to assess and prioritize risks.

Adaptation Pathways Planning for long-term, flexible climate resilience strategies.

Enterprise Risk Register using bow-tie methodology for evaluating and managing risks.

Targeted interventions for high-risk building and system assets, including drainage, earthworks, and signaling upgrades.

These approaches are aligned with global best practices, such as the ISO 55000 series on Asset Management and ISO 14090:2019 on Climate Change Adaptation.

Additional Context

The document emphasizes the importance of collaboration with external stakeholders, such as the Environment Agency, to address shared risks like flooding and coastal erosion. It also highlights the need for ongoing investment in asset knowledge, monitoring technologies, and resilience measures to adapt to the increasing frequency and intensity of extreme weather events.

DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	Formal Risk Management Approaches for Climate Change Risks The document outlines several formal approaches to managing climate change risks, adhering to recognized standards and methodologies. These approaches are applied across various infrastructure and asset types within the North West & Central (NW&C) region. Below are the key highlights:  Key Approaches and Standards Utilized Network Rail Climate Change Risk Assessment This assessment is a cornerstone for scrutinizing investments in Control Period 7 (CP7, 2024–2029). It evaluates whether planned expenditures adequately control climate risks. The assessment builds on lessons learned from earlier control periods (e.g., CP6) and incorporates both qualitative and quantitative risk evaluations. Adaptation Pathways A structured methodology called "adaptation pathways" is employed to prioritize and stagger investments in climate resilience over time. This approach identifies high-risk areas through multi-criteria screening and rapid assessments, followed by detailed modeling for the most critical locations. Trigger points and thresholds are established to revisit decisions as conditions evolve. Standards Adherence Renewals and enhancements adhere to established standards such as Network Rail (NR), ISO, and EN standards, ensuring that interventions are climate-resilient. The document emphasizes the importance of designing assets to withstand future climate conditions, not just current risks. Risk Scoring and Prioritization A risk scoring matrix evaluates the likelihood and impact of climate risks across horizons (e.g., 2050, 2080). Risks are categorized from minimal to catastrophic, guiding prioritization efforts. For instance, risks to drainage systems, earthworks, and signaling equipment are scored and prioritized based on their potential impact on safety and operations. Weather Risk Taskforce (WRTF) Action Plans The WRTF has developed 19 action plans to address risks such as flooding, extreme heat, and earthwork failures. These plans include: Enhanced drainage inspections. Use of digital monitoring tools like the Rail Operations Weather Service (ROWS). Integrated management of geotechnics, drainage, and vegetation. Quantitative Climate Risk Assessments CP7 investments aim to transition from qualitative to quantitative risk assessments, enabling more precise identification and mitigation of climate risks.  Examples of Risk Prioritization for Building and System Assets Buildings and Infrastructure
--------	---	---	---

			Buildings are being refurbished to improve resilience to rain, wind, and temperature fluctuations. For example: Station roofs and lineside buildings are undergoing structural repairs to withstand extreme weather. Insulation improvements are being prioritized to reduce reliance on cooling systems during heatwaves. Drainage and Earthworks Drainage systems are being upgraded to handle increased precipitation and prevent flooding. This includes: Renewals of track drainage (66,000 meters planned). Installation of failure monitoring equipment for earthworks to prevent landslides and subsidence. Signaling and Overhead Line Equipment (OLE) Resilience measures include: Re-tensioning of OLE wires to prevent sagging during heatwaves. Installation of axle counters and fiber optic cables to improve signaling reliability during extreme weather. Coastal and Flood Defenses Coastal defenses on vulnerable sections like the Cumbrian coastal line are being refurbished to withstand 1-in-200-year storm events. Nature-based solutions (NbS) are being explored to manage flood risks while enhancing biodiversity. ☑ Summary The document identifies several formal risk management approaches for climate change risks, emphasizing adherence to established standards and the use of structured methodologies like adaptation pathways. Key strategies include: Conducting climate risk assessments and prioritizing investments based on risk scores. Enhancing asset resilience through targeted renewals and adherence to updated standards. Employing digital tools and monitoring systems for proactive risk management. Leveraging nature-based solutions and partnerships to address broader environmental challenges. These approaches collectively aim to ensure that the railway infrastructure in the NW&C region is better prepared for future climate challenges. 🔗 Additional Context Implications for Future Investments: The transition to quantitative risk assessments and adaptation pathways will provide a clearer roadmap for future control periods (e.g., CP8). Broader Benefits: Initiatives like NbS not only enhance resilience but also contribute to environmental sustainability by improving biodiversity and water quality.
DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	Yes, formal risk management frameworks are embedded throughout: ARP3 Risk Assessment: The plan uses the ARP3 methodology to systematically evaluate and score climate risks across asset classes, with clear criteria for likelihood, consequence, and confidence 1. Prioritisation: Assets are prioritised for intervention based on risk scores, operational criticality, and historical failure data. Adaptation Pathways: A structured, scenario-based approach to investment planning, allowing for dynamic adjustment as new data emerges. Risk Matrices: Used for both asset-level and route-level decision-making, ensuring consistency and transparency in risk prioritisation.
DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	Yes – a formal risk management methodology underpins the document’s assessment process. • For example, the ARP3 (Asset Resilience Planning Process) method is explicitly described, outlining how risk scores are generated for each asset or system. • The approach is systematic: it includes a step-by-step evaluation of climate exposure, asset vulnerability, and the likelihood of failure – subsequently informing prioritization of investments and remedial actions. • Diagrams and decision trees provided in the document further illustrate how these risk scores are used to guide operational and strategic decisions.
DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	• Yes. The document describes a structured risk assessment process that includes: • An asset hierarchy (to identify key asset groups) • Hazard screening and a defined “climate hazard hierarchy” • Risk scoring that includes future scenarios (current, 2050s, 2080s) to prioritize risks This formal methodology helps link specific hazards with asset vulnerabilities and informs decision-making on which assets (including buildings and system components) require intervention. It is a clear example of applying a standardized risk management approach to climate change risks [Scotlands-Railway-CP7-Climate-Ready-WRCCA-Plan.pdf].
DOC-08	Eastern Region Strategic Business Plan	6	• Yes. The plan implements formal risk management methodologies as part of its overall risk-based maintenance strategy. It details the use of risk models (for example, the RM3 framework) to assess, prioritise, and manage risks across multiple asset classes. While these methodologies are applied generally, they include climate-related risks (such as extreme weather impacts on infrastructure) and guide the prioritisation of capital investment and maintenance actions with an eye toward mitigating residual risks.

DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	6	The North West and Central CP7 Strategic Business Plan outlines several formal risk management frameworks and methodologies, particularly in the context of climate change risks and asset prioritization. Below are the key highlights: 1. Adherence to ISO31000 Risk Management Framework The document specifies that the risk management methodology is built on the ISO31000 Risk Management standard, which is a globally recognized framework for managing risks effectively. This framework underpins the entire approach to risk management, ensuring a structured and systematic process for identifying, assessing, and mitigating risks 1. 2. Risk Prioritization and Escalation Risks are prioritized and escalated in alignment with Network Rail's published risk appetite statements. Techniques such as treat, transfer, tolerate, and terminate are used to manage risks. A risk heatmap is employed to visually prioritize risks, supported by data-driven assessments and expert opinions. This ensures that the most critical risks are addressed first, based on their potential impact and likelihood 1. 3. Climate Change and Weather Resilience The plan acknowledges the increasing frequency of severe weather events due to global climate change, which poses risks to drainage and earthworks infrastructure. To address these, the plan includes: Remote condition monitoring to detect and mitigate risks associated with embankment failures. Deployment of dedicated inspection teams and enhanced vegetation management to prevent asset failures. Implementation of climate adaptation pathways and Weather and Climate Change Impact Assessments for all projects. These assessments guide design decisions, such as increasing drainage capacity to handle extreme weather events 1. 4. Integration of Risk Management with Asset Strategies The document emphasizes the integration of risk management with asset strategies. For example: Maintenance and renewal activities are aligned with risk assessments to ensure that resources are allocated efficiently. High-priority sections of the network, such as those most used by passengers or at higher risk of failure, are given precedence in infrastructure plans 1. 5. Specific Climate Change Adaptation Initiatives The plan includes targeted initiatives to enhance the resilience of assets to climate change, such as: Drainage renewals and geotechnical renewals at high-risk weather-impacted sites. Improvements to overhead line equipment (OLE) resilience and coastal defenses. Compliance with recommendations from Lord Mair and Dame Slingo regarding weather resilience and climate change adaptation 1. 6. Horizon Scanning and Emerging Risks The plan incorporates horizon scanning to identify and address emerging risks proactively. This process considers the broader context, including social, cultural, political, legal, regulatory, financial, technological, and economic factors that may impact the organization 1. ☑ Summary The document demonstrates a comprehensive application of formal risk management approaches, particularly for climate change risks. Key elements include: Alignment with the ISO31000 Risk Management framework. Use of risk heatmaps and data-driven prioritization techniques. Implementation of climate adaptation pathways and impact assessments for infrastructure projects. Focus on weather resilience through targeted initiatives like drainage and geotechnical renewals. Horizon scanning to address emerging risks in a broader context. 📖 Additional Context The integration of risk management with asset strategies ensures that resources are directed to areas of greatest need, such as high-risk weather-impacted sites and critical infrastructure. This approach not only mitigates risks but also aligns with broader organizational and governmental objectives, including sustainability and climate change adaptation.
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	1	• The document outlines a formal risk management framework that aligns with established practices (for example, noting processes reminiscent of ISO 31000). It details steps such as understanding context, risk identification, analysis, evaluation, and monitoring. However, while this overall risk management approach is clearly laid out, it is not exclusively focused on climate change risks nor does it identify a separate, climate-specific risk prioritisation process for building and system assets.
DOC-11	Southern Region: CP7 Region Strategic Business Plan	1	• Partially. The CP7 plan incorporates a "risk-adjusted plan" where climate factors are included among the suite of risks. • It outlines an enterprise risk management approach that considers a range of uncertainties (including weather-related events). • However, while climate-related risks are integrated into the overall risk framework and prioritisation methodology, the plan does not describe the use of a formal, widely recognized standard solely dedicated to climate change risk management for buildings and systems.

DOC-12	Scotland Region: CP7 Region Strategic Business Plan	6	Structured Risk Assessment: The plan employs formal risk management methodologies by integrating risk-based assessment strategies that include asset condition evaluations and prioritisation frameworks. Techniques such as risk matrices and vulnerability assessments are implied, helping stakeholders understand which assets are at higher risk due to climate impacts. • Risk Mitigation Strategies: One key component is the establishment of a risk fund, designed to finance rapid response and longer-term adaptation measures when disruptions occur. The overall framework supports continuous improvement through iterative monitoring and reassessment, ensuring that risk management strategies evolve as new data and climate projections become available. Summary The plan establishes a comprehensive risk management framework that begins with detailed identification and evaluation of climate-related risks through structured registers and risk matrices. • Continuous monitoring via smart sensors and predictive analytics ensures that asset conditions are regularly assessed and risks dynamically updated. • Risk mitigation strategies include the allocation of dedicated financial resources, contingency planning through reactive workbanks, and scenario-based safety protocols to support business continuity. • A strong governance structure, with integrated committees and regular reporting, underpins the risk management approach, ensuring that methodologies evolve based on new data, technological advancements, and post-incident reviews.
DOC-13	Eastern Delivery Plan - Year 2 Update	0	### 📄 Analysis of Formal Risk Management Approaches The document outlines several structured approaches to risk management, particularly focusing on climate change risks and their implications for building and system assets. Here are the key points: ISO55001 Certification: Eastern's asset management practices adhere to ISO55001, an international standard for effective asset management, which was achieved in 2024. This certification ensures a formalized framework for managing risks associated with asset performance and sustainability 1. Risk-Based Planning: The CP7 strategic planning framework employs a risk-based approach to allocate work volumes. Safety is prioritized as the cornerstone of the market-led plan. This includes refurbishments and targeted life extensions to mitigate risks associated with reduced renewals 1. Safety Risk Assessment Framework: A dedicated safety risk assessment framework evaluates the impact of shifts in risk profiles due to lower planned levels of renewals. This framework identifies mitigations and tracks safety risk levels across all asset classes. It has been embedded into national and regional assurance processes to assess changes in asset management plans 1. Asset Weather Resilience Investments: Approximately £0.4 billion is being invested in asset weather resilience, focusing on flooding, wind, and heat impacts. This includes targeted interventions for drainage, earthworks, signaling, and electrification assets 1. Integrated System-Level Approach: The document highlights an integrated approach to water management, combining drainage, earthworks, off-track structures, and track interventions. This strategy aims to manage risks at sites prone to earthwork failures and persistent flooding 1. Climate Change and Sustainability Objectives: The CP7 plan includes objectives to manage climate risks and extreme weather impacts. Key initiatives involve reducing carbon emissions by 20% and achieving biodiversity net gain by the end of the control period. The deployment of PAS2080 carbon management standards further supports these efforts 1. ### 🎯 Prioritization of Risks to Building and System Assets The document provides specific examples of how risks to building and system assets are prioritized: Buildings: Major interventions are planned at Liverpool Street station and other key sites to address assets at risk of failure. This includes refurbishments focused on high-risk platforms to mitigate slips, trips, and falls 1. Electrification and Fixed Plant: Efforts are concentrated on improving system reliability for overhead line equipment and signaling power. This includes replacing components with higher failure rates to reduce the likelihood of de-wirements and safety risks 1. Drainage and Earthworks: Targeted interventions are prioritized at sites with a history of flooding and earthwork failures. This integrated approach aims to enhance resilience and reduce performance risks 1. Summary The document identifies several formal risk management approaches for climate change risks, including adherence to ISO55001 standards, a risk-based planning framework, and a safety risk assessment framework. Investments in weather resilience and integrated water management further demonstrate a structured approach to mitigating risks. Prioritization of risks to building and system assets is evident through targeted interventions in drainage, earthworks, electrification, and building refurbishments. Risk management is not climate focused, therefore the score is low

DOC-14	North West and Central Delivery Plan - Year 2 Update	0	 Formal Risk Management Approaches for Climate Change Risks The document highlights several structured approaches to managing climate change risks, including prioritization strategies for building and system assets. Here are the key points: Weather Resilience and Climate Change Adaptation (WRCCA): The railway faces increasing challenges from climate change, including severe weather events. Addressing these challenges is a priority, and the WRCCA plan is central to mitigating risks. Priority assets will be renewed with features such as scour protection and drainage systems to improve resilience. For assets outside renewal programs, technology will be leveraged to enhance risk forecasting and management 1. Technology Integration for Risk Management: The document mentions the use of advanced technologies such as digital lineside inspection, slope monitoring equipment, and extreme weather management tools like PRIMA (Proportionate Risk response to Implementing Mitigating speeds to Assets). These tools are vital for environmental surveillance and proactive risk management 1. Risk-Based Maintenance and Renewal Plans: Strategic Route Sections (SRS) are used to focus decision-making on areas of high usage and engineering significance. Risk assessments for each SRS include safety bow-ties, which introduce proportionate mitigations into maintenance and renewal plans 1. Stakeholder Engagement and Prioritization: Stakeholders have emphasized the importance of weather resilience. As a result, targeted interventions are planned to improve flood resilience, drainage systems at high-risk sites, and vegetation management. These measures aim to reduce the impact of severe weather on infrastructure 1. Safety Bow-Tie Framework: This structured framework is employed to manage risks arising from infrastructure failures due to climate change. It ensures that train accident risks are kept as low as reasonably practicable, with no increase in risk across the network during the control period 1.  Prioritization of Risks to Building and System Assets The document outlines a systematic approach to prioritizing risks: Renewals Targeting High-Risk Areas: Drainage renewals focus on areas prone to flooding, while earthworks schemes address sites at the highest risk from adverse weather events. Integration of Maintenance and Renewals: Maintenance and renewals plans are aligned to optimize expenditure and address risks effectively. Technology-Driven Decision Making: Investments in surveillance technologies enable quick, responsive decisions to mitigate risks to infrastructure 1. Summary The document identifies formal risk management approaches for climate change risks, emphasizing: The WRCCA plan for resilience. Use of advanced technologies for risk forecasting and management. Structured frameworks like safety bow-ties for risk mitigation. Stakeholder-driven prioritization of interventions targeting high-risk areas. Risk management is not climate focused, therefore the score is low
--------	--	---	---

DOC-15	Wales and Western Delivery Plan - Year 2 Update	0	### 📄 Formal Risk Management Approaches for Climate Change Risks The document outlines several applications of formal risk management approaches, particularly in the context of climate change risks and their impact on building and system assets. Here are the key points: 1. Risk Management Process The document mentions a defined risk management process aimed at minimizing threats and maximizing opportunities. This process is designed to ensure the delivery of outcomes despite changing circumstances during CP7 (Control Period 7) 1. 2. Weather Resilience and Climate Change Adaptation Investments are being made to enhance weather resilience and adapt assets to climate change. This includes robust incident response mechanisms to mitigate service disruptions, costs, and reputational impacts caused by weather-related incidents 1. Specific measures include: Drainage Improvements: Refurbishment of drainage systems to prevent pooling of water and protect signaling equipment from flooding, as seen in the Chipping Sodbury tunnel project 1. Earthworks: Investments in failure detection equipment and geotechnical instrumentation to improve resilience against extreme weather 1. 3. Risk-Based Asset Renewals The document highlights the use of risk-based renewals to enhance asset sustainability and reliability. For example: Overhead line systems are being made more resilient to weather impacts. Investments are directed toward climate change adaptation of assets 1. 4. Safety Bow-Tie Risk Assessment Framework A safety bow-tie risk assessment framework is employed to address unanticipated safety issues. This framework helps identify potential risks and operational restrictions, ensuring readiness to increase expenditure if required 1. 5. RM3 Risk Maturity Framework The RM3 risk maturity framework is utilized in collaboration with industry partners to manage risks, identify areas for improvement, and benchmark year-on-year performance 1. ### 🔄 Prioritization of Risks to Building and System Assets The document demonstrates a clear approach to prioritizing risks: High-Risk Areas: Funding is allocated to high-risk areas to ensure safety, performance, and reliability. Maintenance regimes are strengthened, and renewals funds are re-prioritized to support performance improvements on key routes 1. Asset Management Plans: Safety risk assessments are embedded into national and regional assurance processes, focusing on Electrification and Fixed Plant assets. This iterative process ensures alignment between renewals and maintenance plans 1. ### ✅ Summary Formal Risk Management: The document identifies structured approaches such as the RM3 framework, safety bow-tie risk assessments, and risk-based asset renewals to address climate change risks. Prioritization: High-risk areas are prioritized for funding and maintenance, with a focus on weather resilience, drainage improvements, and geotechnical instrumentation. Climate Change Adaptation: Investments are made to adapt assets to climate change, ensuring sustainability and reliability. Risk management is not climate focused, therefore the score is low
--------	---	---	--

DOC-16	Southern Delivery Plan - Year 2 Update	0	 Analysis of Climate Change Risk Management in the Document Key Observations The document highlights several initiatives and strategies related to climate resilience and risk management. Here are the relevant points: Climate Resilience Program: The program emphasizes building and maintaining a railway resilient to severe weather events and climate change. This includes: Collaborative efforts across the industry to reduce weather-related risks to railway safety and performance. Enhancing asset resilience during severe weather events through long-term planning and climate-focused investment decisions. Delivering the CP7 Weather Resilience and Climate Change Adaptation (WRCCA) Plan, which includes creating long-term climate adaptation pathways for vulnerable locations across the network 1. Formal Risk Management Framework: The document mentions the use of systematic and proactive risk management approaches to prevent adverse events. This includes embedding safety risk assessments into assurance processes and assessing changes to asset management plans throughout the year 1. Prioritization of Risk to Building and System Assets: The strategy involves identifying vulnerable locations and focusing investment decisions on climate adaptation measures. This prioritization is informed by safety risk assessments and data analysis on reliability and failure modes 1. Integration of Standards: The Southern Region maintains an ISO 14001-certified Environmental Management System, which supports systematic environmental risk management and compliance with international standards 1. Collaborative Industry Efforts: The program includes working with partners to improve air quality, reduce pollution, and enhance biodiversity. These efforts align with broader climate resilience goals 1.  Summary The document identifies several formal approaches to managing climate change risks: Risk Prioritization: Focused on vulnerable locations and informed by systematic risk assessments. Standards and Frameworks: Utilization of ISO 14001 and other structured methodologies. Climate Resilience Initiatives: Long-term planning and investment in asset resilience. Collaborative Efforts: Industry-wide partnerships to address environmental impacts. These strategies reflect a comprehensive approach to mitigating climate change risks to building and system assets. Risk management is not climate focused, therefore the score is low
--------	--	---	---

DOC-17	Scotland Delivery Plan - Year 2 Update	0	 Key Findings on Risk Management for Climate Change The document outlines several approaches and strategies related to managing climate change risks, including formal methods and prioritization mechanisms. Here's a breakdown: 1. Commitment to Climate Change Resilience The document emphasizes embedding climate change resilience across Scotland's Railway network. It recognizes the increasing frequency and severity of weather events, particularly rainfall, which significantly impacts the rail network in Scotland more than in England and Wales. Collaborative efforts have been made to identify critical drainage and earthworks assets that require increased investment to enhance network resilience. 2. Development of a Climate Change Adaptation Strategy A long-term climate change adaptation strategy is being developed for Scotland's Railway. This strategy is informed by a novel "adaptation pathways project," which addresses uncertainties in future climate scenarios. This approach allows for planning and preparation for multiple potential climate outcomes. 3. Risk-Based Investment Prioritization The document highlights a shift toward a risk-based investment prioritization approach. Specifically, it mentions prioritizing asset renewals and refurbishment investments to ensure safety and performance. This includes: Protecting renewals investment in critical infrastructure such as structures, earthworks, and drainage assets. Implementing a "whole systems" approach for earthworks and drainage assets to maintain safety and performance. 4. Use of Data and Technology The organization is leveraging improved data on asset conditions and climate science to refine asset models. This data-driven approach supports better decision-making and helps allocate investment across asset classes based on risk and performance outcomes. 5. Focus on Extreme Weather Risks The document identifies climate change and extreme weather as key risks that could impact both safety and performance. In response, investment is focused on asset classes most likely to be affected by extreme weather, such as earthworks and drainage systems. 6. Safety Risk Assessment Framework A safety risk assessment framework has been developed to understand and mitigate risks associated with lower-than-planned levels of renewals. This framework is embedded into national and regional assurance processes and focuses on asset and safety risks. 7. Integration with Broader Sustainability Goals Climate resilience initiatives are part of the broader Climate Action Plan, which includes themes like "Climate Ready," "Net Zero," and "Environmental Management." These initiatives aim to improve the resilience of railway assets and reduce greenhouse gas emissions.  Summary The document identifies formal risk management approaches for climate change risks, particularly through: - Risk-based prioritization of investments in critical assets like drainage and earthworks. - Development of a long-term climate adaptation strategy informed by climate science and adaptation pathways. - Embedding a safety risk assessment framework into planning and assurance processes. - Leveraging data-driven decision-making to optimize asset management and prepare for extreme weather scenarios. These efforts align with broader sustainability and resilience goals, ensuring that Scotland's Railway can adapt to and mitigate the impacts of climate change effectively. Risk management is not climate focused, therefore the score is low
--------	--	---	---

DOC-18	GB - CP7 Delivery Plan - Year 2 Update	0	###  Analysis of Climate Change Risk Management in the Document The document outlines several initiatives and strategies related to climate change risk management, emphasizing resilience and adaptation for railway infrastructure. Below are the key points: Formal Risk Management Approaches • Weather Resilience and Climate Change Team: The document mentions the transfer of the weather resilience and climate change team to the System Operator. This unification aims to better embed climate change considerations into standards, processes, and operational work 1. • Safety Risk Assessment Framework: A safety risk assessment framework has been implemented to assess the impact of changes in risk profiles due to lower planned renewals. This framework identifies mitigations and has been embedded into national and regional assurance processes 1. Prioritization of Risks to Building and System Assets • Investment in Resilience: The document highlights a planned investment of £2.6 billion during CP7 to improve the resilience of railway assets to extreme weather events. Specific measures include: Enhancing track assets to mitigate heat-related buckling risks. Improving drainage systems to reduce flooding risks. Strengthening earthworks to prevent landslips 1. • Market-Led Planning: Asset management decisions are informed by passenger and freight needs, emphasizing interventions on assets with the highest social and economic value. This approach prioritizes activities on busier lines while ensuring appropriate service levels in less trafficked areas 1. • Technology Integration: Intelligent Infrastructure (II) and Infrastructure Monitoring (IM) programs are being utilized to provide real-time insights into asset conditions, enabling proactive maintenance and renewal planning 1. Additional Measures • Weather Risk Task Force (WRTF): This initiative focuses on understanding extreme weather impacts, such as rainfall events, and developing operational processes to address high-risk areas without imposing blanket disruptions 1. • Freight Safety Improvement Program: Includes schemes to address climate change resilience, such as enhanced security and trespass prevention measures 1. Summary The document identifies several formal risk management approaches for climate change risks, including: Unified Climate Change Team: To embed considerations into standards and processes. Safety Risk Assessments: Frameworks to evaluate and mitigate risk profiles. Resilience Investments: £2.6 billion allocated for infrastructure improvements against extreme weather. Technology Integration: Use of digital tools for proactive asset management. Market-Led Planning: Prioritization based on passenger and freight needs. These strategies collectively aim to enhance the resilience of railway infrastructure while minimizing disruptions and ensuring safety. Risk management is not climate focused, therefore the score is low
DOC-19	System Operator CP7 Delivery Plan	0	• No. The document discusses risk management in general through its enterprise risk management framework and mentions monitoring tools for weather-related risks. However, it does not elaborate on any formal risk management methodology specifically tailored to climate change risks for building or system assets.
DOC-20	The CP7 Buildings & Architecture Policy (2021)	0	– The document incorporates formal risk management practices by applying methods like the Asset Risk Score (ARS), the Percentage Asset Remaining Life (PARL) framework, and the Corporate Risk Assessment Matrix (CRAM). These tools support the prioritisation of interventions and address multiple sources of risk, including those that may be influenced by climate change. However, the approach is integrated into a wider asset risk management strategy rather than exclusively focusing on climate change risks.
DOC-21	"Additional information for asset managers" (2025)	2	• Risk Management Frameworks: The document outlines formal risk assessment and prioritisation frameworks (e.g. the CRAM matrix, PARL/ARS methodology) used to decide on asset interventions. • Incorporation of Climate Resilience: These systematic approaches incorporate sustainability and resilience considerations, which implicitly include the management of climate change risks. • Focus: Although the risk management methods are comprehensive, they are framed within the context of overall asset performance rather than as a standalone climate risk management model. • Conclusion: Yes, formal risk management approaches are featured, and while they cover the broad spectrum of asset risks (including those influenced by climate change), they do not isolate climate change risk as a separate category
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authorit	0	• Although the document outlines strategic principles for asset engineering and sustainable building practices, it does not detail any application of formal risk management approaches specific to climate change risks. • The focus remains on strategic design implementation rather than on a structured risk assessment method for physical climate impacts
DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	5	Not used AI as it is a sensitive document

DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	2	Not used AI as it is a sensitive document
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	0	- While the document describes adaptation efforts and capability improvements (through CaDD response levels), it does not detail the use of any formal risk management methodologies or standardised processes for climate change risk analysis. - The emphasis is on assessing and tracking progress in adaptive capacity rather than outlining a formal risk management framework.
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	The report does not describe any formal risk management approaches or standardized methods specifically for climate change risks (physical hazards). While risk is implicitly a part of designing for sustainability, no standard method for prioritising risks to building or system assets from climate change is outlined.
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	- The document does not include any reference to formal risk management approaches for climate change risk assessment. - There is no mention of standardized methods, risk prioritisation, or climate-specific risk management strategies.
DOC-28	NR's 'The Greener Railway Strategy' (May 2025)	1	- The strategy mentions undertaking comprehensive assessments of physical climate change risks, which implies the use of formal risk management or adaptation planning processes. - Nonetheless, the document does not provide detailed information on the specific methodologies or standard frameworks used for risk prioritisation of individual building or system assets.
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	0	The Blueprint talks about climate change adaptation and resilience in broad terms. However, it does not describe a formal risk management method or standard procedure explicitly used for prioritizing climate change risks to specific assets. The discussion is strategic rather than detailing a formal, methodical risk management framework 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	6	Yes. Formal risk management approaches are applied through methodologies such as Risk Based Maintenance (RBM) and Reliability Centred Maintenance (RCM). These frameworks are used to systematically assess and prioritize risks associated with extreme heat impacts on assets. The document explains the process of data collection, evaluation, risk prioritization, and the establishment of maintenance regimes based on this analysis.
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	3	- The report discusses formal risk management practices, including scenario-based planning and risk assessments. - Notably, it introduces the Gross Disproportionality Factor (GDF) model—a framework designed to provide a more scientifically based approach to setting trigger points and managing speed restrictions under extreme weather conditions. - This risk management approach is tailored to rail operations; while it may not follow a generic "climate change risk" standard, it does prioritize and quantify risk to critical assets.
DOC-32	EHTF Weather and Climate Change Report (March 2023)	1	- The report outlines a risk-based framework in its analysis of future heat projections and the multiple ensemble forecasts it employs. - However, it stops short of detailing any formalized risk management approach (i.e. a standardized method) specifically for prioritising risk to building or system assets. - The overall approach is more about assessing risk probability and potential impacts rather than applying a formal standard risk management methodology.
DOC-33	352_WSFData_20252026 07 Final - Building Only	0	Not used AI as it is a sensitive document

AI Agent Summary - Q7: Are there any applications of adaptation methods that may be appropriate for the climate change risks identified, including good practice approaches to strengthening aging and Victorian Buildings asset groups through reducing vulnerabilities using proportionate, performance-based interventions, identified in the document?

Doc Ref	Document name	Score	Document detail
DOC-01	The NR Climate Projections Guidance Note (2023)	5	### 📄 Adaptation Methods for Climate Change Risks The attached document, "NR Climate Projections Guidance Note (2023)," provides detailed guidance on climate change adaptation and resilience strategies. Below are key insights relevant to Victorian buildings and aging asset groups: Proportionate, Performance-Based Interventions • Risk Assessment Process: The document emphasizes using climate projections to model risks such as flooding, temperature extremes, and humidity. For example, electrical panels in flood-prone buildings can be redesigned to minimize impacts by modeling flood risks and temperature changes using climate projections for the 2070s or 2080s 1. • Design Life Considerations: When interventions are planned for assets with a design life extending beyond the 2050s, sensitivity tests using higher climate projections are recommended. This ensures that designs are robust against worst-case scenarios 1. • Examples of Interventions: Options include waterproof cabinets, floodproofed buildings, raising equipment height, reducing solar gain, or incorporating low-carbon climate control systems 1. Good Practice Approaches • Using Quantitative and Qualitative Data: The guidance outlines a flowchart-based approach to select appropriate climate data for decision-making. This ensures interventions are based on reliable projections 1. • Local Effects Consideration: Victorian buildings, often located in urban areas, may experience unique microclimates. Factors such as shading, topology, and material properties should be considered in adaptation designs 1. • Humidity and Temperature Management: Increased humidity and temperature extremes can affect materials and workforce welfare. Specific humidity data and temperature projections are provided to guide interventions 1. Flood Risk and Coastal Erosion • Floodproofing Strategies: The document highlights the importance of flood risk assessments (FRAs) using peak rainfall intensity and river flow allowances. Victorian buildings in flood-prone areas may benefit from tailored flood defenses 1. • Coastal Erosion: For buildings near coastlines, interventions should account for projected sea-level rise and storm surges. Recommendations include using regulator guidance for allowances and sensitivity tests 1. Climate Scenarios and Planning • Primary and Higher Scenarios: The guidance uses UKCP18 climate projections to model medium and high emission scenarios. These scenarios help planners understand the range of potential impacts and design interventions accordingly 1. • Worked Examples: Practical examples, such as renewing electrical panels in flood-prone buildings, illustrate how to apply climate data to strengthen assets 1. Summary The document provides a comprehensive framework for adapting Victorian buildings and aging assets to climate change risks. Key methods include: Proportionate, performance-based interventions such as floodproofing, raising equipment height, and incorporating climate control systems. Good practice approaches that leverage both quantitative and qualitative climate data, while considering local microclimates and asset-specific vulnerabilities. Flood risk and coastal erosion management using tailored FRAs and regulator guidance. Scenario-based planning to ensure interventions are robust against medium and high emission projections.
DOC-02	The WRCCA Strategy (2017) from the System Operator	4	• Adaptation Measures Covered: The document outlines a dual approach with 'hard' (engineering) and 'soft' (administrative) adaptation measures. Examples include physical interventions such as raising track/signalling equipment and enhancing drainage in flood-prone areas, as well as process improvements like streamlining emergency response procedures. • Best Practices & Interventions: It also discusses the implementation of climate change adaptation plans through revised design, construction practices, and ongoing maintenance/upgrades to meet future climatic conditions. • Conclusion: Yes, the document describes multiple adaptation methods, including performance-based interventions and engineering solutions, though it focuses on infrastructure rather than specifically on aging or Victorian building groups 1.

DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	Adaptation Pathways Planning Overview: Adaptation pathways planning is a globally recognized best practice for structured, flexible decision-making. It helps prioritize and phase investments over time to enhance resilience against climate change. Key Features: - Identifies trigger points and thresholds for action. - Develops long-term, adaptable investment plans. - Allocates funding to high-risk locations for resilience measures. Benefits: This approach minimizes premature investments and avoids costly delays due to late interventions. It is particularly relevant for aging assets, ensuring they remain functional and safe under changing climate conditions 1. 2. Proportionate, Performance-Based Interventions Examples: - Structural Upgrades: Refurbishing crest drains, installing rock netting, and applying scour protection to prevent erosion and landslips. - Material Improvements: Replacing timber layouts with modern materials to withstand extreme weather conditions. - Monitoring Systems: Deploying remote condition monitoring tools like tiltmeters and inclinometers to detect vulnerabilities early. Impact: These interventions enhance the reliability and resistance of Victorian buildings and other aging assets, ensuring they can withstand extreme weather events such as floods, heatwaves, and storms 1. 3. Nature-Based Solutions Approach: Collaborating with third parties to integrate nature-based solutions, such as catchment-based flood management schemes, into resilience strategies. Examples: - Vegetation management to reduce desiccation risks. - Establishing fire breaks around lineside buildings to mitigate wildfire risks. Advantages: These solutions complement engineering interventions and promote sustainability while reducing vulnerabilities 1. 4. Enhanced Asset Knowledge Initiatives: - Conducting detailed surveys and inspections to understand drainage and earthwork vulnerabilities. - Developing earthwork management plans tailored to specific risks like desiccation and saturation. Outcome: Improved asset knowledge enables targeted interventions, reducing the likelihood of failures and enhancing resilience 1. 5. Collaborative Efforts Partnerships: Working closely with local authorities, the Environment Agency, and other stakeholders to address shared risks, such as flooding and coastal erosion. Example: Joint flood management projects and integrated risk assessments for vulnerable locations. Benefit: Collaboration ensures a holistic approach to resilience, leveraging shared resources and expertise 1. ### 📌 Summary The document outlines several adaptation methods suitable for addressing climate change risks to Victorian buildings and aging assets: - Adaptation Pathways Planning: Strategic investment planning for long-term resilience. - Performance-Based Interventions: Targeted upgrades and monitoring systems to reduce vulnerabilities. - Nature-Based Solutions: Sustainable approaches like vegetation management and fire breaks. - Enhanced Asset Knowledge: Comprehensive surveys and management plans for proactive interventions. - Collaborative Efforts: Partnerships with stakeholders for integrated solutions. These strategies emphasize proportionate and performance-based interventions that align with the unique challenges posed by aging infrastructure. ### ⚡ Additional Context Victorian buildings often feature materials and designs less suited to modern climate extremes. By combining engineering upgrades with nature-based solutions and leveraging collaborative efforts, these assets can be preserved and adapted to withstand future climate challenges effectively.
--------	--	---	--

DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	4	Key Applications of Adaptation Methods for Climate Change Risks The document outlines several adaptation pathways and performance-based interventions that are crucial for addressing climate change risks, particularly for aging infrastructure, including Victorian buildings. Here are the key approaches: 🔗 Proportionate, Performance-Based Interventions Structural Adaptation Pathways: Renewals and Refurbishments: Focus on upgrading aging buildings and structures to meet current climate resilience standards. For example: Refurbishment of deteriorating lineside buildings to improve resilience to rain and temperature 1. Renewal of station roofs and drainage systems to enhance resilience against wind and rain 1. Scour Mitigation: Implementing physical interventions to protect structures like culverts and underbridges from flood and erosion risks. This includes targeting high-risk scour sites 1. Non-Structural Adaptation Pathways: Digital Monitoring: Use technologies such as Light Detection and Ranging (LiDAR) and hyperspectral analysis for proactive asset management. This helps identify vulnerabilities in vegetation and structural elements that may be exacerbated by extreme weather 1. Weather Risk Tools: Tools like the Rail Operations Weather Service (ROWS) and Convective Alert Tool (CAT) dynamically manage risks related to extreme weather events 1. 🌿 Nature-Based Solutions (NbS) Floodplain Reconnection: Reconnecting rivers to floodplains and restoring natural landscapes to reduce flood risks and improve biodiversity. For example: Collaboration with local agencies to restore river meanders, reducing scour risks to railway earthworks while enhancing wildlife habitats 1. Vegetation Management: Managing vegetation to balance cooling and shading benefits while reducing risks of obstruction or damage to infrastructure during storms 1. 🏠 Resilience Through Standards and Renewals Adherence to Updated Standards: Ensuring that renewals and refurbishments comply with updated standards (e.g., NR, ISO, and EN) to enhance resilience against extreme weather conditions 1. Climate-Ready Renewals: Incorporating climate risk assessments into the design and construction phases to ensure assets are resilient for future climate scenarios 1. 📋 Investment and Prioritization Targeted Investments: Prioritizing interventions for high-risk areas and strategic route sections, such as the Cumbrian coastal line, which faces significant flood and erosion risks 1. Integrated Approaches: Combining drainage, earthworks, and vegetation management to optimize resilience and reduce operational risks 1. Summary The document emphasizes a whole-system approach to climate adaptation, combining structural and non-structural methods, nature-based solutions, and adherence to updated standards. Key strategies include refurbishing aging assets, implementing digital monitoring technologies, and leveraging nature-based solutions to reduce vulnerabilities. These interventions are tailored to the specific risks posed by climate change, such as flooding, extreme heat, and erosion. Additional Context The adaptation pathways outlined are part of a broader strategy to ensure the resilience and sustainability of critical infrastructure. These methods not only address immediate risks but also lay the groundwork for long-term adaptation planning. For Victorian buildings, the focus on refurbishments and adherence to updated standards ensures their historical value is preserved while enhancing their resilience to climate impacts
DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	Yes, the plan details a range of adaptation strategies and good practice interventions: Asset Renewal and Strengthening: Targeted renewal of Victorian and legacy assets, with performance-based upgrades to meet modern resilience standards 1. Earthworks and Drainage: Use of rock armour, improved drainage, and embankment reinforcement to reduce flood and erosion risk. Building Upgrades: Retrofitting insulation, improving HVAC, and reinforcing roofs/walls to withstand heat, wind, and water ingress. Nature-Based Solutions: Collaboration with Natural Resources Wales and others to implement catchment-wide flood management and habitat restoration. Monitoring and Early Warning: Deployment of remote condition monitoring, tilt sensors, and real-time weather response protocols. Proportionate Interventions: Emphasis on cost-effective, risk-based upgrades rather than blanket replacement, ensuring value for money and targeted resilience.
DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	• Yes – adaptation strategies receive a significant focus in the plan. • Detailed “adaptation pathways” are outlined which include both short-term reactive measures and long-term, performance-based interventions designed to retrofit aging assets. • The plan describes upgrading and reinforcing infrastructure using modern design standards as well as implementing enhanced monitoring systems to detect early signs of asset degradation. • Furthermore, there is an emphasis on proportionate interventions – targeting the most vulnerable systems first while developing scalable solutions that can be adapted as climate projections are updated.
DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	• Yes. The plan outlines a range of adaptation methods including: • Asset refurbishment and targeted renewals (e.g., the critical lineside building refurbishment programme) • Installation of new technologies (e.g., remote monitoring systems, sensors, and digital dashboards) • Adaptation pathways that are being developed to support long-term, transformational changes While the document covers many assets, it incorporates best-practice adaptation strategies such as performance-based interventions to enhance asset resilience. Although the focus spans across various asset classes (including aging infrastructure), it does not specifically single out “Victorian Buildings” by name but does address many traditional, older asset groups through proportionate, performance-based interventions [Scotlands-Railway-CP7-Climate-Ready-WRCCA-Plan.pdf].
DOC-08	Eastern Region: CP7 Region Strategic Business Plan	3	• Adaptation methods form an integral part of the plan. The document outlines weather resilience and climate change adaptation initiatives such as: – Investment in renewals, refurbishment, and life extension works for aging infrastructure. – Risk-based maintenance strategies that adjust for vulnerable drainage, track, and structural assets. – Proactive measures aimed at mitigating the effects of extreme weather, which include rapid recovery and adaptation pathways. While there is extensive discussion on adaptation and resilience (and even discussion of “remediation” and “proportionate, performance-based interventions”), the focus is primarily on systemic infrastructure upgrades and renewals rather than on a detailed study of Victorian building groups specifically.

DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	4	The document discusses climate adaptation methods as part of its broader environmental sustainability and asset management strategies. Key points include: • Climate Change Adaptation and Weather Resilience: – The document outlines a “Weather Resilience and Climate Change Adaptation” plan which builds on previous control period work. It notes that extreme weather events (e.g., increased flooding, severe rainfall, and temperature extremes) are identified as key risks. – In response, the plan incorporates additional works in infrastructure renewals and maintenance. For example, drainage schemes and earthworks are being enhanced (with design adjustments such as specifying greater capacity for drainage) to mitigate the increased risk from severe weather events. – There is also an emphasis on remote condition monitoring and data-driven maintenance practices to more rapidly identify vulnerabilities that may be exacerbated by climate change, enabling timely, performance-based decision making. • Performance-Based, Proportionate Interventions: – The document consistently emphasizes using a performance-based, risk-based approach in its asset management strategies. This means that interventions are designed to be proportionate to the level of risk or performance degradation identified. – By capturing metrics such as the Composite Sustainability Index (CSI) and other performance indicators, the strategy aims to guide decisions on maintenance and renewal volumes. This approach helps target resources efficiently and ensures that the interventions—whether on tracks, earthworks, or buildings—deliver measurable benefit. • Asset Sustainability for Aging Infrastructure and Buildings: – Although the document focuses on a wide spectrum of rail assets (track, structures, signaling, etc.), it also discusses the “Buildings” asset group. While it does not specifically mention “Victorian Buildings,” the underlying principles of its asset management approach apply: • The document outlines good practices such as adopting international maintenance standards (e.g., for categorizing maintenance activities) and integrating maintenance with renewals planning. • It advocates for detailed condition assessments and using risk-based methods to determine the necessary intervention level. This means that older assets, including those of historical significance like Victorian buildings, can be assessed against performance metrics to determine if cost-effective upgrades, refurbishments, or renewals are required. • By focusing on performance metrics and whole-life cost optimization, the approach calls for proportionate interventions that are neither over-engineered nor underdeveloped, thereby strengthening the resilience of aging structures. • Good Practice Approaches: – The plan promotes the use of modern analytical tools—for example, the integration of remote condition monitoring and advanced performance modeling—which supports timely and evidence-based decision making. – It emphasizes cross-asset optimization and sector-wide review processes, which encourage learning from other asset groups. While the text does not explicitly detail interventions for Victorian buildings, the same methodology could be adopted. In practice, this might include condition monitoring, targeted refurbishment projects based on performance thresholds, and the application of modern standards to historic or aging buildings. – There is also an emphasis on stakeholder engagement and aligning technical decisions with long-term sustainability goals (such as a 21% reduction in carbon emissions and eventual net zero), ensuring that any intervention is proportionate to both the risk and the asset’s strategic value. In summary, the document does describe several adaptation methods that are appropriate for addressing climate change risks. These include:
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	4	• Yes. The CP7 Plan includes adaptation measures targeted at enhancing climate resilience. Notably, it allocates significant funding (e.g. £27m) for weather resilience and climate change adaptation initiatives. These include updating Regional Weather Resilience and Climate Change Adaptation Plans and investing in infrastructure measures—such as decarbonisation initiatives and other performance-based interventions—that indirectly serve to reduce vulnerabilities of aging or high-risk assets. • Strategic Adaptation Initiatives: The CP7 Strategic Business Plan demonstrates a forward-looking approach by embedding climate resilience within broader asset management and operational strategies. It recognizes that climate change is an ever-evolving risk, and thus the plan urges the development of region-specific Weather Resilience and Climate Change Adaptation Plans. These regional strategies are designed to tailor adaptation measures to local environmental conditions and vulnerabilities, ensuring that each area addresses its specific risks. • Significant Investment for Resilience: A highlight of the CP7 Plan is the allocation of dedicated funding—reported to be on the order of £27m—for climate change adaptation initiatives. This funding is earmarked for projects that directly enhance the resilience of critical infrastructure. By investing in asset upgrades and renewal programs that factor in weather-induced stressors, the plan ensures that aging infrastructure is reinforced against the impacts of extreme weather events. • Infrastructure Upgrades and Modernisation: The adaptation strategy also includes targeted interventions aimed at enhancing physical asset robustness: • Upgrading old or vulnerable components to increase their resistance to extreme weather, such as retrofitting buildings or boosting the integrity of key infrastructure assets. • Integration of decarbonisation initiatives that not only reduce carbon emissions but also contribute to lower energy use and improved asset performance, which indirectly enhances resilience. • Modernizing building systems by incorporating energy-efficient and climate-resilient technologies which help extend asset lifecycle in the face of increasingly severe weather patterns. • Dynamic Risk-Based Asset Management: The CP7 Plan employs a risk-based management framework to continuously assess and prioritize risks associated with climate change. This includes: • Regularly updated assessments of asset vulnerability. • Incorporation of climate modelling and forecasting data to anticipate future weather patterns and stressors. • Adjusting maintenance, repair, and upgrade strategies based on emerging climate risks to mitigate future impacts. These measures ensure that adaptation is not a static exercise but an ongoing process, adapting to both immediate and longer-term climate projections. • Cross-Sector Collaboration and Data Integration: Another critical element is the integration of insights from local authorities, climate experts, and regulatory bodies. By aligning with external best practices and evolving standards, the plan creates a robust framework where strategic planning benefits from the latest climate data and resilience methodologies. This helps build a more comprehensive, quality-assured adaptation strategy that supports operational continuity across the network.

DOC-11	Southern Region: CP7 Region Strategic Business Plan	6	• Yes. The plan describes an adaptation approach known as the “adaptation pathway methodology.” • This method is designed to support long-term investment planning that can be adjusted based on trigger points related to climate change impacts. • Although the discussion is broader and applies across the portfolio rather than focusing exclusively on Victorian or aging building groups, it does reflect good practice by advocating performance-based interventions and resilience measures (e.g., improved drainage and water management systems) to reduce vulnerabilities. • Adaptation Pathway Methodology: The plan outlines the use of an adaptation pathway methodology. This method is designed as a decision-making framework where investments and strategies can be modified over time as climate-related risks materialize or evolve. The methodology creates iterative planning milestones (or trigger points) that enable project managers to reassess asset conditions and performance thresholds, thereby allowing for timely interventions when certain risk levels are reached. • Performance-Based Interventions: The document emphasizes interventions that are proportionate to the assessed risk. This involves identifying key performance indicators (such as improved drainage efficiency or enhanced structural integrity) that, once reached, suggest the need for targeted adaptation measures. Such interventions are tailored to address broad asset group vulnerabilities rather than one-off fixes, ensuring that aging buildings like those in the Victorian asset group receive resilience upgrades that match their specific risk profiles. Application to Aging and Victorian Buildings • Asset Group Prioritization: While the plan covers a broad portfolio of assets, it pays specific attention to building groups that are aged or historically significant. For instance, Victorian buildings may be prioritized for interventions that bolster their resilience against identified climate risks. Such prioritization is based on factors like historical construction methods, material vulnerabilities, and the potential impact of severe weather events. • Good Practice Approaches: The CP7 plan considers best practice measures, including retrofitting and system upgrades that align with modern performance standards. This involves using proportionate, performance-based interventions aimed not only at extending the life span of the assets but also at reducing the potential for cascading failures in the event of climate-related disruptions. Adaptation measures might include improved insulation, enhanced waterproofing, retrofitting for energy efficiency, and reinforcing infrastructure to withstand extreme weather impacts. Integration with Risk Management • Risk-Adjusted Planning: The use of adaptation methods is embedded within a larger risk management framework where climate risks contribute to the overall risk portfolio. The integration ensures that adaptation measures are not standalone but are considered part of the broader strategy to maintain asset performance under varying environmental conditions. A contingency allocation is incorporated within financial planning to accommodate these adaptation investments, acknowledging that residual risks may persist despite proactive interventions. • Iterative and Flexible Approach: One key strength of the adaptation methodology is its iterative process. The plan allows for flexibility in response to new data or evolving climate conditions, ensuring that adaptation strategies remain relevant and effective over time. This dynamic approach helps in adjusting maintenance schedules, retrofit projects, and overall asset management strategies as part of a continuous improvement cycle. ☒ Summary • Core Adaptation Technique: The CP7 Strategic Business Plan utilizes an adaptation pathway methodology to enable flexible, iterative planning based on evolving climate risks. • Good Practice Measures: It incorporates performance-based, proportionate interventions targeted at improving the resilience of aging assets such as Victorian buildings. • Risk Management Integration: Adaptation methods are embedded within a broader risk-adjusted planning framework, ensuring that investments are prioritized and revised according to measurable performance thresholds and emerging hazards. • Iterative Process: The methodology supports continuous reassessment and adjustment, allowing for timely upgrades and strengthening measures in response to new risk data.
DOC-12	Scotland Region: CP7 Region Strategic Business Plan	4	• Adaptation and Resilience Actions: Adaptation measures are prominently featured in the document. Initiatives include targeted renewals, refurbishment programs, and the upgrading of drainage and monitoring systems to cope with increased climate variability. The “Climate Ready Plan” serves as a central adaptation strategy, outlining proactive steps for both immediate and long-range mitigation of climate risks. • Tailored Approaches for Asset Classes: While the overall adaptation strategy applies broadly to all assets, the document does not delineate separate, detailed interventions specifically for subcategories like “Victorian Buildings.” Instead, it emphasizes proportionate, performance-based interventions applicable universally, with a focus on ensuring that all legacy and contemporary assets are brought up to a standard capable of withstanding adverse conditions.

DOC-13	Eastern Delivery Plan - Year 2 Update	Applications of Adaptation Methods for Climate Change Risks in Victorian and Aging Buildings The Eastern CP7 Delivery Plan outlines several strategies and adaptation methods that can be applied to address climate change risks while improving the resilience of aging infrastructure , including Victorian buildings. Below are the key approaches and good practices identified: Key Adaptation Methods and Practices 1. Weather Resilience and Refurbishment Targeted Life Extension Activities: The plan emphasizes refurbishments and life-extension activities for critical assets, including buildings and structures. This includes: Modernizing roofs and bridges (e.g., Liverpool Street station roof and Highbury & Islington station bridge). Ensuring Heavy Axle Weight capability for key freight routes to support resilience against increased loads and climate impacts. Weather Resilience Contributions: Approximately £0.5 billion is allocated for primary weather resilience benefits (flooding, wind, and heat), with an additional £1 billion for secondary benefits through renewals and refurbishments, particularly for track assets. 2. Risk-Based Maintenance and Monitoring Inspection Regimes: A risk-based inspection and maintenance regime is being implemented , especially for drainage and earthworks. This approach helps identify vulnerabilities in aging structures and prioritize interventions. Safety Bow Tie Risk Assessment Framework: This framework is used to understand and mitigate safety risks, including those exacerbated by climate change, such as extreme heat or flooding. 3. Proportionate Interventions for Victorian Buildings Energy Efficiency Upgrades: Victorian buildings and stations are being retrofitted with energy-efficient lighting, updated heating and ventilation systems, and modern building controls to reduce vulnerabilities to heat and improve sustainability. Platform Resurfacing: To prevent slips and trips, platforms are being resurfaced, which also contributes to safety during extreme weather events. Ventilation Enhancements: Improved ventilation systems are being installed in managed stations to enhance air quality and reduce heat exposure for passengers and staff . 4. Holistic Sustainability and Carbon Reduction Lifecycle Carbon Analysis: Whole lifecycle carbon analysis is being integrated into refurbishment projects to ensure that interventions are both sustainable and effective in reducing climate risks . PAS2080 Standards: The adoption of PAS2080 (a standard for carbon management in infrastructure) ensures that climate resilience is embedded in the design and refurbishment of aging assets. 5. Drainage and Earthworks Integration Systemized Drainage Approach: Drainage interventions are being prioritized to prevent flooding and water damage to Victorian-era structures. This includes integrating drainage improvements with earthworks to enhance overall resilience. 1 Boundary Fences: Investments in boundary fences protect infrastructure from external incursions, which can be exacerbated by climate-related events. 6. Modernization and Digital Integration Digital Technology: The use of digital tools for monitoring and maintenance (e.g., paperless notifications and virtual community events) supports proactive management of aging assets. ETCS Deployment: The East Coast Digital Programme includes re-signaling and targeted refurbishments to modernize the infrastructure while reducing vulnerabilities. ☒ Good Practices for Proportionate, Performance-Based Interventions Prioritization of High-Risk Assets: Focus on high-risk and critical assets, such as Heavy Axle Weight bridges and platforms prone to slips and falls. Use risk-based frameworks to allocate resources effectively. Incremental Modernization: Instead of full-scale replacements, adopt targeted refurbishments and life-extension strategies to balance costs and benefits. Stakeholder Collaboration: Engage with stakeholders, including local authorities and industry partners, to align interventions with broader climate resilience goals. Integration of Sustainability Metrics: Measure the impact of interventions using sustainability indices, such as the Composite Sustainability Index (CSI), to ensure long-term benefits. Summary The Eastern CP7 Delivery Plan provides a comprehensive framework for addressing climate change risks in Victorian and aging buildings. Key adaptation methods include targeted refurbishments, risk-based maintenance, energy efficiency upgrades, and integration of sustainability standards like PAS2080. These interventions are designed to be proportionate and performance-based, ensuring that resources are allocated effectively to reduce vulnerabilities and enhance resilience. The AI response generated above has extrapolated informaiton from the document and has tried to apply similar intervention to Victorian buildings . Therefore, this document does not explicitly reference Victorian buildings and has been scored low.
--------	---------------------------------------	--

DOC-14	North West and Central Delivery Plan - Year 2 Update	1	 Key Adaptation Methods and Practices for Climate Change Risks 1. Risk-Based Maintenance and Renewals The document emphasizes the importance of risk-based maintenance and renewal strategies to address aging infrastructure. For Victorian buildings and similar assets, this involves: Conducting risk assessments for each strategic route section (SRS) to identify vulnerabilities. Integrating proportionate mitigations into maintenance and renewal plans to ensure safety and sustainability. Using structured frameworks, such as the safety bow-tie framework, to manage risks effectively 1. 2. Weather Resilience and Climate Change Adaptation (WRCCA) Climate change poses significant challenges, including severe weather impacts. The document outlines several adaptation measures: Renewing priority assets with features like scour protection and enhanced drainage systems to improve resilience. Investing in digital lineside inspection technologies for vegetation and slope monitoring. Utilizing tools like PRIMA (Proportionate Risk Response to Implementing Mitigating Speeds to Assets) for better risk forecasting and management 1. 3. Technological Interventions Advanced technologies are integral to improving resilience and reducing vulnerabilities: Remote Condition Monitoring (RCM) to predict and prevent failures. Deployment of extreme weather management tools to anticipate and mitigate risks. Use of advanced imaging technology to reduce inspection costs and improve accuracy 1. 4. Integrated Maintenance and Renewal Plans The document highlights the integration of maintenance and renewal efforts to optimize expenditure and improve outcomes: Aligning maintenance with renewal strategies to address the increased risks posed by life-expired assets. Implementing totex optimization (total expenditure optimization) to balance maintenance and renewal costs effectively 1. 5. Sustainability and Decarbonization To address long-term climate risks, the plan includes: Transitioning to zero-emission vehicles and improving energy efficiency in buildings. Enhancing biodiversity through habitat management and sustainable design in renewals. Promoting the reuse and recycling of non-hazardous materials to align with circular economy principles 1.  Good Practices for Victorian Buildings and Aging Assets For Victorian buildings and similar aging asset groups, the following good practices are particularly relevant: Localized Risk Assessments: Tailoring interventions to the specific vulnerabilities of each building or asset. Performance-Based Interventions: Prioritizing actions that deliver measurable improvements in resilience and safety. Community Engagement: Collaborating with local stakeholders to align interventions with community needs and heritage preservation goals. Incremental Improvements: Implementing phased upgrades to balance cost and impact, ensuring minimal disruption to users and communities. Summary The document outlines a comprehensive approach to addressing climate change risks for aging assets, including Victorian buildings. Key strategies include risk-based maintenance, technological innovations, and integrated renewal plans. These methods aim to enhance resilience, reduce vulnerabilities, and ensure sustainability through proportionate and performance-based interventions. The AI response generated above has extrapolated information from the document and has tried to apply similar intervention to Victorian buildings. Therefore, this document does not explicitly reference Victorian buildings and has been scored low.
--------	--	---	---

DOC-15	Wales and Western Delivery Plan - Year 2 Update	1	 Adaptation Methods for Climate Change Risks The document identifies several approaches and initiatives that may be relevant for addressing climate change risks and vulnerabilities, especially for aging and Victorian buildings. Here are the key points:  Good Practice Approaches Weather Resilience and Climate Change Adaptation: Investment in weather resilience measures is highlighted as a priority. This includes robust incident response mechanisms and proactive adaptation strategies to mitigate the impacts of extreme weather events ¹. Specific interventions, such as geotechnical instrumentation and failure detection equipment, are being deployed to improve resilience against extreme weather and climate change. These methods could be adapted for Victorian buildings to enhance their structural integrity and reduce vulnerabilities ¹. Drainage and Flood Management: Significant investments in drainage maintenance and refurbishment are noted, with dedicated teams focusing on improving performance during severe rainfall. For Victorian buildings, similar drainage upgrades could prevent water damage and structural degradation ¹. Enhanced Maintenance Regimes: Risk-based maintenance capabilities are being developed to extend asset life and ensure efficient operations. Victorian buildings could benefit from tailored maintenance plans that focus on their unique architectural and material needs ¹. Energy Efficiency and Carbon Reduction: Energy intervention initiatives aim to reduce consumption and transition to alternative energy sources. Victorian buildings could integrate energy-efficient technologies while preserving their historical features ¹.  Proportionate, Performance-Based Interventions Risk-Based Asset Renewals: Investments in renewing overhead lines and conductor systems are mentioned as examples of proportionate interventions. For Victorian buildings, this could translate into targeted structural reinforcements and upgrades that balance historical preservation with modern safety standards ¹. Modernized Maintenance Organization: The document discusses sending the right number of skilled personnel to perform necessary work safely and efficiently. This approach could be applied to Victorian buildings by involving specialized conservation experts alongside climate adaptation professionals ¹.  Sustainable Growth and Biodiversity Green Infrastructure: Initiatives such as green roofs and community gardens are being developed to enhance biodiversity and sustainability. Victorian buildings could incorporate these features to improve environmental performance while maintaining aesthetic appeal ¹. ☒ Summary The document outlines several adaptation methods and good practices that can be applied to aging and Victorian buildings to address climate change risks: Weather resilience through geotechnical instrumentation and failure detection. Drainage improvements to manage severe rainfall and prevent structural damage. Enhanced maintenance regimes tailored to the unique needs of historical structures. Energy efficiency measures to reduce carbon footprint while preserving architectural integrity. Proportionate interventions focusing on risk-based renewals and modernized maintenance. Sustainable growth initiatives, such as green roofs and biodiversity enhancements. The AI response generated above has extrapolated information from the document and has tried to apply similar intervention to Victorian buildings. Therefore, this document does not explicitly reference Victorian buildings and has been scored low.
--------	---	---	---

DOC-16	Southern Delivery Plan - Year 2 Update	1	 Insights from the Document The document outlines several sustainability and climate resilience initiatives that could be relevant to addressing climate change risks for aging and Victorian buildings. Key highlights include: Climate Resilience Program: Focuses on building and maintaining infrastructure resilient to severe weather events and climate change. Includes long-term planning and climate-focused investment decisions to improve asset resilience during extreme weather events. Development of climate adaptation pathways for vulnerable locations across the network 1. Sustainability Integration: Embedding sustainability into design, construction, and maintenance processes. Specific initiatives include reducing energy consumption, transitioning to renewable energy sources, and implementing biodiversity net gain strategies 1. Proportionate Interventions: The document mentions a risk-based approach to design and maintenance, which could be adapted to Victorian buildings by prioritizing interventions based on vulnerability and performance needs 1. Innovative Tools: Use of digital tools and technologies like hyperspectral vegetation tools and thermal imaging for inspection and risk identification, which could be extended to monitor the structural health of aging buildings 1.  Good Practice Approaches for Victorian Buildings To strengthen Victorian buildings against climate change risks, the following adaptation methods and practices are recommended: Performance-Based Interventions: Conduct detailed vulnerability assessments to identify specific risks (e.g., flooding, heat stress, or structural degradation). Use performance-based retrofitting techniques to enhance structural integrity while preserving historical features. Energy Efficiency Upgrades: Install energy-efficient systems like improved insulation, double-glazed windows, and renewable energy sources (e.g., solar panels) where feasible. Use sustainable materials that align with the building's historical character. Flood and Moisture Management: Implement flood defenses such as raised foundations, permeable landscaping, and water-resistant materials. Address moisture ingress by improving drainage systems and using breathable materials to prevent dampness. Heat Resilience: Introduce passive cooling techniques, such as shading devices, reflective roofing, and natural ventilation. Use green roofs or walls to reduce heat absorption and improve thermal comfort. Digital Monitoring and Maintenance: Employ digital tools for real-time monitoring of structural health and environmental conditions. Use predictive maintenance strategies to address issues before they escalate. Community and Stakeholder Engagement: Collaborate with local communities, heritage bodies, and sustainability experts to ensure interventions respect the historical and cultural significance of the buildings. ☒ Summary The document highlights several adaptation strategies, including climate resilience planning, sustainability integration, and innovative tools, which can be applied to Victorian buildings. Best practices for strengthening these structures involve performance-based retrofitting, energy efficiency upgrades, moisture and heat management, and leveraging digital tools for monitoring and maintenance. The AI response generated above has extrapolated information from the document and has tried to apply similar intervention to Victorian buildings. Therefore, this document does not explicitly reference Victorian buildings and has been scored low.
--------	--	---	---

DOC-17	Scotland Delivery Plan - Year 2 Update	1	 Applications of Adaptation Methods for Climate Change Risks in Victorian and Aging Buildings Identified Climate Change Risks The document highlights several climate-related challenges that impact infrastructure, including: Increased rainfall and extreme weather events: These are particularly significant in Scotland, where the rail network and associated infrastructure are affected more severely than in other regions. Drainage and earthworks vulnerabilities: Critical drainage systems and earthworks require investment to enhance resilience against more frequent and severe weather events. Good Practices and Proportionate Interventions To address these risks, several adaptation strategies and performance-based interventions have been outlined: 1. Climate-Ready Asset Management - Investment in Resilience: The plan includes targeted investments in assets to improve their resilience against extreme weather. This involves developing a long-term climate change adaptation strategy that uses novel adaptation pathways to prepare for multiple future climate scenarios. - Drainage and Earthworks: Increased activity in drainage systems and earthworks is prioritized, adopting a whole-system approach to improve resilience. 2. Proportionate and Performance-Based Interventions - Targeted Renewals and Maintenance: Moving away from full system renewals, the strategy emphasizes mid-life refurbishments and targeted maintenance to extend the life of assets. This approach is both cost-effective and efficient. - Structures and Buildings: Specific interventions include stabilizing parapet and spandrel walls, renewing culverts, and addressing safety-related platform and footbridge issues. These measures are critical for Victorian and aging buildings that may have unique structural vulnerabilities. 3. Data-Driven Decision Making - Improved Asset Models: Enhanced data collection on asset conditions allows for better prioritization of investments. This ensures that interventions are targeted where they are most needed, reducing variability and improving outcomes. - Climate Science Integration: Developing additional climate science and adaptation capabilities strengthens decision-making processes and ensures that interventions are informed by the latest research. 4. Sustainability and Environmental Management - Biodiversity and Vegetation Management: Incorporating biodiversity specifications into frameworks and creating habitat management plans help align infrastructure resilience with environmental goals. - Carbon Emissions Reduction: Efforts to reduce greenhouse gas emissions across the network, including transitioning to zero-emission vehicles and implementing energy efficiency measures, contribute to broader climate action goals. 5. Collaborative and Innovative Approaches - Stakeholder Engagement: Collaboration with technical authorities, supply chains, and local communities ensures that adaptation strategies are inclusive and effective. - Research and Development: Leveraging innovation and new technologies, such as intelligent infrastructure systems, enhances the ability to predict and respond to climate-related challenges. Examples of Application Victorian Buildings: For aging Victorian buildings, interventions such as stabilizing walls, improving drainage, and incorporating modern materials in refurbishments can reduce vulnerabilities while preserving historical integrity. Railway Infrastructure: The use of real-time monitoring solutions and targeted vegetation management has already shown effectiveness in mitigating risks like temporary speed restrictions caused by weather-related damage.  Summary The document outlines a comprehensive approach to strengthening aging and Victorian buildings against climate change risks. Key methods include: Investing in resilience through targeted renewals and maintenance. Using data-driven models and climate science to prioritize interventions. Enhancing sustainability through biodiversity and carbon reduction initiatives. Collaborating with stakeholders and leveraging innovation for effective adaptation. These strategies ensure that interventions are proportionate, performance-based, and aligned with broader climate action goals. The AI response generated above has extrapolated information from the document and has tried to apply similar intervention to Victorian buildings. Therefore, this document does not explicitly reference Victorian buildings and has been scored low.
--------	--	---	---

DOC-18	GB - CP7 Delivery Plan - Year 2 Update	0	 Applications of Adaptation Methods for Climate Change Risks The document outlines several initiatives and strategies that could be relevant for addressing climate change risks and strengthening aging and Victorian buildings . Here are the key points: 1. Climate Change Resilience Investments A significant investment of £2.6 billion is allocated in CP7 (Control Period 7) to improve the resilience of infrastructure to extreme weather events. This includes: Track assets: Reducing risks like heat-related track buckling. Drainage systems: Mitigating flooding risks through enhanced drainage resources. Earthworks: Addressing landslips and ensuring stability of structures 1. 2. Weather Risk Task Force (WRTF) The WRTF supports updates to operational processes, enabling targeted weather interventions in high-risk areas. This approach minimizes unnecessary disruptions and focuses on localized vulnerabilities rather than blanket measures 1. 3. Proactive Maintenance and Renewals Maintenance strategies emphasize planned preventative maintenance to monitor and reduce the likelihood of asset failures. This includes: Inspections and minor works to extend the life of assets. Renewals focused on the busiest and most vulnerable parts of the network to ensure safety and reliability 1. 4. Embedding Climate Change Considerations A dedicated weather resilience and climate change team has been established to integrate climate considerations into standards , processes, and project delivery. This ensures that interventions are performance-based and proportionate to the risks identified 1. 5. Technology and Data-Driven Approaches Investment in Intelligent Infrastructure (II) and Infrastructure Monitoring (IM) programs provides real-time insights into asset conditions. These tools help predict and prevent failures, enabling targeted interventions for aging structures, including Victorian-era buildings 1. 6. Vegetation Management Enhanced vegetation management plans are in place to prevent disruptions caused by falling trees and to protect biodiversity. This approach balances ecological considerations with the need to safeguard infrastructure 1. 7. Market-Led Planning A market-led approach ensures that interventions are informed by the needs of stakeholders, including passengers and freight operators. This includes prioritizing assets that deliver the greatest social and economic value, which may include heritage structures like Victorian buildings 1.  Good Practice Approaches To strengthen aging and Victorian buildings against climate change risks, the following good practices are highlighted: Performance-Based Interventions: Focus on interventions that are proportionate to the identified risks, such as targeted drainage improvements or structural reinforcements for landslip-prone areas. Whole-Life Carbon Monitoring: Incorporate carbon impact assessments into renewal activities to ensure sustainability while addressing vulnerabilities. Local Adaptation Strategies: Develop localized strategies that consider the unique characteristics of Victorian-era buildings, such as their materials and construction methods. Collaboration Across Stakeholders: Engage with local communities, conservation experts, and climate scientists to ensure interventions respect the historical value of Victorian assets while enhancing their resilience . ☒ Summary The document outlines a comprehensive approach to addressing climate change risks for aging and Victorian buildings . Key strategies include significant investments in resilience, targeted maintenance and renewals, data-driven monitoring, and localized adaptation measures. These efforts aim to reduce vulnerabilities through proportionate, performance-based interventions while balancing sustainability and heritage preservation. The AI response generated above has extrapolated information from the document and has tried to apply similar intervention to Victorian buildings . Therefore, this document does not explicitly reference Victorian buildings and has been scored low.
DOC-19	System Operator CP7 Delivery Plan	0	• No. Although operational adaptation measures—such as those managed by the Weather Risk Task Force—are described to enhance resilience against extreme weather, there is no mention of adaptation methods targeted at the retrofitting or strengthening of aging or Victorian building assets.
DOC-20	The CP7 Buildings & Architecture Policy (2021)	0	– The policy outlines a range of intervention types (e.g. full renewals, major refurbishments, and predictive maintenance) that aim to enhance resilience and sustainability across the asset portfolio. These are developed using performance-based approaches and design principles. However, it does not provide specific adaptation methods targeted to particular building typologies (for example, aging or Victorian buildings) or a detailed adaptation programme solely focused on such asset groups.
DOC-21	"Additional information for asset managers" (2025)	2	• Adaptation Strategies Highlighted: The policy details various intervention types (renewal, refurbishment, maintenance) aimed at enhancing asset resilience and sustainability. These can be seen as adaptation measures that improve performance under a range of future stresses. • Examples: It discusses updating building management systems, implementing energy performance improvements, and revising intervention trigger points—actions that collectively build resilience to environmental stressors. • Specific Asset Groups: However, there is no dedicated section that singles out "aging or Victorian Buildings" or explicitly details adaptation measures for historically specific assets. • Conclusion: Adaptation methods are broadly applied through performance-based interventions and resilience measures, but the document does not provide specific adaptation approaches targeted solely at older or Victorian asset groups.
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authorit	0	• There is no evidence in the reviewed content to suggest that adaptation methods explicitly addressing physical climate vulnerabilities (such as according to performance-based interventions for aging building groups) are outlined. • The document primarily targets overall sustainability improvements and carbon neutrality without directly detailing adaptation methods for climate-related risks

DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	4	Not used AI as it is a sensitive document
DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	0	Not used AI as it is a sensitive document
DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	0	- The report outlines improvement activities and actions aimed at increasing overall adaptive capacity. - However, it does not provide any detailed discussion or case examples of adaptation methods specifically targeted at aging assets or Victorian building asset groups. - The adaptation discussion is more general, aimed at boosting resilience within the rail sector rather than detailing asset-specific interventions.
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	There is no mention of applications of adaptation methods for climate risks in the document. It does not discuss measures aimed at reducing vulnerabilities of aging or heritage (e.g. Victorian) buildings through proportionate, performance-based interventions.
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	- Adaptation methods, including performance-based interventions or other approaches to reduce vulnerabilities, are not covered anywhere in the document. - The content remains limited to the procurement of maintenance and renewal works.
DOC-28	NR's 'The Greener Railway Strategy' (May 2025)	0	- The adaptation methods described focus broadly on making the railway system more resilient – for example, through proactive weather planning and improving overall operational response. - There is no explicit mention of adaptation methods that specifically target aging buildings or Victorian asset groups through specialized interventions.
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	0	While there is a strong emphasis on climate change adaptation—as evidenced by the "Prepared for a Changing Climate" theme—the document does not include specific adaptation methods targeted at aging or heritage (e.g., Victorian) buildings. The focus remains on strategic resilience and adaptation measures across the broader rail infrastructure rather than detailed, asset-specific interventions 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	6	Yes. The document sets out adaptation methods and best practices to reduce vulnerabilities. It includes recommendations for enhancing resilience—for example using passive ventilation, reflective coatings (like the Lemur AG15 system), improved insulation, and adjustments to the cooling systems. Such interventions are discussed as part of performance-based approaches to strengthen aging assets, including older or Victorian buildings, by reducing their exposure to high temperatures.
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	0	- The document includes recommendations for adapting rail operations to extreme heat through improved procedures, new trigger points, updated operational plans, and enhanced contingency measures. - However, it does not discuss adaptation methods specifically aimed at buildings, building systems, or Victorian asset groups. - Its focus remains strictly on rail infrastructure and operational practices.
DOC-32	EHTF Weather and Climate Change Report (March 2023)	0	- The report does provide recommendations to improve resilience and adaptation, including: - Integrating advanced forecasting tools and ensemble predictions to enhance early warning capabilities. - Investing in R&D programs and engaging with the newly formed Weather and Climate Impacts Team to develop targeted mitigation strategies for rail infrastructure. - That said, while the document mentions adaptation in terms of improving operational resilience, it does not contain specific applications or detailed case studies on adaptation methods specifically for aging buildings (e.g. Victorian asset groups) using performance-based interventions.
DOC-33	352_WSFData_2025202607 Final - Building Only	0	Not used AI as it is a sensitive document

AI Agent Summary - Q8: Are any applications where residual risk is identified or addressed?

Doc Ref	Document name	Score	Document detail
DOC-01	The NR Climate Projections Guidance Note (2023)	2	 Applications Where Residual Risk is Identified or Addressed Residual risk refers to the level of risk that remains after all mitigation efforts have been applied. It is a key consideration in industries where safety, compliance, and operational efficiency are paramount. Below are some notable applications: 1. Construction and Infrastructure Projects • Risk Assessments: Residual risk is identified during project planning phases, particularly in health and safety risk assessments. For example, after implementing safety measures like guardrails or personal protective equipment (PPE), the remaining risks (e.g., human error or equipment failure) are considered residual risks. • Compliance with Standards: Standards like ISO 45001 (Occupational Health and Safety) require organizations to assess and manage residual risks to ensure worker safety. 2. Environmental Management • Impact Assessments: In environmental projects, residual risks are addressed after mitigation measures (e.g., pollution controls or habitat restoration) are implemented. For example, residual risks might include unforeseen environmental impacts or long-term ecological changes. • Climate Adaptation: Residual risks are identified in climate resilience projects, such as those involving flood defenses, where risks like extreme weather events may still pose a threat despite mitigation efforts. 3. Information Technology and Cybersecurity • Threat Modeling: In IT, residual risks are identified after implementing security controls like firewalls, encryption, and intrusion detection systems. These risks might include zero-day vulnerabilities or insider threats. • Compliance Frameworks: Standards such as ISO 27001 (Information Security) require organizations to document and address residual risks in their risk treatment plans. 4. Financial Services • Operational Risk Management: Financial institutions assess residual risks after implementing controls to address fraud, market volatility, or regulatory compliance. For example, even with anti-fraud systems in place, the risk of sophisticated fraud attempts remains. • Stress Testing: Residual risks are evaluated during stress testing and scenario analysis to ensure financial resilience under adverse conditions. 5. Healthcare and Pharmaceuticals • Clinical Trials: Residual risks are identified in clinical trials after implementing safety protocols. These might include unforeseen side effects or long-term health impacts of a drug. • Medical Device Manufacturing: Standards like ISO 14971 require manufacturers to assess residual risks associated with medical devices, ensuring they are acceptable for patient use. 6. Aerospace and Defense • Safety Management Systems (SMS): Residual risks are addressed in aviation and defense sectors through rigorous safety protocols and risk assessments. For example, even with redundant systems in place, the risk of catastrophic failure is evaluated and minimized. • Mission Planning: In defense operations, residual risks are identified after implementing strategies to mitigate threats, such as enemy actions or environmental hazards. 7. Energy and Utilities • Hazard Analysis: Residual risks are identified in energy production (e.g., nuclear, oil, and gas) after implementing safety measures like containment systems or emergency response plans. • Renewable Energy Projects: In wind or solar energy projects, residual risks might include equipment failure or unpredictable weather impacts, even after mitigation efforts. 8. Insurance • Underwriting Processes: Residual risks are a key consideration in insurance underwriting. For instance, after assessing and mitigating risks through policy conditions, exclusions, or premiums, insurers evaluate the remaining risks they are willing to accept. • Reinsurance: Insurers often transfer residual risks to reinsurers to manage their exposure.  How Residual Risks Are Addressed Addressing residual risks typically involves: - Risk Acceptance: Determining if the residual risk is within acceptable limits based on organizational policies or industry standards. - Contingency Planning: Developing plans to respond to residual risks, such as emergency response protocols or disaster recovery plans. - Continuous Monitoring: Regularly reviewing and updating risk assessments to account for changes in the environment, technology, or operations. - Insurance Coverage: Transferring residual risks to third parties through insurance policies. - Stakeholder Communication: Ensuring all stakeholders are aware of residual risks and their potential impacts. Summary Residual risk is identified and addressed across a wide range of applications, including construction, environmental management, IT, healthcare, aerospace, energy, and insurance. It represents the risks that remain after mitigation measures are applied and is managed through acceptance, contingency planning, monitoring, and communication. These practices ensure that organizations can operate safely and efficiently while minimizing unforeseen impacts.

DOC-02	The WRCCA Strategy (2017) from the System Operator	6	• Residual Risk Discussion: The strategy acknowledges that despite mitigation and adaptation efforts, some residual risk will remain once all control measures have been applied. It discusses the need for ongoing monitoring, performance metrics, and a reporting framework to track when risks exceed acceptable thresholds. • Approach: The document hints at the importance of managing residual risk – for instance, by establishing contingency measures and the GRIP process to ensure that risks that persist are addressed appropriately in planning and operations. • Conclusion: Yes, the document does address the concept of residual risk and outlines monitoring and governance processes to manage it 1.
DOC-03	Eastern Region: CP7 Regional WRCCA Plan (period 2024-2029)	6	Residual Risk Identified or Addressed in the Document 1. Managing Residual Risks The document explicitly discusses the management of residual risks in the context of weather resilience and climate change adaptation. It acknowledges that the investment profile for asset renewals is not always smooth, and trade-offs are often necessary. As a result: Renewals investment is targeted at the most vulnerable assets. Workbanks are transitioning from full renewals to a blend of renewals and life-extending interventions. This approach results in a greater reliance on reactive and unplanned interventions for existing assets. To mitigate residual risks, the document outlines the following strategies: Targeted Refurbishment and Maintenance: Focused on maintaining safety and reliability. Remote Monitoring: Increased use of technologies like tilt meters, water telemetry, and remote condition monitoring to manage risks. Improved Forecasting: Enhancing forecasting capabilities to better predict and respond to weather and climate-related risks. Climate Risk Assessments: Developing improved methodologies for assessing climate risks and creating long-term adaptation pathways for high-risk locations. 2. Examples of Residual Risk Management The document provides specific examples of how residual risks are identified and addressed: Flood Risk Mitigation: Drainage systems are being improved to mitigate flood risks. However, there is an acknowledgment of residual risks due to incomplete knowledge of drainage assets and their interdependencies with third-party flood defenses. Earthworks and Embankments: Prolonged wet weather and extreme heat pose risks to earthworks, such as desiccation and saturation. Residual risks are managed through an earthwork evaluation program, which includes monitoring, refurbishment, and renewal of embankments and cuttings. Scour Protection: Residual risks related to bridge scour during severe flood events are addressed through physical protection measures and ongoing resilience workstreams. Climate Change Adaptation Pathways: The document mentions the use of adaptation pathways to manage long-term residual risks, particularly for coastal and tidal flooding risks. 3. Specific Initiatives to Address Residual Risks Drainage Asset Management: The document highlights initiatives such as improved drainage knowledge, flood resilience reviews, and targeted drainage maintenance to manage residual flood risks. Remote Monitoring Systems: Technologies like tilt meters, inclinometers, and water telemetry are deployed to provide early warnings and manage risks proactively. Collaborative Efforts: The document emphasizes working with third parties, such as the Environment Agency, to address shared risks and find integrated solutions. Summary The document identifies and addresses residual risks in several areas, particularly in the context of weather resilience and climate change adaptation. Key strategies include targeted maintenance, remote monitoring, improved forecasting, and collaborative efforts. Specific examples include flood risk mitigation, earthwork stability, and scour protection for bridges. Additional Context Residual risks are inherent in large-scale infrastructure projects, especially when dealing with unpredictable factors like climate change. The strategies outlined in the document aim to balance immediate needs with long-term resilience, ensuring that the railway network remains safe and reliable despite these challenges.

DOC-04	North West and Central Region: CP7 Regional WRCCA Plan (period 2024-2029)	4	Applications Where Residual Risk is Identified and Addressed Residual risk refers to the risk that remains after all mitigation measures have been applied. It is a key consideration in many fields, including engineering, environmental planning, and project management. Below are some common applications: Environmental Risk Management - Residual risk is often identified in environmental impact assessments (EIAs). After implementing mitigation strategies to reduce environmental harm, residual risks are documented to ensure they are within acceptable levels. - For example, in water resource management, residual risks such as potential contamination or flooding after infrastructure improvements are carefully monitored and addressed. Engineering and Construction Projects - In engineering, residual risks are identified during the design and construction phases of projects. These risks may include structural vulnerabilities, operational hazards, or unforeseen maintenance needs. - Risk registers are commonly used to document residual risks, ensuring they are tracked and managed throughout the project lifecycle. Safety and Health Management - In occupational health and safety, residual risks are assessed after implementing safety measures like protective equipment, training, and hazard elimination. - Residual risks might include the potential for human error or equipment failure, which are addressed through ongoing monitoring and contingency planning. Climate Change Adaptation - Residual risks are a key focus in climate change adaptation planning. Even after implementing strategies to reduce vulnerabilities (e.g., flood barriers, drought-resistant crops), residual risks such as extreme weather events are identified and addressed. - These risks are often managed through adaptive management frameworks that allow for continuous improvement. Compliance and Regulatory Frameworks - Residual risks are documented in compliance audits, particularly in industries like pharmaceuticals, aviation, and energy. These risks are addressed through additional controls or operational adjustments to meet regulatory standards. Risk Management Software and Tools - Applications like risk management software (e.g., ScopeX, RiskWatch) are designed to identify, quantify, and address residual risks across various industries. - These tools often provide dashboards and analytics to help organizations prioritize residual risks and allocate resources effectively.  Addressing Residual Risk Residual risk is typically addressed through: Monitoring and Review: Continuous tracking of residual risks ensures they remain within acceptable thresholds. Contingency Planning: Developing plans to respond to residual risks if they materialize. Adaptive Measures: Implementing flexible strategies that can evolve as conditions change. Stakeholder Engagement: Collaborating with stakeholders to ensure transparency and shared responsibility in managing residual risks. Summary Residual risk is identified and addressed in various applications, including environmental management, engineering, safety, climate adaptation, compliance, and risk management software. It is managed through monitoring, contingency planning, adaptive measures, and stakeholder collaboration to ensure risks remain within acceptable levels.
DOC-05	Wales and Western Region: CP7 Regional WRCCA Plan (period 2024-2029)	4	Yes, residual risk is explicitly acknowledged and managed: Residual Risk Section: The plan recognises that not all risks can be eliminated, especially given funding and resource constraints 1. Contingency Planning: Schemes are prioritised, but some high-risk sites may not be addressed within the current control period, leaving residual risk that is monitored and reassessed. Ongoing Monitoring: Residual risks are tracked through enhanced monitoring, periodic reviews, and adaptation pathways, with a commitment to revisit decisions as new data becomes available. Transparency: The plan is clear about the limitations of current interventions and the need for continuous improvement and future investment.
DOC-06	Southern Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	- Yes – the management of residual risk is addressed in several sections of the document. - After detailing all planned preventative measures, the document acknowledges that not every risk can be eliminated. It identifies the concept of “residual risk” – the inherent risk remaining after controls are applied. - Strategies to manage this residual risk include continuous asset monitoring, contingency planning in budget allocations for emergency repairs, and setting up adaptive management practices that allow rapid responses to unforeseen events. - This balanced approach ensures that while proactive risk mitigation measures significantly reduce vulnerability, the organisation remains prepared to address unexpected incidents.

DOC-07	Scotland Region: CP7 Regional WRCCA Plan (period 2024-2029)	5	• Yes. In multiple sections the document discusses residual risk. For each asset class (like electrification, earthworks, buildings, signalling, etc.), after detailing the planned interventions, it elaborates on measures to manage remaining or "residual" risk. This includes: • Implementing ongoing maintenance, monitoring, and reactive measures (such as the Adverse and Integrated Weather Management Plan) • Using remote condition monitoring to continuously assess and manage performance even after initiatives have been implemented This demonstrates a mature approach where risk is not entirely "eliminated" but is consciously reduced and managed [Scotlands-Railway-CP7-Climate-Ready-WRCCA-Plan.pdf].
DOC-08	Eastern Region: CP7 Region Strategic Business Plan	4	• Yes, a risk-adjusted plan is a prominent feature of the document. It explicitly acknowledges that even after mitigation measures are applied, some residual risk remains. The plan includes contingency measures, alternative funding models to address risk, and outlines how residual risks are factored into performance forecasts and maintenance planning. This approach ensures that any remaining risks are continuously monitored and managed. In-Depth Analysis: Addressing Residual Risk in the Document • Explicit Acknowledgement of Residual Risk: - The plan clearly recognizes that even after implementing mitigation measures, not all risks can be entirely eliminated. This acceptance leads to explicit planning for residual risks, acknowledging them as an inherent part of operational and capital management. • Risk Management Frameworks: - The document embeds formal risk management methodologies (for example, as part of frameworks like RM3) that are designed to assess not only the immediate hazards but also the long-term residual risks once mitigative actions are in place. - These frameworks provide systematic risk evaluations, ensuring that risk exposure from extreme weather or climate events is continually re-assessed against updated performance data and changing environmental conditions. • Risk-Based Maintenance and Investment Decisions: - Strategic prioritization in the plan is based on an in-depth analysis of risk exposure. While mitigation measures are employed, the plan continues to recognize and plan for the risks that remain after such measures are applied. - This risk-informed prioritization helps in allocating maintenance and capital investments where they are most needed, ensuring that residual risks are kept within acceptable thresholds over the asset lifecycle. • Contingency and Adaptive Measures: - Contingency Planning: The document outlines contingency measures to address unexpected outcomes or failures that could occur despite mitigation actions. This may include emergency response protocols and backup operational plans designed to minimize service interruptions. - Adaptive Strategies: The plan supports continuous monitoring and adaptive management practices. It emphasizes the need to periodically review risk assessments, refining strategies as new data or lessons learned become available. - Alternative Funding Models: Recognizing that residual risks can have unforeseen financial impacts, the plan discusses potential alternative funding models that can support rapid response measures or additional capital investments if further disruptions occur. • Continuous Monitoring and Reporting: - Residual risk is not treated as static; rather, the plan incorporates ongoing assessment and reporting mechanisms. This dynamic process ensures that as conditions evolve—whether from new climate data, infrastructural adjustments, or regulatory changes—the risk profile is continuously updated. - Reporting structures are in place to ensure that management and relevant stakeholders are aware of any changes in risk status, supporting a proactive approach to risk mitigation and resource allocation. • Integration with Broader Regulatory and Operational Goals: - Although the plan does not detail every code or standard specifically for residual risk, its alignment with overarching regulatory requirements (like those from Network Rail or other regulatory bodies) implies that residual risks are managed within a comprehensive compliance framework. - This integration ensures that residual risk assessments inform not just internal planning strategies but also contribute to a broader dialogue on safety, efficiency, and resilience in operational standards. ☒ Summary • The strategic business plan explicitly accepts that residual risks will remain after mitigation and integrates measures to address them. • A formal risk management framework (such as the RM3 framework) is used to assess, prioritize, and manage these risks systematically. • Risk-based maintenance decisions and adaptive strategies are implemented to ensure that any remaining risks are carefully monitored and managed. • The plan establishes contingency measures, continuous monitoring, and even alternative funding models to address unexpected residual risks. • Residual risk management is embedded within a broader regulatory and operational context, ensuring that risk assessments inform comprehensive asset and investment strategies.

DOC-09	North West and Central Region: CP7 Region Strategic Business Plan	4	• The plan is built upon a comprehensive risk management framework aligned with ISO standards (e.g. ISO31000 and ISO55001). It outlines how risks are identified, assessed, and managed across various asset areas and services. • A "risk-adjusted" approach is described in the document. For example, it specifically mentions that approximately 5% of the total plan is allocated as contingent or "contingent expenditure." This represents a financial safeguard for risks that may not be completely mitigated by existing controls—essentially addressing residual risk. • The document details continuous monitoring and review processes (e.g. through assurance activities, governance review, and risk registers) that are designed to track risks as they evolve over CP7. These mechanisms also help ensure that any residual risk is understood and managed over time. • In discussions related to asset renewal, operational performance, and safety, the plan acknowledges that despite proactive controls, some risk may materialize. This "leftover" risk is addressed by adjusting work outputs, maintaining robust maintenance plans, and implementing risk mitigation measures (such as enhanced inspections or extended contingency measures) which are designed to manage the residual risk if it remains. • While the plan covers a wide array of risk factors (weather, operational, financial, etc.), the overall risk management strategy—including proactive reviews and escalation protocols—is intended to factor in those residual risks that persist after initial control measures have been applied. Summary: The document does address residual risk indirectly through its risk-adjusted planning. Although the exact phrase "residual risk" may not appear frequently, the plan allocates contingency funding, outlines ongoing assurance procedures, and deploys monitoring measures to manage the risks that remain after standard mitigation steps are implemented. Additional Context: These approaches are common in large-scale infrastructure and strategic planning documents. By setting aside contingency funds (here about 5% of the total budget) and embedding continuous review mechanisms, the plan ensures that any residual risk—in terms of financial impacts, performance issues, or safety outcomes—is monitored and managed actively over the life of the control period. This methodology supports both the short-term deliverability of the plan and the long-term sustainability of the railway infrastructure.
DOC-10	Wales and Western Region: CP7 Region Strategic Business Plan	2	• Yes. The overall risk management section describes measures in place to address residual risks. The plan discusses the use of contingent expenditure to mitigate impacts should key risks materialise and incorporates a process to continuously review and manage risk exposures. Although not exclusively tied to climate change, this process includes the identification and treatment of residual risks that may remain even after mitigation measures are applied.
DOC-11	Southern Region: CP7 Region Strategic Business Plan	5	• Yes. The document explicitly discusses the concept of residual risk. • It includes a "risk-adjusted" financial plan that allocates contingency funding (for example, deferring or de-scoping projects by around 5.7% of the total plan) to address risks that might materialize. • This approach ensures that residual risk—including that arising from climate and severe weather events—is recognized and addressed within the broader asset management and renewal strategies.
DOC-12	Scotland Region: CP7 Region Strategic Business Plan	4	• Acknowledgement of Residual Risk: The plan realistically acknowledges that even after the implementation of mitigation and adaptation measures, residual risks—meaning those risks that remain unreduced—will persist. This honest appraisal is key to developing contingency plans and ensuring that stakeholders are aware of ongoing vulnerabilities. • Management Tactics: To manage these residual risks, the document outlines the use of reactive measures such as establishing a workbank for maintenance issues that arise unexpectedly. Monitoring systems are enhanced to quickly detect, report, and address residual impacts, ensuring a rapid response to emerging hazards. Regular reviews and adjustments to risk assessment frameworks ensure that the residual risk is continuously evaluated against emerging climate data and operational feedback.

DOC-13	Eastern Delivery Plan - Year 2 Update	0	 Applications Where Residual Risk is Identified or Addressed 1. Construction and Engineering Projects • Risk Assessments in Project Planning: During the planning phase of construction or engineering projects, residual risks are identified after implementing safety measures, design changes, or other mitigation strategies. • Health and Safety Plans: Residual risks are documented in safety plans to ensure that workers are aware of potential hazards that cannot be fully eliminated. • Structural Integrity Assessments: In large-scale infrastructure projects, residual risks related to structural failures are evaluated and monitored over the lifecycle of the asset. 2. Environmental Management • Environmental Impact Assessments (EIAs): Residual risks to ecosystems, water quality, or air quality are identified after mitigation measures like pollution controls or habitat restoration are implemented. • Climate Change Adaptation Plans: Residual risks from extreme weather events or rising sea levels are addressed in adaptation strategies for communities and infrastructure. 3. Occupational Health and Safety • Job Hazard Analysis (JHA): Residual risks are identified after applying engineering controls, administrative controls, or personal protective equipment (PPE). • Emergency Response Plans: Residual risks, such as those associated with fire, chemical spills, or equipment failure, are included in emergency preparedness and response plans. 4. Cybersecurity and IT Risk Management • Risk Assessments in IT Systems: Residual risks are identified after implementing firewalls, encryption, and other cybersecurity measures. • Data Breach Response Plans: Organizations address residual risks by preparing for potential breaches despite robust security protocols. 5. Financial Risk Management • Investment Portfolios: Residual risks are analyzed after diversification and other risk-reduction strategies are applied to investment portfolios. • Insurance Underwriting: Insurers assess residual risks to determine premiums or exclusions after mitigation measures are implemented by the insured party. 6. Regulatory Compliance • ISO Standards (e.g., ISO 31000, ISO 45001): Residual risk is a key concept in compliance with international standards for risk management and occupational health and safety. • Audits and Inspections: Residual risks are documented and reviewed during audits to ensure compliance with regulations. 7. Product Design and Manufacturing • Failure Mode and Effects Analysis (FMEA): Residual risks are identified after design improvements and quality control measures are implemented. • Product Safety Testing: Residual risks are addressed in user manuals and warning labels to inform end-users of potential hazards. 8. Emergency and Disaster Management • Disaster Recovery Plans: Residual risks are identified in the aftermath of disasters, focusing on scenarios that could not be fully mitigated. • Community Resilience Programs: Residual risks are addressed through public awareness campaigns and infrastructure improvements. Summary Residual risks are identified and addressed in a wide range of applications, including construction, environmental management, occupational safety, cybersecurity, financial management, regulatory compliance, product design, and disaster management. These risks are typically documented, monitored, and managed through comprehensive plans, standards, and protocols to minimize their impact. This answer shows there isn't a climate focus on residual risks identified
--------	--	---	--

DOC-14	North West and Central Delivery Plan - Year 2 Update	0	 Applications Where Residual Risk is Identified and Addressed 1. Project Management and Engineering Risk Registers: In project management, residual risks are documented in risk registers after mitigation strategies are applied. This helps project teams monitor and manage these risks throughout the project lifecycle. Construction and Infrastructure Projects: Residual risks are identified during safety assessments, especially in high-risk projects such as tunneling, bridge construction, or hazardous material handling. Environmental Impact Assessments (EIA): Residual risks to ecosystems and communities are evaluated after implementing mitigation measures for environmental impacts. 2. Health and Safety (HSE) Workplace Safety: Residual risks are addressed in Job Hazard Analyses (JHA) or Safety Risk Assessments (SRA). For example, after implementing safety measures like protective gear, the remaining risks (e.g., human error) are managed through training and monitoring. Occupational Health: In industries like manufacturing or mining, residual risks related to noise, vibration, or chemical exposure are managed through ongoing monitoring and health surveillance. 3. Cybersecurity and IT Risk Management Frameworks: Residual risks are identified as part of cybersecurity frameworks like NIST or ISO 27001. After implementing controls (e.g., firewalls, encryption), organizations assess the remaining risks to data and systems. Incident Response Plans: Residual risks are addressed by preparing for potential breaches or failures that could occur despite preventive measures. 4. Environmental and Disaster Management Flood and Disaster Risk Reduction: Residual risks are identified in disaster management plans, such as those for flood-prone areas. Even after building levees or dams, the remaining risks (e.g., extreme weather events) are managed through emergency preparedness and response plans. Climate Change Adaptation: Residual risks from climate change (e.g., rising sea levels, extreme heat) are addressed through long-term adaptation strategies like urban planning and resilient infrastructure. 5. Financial and Insurance Sectors Enterprise Risk Management (ERM): Financial institutions assess residual risks after implementing controls for credit, market, or operational risks. Insurance Underwriting: Residual risks are factored into policy terms, premiums, and exclusions. For example, after implementing fire safety measures, the remaining risk of fire damage is considered in insurance coverage. 6. Product Design and Manufacturing Failure Mode and Effects Analysis (FMEA): Residual risks are identified after addressing potential failure modes in product design. ISO 14971 for Medical Devices: This standard requires manufacturers to evaluate residual risks after implementing risk controls, ensuring that devices are safe for use. 7. Legal and Compliance Regulatory Compliance: Residual risks are addressed in compliance audits. For example, after implementing anti-corruption measures, organizations assess the remaining risk of non-compliance with laws like the Foreign Corrupt Practices Act (FCPA). Data Privacy: Residual risks related to data breaches are managed under regulations like GDPR, even after implementing encryption and access controls. 8. Aviation and Transportation Safety Management Systems (SMS): In aviation, residual risks are identified after implementing safety measures, ensuring that the remaining risks are within acceptable levels. Rail and Road Safety: Residual risks are addressed in transportation projects, such as risks from human error or mechanical failures. 9. Nuclear and Hazardous Industries Nuclear Safety Assessments: Residual risks are a key focus in nuclear power plants, where even low-probability risks (e.g., reactor failure) are managed through stringent safety protocols. Chemical Process Safety: Residual risks in chemical plants are addressed through emergency response plans and regular safety drills. 10. Defense and Security Military Operations: Residual risks are identified in mission planning, especially in high-stakes scenarios where complete risk elimination is impossible. Critical Infrastructure Protection: Residual risks to critical infrastructure (e.g., power grids, water supply) are managed through redundancy and contingency planning.  Summary Residual risk is a universal concept that applies across industries and domains. It is identified and addressed in: Project Management: Risk registers and ongoing monitoring. Health and Safety: Workplace safety assessments and training. Cybersecurity: Frameworks like NIST and ISO 27001. Environmental Management: Disaster preparedness and climate adaptation. Finance and Insurance: Risk modeling and underwriting. Product Design: Standards like ISO 14971. Transportation and Aviation: Safety Management Systems. Hazardous Industries: Emergency response and drills. Defense: Contingency planning for critical operations. This answer shows there isn't a climate focus on residual risks identified
--------	--	---	--

DOC-15	Wales and Western Delivery Plan - Year 2 Update		 Applications Where Residual Risk is Identified or Addressed 1. Engineering and Construction Projects Risk Assessments: During the design and construction phases, risks are assessed, and mitigation measures are implemented. Residual risks are documented to ensure stakeholders are aware of potential hazards that remain despite controls. Safety Management Plans: Residual risks are addressed in safety plans, particularly in high-risk industries like oil and gas, rail, and infrastructure development. Compliance with Standards: Standards such as ISO 31000 (Risk Management) and ISO 45001 (Occupational Health and Safety) require the identification and management of residual risks. 2. Environmental Impact Assessments (EIA) Mitigation Hierarchy: In environmental planning, after applying avoidance, minimization, and restoration measures, residual impacts are identified. These are often addressed through offsetting or compensatory actions. Sustainability Reporting: Residual risks to ecosystems, biodiversity, or communities are disclosed in sustainability reports. 3. Health and Safety Management Job Hazard Analysis (JHA): Residual risks are identified after implementing engineering or administrative controls. These risks are communicated to workers and managed through personal protective equipment (PPE) or other measures. Incident Investigation: After accidents, residual risks are analyzed to determine whether prior controls were insufficient and what risks remain. 4. Cybersecurity and IT Systems Risk Management Frameworks: Frameworks like NIST or ISO 27001 require organizations to identify residual risks after implementing security controls. Vulnerability Management: Even after patching and hardening systems, residual risks from unpatched vulnerabilities or zero-day exploits are documented and monitored. 5. Financial and Investment Planning Risk-Adjusted Returns: In finance, residual risks are considered when evaluating investment portfolios. These include risks that cannot be diversified away, such as market or systemic risks. Stress Testing: Financial institutions assess residual risks under extreme but plausible scenarios to ensure resilience. 6. Product Design and Manufacturing Failure Mode and Effects Analysis (FMEA): Residual risks are identified for potential product failures that remain after design improvements. 0 Consumer Safety: Residual risks are communicated to users through warnings, instructions, or labels. 7. Insurance and Risk Transfer Policy Exclusions: Residual risks are often those not covered by insurance policies. These are explicitly identified and managed by the insured party. Risk Sharing: Organizations may transfer residual risks to third parties through contracts or partnerships. 8. Emergency and Disaster Management Contingency Planning: Residual risks are addressed in emergency response plans to prepare for scenarios where mitigation measures fail. Community Resilience: Residual risks from natural disasters, such as floods or earthquakes, are managed through public awareness and infrastructure improvements. 9. Regulatory Compliance and Audits Compliance Gaps: Residual risks are identified during audits or inspections when full compliance with regulations is not feasible. Continuous Improvement: Organizations address residual risks through ongoing monitoring and corrective actions. 10. Project Management Risk Registers: Residual risks are documented in risk registers and monitored throughout the project lifecycle. Decision-Making: Project managers use residual risk information to make informed decisions about resource allocation and contingency planning.  Summary Residual risk is identified and addressed across various domains, including engineering, environmental management, health and safety, cybersecurity, finance, and more. The common thread is the systematic evaluation of risks that remain after mitigation measures are applied, ensuring they are either accepted, transferred, or further managed. Compared to other documents, the detail is less This answer shows there isn't a climate focus on residual risks identified
--------	---	--	---

DOC-16	Southern Delivery Plan - Year 2 Update	Applications Where Residual Risk is Identified or Addressed Residual risk refers to the risk that remains after all mitigation measures have been implemented. It is a key consideration in risk management frameworks, as it ensures that even after controls are applied, potential risks are acknowledged and managed. Below are some key applications where residual risk is identified or addressed: 1. Construction and Engineering Projects • Risk Assessments in Project Planning: During the planning phase of construction projects, risk assessments are conducted to identify potential hazards. After implementing mitigation measures, residual risks are documented and monitored throughout the project lifecycle. • Safety Management Systems: Residual risks are addressed in safety management systems to ensure worker safety and compliance with regulations like OSHA (Occupational Safety and Health Administration) or ISO 45001. • Structural Integrity and Design: In engineering, residual risks related to structural failures or design limitations are evaluated to ensure long-term safety and performance. 2. Environmental Impact Assessments (EIA) • Post-Mitigation Risk Analysis: Environmental projects often involve EIAs, where residual risks are identified after mitigation measures are applied to minimize environmental harm. • Sustainability Planning: Residual risks are factored into sustainability plans to address long-term environmental impacts, such as carbon emissions or habitat disruption. 3. Health and Safety Management • Workplace Risk Assessments: Residual risks are a core part of workplace safety assessments, ensuring that all potential hazards are accounted for even after safety controls are implemented. • Emergency Response Plans: Residual risks are considered in emergency response planning to prepare for scenarios where primary controls fail. 4. Financial and Business Risk Management • Enterprise Risk Management (ERM): Businesses identify residual risks in ERM frameworks to address financial, operational, and strategic risks that remain after implementing controls. • Insurance and Liability: Residual risks are often addressed in insurance policies, where coverage is tailored to account for risks that cannot be entirely eliminated. 5. Cybersecurity and IT Systems • Risk Mitigation in IT Security: Residual risks are identified in cybersecurity frameworks, such as NIST (National Institute of Standards and Technology) or ISO 27001, to address vulnerabilities that persist after implementing security measures. • Incident Response Planning: Residual risks are factored into incident response plans to prepare for potential breaches or system failures. 6. Regulatory Compliance and Auditing • ISO Standards: Many ISO standards, such as ISO 31000 (Risk Management) and ISO 14001 (Environmental Management), require the identification and management of residual risks as part of compliance. • Audits and Reviews: Residual risks are documented and reviewed during audits to ensure that organizations remain compliant with industry standards and regulations. 7. Product Development and Manufacturing • Quality Assurance: Residual risks are addressed in quality assurance processes to ensure that product defects or failures are minimized. • Product Safety: In industries like automotive or aerospace, residual risks are identified during safety testing to ensure compliance with safety standards. 8. Disaster Management and Resilience Planning • Natural Disaster Preparedness: Residual risks are considered in disaster management plans to address risks that cannot be fully mitigated, such as secondary impacts of earthquakes or floods. • Resilience Strategies: Residual risks are factored into resilience strategies to ensure communities and organizations can recover quickly from adverse events. Summary Residual risk is a universal concept applicable across various domains, including construction, environmental management, health and safety, cybersecurity, and more. It ensures that risks remaining after mitigation are acknowledged, monitored, and managed effectively. By addressing residual risks, organizations enhance their preparedness, compliance, and resilience. This answer shows there isn't a climate focus on residual risks identified
--------	--	---

DOC-17	Scotland Delivery Plan - Year 2 Update	0	 Applications Where Residual Risk Is Identified or Addressed 1. Construction and Infrastructure Projects Risk Assessments: During the planning and execution phases of construction projects, residual risks are identified after implementing safety measures, such as structural reinforcements or environmental controls. For example: Risks associated with unforeseen geological conditions despite soil testing. Safety risks remaining after implementing worker protection protocols. Project Management Tools: Tools like risk registers and risk matrices are used to document residual risks and assign responsibility for monitoring them throughout the project lifecycle. 2. Environmental Management Impact Assessments: Environmental impact assessments (EIAs) often identify residual risks related to pollution, habitat disruption, or climate change effects after mitigation strategies are applied. These risks are monitored through adaptive management plans. Remediation Projects: In contaminated site cleanups, residual risks like trace pollutants may remain even after remediation efforts. Long-term monitoring and contingency plans are used to address these risks. 3. Health and Safety Occupational Safety: Residual risks are addressed in workplace safety programs. For example: After implementing safety equipment, risks such as human error or equipment malfunction are considered residual risks. Safety audits and training programs are designed to minimize these risks. Emergency Response Planning: Residual risks from natural disasters or industrial accidents are accounted for in emergency response plans, ensuring preparedness for worst-case scenarios. 4. Engineering Design System Reliability: In engineering design, residual risks such as component failure or system overload are identified after implementing redundancies and safeguards. These risks are managed through regular maintenance and testing protocols. Structural Analysis: Residual risks in structural integrity are addressed by designing for extreme conditions, such as earthquakes or high winds, even after applying standard safety factors. 5. Cybersecurity Risk Management Frameworks: In IT and cybersecurity, residual risks are identified after implementing firewalls, encryption, and other security measures. These risks may include insider threats or zero-day vulnerabilities. Continuous monitoring and incident response plans are used to address them. 6. Financial Risk Management Investment Strategies: Residual risks in financial portfolios, such as market volatility or geopolitical events, are identified after diversification and hedging strategies are applied. These risks are managed through contingency planning and dynamic adjustments. Corporate Risk Management: Residual risks in business operations, such as supply chain disruptions or regulatory changes, are addressed through scenario planning and insurance coverage. 7. Aerospace and Defense Safety Protocols: In aerospace engineering, residual risks such as system malfunctions or human error are identified after implementing rigorous testing and redundancy measures. These risks are managed through real-time monitoring and fail-safe mechanisms. Mission Planning: Residual risks in military operations or space missions are addressed through contingency plans and risk mitigation strategies. 8. Legal and Regulatory Compliance Risk of Non-Compliance: Residual risks related to legal or regulatory compliance are identified after implementing policies and procedures. These risks are managed through audits and continuous improvement programs.  How Residual Risk Is Addressed Residual risk is typically addressed through: Monitoring and Reporting: Continuous tracking of risks using dashboards, audits, and inspections. Contingency Planning: Developing backup plans to respond to residual risks effectively. Insurance and Financial Instruments: Using insurance policies or financial reserves to mitigate the impact of residual risks. Training and Awareness: Educating stakeholders about residual risks and how to manage them. Adaptive Management: Revising risk management strategies based on new information or changing conditions. ☒ Summary Residual risk is identified and addressed across various applications, including construction, environmental management, health and safety, engineering, cybersecurity, finance, aerospace, and legal compliance. These risks are managed through monitoring, contingency planning, insurance, training, and adaptive strategies to ensure that even the smallest remaining risks are accounted for. This answer shows there isn't a climate focus on residual risks identified
--------	--	---	---

DOC-18	GB - CP7 Delivery Plan - Year 2 Update	Applications Where Residual Risk is Identified or Addressed Residual risk refers to the level of risk that remains after all mitigation measures have been implemented. It is a key component of risk management frameworks and is addressed in various applications across industries. Below are some notable areas: Engineering and Construction Projects - Health and Safety Assessments: Residual risks are identified during job hazard analyses (JHAs) or safety risk assessments. For example, after implementing safety measures like guardrails or PPE, any remaining risk (e.g., human error) is documented and monitored. - Design Risk Management: In construction and engineering, residual risks are addressed during the design phase by ensuring that structures are built to withstand identified hazards, such as earthquakes or floods, while accounting for risks that cannot be fully eliminated. - Project Risk Registers: Residual risks are recorded in project risk registers, which track risks throughout the project lifecycle and ensure accountability for ongoing monitoring. Environmental Management - Environmental Impact Assessments (EIA): After implementing mitigation strategies to reduce environmental harm (e.g., pollution control measures), residual risks such as minor emissions or habitat disturbances are analyzed and managed. - Sustainability Planning: Residual risks are considered in long-term environmental plans, ensuring that any remaining risks are acceptable within regulatory and ethical standards. Occupational Health and Safety (OHS) - ISO 45001 Compliance: This international standard for occupational health and safety requires organizations to identify and address residual risks as part of their risk management processes. - Safety Management Systems: Residual risks are addressed through ongoing training, emergency preparedness plans, and routine safety audits to ensure that workers are aware of and prepared for remaining hazards. Cybersecurity and IT Risk Management - Risk Assessments: In cybersecurity, residual risks are identified after implementing controls like firewalls, encryption, and access restrictions. These risks are then monitored and managed through incident response plans. - Business Continuity Planning: Residual risks, such as data breaches or system downtime, are factored into disaster recovery and business continuity plans to ensure resilience. Financial Risk Management - Investment Portfolios: Residual risks, such as market volatility or inflation, are addressed through diversification and hedging strategies. - Operational Risk Assessments: In banking and finance, residual risks related to fraud, compliance, or process failures are monitored and mitigated through internal controls and audits. Aerospace and Defense - Safety Case Development: Residual risks in aerospace systems (e.g., aircraft or spacecraft) are documented in safety cases, which outline how risks are reduced to an acceptable level. - Military Operations: Residual risks are addressed in mission planning, where potential threats are mitigated but acknowledged as part of operational realities.
--------	--	--

		0	7. Product Development and Manufacturing • Failure Mode and Effects Analysis (FMEA): Residual risks are identified after implementing design or process improvements to minimize defects or failures. • Quality Assurance: Residual risks in manufacturing processes are managed through quality control systems and continuous improvement initiatives. 8. Insurance and Risk Transfer • Policy Underwriting: Residual risks are considered when determining insurance premiums and coverage limits. • Claims Management: Insurers address residual risks by setting aside reserves for potential claims that may arise despite preventive measures. 9. Regulatory Compliance • Environmental, Health, and Safety (EHS) Regulations: Residual risks are addressed to ensure compliance with legal standards, such as those set by OSHA, EPA, or equivalent bodies in other countries. • Audits and Inspections: Regulatory audits often focus on how organizations manage residual risks to ensure they meet compliance requirements. 10. Emergency and Disaster Management • Contingency Planning: Residual risks are factored into emergency response plans to prepare for scenarios where mitigation measures fail or are insufficient. • Community Resilience: Residual risks from natural disasters, such as hurricanes or wildfires, are addressed through public awareness campaigns and infrastructure improvements. 🔑 Key Steps in Addressing Residual Risk To effectively manage residual risks, organizations typically follow these steps: Risk Identification: Determine what risks remain after mitigation measures are applied. Risk Evaluation: Assess the likelihood and impact of residual risks. Risk Acceptance: Decide whether the residual risk is acceptable or requires further action. Monitoring and Review: Continuously monitor residual risks and update mitigation strategies as needed. Summary Residual risk is a fundamental concept in risk management and is addressed across diverse applications, including engineering, environmental management, cybersecurity, and more. It ensures that risks are not only mitigated but also monitored and managed to acceptable levels. By identifying and addressing residual risks, organizations enhance safety, compliance, and resilience. This answer shows there isn't a climate focus on residual risks identified
DOC-19	System Operator CP7 Delivery Plan	0	• No. The document outlines overall risk management and mitigation strategies but does not explicitly describe how residual risk from climate related hazards (after adaptations or risk reduction strategies) is identified or managed.
DOC-20	The CP7 Buildings & Architecture Policy (2021)	1	– Yes. The document embeds risk management into its asset evaluation process. It includes mechanisms (such as the CRAM matrix and deferral management processes) that inherently address residual risk by setting performance thresholds, intervention triggers, and follow-up risk assessments. Although residual risk from climate hazards is not isolated as a distinct category, the overall approach ensures that risks not fully eliminated through interventions are documented and managed as part of the broader asset risk framework.
DOC-21	"Additional information for asset managers" (2025)	3	• Residual Risk Consideration: The document does address the concept of residual risk in its overall risk management approach. For example, it acknowledges that if an intervention cannot be fully executed—sometimes due to funding constraints or technical limitations—the residual risk remains and must be managed (such as through deferred renewals and reporting in the strategic business planning process). • Use of CRAM: The use of the Corporate Risk Assessment Matrix helps to classify and monitor residual risks, ensuring that even after interventions there is an understanding of ongoing or remaining vulnerabilities. • Conclusion: Yes, the policy explicitly considers residual risk through its risk rating systems and by requiring asset managers to report and communicate any deferred or incomplete interventions.
DOC-22	The short Buildings and Architecture Strategy (2021) for the NR Technical Authorit	0	• The strategy emphasizes measurable sustainability outcomes and integrated asset management but does not provide details on the identification or management of residual risk in the context of physical climate hazards. • No specific discussions on residual risk are identified within the material we reviewed
DOC-23	NR/L3/CIV/190: Developing Extreme Weather Plans	2	Not used AI as it is a sensitive document
DOC-24	Records and reports of weather-related failures or Wrong Side Failure (WSF) events affecting building	0	Not used AI as it is a sensitive document

DOC-25	RSSB's Climate adaptation maturity in GB rail (September 2024)	1	- There is no specific section in the document that discusses residual risk—i.e. the remaining risk after adaptation measures are implemented. - The focus remains on measuring improvement across different response levels in climate adaptation rather than addressing strategies for managing any residual risks.
DOC-26	The Design Council's "The Value of Design to UK Rail Infrastructure" (2021)	0	Lastly, the report does not address or identify applications where residual risk (i.e. risk remaining after mitigation measures) related to climate change is explicitly identified or managed.
DOC-27	"CP7 Frameworks for Building and Civils Renewals Works" (March 2022)	0	There is no discussion on residual risks or any measures to address such risks within the context of climate change.
DOC-28	NR's 'The Greener Railway Strategy' (May 2025)	1	- The document outlines the importance of risk assessments and adaptive measures as part of a long-term strategy. - However, it does not provide details about the treatment of residual risks (i.e. risks that remain after mitigation efforts) beyond the overall emphasis on building a resilient and adaptable system.
DOC-29	The RSSB 'Sustainable Rail Blueprint' (2023)	0	There is no clear discussion of residual risk (i.e. the risk remaining after mitigation measures are implemented) within the document. The Blueprint emphasizes proactive adaptation and resilience strategies but does not specifically address or quantify residual risks 1.
DOC-30	Extreme Heat Taskforce Final Engineering Report (August 2023)	6	Yes. The residual risk (i.e. the risk remaining after applying mitigation and adaptation measures) is addressed. The report discusses both the immediate interventions to reduce impact and the need for ongoing monitoring and reassessment to manage residual risks once the primary adaptations are implemented.
DOC-31	The Operations Review into the management and performance of Network Rail during the extreme hot weather in the UK in July 2022. (Final Report)	4	- Yes – the report acknowledges that despite current measures, residual risks remain. - It highlights areas such as the risk of stranded trains in extreme conditions, potential cascading failures due to imprecise trigger points, and vulnerabilities stemming from insufficient maintenance. - Recommendations are provided to better manage these residual risks through ongoing process improvements, enhanced collaboration, and a more proactive, systematic risk management approach.
DOC-32	EHTF Weather and Climate Change Report (March 2023)	4	- The document acknowledges that, despite enhanced forecasting and proactive measures, certain risks remain unavoidable. - It discusses residual risks arising from extreme and unpredictable events, and notes that some extreme weather events (like the unprecedented heat of July 2022) may still occur despite best planning efforts. - This residual risk is framed in terms of inherent uncertainties in climate predictions and the limits of current adaptation measures.
DOC-33	352_WSFData_2025202607 Final - Building Only	0	Not used AI as it is a sensitive document

Appendix D Document copies

Specific strategies and tools used to mitigate climate risks, lessons learned and transferable practices

Strategies, policies and change to industry

Historically, the DfT has had limited oversight of how Network Rail manages climate risk, specifically in relation to the development of the Adaptation Pathways approach. This approach is heralded as the core strategy Network Rail uses to mitigate climate risk for its key assets. Despite the DfT having limited control over developing the overall scope, and the subsequent impact this may have had to initiate joined up thinking across the industry, Network Rail and Train Operating Companies (TOCs) are beginning to take a more collaborative approach when managing assets across the regions, which will help to inform how the Adaptation Pathways will be implemented going forward.

A significant change is expected within the rail industry, as select TOCs are due to go into public ownership and will be managed under Great British Railways (GBR), the body to be made responsible for passenger services and asset infrastructure. As such, the DfT are seeking to mainstream adaptation into policy by developing new strategies and guidance to strengthen climate mitigation for their assets over the long-term. For instance, TOCs have been asked by the DfT to complete a WRCCA strategy by January 2026. However, this guidance remains high-level and applies to assets in a general sense, without a particular focus on building assets.

Another document that has recently been developed to mainstream adaptation includes The Climate Adaptation Strategy for Transport²⁷ which lists actions to set long-term strategic direction to mitigate the impact of climate change for the transport sector. One of the main actions to mainstream adaptation across the industry includes the development of a new specification to support the Adaptation Pathways, to ensure this is a 'flexible, decision-focused approach to planning for climate change'. Another action focuses on the role of Network Rail to establish the first regional long-term Adaptation Pathways strategies based on assessment of high-priority locations by the end of March 2029. Likewise, the strategy will encourage participation of transport operators and collaboration with contributors to the fourth round of adaptation reporting (AR4) on progress against actions. Although these actions highlight a change in how the industry seeks to approach climate mitigation, it is yet unclear whether the Adaptation Pathway strategies will be targeted to enable a detailed assessment of how climate hazards may affect building assets specifically.

The CP7 Buildings and Architecture Policy and associated technical standards set by Network Rail are assembled by working with external industry experts, whilst merging applicable and relevant standards already set within the organisation. This policy drives the regional decision-making for maintenance, refurbishment and renewals activities for their assets, and is centred around passenger satisfaction, stewardship, safety and sustainability. Resilience is a core theme that weaves throughout the policy and is a key indicator on the Genius of Place Wheel for regions to refer to when scoring actions that need to be taken and associated progress over time. As this approach is part of company policy, this requires regions to consider the resilience of their assets in relation to the Wheel. However, due to lack of funding and resources, Network Rail are unable to provide adequate assurance that this approach is being implemented across the regions, particularly whether resilience is being improved across building assets overtime.

Assurance procedures

Network Rail has not approached regions separately to understand if they are internally tracking assurance against the Wheel and instead Network Rail provides assurance following the submission of quarterly regional plans. This can mean assurance for the resilience of buildings may lack forward-thinking when considering the long-term risk of climate change and equally this prevents active collaboration between the central and regional teams. Additionally, weather resilience is not perceived as a short-term and high-level risk in relation to the organisation's wider risk portfolio, and therefore hazards are balanced to prioritise acute risks that pose a greater threat to immediate passenger safety and operational downtime compared to chronic hazards, despite being rarer in occurrence. As the network is described as an asset in 'managed decline', the strategic direction maintains funding and resourcing to manage and build resilience against acute risks. This can mean chronic hazards that can substantially impact the material fabric and integrity of building assets overtime are not being addressed earlier in the process, which could impact the decision-making process when selecting the most effective adaptation or retrofit measures.

²⁷ <https://www.gov.uk/government/publications/climate-adaptation-strategy-for-transport/climate-adaptation-strategy-for-transport>

PACE Process

The ESR mandates climate impact assessments during project design phase. Efforts are ongoing to make these assessments mandatory as part of the PACE process to budget and incorporate resilience considerations from the outset. As mentioned previously, ESR has been updated to require Asset Managers to identify if a project is located within an area covered by the Adaptation Pathways, and facilitate a WCCIA is developed during PACE 1 of the design development process. Although these changes do not clarify how risks for buildings should be incorporated into design, this will enable that any projects related to buildings within the portfolio will require a risk assessment in a standardised format for regions to manage risk.

Building regulations and contracting models

Classified as a statutory undertaker under the Buildings Act²⁸, Network Rail does not have to comply with Building Regulations Part L, except when constructing showrooms or offices. The Regulation sets mandatory minimum standards for the energy performance and conservation of fuel and power in new and existing buildings. However, Network Rail is still required to apply the regulations through their building control assurance processes to meet best practice across the industry. The role as statutory undertaker appears to have caused confusion in the past in terms of whether the regulations need to be *complied* or *applied* to building assets, despite the delivery of multiple briefing documents and meetings across the business to provide clarification. To rectify this, there has been a major update to one of the internal standards to ensure that the roles and responsibilities Network Rail has to the regulation is fundamentally clear. Despite these changes, cost and apathy are noted as persistent barriers to the regulation not being applied across the organisation, as well as supply chain interference where following the regulation can be more beneficial to the supply chain itself rather than the asset owner.

A solution could be to adapt contracting models to require conformance with outcome-based standards and outcome-based approaches for climate resilience, although this is reliant on regions driving the decision-making process as they have accountability over procurement, as the technical authority does not have the ability to influence the contracting approaches. This lack of technical oversight of regional procurement processes, as well as a tendency for frameworks to aggregate buildings with larger structures as part of a wider portfolio, prevents the ability to specify climate resilience outcome-based standards and approaches at the asset level.

Sustainability certification frameworks

Network Rail provides guidance to regions about how to approach implementing climate resilience to buildings within the Climate Action Design Manual for Buildings and Architecture (NR/GN/CIV/100/04)²⁹. When developing this guidance, it was decided early on that mandating the implementation of BREEAM Buildings or similar certification frameworks could potentially restrict projects to achieving a specific rating and not consider the environmental impact in a holistic manner. Likewise, due to the nature of some of Network Rail's assets not being clearly defined as either a building or a structure, due to aspects such as air tightness, it was perceived that by applying the BREEAM framework to projects could result in unclear outcomes. Network Rail are expecting to revisit this document in 2026, which could mean potential scope to improve climate resilience outcome-based measures that align to elements of BREEAM Buildings or similar frameworks.

Examples of innovation

There are recent examples where Network Rail has worked collaboratively with technical authorities to retrofit building assets to manage building degradation and subsequently also improve resilience to climate-related risks. An example of this is a wrap system surrounding lineside buildings, which are typically single-skin and thermally inefficient. The wrap system applies a modular kit-design which insulates the building³⁰, reducing exposure to severe wind and rain which can help to maintain the integrity of the building and ensure that the electrical equipment stored inside is less at risk of becoming damaged. Following the success of this initiative, Scotland has actively deployed this retrofit system across the region, with the design is now adopted by the wider supply chain³¹. However, it was noted that despite Scotland taking the lead to implement this across the region, other regions may be more resistant to taking a more innovative approach due to the costs and perceived risks involved.

Understand stakeholder engagement and partnerships models

Innovation

Organisational culture as well as contracting and procurement systems are noted as the main issues preventing the internal technical standards framework to innovate beyond what is contractual. Although the framework has mechanisms in place already to challenge standards systems and enable derogations, there are instances where

²⁸ <https://www.legislation.gov.uk/ukpga/1984/55>

²⁹ https://www.networkrail.co.uk/wp-content/uploads/2023/09/NR-GN-CIV-100-04_Climate-Action-Design-Manual.pdf

³⁰ <https://www.youtube.com/watch?v=KPGgn4Sxwts>

³¹ <https://www.ubinfrrastructure.co.uk/solutions/existing-structures/>

teams across the organisation revert to legacy designs and standards that are still adopted within the wider supply chain. This has been seen previously where a detailed Bill of Materials was produced internally as part of a design manual for footbridges to capture specific embodied carbon throughout the various material elements but was not actively used due to perceived risk associated with cost. From a weather resilience perspective, internal standards which may seek to innovate asset design to respond to acute and chronic risks may be overlooked if this is going beyond what is currently expected across the industry supply chain.

Regional engagement

Due to the recent transfer of Scotland's ScotRail franchise going into public ownership in 2022, the Scotland CP7 WRCCA covers activities related to Network Rail and ScotRail. This has enabled collaboration between Network Rail and TOCs to enhance climate resilience for assets in the region.

As part of CP7, the Southern region has introduced a quarterly working group with TOCs and other stakeholders to manage interdependencies related to climate risk, as well as collaborate on a cross-industry charter which will seek to achieve various objectives, including scenario planning alignment and solidifying a unified strategic approach as defined in the WRCCA Plan.

External partners

Externally, Network Rail is a part of various steering groups and organisations that seek to explore climate-related interdependencies and improve the resilience of rail assets against future climate change. This includes the Infrastructure Operations Adaptation Forum led by the Environment Agency, and the Transport Adaptation Steering Group led by Transport for London. Despite these forums bringing together stakeholders across the industry to share knowledge and best practice, the resilience of building assets is not discussed as a separate issue to larger infrastructure assets.

Partners external to Network Rail such as the Environment Agency, local government and TOCs are all involved in workshops as part of the Adaptation Pathway strategy workstream. It was identified in the interviews that currently these workshops have been quite general and high-level when considering asset groups, however as this process evolves overtime, the workshops may be a way to facilitate conversations around specific assets such as buildings.

It was noted that there has been a significant uptake in the TOC's capability to consider and develop plans in relation to their assets and how they interface with climate change, however some may be more advanced than others. As the industry adapts to incorporate changes through GBR, and the TOCs become part of integrated business units, this will increase all their capabilities to a similar level, especially as TOCs will need to follow Network Rail governance structures and a standardised WRCCA process.

Explore the use of technology and analytics in resilience planning

Data taxonomy

Network Rail currently gathers analytical data of the condition of their assets through the Percentage Asset Remaining Life (PARL) metric to understand how much of the asset's life remains, which can be used to target specific renewal or replacement options. As this metric fundamentally allows Network Rail to consider appropriate and feasible renewal and replacement options, and many of the regions have already identified that renewal or refurbishment activities are the most cost-effective approach to improve their asset portfolio resilience to the impacts of climate change, a performance-based approach could present regions with a way to also measure how often assets are exposed to certain hazards which could affect how renewal or refurbishment options are considered to prevent future exposure. For instance, the performance-based approach could highlight that a particular station platform is exposed to heavy rainfall 40% during the year, and the relevant region could determine an achievement level to reduce this exposure to 25%. Therefore, this could provide the region with a greater understanding of which renewal or refurbishment activities would be best suited to achieve this target, which can help to better understand the impact this could have to investment cycles and the wider climate resilience strategy.

During the interview with Network Rail, it was mentioned that the organisation is keen to develop performance-based approaches to building assets and sees the value to developing this further, following recommendations contained within the Extreme Heat Taskforce Final Engineering Report³² as well as recent work looking at the capabilities of smart buildings that could be incorporated into the wider estate portfolio. Likewise, Network Rail has recently moved to a modern asset management system and has data standards in place which has improved their capabilities to absorb Internet of Things (IoT), which could help to provide better access to data to measure

³² <https://www.networkrail.co.uk/wp-content/uploads/2024/04/Extreme-Heat-Task-Force-Engineering-Report.pdf>

performance. Despite their appetite to adapt their approach and the potential to improve the asset management structures further, it was identified that lack of investment remains the primary barrier.

Digital transformation

As highlighted during the interview with Network Rail, one of the key policy targets to be achieved by the end of CP7 is to 3D scan all buildings across each of the regions to support the development of digital twins. Many of the buildings have already been scanned, however there is an ongoing challenge where regions may not understand the full value or potential use cases of scanning each of their buildings. This presents an opportunity for Network Rail to potentially develop further guidance of how the technology will be utilised to inform regional weather resilience strategies, such as early identification of climate-related defects (i.e. instances of water ingress) and monitoring frequency and severity of hazards overtime through remote systems to better understand the impact to Network Rail's operation. Building guidance and information of what these capabilities are and how it can support each of the regions may help to improve the organisation's cultural mindset and uptake to digital transformation.

Ranking exposure

As risks associated with buildings originate from the UK-wide climate change risk assessment, regions have yet to identify location-specific risks within their building portfolio and are unable to rank these by which are more exposed than others. As the adaptation pathways approach develops, this could be a way in which regions can begin to identify and assign risk at a asset-by-asset level.

SMART

BUILDINGS FRAMEWORK

CONTENTS



Produced by
Design Council and Network Rail

About Network Rail
Network Rail owns, operates and develops Britain's railway infrastructure. We run a large and diverse operation; with more than 2,500 stations, 1,450 footbridges, 5,500 platforms and are responsible for 18,000 buildings of all kinds, from iconic stations like London Paddington and Birmingham New Street to the signal boxes and maintenance depots which are vital in providing a safe and reliable railway for our passengers. These buildings form a significant part of the UK's civic and public realm and impact millions of people every day.

www.networkrail.co.uk

About Design Council
The Design Council has been the UK's national strategic advisor on design for over 75 years. We are an independent, not-for-profit organisation that champions design and its ability to make life better for all. Our work encompasses thought leadership, tools and resources, showcasing excellence and research to evidence the value of design and influence policy. We uniquely work across all design sectors and deliver programmes with business, government, public bodies and the third sector. Our Design for Planet mission aims to accelerate the critical role design must play to address the climate crisis.

www.designcouncil.org.uk
[@designcouncil](#)

Foreword	4
Introduction	6
Smart Buildings Framework	10
Principles:	12
— Environment	18
— Economic and social value	24
— People-centred	28
— Operations	34
— Culture and leadership	40
Further resources and references	46

FOREWORD

Network Rail is custodian of over 2,500 stations and 18,000 back-of-house buildings. Strong leadership and investment are required to ensure this huge estate contributes towards the UK’s commitments to some of its key electoral promises including tackling climate change, levelling up parts of the UK and providing a low-carbon transport system that is reliable and meets the needs of future generations. Between 2019 and 2024, Network Rail plans to spend around £48bn in England and Wales and around £5bn in Scotland. Our role is to ensure that we invest in the operation, maintenance, and improvement of our railways, including making our built estate work harder and smarter.

Smart buildings are crucial to powering the railway behind the scenes. They are people-focussed hubs that interconnect with other services and transport networks, providing resources to serve local communities.

As the greenest form of motorised transport, we believe Network Rail is already well placed to play an active role in supporting the UK’s transition to a zero-carbon future by 2050. We are already taking steps to decarbonise the rail network through the electrification of a greater number of lines and phasing out of diesel-only trains. Stations and lineside buildings need to keep pace with the low-carbon innovation in trains and rolling stock and will be crucial in ensuring that future rail industry integration and modernisation happens seamlessly and is able to take advantage of new technologies. A transformed net zero railway will empower the economy, benefit the environment, and promote health and wellbeing.

Yet a focus on rail track and train only restricts us from an even greater contribution to the zero-carbon economy. The Smart Buildings Framework highlights the untapped potential of our building assets. It helps decision makers take a longer-term view and by drawing together the wider considerations set out in its five principles enables them to say ‘yes’ to better and more connected places across Great Britain.



Anthony Dewar
Professional Head
Buildings and Architecture
at Network Rail



Dr. Garry Bosworth
Project Lead
Principal Engineer,
Technical Authority –
Buildings & Architecture,
Network Rail

The journey ahead is exciting, and one in which we will:

- 1 Demonstrate why decisions based on the framework, and informed by the drive to net zero, lead to benefits for passengers, operations, and the planet.**
- 2 Prove that by using the framework we are releasing untapped potential to make good business decisions, stimulate economic growth, reduce costs, and improve efficiency.**
- 3 Embed smart buildings across Network Rail with the help of a road map drawn from an assessment of the different levels of maturity against the five principles of the Framework.**

Under Network Rail’s custodianship, the building stock will be refocussed so that it contributes to our commitment to net zero, delivering a building asset legacy that makes the next generation proud.

Our infrastructure is arguably one of the greatest gifts the Victorians gave us. From exquisite statement stations heralding a magnificent sense of arrival at the end of a journey, to the vernacular understated signal box, driven by function and not form.

Time has not stood still and new buildings, grand and simple, have been added to create a rich portfolio that now forms the extensive estate Network Rail is privileged to curate. Two hundred years on from when engineers and architects were drawing up their plans, the Design Council is collaborating with Network Rail to shape a framework that will guide the function and purpose of railway buildings for the next half century.

By drawing together the knowledge and expertise of diverse people within and outside the railway industry, the Smart Buildings Framework aims to boost the value and relevance of Network Rail’s buildings. In so doing, it will revitalise their purpose to create smart buildings that people continue to enjoy, that drive economic and social value and that add their weight to the united endeavour of delivering net zero.



Minnie Moll
Design Council
Chief Executive

INTRODUCTION

What is the Smart Building Framework?

The Smart Buildings Framework is a tool to help Network Rail, alongside our partners and stakeholders, to achieve our objectives and become a force for industry change. It provides a shared vision that sets ambitions for our built estate, without restricting innovation. It applies to all our buildings – from the largest interchange stations to the smallest lineside sheds – and can be practiced intelligently depending on the needs and context of each. It is intended to assist decision makers to ask the right questions, considering what our buildings might provide in their broadest economic, environmental, and social sense, and to make smart choices for long-term success.

The framework sets out five principles that we should be working towards and includes case studies and examples illustrating what good might look like at various levels of maturity.

Why it is important?

Network Rail has an active leadership role to undertake as we move towards the zero-carbon economy of the future. The framework creates a common language from which we can set in motion a culture of continuous improvement of our built assets.

Our estate encompasses a vast and diverse range of buildings with inconsistent levels of efficiency, inclusivity, and delight. We aim to become better custodians of these assets through a longer-term view. By asking what they could be, rather than simply maintaining them as they are, we can improve our buildings to reflect 21st century needs and future proof our estate for generations to follow.

This framework will help decision makers to identify the often hidden value of our built estate and reveal the opportunity that can be unlocked when we consider our buildings as one part of a wider system to improve staff and passenger experience.

“What should the future look like? If you could choose, if you weren’t constrained by history or by resources, what would it be?”

Dr Stuart Russell, Reith Lectures 2021.

In this Smart Buildings Framework, we set out how we are seeking to answer Dr Russell's question as we look to the future of our built assets.

What are smart buildings?

To Network Rail, being ‘smart’ is about far more than the latest technology. We favour a proactive and holistic approach that avoids the pitfalls of reactive trends such as the rapid obsolescence of technologies which can create abortive work and use of resource.

Smart buildings require three factors to integrate harmoniously: the physical buildings, technology that enables a multi-directional exchange of data between buildings and a culture that uses this data wisely to inform better decision making.

Smart buildings:

- interact with the environment and the people using them
- enhance the ease with which people navigate through and around them
- facilitate their operation and maintenance for a safer and more resilient railway
- unlock latent economic, social, and environmental potential and contribute to better placemaking

What is the timeframe and when should it be used?

The Smart Buildings Framework provides guidance to ensure a system wide, measurable approach to Network Rail's buildings now, and for the next 50 years.

Amassing such an extensive and varied built estate has taken centuries. Our context continues to shift and the next 50 years will see ever increasing change. This framework marries the long timelines of the architectural world with the fast timelines of the digital and technological world, to create a living document that can be refined as new intelligence is gathered and project experience is amassed.

The Smart Buildings Framework should provide a basis for decision making, to be used at key points such as:

- obtaining funding for new research and development projects
- commissioning research and development projects
- deciding which of these projects should be taken forwards and piloted
- at the start of individual pilots, as part of the objective setting and methodology planning
- at key milestones throughout pilots, to check progress
- at the end of a pilot, or to reflect and evaluate
- deciding which pilots should be taken forward as permanent projects/wider programmes
- throughout the lifecycle of those projects/programmes.

In practice, this may change according to the work or activity.

The Smart Buildings Framework has been designed to sit above and complement existing policies, and to be flexible enough to apply whatever the context or task.

INTRODUCTION

How was it developed?

The framework is the culmination of intelligence gathered from desktop research; the collective thoughts of our staff, our passengers and wider colleagues within the rail industry; and the expertise and advice we have gained from an independent steering group.

Steering group



Anthony Dewar
Professional Head Buildings and
Architecture, Network Rail

Anthony is a chartered engineer with over 20 years experience. Managing Network Rail’s extensive built portfolio, and as a member of the National Infrastructure Commission Design Group, he elevates design quality and innovation within Network Rail and the wider industry.



Professor Hanif Kara OBE
Design Council Ambassador

Professor Hanif Kara OBE offers 40+ years’ experience. He co-founded the UK engineering practice AKT II, and now consults for public organisations throughout the UK.



Tim Stonor
Design Council Ambassador

Tim is an architect and urban planner. He specialises in the use of digital design techniques that forecast human behaviour patterns, land values and environmental impacts. Tim is the Managing Director of Space Syntax and Deputy Chair of Design Council.



Zung Nguyen Vu
Design Council Expert

Zung is a researcher, designer, and urbanist working to improve public service and public spaces by adapting methodologies from the digital world to the built environment. She is Project Director at TPXimpact (previously FutureGov), and an Advisor to the Mayor of London.



Clare Lowe
Design Council Expert

Clare is a sustainability consultant with over 25 years’ experience, from private consultancy to national policy design. At BRE Clare was instrumental in the international adaptation and growth of BREEAM environmental building standards.



Usman Haque
Design Council Ambassador

Trained as an architect designing both physical environments & software systems, Usman is founder and creative director of Umbrellium, a design and build studio dedicated to transforming urban environments and getting communities meaningfully involved.



Haydon Bartlett-Tasker
Managing Director of Hack Partners

Haydon is a leader in providing award-winning AI software for automated inspection, fault detection and IoT technologies in rail systems – many of which he has pioneered in partnership with Network Rail.



Deborah Nagan
Design Council Expert

Deborah is a landscape, biodiversity, public and urban realm designer. She founded Uncommon Land, but is now Head of Place & Nature at Future Homes Hub, and Mayors Design Advocate. She is adept at turning project constraints into positive sustainable and economic outcomes.

Project lead



Dr. Garry Bosworth
Principal Engineer, Technical Services –
Buildings & Architecture

Garry is an expert in the built environment with a proven track record of programme management including delivery of award-winning sustainable buildings and cutting edge innovation. As well as Smart Buildings, he is currently leading research into low/zero carbon plant room designs and adapting buildings to better cope with extreme weather.

Authors

Design Council:
Roland Karthaus
Kirsty McMullan
Frances Fernandes (Design Council Expert)
Maayan Ashkenazi (Design Council Expert)
Rowena Hay (Design Council Specialist)
Olivia Cornaz

Contributors:
Shaherah Jordan (research)
Jason Badrock (graphic design)
Eve McGowan (copy editing)

SMART

BUILDINGS FRAMEWORK

SMART BUILDINGS PRINCIPLES

PRINCIPLES

The Smart Buildings Framework helps Network Rail to capitalize on the richness of our built estate whilst exploring how digital infrastructure, and on occasions technology, can be integrated. Our buildings can then become active elements of a wider system, sharing information across the estate to inform decision making.

The smart buildings principles set out what we should be working towards at all times when it comes to our buildings, to ensure that they not only remain relevant, but also serve communities as well as they can, and contribute to the government's commitment to net zero. Smart buildings principles are designed to be applied to projects at different stages of thinking and development and the principles themselves will adapt and flex over time.

There are five principles covering different aspects of Network Rail's remit:

1

Environment

SUSTAINABLE, RESILIENT, REGENERATIVE

Take a visionary and holistic approach to the environment.

2

Economic and Social Value

ENHANCING, EMPOWERING, LASTING

Engage communities and businesses to secure lasting economic opportunities and social value.

3

People-centred

HUMANISED, ATTENTIVE, ENJOYABLE

Act inclusively and create spaces that enable everyone to fulfil their potential.

4

Operations

ADAPTABLE, INNOVATIVE, PIONEERING

Operate with stewardship and foresight to optimise performance.

5

Culture and Leadership

OPEN, GALVANISING, VENTURING

Practice leadership and nurture a culture of continuous improvement.



LEVELS OF MATURITY

To become a railway ready for the next 200 years requires leadership that is open to different approaches and potential solutions. Some projects will be successful and others less so. Some will be easy to implement, have short timescales and achieve success quickly. Others will be complex, long and delivered in phases over time. Each principle is therefore accompanied by a set of examples relating to different levels of maturity. These maturity levels are a means through which progress can be evaluated along the way so that we can **catch up** with current good practice, **keep up** with emerging developments and **jump ahead** through innovation. These are not exhaustive lists or recommendations but are illustrative of ways to think and what good might look like.

One common aspect is the need for data to inform decisions and assess progress. We already gather a great deal of data, but not yet comprehensively. Each principle is therefore accompanied by a data maturity illustration, taking a recognisable problem and working it through to explain what good might look like at different levels of maturity. **Catching up** means interpreting existing data and acting on it continuously to improve performance, whilst identifying gaps, biases, and limitations. **Keeping up** means gathering more data, filling gaps, and balancing quantitative and qualitative data sets to gain a holistic, dynamic picture of an asset. **Jumping ahead** will likely mean that a wide range of datasets are openly and iteratively created and interpreted to create an information base for our operators, users, and communities.

Signalling room, Doncaster.
Image © Adelina Iliev.

SMART CITIES PROGRAMME – INTEGRATED AND SUSTAINABLE TRAVEL

Location:	Germany
Client:	Deutsche Bahn AG and various German cities
Relevance:	This case study demonstrates the role that smart buildings play in delivering 'Mobility as a Service', as set out in Network Rail's vision. It shows how good master planning of logistics can put stations at the heart of a wider system of integrated and sustainable travel, and can have wider social and economic benefits.
Date:	Cologne 2019-2024, Hamburg 2020-2025, Hannover 2022-2027



Deutsche Bahn is leading the way in integrated urban mobility and logistics through their Smart Cities programme. Five-year Memorandums of Understanding have been signed with Cologne, Hamburg, and Hannover for pilot implementation across several stations in the cities. The common goal is to future-proof mobility and strengthen the cities as environmentally friendly, well-connected places that people want to live in.

The pilots contain smart initiatives including on-demand shuttles, cyclist services, smart delivery storage locker facilities, new monitors for passenger information and optimised route guidance. Many of these facilities have built in intelligent controls, making them faster to use and cheaper to run. This enhanced offer aims to meet changing mobility habits, reduce vehicle emissions, and address last mile transport challenges. To make this as flexible as possible for the host stations, Deutsche Bahn is developing infrastructure that is open and supported by a wide range of mobility providers.

Hannover Station and smart city,
Deutsche Bahn.
Image (left) © PancrasPZ
(iStock / Getty Images Plus).
Image (right) © DB AG / Nikolas Blum.

Deutsche Bahn's approach to stations builds on their function as anchors for community life by trialling socio-economic and cultural place-making initiatives. By providing spaces for recreation, the programme facilitates social interaction, increasing quality of life for visitors, staff and residents, and enabling stations to become integrated parts of their local economy with an urban mobility and logistics regenerative effect.

To gradually test this new approach, the city of Hamburg was selected as an early showcase. Working in close cooperation with the urban administrations of Hamburg, Deutsche Bahn have helped to integrate urban analytics and data into their strategies for urban mobility and logistics.

SMART BUILDINGS PRINCIPLES

1

Environment

Sustainable, resilient, regenerative

Take a visionary and holistic approach to the environment

A healthy environment will benefit everyone, and Network Rail are committed to playing our part in delivering the government's obligation to move to net zero carbon. Urgent action will be taken to reduce the environmental impact of our existing built assets and set the highest standards for new builds, including their whole life cycle, performance, and maintenance. Smart buildings will help us take a holistic approach to protect the planet, ensuring buildings are sustainable; can be adapted for the unavoidable challenges of climate change, ensuring buildings are resilient; and enhance the natural environment, taking every opportunity to be regenerative. Smart buildings and systems that allow us to track carbon, nitrate deposition, biodiversity and more will allow us to make informed decisions. We will then be able to embed visionary, long term environmental measures into our actions, providing environmental benefits and improving the ecosystem which we are part of.



Green wall reflected in cladding at
Birmingham New Street Station.
Image ©2022 Network Rail.

LEVELS OF MATURITY

SUSTAINABLE

When we manage, maintain, and add to our building stock without compromising on quality or damaging the environment.

Resulting in:
Minimized emissions, waste avoidance, reduction in operational costs including energy usage, more comfortable internal environments for staff and passengers, biodiversity gain.

Achievable through:
Effective carbon counting mechanisms, re-purposing buildings rather than demolition, retrofitting existing assets to improve environmental performance, raising environmental standards required of new builds, introducing renewable energy sources, recovering excess heat, behavioural incentives to reach sustainability targets.

Measured through:
Reduction in our carbon footprint and nitrogen deposition for existing assets, new assets built to net zero, increase in retrofitting and re-purposing, increase in biodiversity, reduction in energy bills.

RESILIENT

When our buildings are future proofed for climate change.

Resulting in:
Zero carbon flagship schemes, reduced impact on services, passengers and assets from extreme weather events, energy bill savings, biodiversity net gain, designs that cater for different habitats and a range of species.

Achievable through:
Nature-based solutions, effective weather response systems, smart internal environment monitoring systems, renewable energy sources, digital twins building in environmental aspects at the same time as repairs, selecting suppliers and products that meet high standards for embodied carbon, increased use of artificial intelligence to resolve problems, and redirecting funding to enable engagement in research.

Measured through:
Biodiversity monitoring, carbon counting, reduced year-on-year operational energy demand, better forecasting of extreme weather events and management of responses.

REGENERATIVE

When we take proactive action to improve the environment for all living things.

Resulting in:
Influencing current and future policy and acting as a catalyst for environmental improvement. Redefining value to be about more than cost and to instead incorporate wider factors such as prioritization of quality social and environmental contributions.

Achievable through:
Creating our own renewal energy and water to supply our needs and support nearby communities or sell back to the grid to reinvest in green initiatives, selecting demonstrator projects, acting on new discoveries from research and development, reprofiling skills and accountabilities within the organization, establishing a carbon planning accounting system, establishing formal and informal partnerships with external organizations such as the RTPI, RICS and RIBA, working with the wider community through a sortition process to harness knowledge and demand for change.

Measured through:
Garnering feedback from the community and stakeholders through hearings, running Citizens Assembly’s and acting on their recommendations, supportive design review expert letters, external commitments and high-level support.



Signalling room, Doncaster.
Image © Adelina Iliev.

DATA MATURITY ILLUSTRATION

An estate with a large portion of older building stock presents us with significant environmental challenges. **Catching up** means monitoring existing building performance and using that data to make smart decisions about where to invest retrofitting measures such as insulation, shading louvres, air source heat pumps and photo voltaic panels. **Keeping up** means taking post-occupancy and local climatic data to rethink buildings from a holistic perspective, such as upgrading to Passivhaus standards where environmental performance is optimised and technology enhances smart decisions. **Jumping ahead** might mean further refining this holistic approach to ensure buildings interact dynamically with their environment, taking advantage of contextual opportunities such as building orientation, and adapting to unexpected situations generated by climate change.

PREMIER LEAGUE CLUBS – LEADING BY EXAMPLE

Location:	National, UK
Client:	Sport Positive, United Nations Framework Convention on Climate Change (UNFCCC)
Relevance:	This case study demonstrates how active leadership combined with excellent engagement with staff, players and fans can bring greater focus to specific business objectives, in this example, working towards net zero.
Date:	Annual rankings table since 2019



Tottenham Hotspurs Stadium.
Image (left) @Shutterstock.
Tottenham Hotspurs Stadium – solar shading close up.
Image (above) @Shutterstock.

Since 2019, the environmental sustainability of Premier League Football Clubs has been under scrutiny by United Nations backed Sport Positive, a UK-based organisation that focuses on supporting global sports organisations to increase ambition and action on climate change.

A league table is published each year based on points awarded for different categories of effort, with more points given to clubs that are acting strategically across all their sites and operations, have policies in place and are engaging fans, staff and players in their work. Bonus points are also added for external commitments to net zero.

The sustainability rankings table encourages friendly competition between the Premier League clubs. A key outcome has been to establish a 'conversation' heightening attention and bringing greater focus to environmental issues that extends beyond the individual club to supporters as well. When the league table started, few clubs published information about how they were addressing negative environmental impacts. Today, clubs are sharing the ways in which they manage their physical estate, use water and energy, and how they manage and recycle waste. At the Academy and AXA Training Ground complex, Liverpool Football Club has installed an additional water bore hole unit that provides natural rainwater for irrigating pitches across the entire training ground site, whilst at Tottenham Hotspur's Training Centre, a sedum 'green roof' has been installed to significant portions of the main building to enable the capture and re-harvesting of rainwater across the site. Leading by example, the clubs are also hoping to have a scale effect on the behaviour of those who attend and watch football matches.

SMART BUILDINGS PRINCIPLES

2

Economic and Social Value

Enhancing, empowering, lasting

Engage communities and businesses to secure lasting economic opportunities and social value.

Our network does much more than just move people from A to B, it mobilises wider economic and social benefits for public good. Our vast estate contributes to neighbourhoods and landscapes across Great Britain, not only through our stations but the many back-of-house buildings that keep the network running, enabling access to jobs, education, leisure, friends and family. As travel patterns and regional needs change, Network Rail will engage and evolve. Our buildings will celebrate their individual distinctiveness whilst integrating into their local context, enhancing our built environment, and realising local ambition. We will explore opportunities for new revenue generation that go hand in hand with social benefits. It is crucial that communities and businesses are empowered to be part of the decision-making processes that affect them. This will not only establish ownership and civic pride but will create lasting economic opportunities and social value. Smart buildings will support inclusive mobility and economic growth by harnessing technology to find synergies. This will maximise embedded value to the benefit of all, focusing our minds to tackle complex challenges head on.

King's Cross Station, London.
Image © Adelina Iliev.



LEVELS OF MATURITY

ENHANCING

When we create and improve relationships with physical assets, introducing opportunities for economic and social value.

Resulting in:
Terminus buildings that are important public spaces (even for non-passengers), workplaces that improve wellbeing, meeting financial and socio-economic aspirations.

Achievable through:
Thinking of stations as community assets (perhaps by adding facilities such as exchange libraries or bicycle repairs), interfacing positively with towns and landscape beyond our buildings, providing the public with access to shared spaces, being child friendly, promoting physical and mental health and wellbeing, harnessing local knowledge, promotion of local businesses, consulting freight and retail customers alongside other stakeholders, aligning with capital investment programmes for new station buildings and infrastructure.

Measured through:
Evaluating the social and economic value and impact of our smart buildings, uptake of community facilities, increase in staff and passenger health and wellbeing, increase in use of the network for freight (and associated income generated), communities feeling part of decision-making processes.

EMPOWERING

When we enable others to shape our evolution, creating buy in.

Resulting in:
Business models that can stimulate external innovation investment, increasing our visibility in communities, meeting socio-economic aspirations, increased sense of personal safety, increasing benefits beyond the railway, new forms of revenue generation, public service that considers everyone in Great Britain as a stakeholder.

Achievable through:
Promoting community empowerment through initiatives with multiple benefits (e.g. redundant buildings being repurposed and underused spaces hosting pop-up facilities – creating 24 hour security, local revenue generation, and places for social connection), considering ways to help people enjoy the romance of travel, addressing spaces between buildings, making data available to local businesses/communities, sophisticated time management of spaces to maximise usage, engaging freight and retail customers to contribute to sustainable growth.

Measured through:
Holistic evaluation of the social and economic impact of rail infrastructure (including beauty and sense of place), uptake of community facilities, increase in staff and passenger health and wellbeing, communities co-designing solutions, increased footfall in local businesses.

LASTING

When we set up legacies that will protect and strengthen economic opportunities and social value for future generations.

Resulting in:
Creating a positive legacy of smart buildings, providing places which are welcoming, inclusive and central to driving regeneration opportunities, Smart Cities which embed Network Rails’ diverse property portfolio into their masterplanning, encouraging and implementing visionary ideas to repurpose and reuse buildings of all size and scale, community pride in the built assets owned and operated by Network Rail.

Achievable through:
Proactive steps to harness local interest and participation in choices about the future of different property assets, encouraging good ideas through competitions and awards for a range of audiences, creating a forum for good practice, exploring natural based assets, projecting Network Rail smart buildings as places where people are encouraged to visit and enjoy as destinations in their own right.

Measured through:
Inclusion of a smart buildings champion at board level within Network Rail, strong external public profile, extensive and positive social media following, regular showcase sessions to disseminate good practice across local, national and international audiences, becoming the ‘go to’ precedent for others looking to adopt smart building principles.



Finsbury Park Station office.
Image © Adelina Iliev.

DATA MATURITY ILLUSTRATION

Rail is a thread that connects places through sustainable transport, and station buildings are focal points in local communities. Many stations, however, have constraints that discourage people from using the network, reducing the likelihood of attracting visitors and contributing to local prosperity. **Catching up** means using both qualitative and quantitative data gathered from consultations with local businesses and communities to gain insights on where the issues lie in each context. **Keeping up** means gathering ideas by actively involving local businesses and communities in meaningful engagement processes and sharing data with them to co-create solutions and pilot initiatives that increase satisfaction. **Jumping ahead** might mean using the post-occupancy data from these pilot initiatives to roll out wider reaching programmes that empower communities and businesses across Great Britain, creating lasting value and making the network theirs.

SMART BUILDINGS PRINCIPLES

3

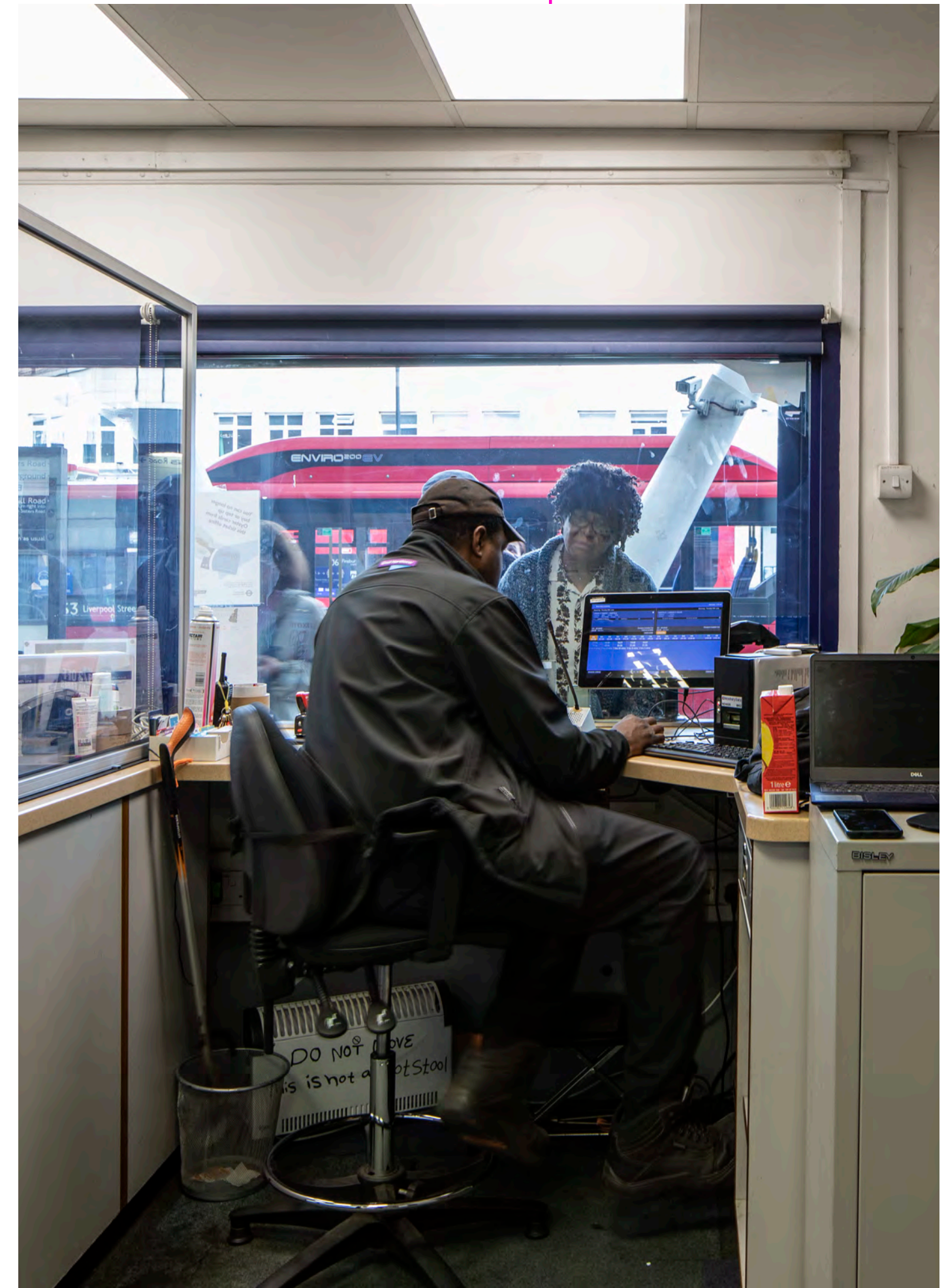
People-centred

Humanised, attentive, enjoyable

Act inclusively and create spaces that enable everyone to fulfil their potential

Being people-centred is more important than ever to provide everyone with equitable access to the railway and an uplifting experience of using it. To be fully inclusive we will humanise our network. We will understand and cater for the full range of physical, cognitive, and sensory impairments that passengers and staff might have, as well as their life circumstances and cultural differences. Network Rail will become an increasingly diverse organisation; one that retains and attracts talented staff who are compassionate and empathetic to passenger needs. Smart buildings will help by utilizing interactive systems that are attentive to people's needs, and the requirements of the buildings that accommodate them, alleviating stress points. The design quality of our buildings affect the people who live, work, and play in or near them. Smart buildings that are proactively and sensitively managed will provide the heritage of the future. Navigation and use of our network will become an enjoyable experience, not a daunting one. Our smart buildings will enable everyone to direct their energies towards the things that will help them to reach their full potential.

Finsbury Park Station ticket office.
Image © Adelina Iliev.



LEVELS OF MATURITY

HUMANISED

When our buildings are accessible and inclusive, with a caring atmosphere.

Resulting in:
People of all mobility levels and backgrounds feel they can navigate the network and find help when they need it, less discomfort for passengers and less stress for staff, especially during disruption or emergency events.

Achievable through:
Up to date and live communication information systems, notifications to passengers ahead of travelling, Wi-Fi areas for passengers to contact loved ones in emergencies, wayfinding that uses technology to provide an individualised experience, effective communication about what is happening and what options are available to passengers, physical spaces with as few obstacles as possible.

Measured through:
Increased use of the network by minority groups and those with physical, cognitive or sensory impairments, decreased staff health issues/absences, more rapid emergency response rates.

ATTENTIVE

When our buildings direct awareness to pertinent issues (such as passenger needs or building defects) in a manner that is informative and relieves stress.

Resulting in:
Keeping passengers satisfied, and staff productive and calm.

Achievable through:
Use of calm technologies (such as those being piloted through smart homes), open-source information systems, interfaces with social media and apps to communicate with passengers; removing ticket barriers in favour of inclusive smart technologies (ensuring no digital exclusivity or in-built biases); integrating last mile travel into journey planner services, smart furniture that can adapt depending on need.

Measured through:
Passenger and staff satisfaction surveys, app usage, positive social media mentions, Wi-Fi usage.

ENJOYABLE

When our buildings are designed or reconfigured to create positive experiences through their functionality, beauty, sense of identity, and ability to facilitate social interaction.

Resulting in:
Passengers enjoy their travel experience and see us as a truly public service, a diverse staff contribute their ideas and enjoy their workspaces.

Achievable through:
Giving passengers something back in return for their data, using technology to allow passengers and staff to feedback to us directly, digital experiences designed with as much care as the physical, introducing playful elements that delight, compensate passengers for loss of time during delays, offering passengers free hot or cold drinks during extreme weather.

Measured through:
Positive passenger and staff feedback, daily mood checks, fewer staff absences, good news stories about Network Rail across media.



Finsbury Park Station ticket office.
Image © Adelina Iliev.

DATA MATURITY ILLUSTRATION

Lifts create an inclusivity challenge because when they are out of service, a station may immediately become inaccessible. **Catching up** means gathering continuous data on lift performance to keep passengers and staff informed and manage expectations. **Keeping up** means comparing data on lift performance and usage to proactively plan to improve accessibility and reduce impact on station staff. **Jumping ahead** might mean creating an inclusive Mobility as a Service (MaaS) digital interface that compares a wide range of live data with user needs, allowing customers to create the best journey experience.

EASTBOURNE STATION – SMART FACELIFT REIGNITES PRIDE

Location:	Eastbourne, UK
Client:	Network Rail
Delivery Team:	Network Rail, Ban Nuttal, Eastbourne City Council, Train Operating Companies, local stakeholders
Relevance:	This visionary project demonstrates the dividends that can be achieved for staff, passengers and the community, and the significant contribution that destination buildings can play in driving economic value and community regeneration.
Date:	2019 – 2022



The £5.5m project to refurbish the station in Eastbourne was prioritized due to repeated maintenance issues relating largely to the Georgian glass roof and atrium. The run down building fabric was also leading to increasing incidents of anti-social behaviour.

Network Rail took the lead in establishing a strong working partnership with Eastbourne City Council and its Heritage Team during the development of plans for the project. As part of its application to secure Listed Building Consent for the works, Network Rail also took opportunities to optimize performance of the train station, integrating modern materials and cutting-edge technology alongside sensitive building restoration.

Main project works included refurbishment of the station façade; refurbishment of the central atrium; stonework repairs and replacement of the slate roof. Passive Infrared Technology was included in the lighting upgrade and the Georgian wired glass roof panels were replaced with polycarbonate panels. A new radial external canopy was also added to the train station to provide covered walkways and shelter from the elements. These various interventions ensure that Eastbourne station is now a welcoming location during daylight and darkness, its maintenance needs are low, and its environmental footprint is kept to a minimum.

The Train Shed, a 240m long building adjacent to Eastbourne station and used for passenger drop off, had been cordoned off for safety reasons. In collaboration with Eastbourne City Council, the Train Shed roof has now been renovated and conversations about how the community can benefit from the use of this heritage structure in the future are underway.

As a result of this project, fresh life has been injected into the area. Eastbourne Station now provides an attractive terminus destination, a good environment to work in, and local businesses are benefitting from increased footfall due to the inclusive and refreshed public spaces. Lasting economic opportunities have been created and pride in the area reignited.



Renovation and upgrading of Eastbourne Station.
Image (left) © Adelina Iliev.
Image (above) ©Adelina Iliev.

SMART BUILDINGS PRINCIPLES

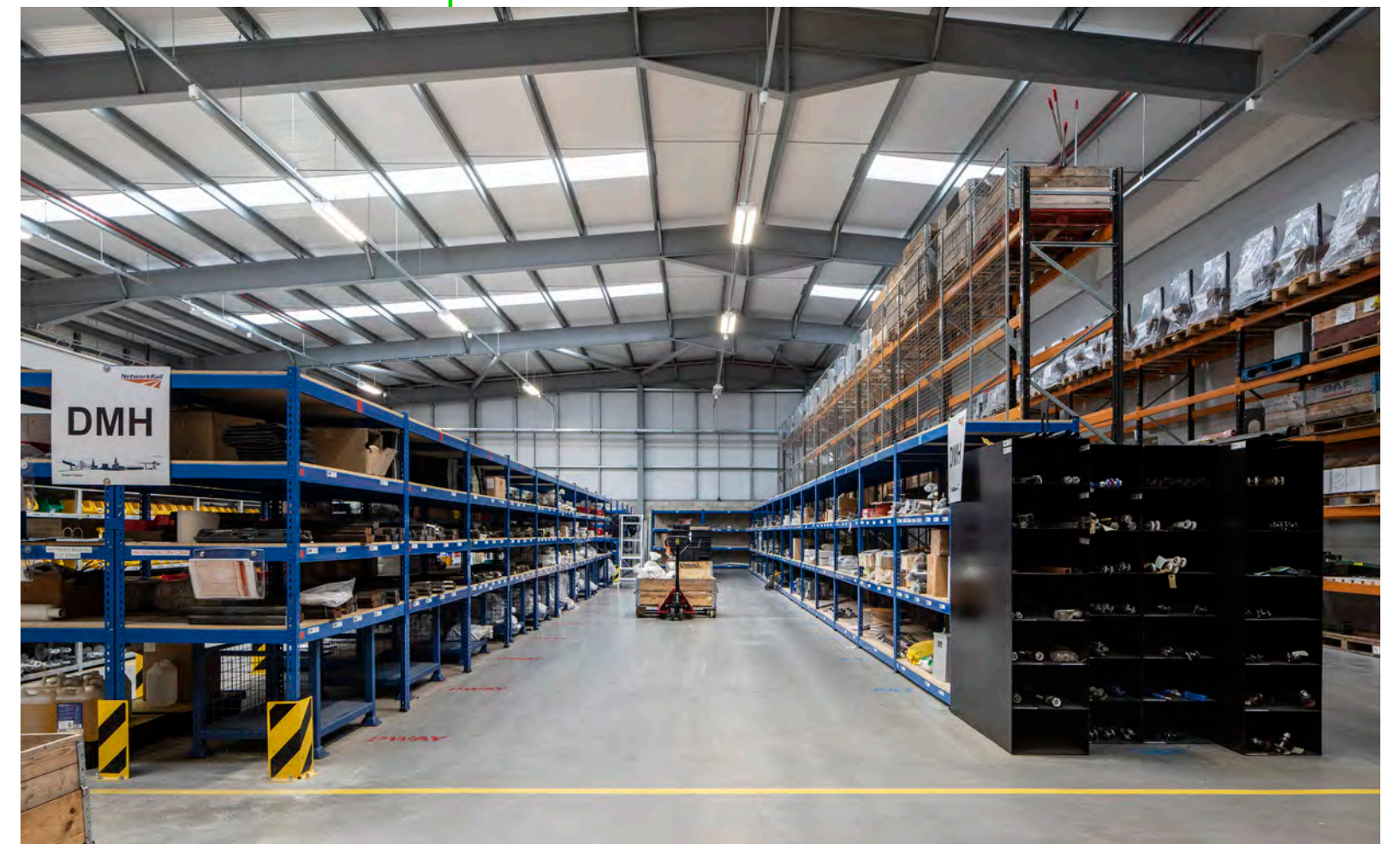
4

Operations

Adaptable, innovative, pioneering

Operate with stewardship and foresight to optimise performance

Safe and effective operations keep services running smoothly for passengers and help staff to do their jobs well. Our buildings accommodate the safe and effective operation of the railway, but our existing physical and digital assets vary greatly in condition. We will practice stewardship and foresight to improve consistency of conditions and standards for a better service. This means taking care of existing products, places, and processes, as well as anticipating problems and having the tools in place to deal with them. Providing our staff with healthy, well-equipped working environments will instil a greater sense of pride in Network Rail as a public service organisation, increase efficiency, and heighten sensitivity to insightful opportunities to do things differently. This will, in turn, allow us to develop and optimise our performance. Smart buildings will have built in flexibility and help us to be agile in adapting to change. They will embrace technology and innovation, allowing us to pioneer where we find opportunities. This will enable us to play a leading role into the future, actively setting the highest possible standards of performance for operations.



Stock room at Doncaster MDU.
Image (above) © Adelina Iliev.
Stock taking digitised using QR
codes at Doncaster MDU.
Image (right) © Adelina Iliev.



LEVELS OF MATURITY

ADAPTABLE

When our operations have built in flexibility, enabling agile working.

Resulting in:
A better maintained, safer and more efficient estate that performs well for its users and saves staff time.

Achievable through:
Staff learning and development opportunities, hybrid working support, streamlined information channels, smart station management, passenger flow optimisation, consolidating existing data sets to draw out useful insights, overcoming inbuilt biases in algorithms.

Measured through:
Staff training take up, staff retention, technology uptake, reduction in delay minutes, reduction in accidents, reduction in operational costs.

INNOVATIVE

When we are able to respond in creative ways to both existing and new challenges.

Resulting in:
Integration of user data, staff time freed up for customer care and creative thinking.

Achievable through:
Use of machine learning/AI/robotics/automation where appropriate, predictive analytics to advise in advance of breakdown, responsible collection of data and metadata, increased connectivity infrastructure, staff time for human touch customer service.

Measured through:
Project completion timescales, increased efficiency in day-to-day operations, use of data collected, technology uptake, passenger satisfaction surveys.

PIONEERING

When we initiate new ways of working that other organisations can learn from.

Resulting in:
Machines and humans working together to create market-leading performance.

Achievable through:
Digital/self-monitoring/self-healing building components (e.g. smart walls with Wi-Fi access), an integrated combination of analogue and digital enablers, open protocol data that is useful to passengers and market innovators, the ability to read across all data so it is integrated and mapped, helping to pick up control issues.

Measured through:
Staff and passenger satisfaction surveys, services on time, accident reduction, increased efficiency of resource use, market innovators pivoting and developing products/services to meet our agenda.



Shipping container used as a stock room and staff welfare facilities in Doncaster. Image © Adelina Iliev.

DATA MATURITY ILLUSTRATION

Stock rooms are often sites of culture challenges at Network Rail. In some locations, resources are wasted by buying new materials when the stock is already there, but the relevant parts cannot be found quickly enough for the task at hand. We have found that streamlining our stock rooms results in more motivated staff who take pride in looking after their workspaces and deliver a more efficient service. **Catching up** means overhauling stock rooms to provide staff with pleasant, organised workspaces including clear data systems for keeping stock of materials. **Keeping up** means harnessing the technologies that are already available (such as QR code labelling) to digitise stock audits and make re-ordering processes faster and more accountable. **Jumping ahead** might mean automating stock taking and ordering, as is beginning to appear in the world of smart fridges for family homes. Reports could be generated at any time to check stock levels. This would free up staff time for skilled work.

UPS DEPOT – RETROFITTED FOR SMART CHARGING OF ELECTRIC VEHICLES

Location:	Camden, London, UK
Client:	UPS
Delivery Team:	UPS, UK Power Network Services, Moixa, The Cross River Partnership
Relevance:	This case study demonstrates how an existing industrial warehouse can be brought up to date through the introduction of new technology to support sustainable operations. It also illustrates the benefits of an active exchange of data and intelligence so that the building makes a positive contribution to operational cost savings and avoids costly and complicated capital investment in grid upgrades.
Date:	2021



E-quad bikes delivering goods in London using cycle lanes.
Image (far left) ©UPS
Electric vehicle fleets.
Image (left) ©UPS

The Electric Vehicle Fleet-Centered Local Energy System (EFLES) project, funded in partnership with Innovate UK, involved retrofitting UPS’s existing depot in Camden, enabling the smart charging of its London fleet of electric vans. The project was a progression from the Smart Electric Urban Logistics (SEUL) project, also funded by Innovate UK, which lay the groundwork for EFLES.

Under the projects, the Camden depot was retrofitted with an active network management system to manage power usage levels. The project also explores how the smart system can be integrated with grid pricing, demand for electric charging, and rapid charging if UPS wants to select an electric van to be ready earlier in the morning for prompt dispatch.

Together, these projects avoided the need for costly upgrades to the existing power supply, as well as grid constraint challenges commonly encountered when introducing the infrastructure necessary to support electric vehicles. The network management system has greatly increased capacity at the facility ensuring there is power to charge electric vans and other parts of the fleet, including the electric assist pedalled Fernhay eQuad. This also has positive implications for UPS’s roll out of electric vehicles across the 220 countries in which it operates.

Through the exchange of data and information about how the building is operating, UPS is beginning to answer the following types of question: how can it operate more sustainably without significant CAPEX investment in the short-term? How can it effectively manage its need for increased electricity as its electric fleet grows? How can it look to replicate this solution in operational centres around the world?

SMART BUILDINGS PRINCIPLES

5

Culture and Leadership

Open, galvanising, venturing

Practice leadership and nurture a culture of continuous improvement

Attaining the right culture is essential to success, and this comes from strong and active leadership. We have a nationally significant built estate, a committed workforce, and dedicated supply chains and stakeholders at our fingertips. Activating these assets will ensure we are an influential organisation that best serves passengers, staff, and communities. Our leaders will endeavour to make people feel valued and will nurture a culture open to new ideas, tools, technologies, and working collaboratively. Our talents will be galvanized by removing barriers to progress and encouraging testing and learning. We will incentivise our supply chains and stakeholders to embed this culture too, creating the conditions for continuous improvement for all who work with us. Smart buildings will help shift our mindset, forming a common understanding of our shared vision, affording clarity of purpose to every project. This will allow Network Rail to grow in confidence, becoming bolder and venturing into new realms of possibility.

Trains undergoing refurbishment
at Hornsey depot, London.
Image © Adelina Iliev.



LEVELS OF MATURITY

OPEN

When we are transparent, collaborative, and receptive to new ideas.

Resulting in:
Catching up with industry developments, strengthened institutional memory, motivated staff, new standards that guide others within our sector.

Achievable through:
Intervening in 'business as usual', multi-disciplinary working, testing new ideas (including incentivising staff to contribute their own) and supporting people when these do not work, learning and development opportunities for staff, stakeholder mapping.

Measured through:
New initiatives being piloted, prototyped, and implemented; staff retention statistics; staff and passenger satisfaction surveys.

GALVANISING

When we create the conditions to stimulate talent, creativity and problem-solving without fear of failure.

Resulting in:
Keeping up with industry developments, thinking beyond incremental improvements, dissemination and ownership within Network Rail, new benchmarks that guide others beyond our sector.

Achievable through:
Quality control measures including design review panels and design champions, introducing metrics early in projects, providing project specific design visions and principles, rewarding creative thinking, pulling siloes together to maximise impact, growing our own thinking and not outsourcing this to others.

Measured through:
Design review panel assessments, staff and passenger satisfaction surveys, increase in staff skills, increase in multidisciplinary working and internal training.

VENTURING

When we drive market innovation to meet our ambitions and have influence beyond our industry.

Resulting in:
Spearheading industry developments – exceeding our corporate objectives and becoming a global trailblazer.

Achievable through:
Allowing the unexpected to find a place, incentivising stakeholders and supply chains, sharing best practice, change management plans, getting our staff onboard to be part of the change.

Measured through:
New products and services invented or adapted to serve our purposes, our work being held up as an example of good practice, stakeholder and public buy-in, shared data sets becoming useful for unintended purposes, increased peer-to-peer learning, staff self-reporting on supportive measures, increased ownership and understanding of ambitions across teams.



Doncaster control room.
Image © Adelina Iliev.

DATA MATURITY ILLUSTRATION

To create a culture of continuous improvement (and be able to put passengers first), leadership must listen to staff, the people who are highly knowledgeable about the issues at hand. **Catching up** means gathering intelligence from our staff that enables us to better understand where the barriers to success lie, in terms of both working culture and the work itself. It also means recording lessons and sharing these insights in a dynamic format with the wider team. **Keeping up** means putting mechanisms in place to continuously collect this data as well as innovative ideas for new solutions. **Jumping ahead** might mean that barriers to change, such as lack of diversity in the workforce and siloed working, have been broken down; unnecessary bureaucracy has been removed and staff can harness data to co-create solutions that improve our service.

HUB STATION – COMMUNITY VISION FOR THE FUTURE OF STATIONS

Location:	National, UK
Client:	Network Rail
Delivery Team:	Design Council, The Glass House, Commonplace, Digital Urban, RIBA, 7N Architects, ARUP, LUC, Gardiner and Theobald
Relevance:	This case study demonstrates application of all the smart buildings principles in a railway environment. In particular, it seeks to jump ahead through exemplary engagement processes and through innovating a genuinely adaptable, sustainable, modular construction approach to public infrastructure buildings.
Date:	2019 — ongoing.



HUB Station designed by 7N Architects (Visualisation by Pillar Visuals).
Image (far left) © 7N Architects.
ExploreStation engagement event using Virtual Reality goggles.
Image (left) © David Lake.

Hub station is a modular approach to building small and medium sized stations. Through a series of ThinkStation workshops organised by the Design Council, Network Rail co-created a brief based on the ThinkStation principles and the organisation's 4S's mission: satisfaction, safety, stewardship and sustainability. We then commissioned an international, public design competition. The winning scheme takes a smart buildings approach through the concept of a kit of parts that is adaptable to different scales and sites, responding to their social, physical, and environmental context. The concept design was tested further through ExploreStation. A series of public engagement events used a range of digital media (including online interaction and virtual reality immersive experiences of the concept model), and live events (including collaborative design workshops and exhibitions) to overcome barriers to digital access and industry jargon, ensuring maximum inclusion in the design process. ExploreStation is our largest engagement programme to date. Over 4,500 people were engaged across 12 cities and towns, as well as globally online.

The insights from ExploreStation are used to refine design guidelines, shaping the creation of a 'kit of parts' that can be adapted to suit the needs and objectives of different communities and contexts across Great Britain. These new guidelines will help to shift the focus away from simple passenger numbers, and towards stations as community assets, with high standards of environmental performance.

FURTHER RESOURCES

Further guidance, tools, and an evidence base explaining our methodology for arriving at the framework is provided in a supplementary document, Smart Thinking.

REFERENCES

General:

Department for Transport (2021), Decarbonising Transport – A Better, Greener Britain. National Archives, London: Department for Transport.

Design Council (April 2021), Beyond Net Zero: A Systemic Design Approach. Available at: <https://www.designcouncil.org.uk/fileadmin/uploads/dc/Documents/Beyond%2520Net%2520Zero%2520-%2520A%2520Systemic%2520Design%2520Approach.pdf> (Accessed: 19th July 2022).

HM Government (October 2021), Net Zero Strategy: Build Back Greener. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf (Accessed 29th July 2022).

National Infrastructure Commission Design Group (February 2020), Design Principles for National Infrastructure. Available at: <https://nic.org.uk/app/uploads/NIC-Design-Principles.pdf> (Accessed: 19th July 2022).

Network Rail, Strategy and Policy Documents (various years). Available at: <https://www.networkrail.co.uk/industry-and-commercial/supply-chain/existing-suppliers/buildings-and-architecture-design-guidance/> (Accessed: 19th July 2022).

Russell, S. 2021, BBC Reith Lectures: Living with Artificial Intelligence. Transcript available at: https://downloads.bbc.co.uk/radio4/reith2021/BBC_Reith_Lectures_2021_3.pdf (Accessed 29th July 2022).

Williams Rail Review (February 2019), The role of the railway in Great Britain: Evidence paper. National Archives, London: Department for Transport.

Eastbourne Station case study:

Baker, D. (2022) 'Eastbourne Station'. Interview by Frances Fernandes (the Design Council), 9th August.

Cowen, A. (28th October 2020). Eastbourne station receives £5m renovation. Available at: <https://www.railtechnologymagazine.com/articles/eastbourne-station-receives-ps5m-renovation> (Accessed 29th July 2022).

Network Rail (2022). Available at: <https://www.networkrail.co.uk/running-the-railway/our-routes/sussex/sussex-railway-upgrade-plan/> (Accessed: 19th July 2022).

Rail Engineer (28th October 2020). Available at: <https://www.railengineer.co.uk/new-look-and-feel-for-eastbourne-station/> (Accessed: 19th July 2022).

Wentworth, I. (31st January 2022), Multi-million pound refurbishment of Eastbourne Railway Station will finish this month. Available at: <https://www.sussexexpress.co.uk/lifestyle/money/multi-million-pound-refurbishment-of-eastbourne-railway-station-will-finish-this-month-3548540> (Accessed 29th July 2022).

Hub Station case study:

Crawford, R. (2022) 'ExploreStation'. Interview by Kirsty McMullan (Design Council), 8th July.

ExploreStation (2022). Available at: <https://explorestation.commonplace.is/> (Accessed: 19th July 2022).

Premier League Clubs case study:

BBC Sport (2nd February 2022) 'How green are Premier League clubs & what are they doing to help?', BBC Sport. Available at: <https://www.bbc.co.uk/sport/football/60196764> (Accessed: 19th July 2022).

Sky (19th September 2021) 'Game Zero: Changing the Game', Sky Group. Available at: <https://www.skygroup.sky/game-zero> (Accessed 10th August 2022).

Sport Positive (2022). Available at: <https://www.linkedin.com/company/sport-positive/> (Accessed: 19th July 2022).

Smart Cities Programme case study:

Deuche Bahn (2022). Available at: <https://smartcity.db.de/en/mou-hamburg> (Accessed: 19th July 2022).

Deuche Bahn (2022). Available at: <https://smartcity.db.de/en/mou-hannover> (Accessed: 19th July 2022).

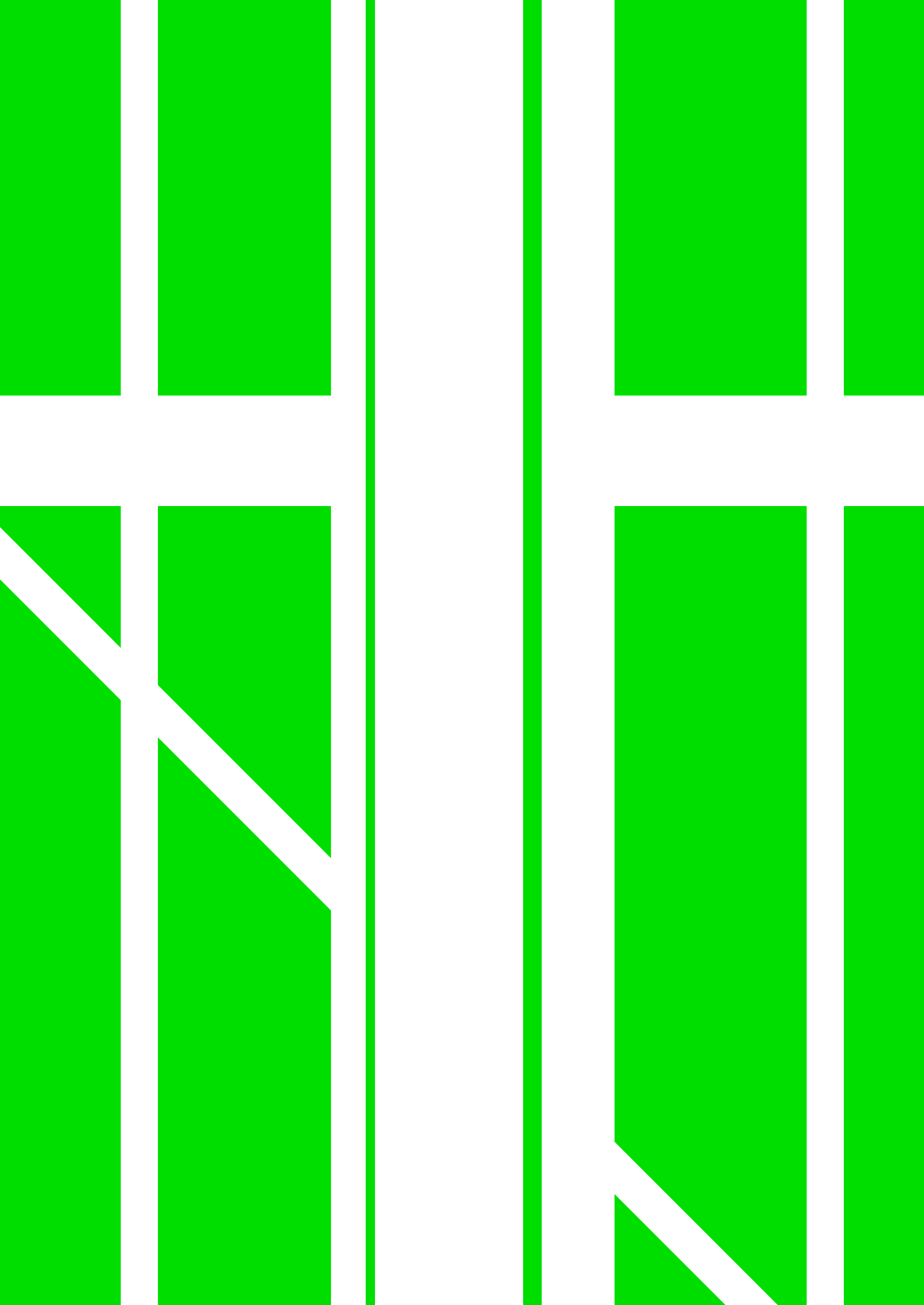
Deuche Bahn (2022). Sustainability at Deuche Bahn. Available at: <https://gruen.deutschebahn.com/en> (Accessed 29th July 2022).

UPS Depot case study:

The Energyst (2022). Available at: <https://theenergyst.com/ups-evs-smart-charging-battery-storage/> (Accessed: 19th July 2022).

UPS (17th February 2022). The future of UPS sustainable urban logistics at Expo. Available at: <https://about.ups.com/us/en/our-stories/innovation-driven/ups-advances-in-sustainable-urban-logistics.html> (Accessed 29th July 2022).

UPS (4th May 2022). New UPS e-bikes are turning heads in the UK. Available at: <https://about.ups.com/us/en/social-impact/environment/sustainable-services/equads-in-the-uk.html> (Accessed 29th July 2022).



SMART

BUILDINGS FRAMEWORK

FOREWORD

As we look ahead, our roles will increasingly require us to develop innovative and holistic solutions as we move into a more sustainable and inclusive future. Being future-ready requires more than applying new resources, technologies and materials, but calls for us to adopt a creative culture and mindset.

The following framework helps us develop a goal-oriented approach to imagine what our assets could do and how they could perform.

Our 2,500 stations and 18,000 back-of-house buildings around the country provide extensive scope for us to rethink the art of the possible, where we can explore opportunities to support our commitments and address climate change, population growth, technological development, and an inclusive green transition for the many communities we serve.

These are big asks, so we will need to pilot new ideas and shift our decision-making priorities towards future readiness. The Smart Buildings Framework challenges us to adopt smarter practices and solutions by outlining a clear and holistic path to sustainable change across our vast and diverse estate. It looks to be a Smarter Buildings Framework where we can situate short-term problems in long-term thinking, to ensure we continue to deliver mobility as a seamless, reliable, and sustainable service.

The following framework does not prescribe solutions but rather, it looks to help us develop a goal-oriented approach to imagine what our assets could do and how they could perform. It provides us with a set of shared themes and objectives to translate into bespoke interventions for places and buildings. Overall, our objective is to move beyond sustainability to regenerative design; sustaining the present no longer assures our survival and wellbeing, so we need to find new ways to replenish and renew our material resources, clean our air, harvest and purify our water, support healthy ecosystems, and design for behaviour change.

While this document is not a final and closed framework, we hope that it will provide us with a basis for ongoing advancement, and we look forward to working with our teams to test, challenge, and shape our smarter buildings together.



Anthony Dewar
Professional Head
Buildings and Architecture
Network Rail



Dr Garry Bosworth
Project Lead
Principal Engineer -
Technical Authority,
Buildings and Architecture,
Network Rail.

CONTENTS



SMART Buildings Framework Phase 1
© 2022



SMART Thinking
© 2022



SMART Buildings Framework
Phase 2: A Tactical Guide

Produced by
Ramboll and Network Rail

About Network Rail
Network Rail owns, operates and maintains Britain's railway infrastructure. We run a large and diverse operation; with more than 2,500 stations, 1,450 footbridges, 5,500 platforms and are responsible for 18,000 buildings of all kinds. Each building; from iconic stations like Birmingham New Street to the signal boxes and maintenance depots, are vital in providing a safe and reliable railway for our passengers. These buildings form a significant part of the UK's civic and public realm and impact millions of people every day.

www.networkrail.co.uk

About Ramboll
Ramboll is a global multi-disciplinary engineering and consultancy company, delivering expertise and sustainable solutions. Ramboll was founded in Denmark in 1945 and now has 17,000 experts in 35 countries, merging local experience with a global knowledge base to create sustainable cities, spaces and societies. With 1,400 staff working across the UK, we are well placed to partner with our clients to drive positive social and environmental change.

www.ramboll.com

© Network Rail, Ramboll
April 2024

Foreword	
Executive Summary	7
Introduction	9
Purpose	9
Context	11
Approach: A Decision Tool	13
How To Use This Guide	15
SMART Buildings Principles	17
1 Environment	19
2 Economic and Social Value	27
3 People-Centred	35
4 Operations	43
5 Culture and Leadership	51
6 Smart Infrastructure	59
Next steps	67
Applying The Compass 2 Ways	67
Business Case Formation	69
References	71
Added Value	71
Tactics: Project Details	73
Images	74
Bibliography	75
Meet the Team	77

EXECUTIVE SUMMARY

The SMART Buildings Framework is a tool to help Network Rail, alongside our partners and stakeholders, to achieve our long-term objectives and become a force for industry change. It is designed to guide our future discussions and decision-making.

Vision and Purpose

As the Buildings & Architecture Technical authority, we are looking to refocus and enhance our approach to estate development and asset management. Our objective is to change how we think about our building stock and reshape our estate so that we become more future-ready, generate long-term value and deliver a resilient legacy for the future of Network Rail. The purpose of this framework is to assist decision-makers in asking the right questions; considering what our buildings might provide in their broadest economic, environmental, and social sense, and making SMART choices for long-term success. It is designed to support decision-making at various stages of projects and programmes, from developing business cases to prioritising investments.

Overview

The SMART Buildings Framework Phase 2 provides us with a common language to improve and manage our network’s diverse built assets. It references the work begun in Phase 1, and sits alongside our Genius of Place Wheel and our 4Ss approach, which together, will guide our response to the challenges our estate faces.

This document offers a framework for applying systems thinking and a holistic perspective to design, develop, and evaluate our projects and programs. It helps us understand where we can bring added value and benefits to our estate through each intervention. To achieve this, we have outlined a set of 6 Principles and 18 Objectives for us to consider in each of our projects and programmes, by using a compass, a visual aid to map out where we are today and where we need to get to. Every section provides a series of case studies to help us imagine how we can incrementally reshape our estate to match our values and long-term objectives. The framework provides a way to analyse and score our assets and visions with a tool and code system as a standard language that will help us collectively and collaboratively find innovative solutions towards a future-ready estate.

SMART BUILDINGS PRINCIPLES

A SMART approach supports holistic, systems thinking across our portfolio. We must create joined-up approaches that consider all 6 Principles and their interrelationships to generate added value.

1 Environment

Our buildings will actively nourish a healthy environment and generate positive ecological impacts for people and planet.

2 Economic and Social Value

Our buildings will create new opportunities for communities and businesses to thrive, highlighting distinctive local qualities and developing sustainable, long-term growth.

3 People-centred

Our buildings will create positive and seamless experiences for all passengers, staff and local communities.

4 Operations

Our buildings and practices will enable efficient, agile and forward-thinking operations to improve services and staff wellbeing.

5 Culture and Leadership

Our buildings and practices will foster innovation, collaboration and continuous learning to pilot new ideas and drive industry standards.

6 Smart Infrastructure

Our buildings will form a network that integrates digital and physical infrastructure, gathering and using data across the estate to realise our ambitions.

INTRODUCTION

As the Buildings & Architecture (B&A) Technical authority, we are looking to refocus and enhance our approach to estate development and asset management. Our objective is to change how we think about our building stock and reshape our estate so that we become more future-ready, generate long-term value, and deliver a resilient legacy for the future of Network Rail.

Purpose

Our estate encompasses a vast and diverse range of buildings, each with varied levels of efficiency, inclusivity, and delight. Redevelopment or maintenance is often driven by immediate needs, with investment focused on short-term availability. As custodians of these assets, we need to establish a longer-term perspective on our built environment. By ambitiously asking what our buildings could be, rather than maintaining them as they are, we can radically improve our network to reflect 21st-century needs and future-proof our estate for generations to follow.

This Framework aims to assist decision-makers in asking the right questions; considering what our buildings might provide in their broadest economic, environmental, and social sense, and making SMART choices for long-term success. It builds on our Smart Buildings Phase 1, interacting Genius of Place Wheel, our 4Ss approach, and incorporates our Principles of Good Design and the United Nations Sustainable Development Goals (Fig.1). This approach will filter into the way we apply our Control Period 7 (CP7) strategy through delivery-based design guidance and create new ways of working that will permeate our future Control Period Strategies.

The SMART Buildings Framework Phase 2 provides us with a common language to improve and manage our network’s diverse built assets. It references the work begun in Phase 1, where we established five key Principles that set out what we should be always working towards. These principles aim to ensure that our built estate remains relevant, serves communities as well as it can, and contributes to the government’s commitment to achieving Net Zero by 2050. The Smart Buildings principles are designed to be applied to projects at all stages of thinking and development, with the principles themselves being able to adapt and flex over time.

This Phase 2 document expands the Phase 1 approach, adopting its five principles and adding a sixth. This addition re-classifies the development of digital and smart infrastructure as a distinct principle in itself rather than a data maturity measure applied across all other principles.

In Phase 2, we consider that each of the principles interact and when applied together, provide a holistic approach to added value. By incorporating data and digital infrastructure as a distinct principle, we emphasise its importance to our estate, while simultaneously highlighting the importance of all principles. We see Operations, for example, as inherently linked to our Environmental approach, which ties in directly with the Economic and Social Value we generate.

We must assess and drive each of the principles in every one of our projects and programmes. This approach challenges us to see how the principles are interrelated, and where we can make positive impacts and add values across them all.

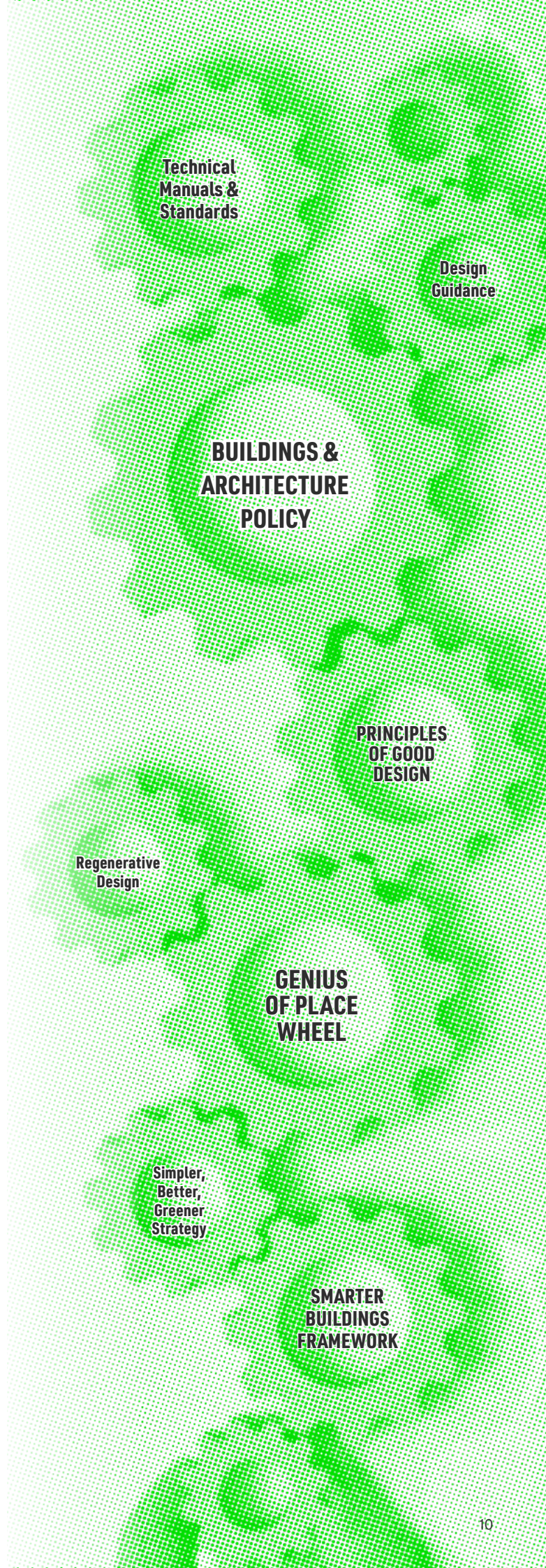


Figure 1: Buildings and Architecture Strategy Ecosystem

Context

Our built environment is facing unprecedented external challenges that our buildings are often not designed to withstand. In Network Rail, as we strive to deliver a continuous and seamless service to our users, we need to ensure that our assets remain fit for purpose today, tomorrow and for generations to come.



Figure 2: Network Rail asset in flooded area

Our teams must constantly make business decisions that require an understanding of the interdependency of different systems, including rail infrastructure, trains, buildings, and passengers. The SMART Buildings Framework looks to expand our systems thinking further by developing problem diagnosis and unlocking innovative solutions that can address 21st-century challenges, including:

- Climate change increases environmental extremes that render existing places vulnerable. They can make our buildings, systems, staff, and the communities we serve more vulnerable too. We must raise our estate’s resilience to reduce the risks of damage, financial loss, and most critically, human injury.
- Resource depletion has been brought on by a global misuse and over-consumption of water, land, energy, and raw materials, made worse by the increased demands of population growth. This scarcity is driving untenable costs of living, and unsustainable ecosystems that will reduce liveability in the coming years unless we change our consumption and procurement patterns.

- Economic shifts have become more frequent and severe, with rising public and private debt, local unemployment, and growing inequality. These are made worse by fragmented and under-resourced local services, amenities, and uneven community health and wellbeing. We can continue to innovate in how we contribute to more inclusive growth.
- Societal changes and trends are shifting the way people use our network and the expectations they may have of our services. COVID-19 created massive shifts in when and where people work, with flexible working continuing to trend. Being overly reliant on ticket sales limits our adaptability through these shifts.

However, there are also opportunities for us to consider, such as:

- Sustainable travel is at the core of rail, and of achieving national net-zero goals. We must continue to ensure that rail travel delivers positive environmental impacts looking to reduce emissions from infrastructure maintenance, new construction, ecosystem degeneration from disturbances and energy use. Network Rail has a robust and industry-leading sustainability strategy to drive us forward, and our building assets must continue to reflect this by positively impacting on the environment to create benefits for people and the planet.
- Economic recovery at a national scale requires local development initiatives. Network Rail has been helping local areas thrive in multiple locations, combining safety, employment opportunities, retail, and cultural destinations. We have an opportunity to leverage the geographic reach of our built assets to support local communities and generate added value.
- Technological progress opens new possibilities for sustainable development, health improvements and more equitable societies. We are witnessing massive progress in modelling software, artificial intelligence, and sensor technology that can help us better manage our assets, make better-informed decisions, and maximise positive impacts.
- Population growth and cultural shifts, when carefully considered can help inform our future development. Railway passenger numbers are expected to increase by around 40% by 2040, while the number of 85-year-olds in the UK is projected to almost double by 2045. Designing for sustainable behaviour change, while communicating our strategies and collaborating on initiatives with a more informed public, can support us in reaching our long-term goals.

Approach: A Decision Tool

This Phase 2 document aims to help us identify opportunities for unlocking the potential of our assets to be future-ready and generate added value. To achieve this, we must make two significant shifts in our thinking:

1.

We must embed vision and future thinking into our design and decision-making processes. We should consider how long-term, large-scale ambitions can be realised through multiple short-term incremental interventions to our estate. This means that even small changes must be considered for their potential added value and how they can play a part in wider transformations.
2.

A SMART approach supports holistic, systems thinking across our portfolio. We must create joined-up approaches that consider multiple aspects of our network. By better understanding and capitalising on inter-dependencies, we can create innovative solutions that benefit multiple aspects of our estate at once. Our role is to consider how one intervention can positively contribute to multiple objectives and add value across several systems.

To support this SMART approach, Phase 2 sets out **6 Principles, each with 3 Objectives, outlined in our SMART Compass** (Fig.3). It is a decision tool that helps us map out what our drivers of change are, where we are today and where we need to get to, so we can incrementally reshape our estate to match our values and long-term objectives.

Together, these Principles and Objectives establish a shared language across teams, providing a clear direction, encouraging innovative thinking, and promoting a cross-disciplinary approach to our network. They can also be used as a transparent decision-making tool from design to delivery, enhancing collaboration with our many stakeholders, by applying it at different key points:

- Mapping baseline conditions to highlight existing needs;
- Identifying priorities for our assets and across our portfolio;
- Clarifying target outcomes for our projects and programmes;
- Developing holistic solutions that deliver on each of our key principles, and consider their wider impacts, opportunities and added value;
- Supporting strategic business cases, recognising and promoting innovative solutions.

This guide aims to support decision-makers in various stages of projects and programmes, from developing business cases to prioritising investments. Its primary objective is to help Route Directors and Route Asset Managers apply SMART principles in crucial decision-making moments, such as setting objectives and planning methodologies for new research and development projects, obtaining funding, monitoring progress, reflecting, and evaluating success, and selecting projects to pilot and advance as wider programmes.

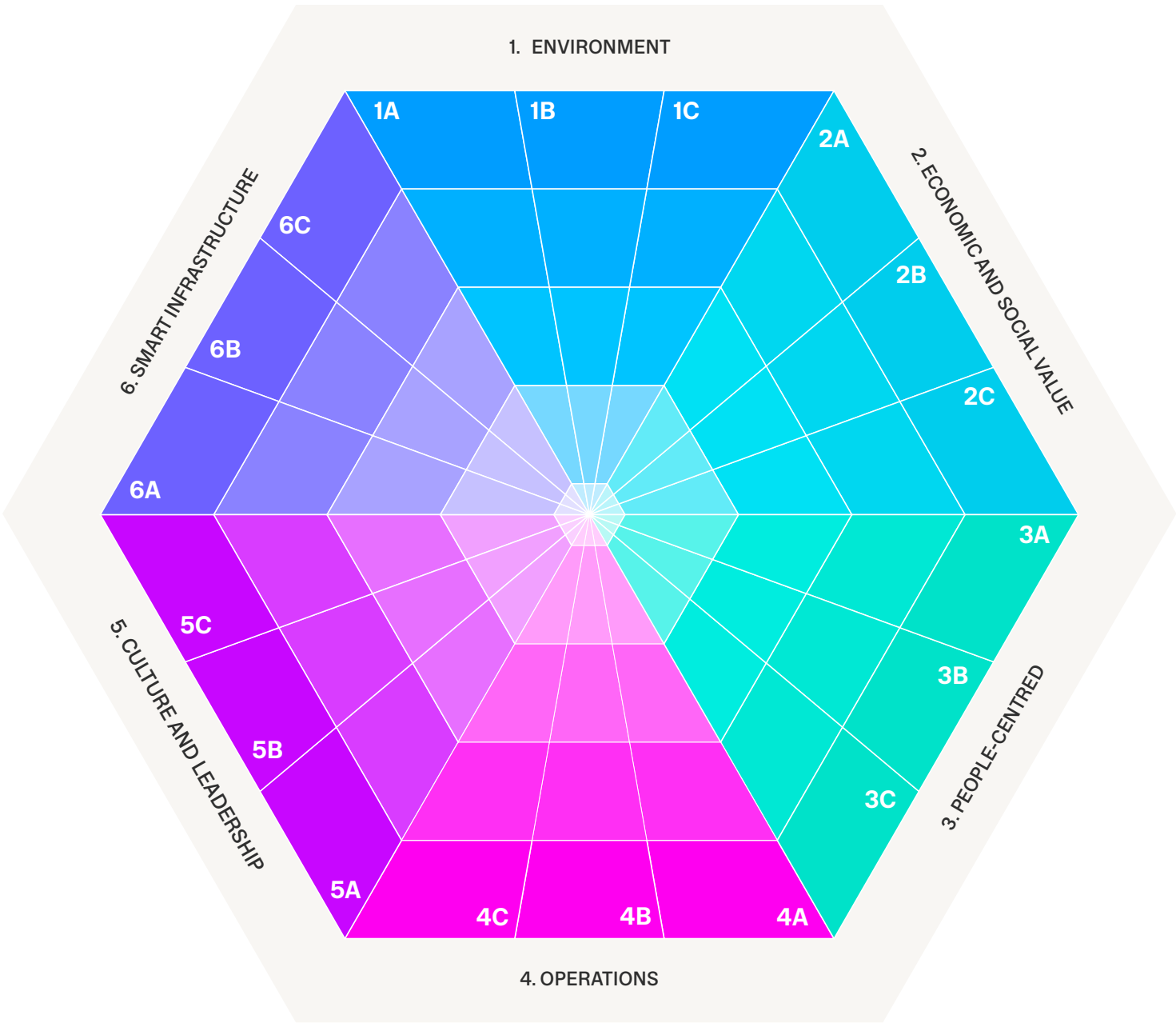


Figure 3: Smart Buildings Compass

How to use this guide

This guide offers a framework for applying systems thinking and a holistic perspective to design, develop, and evaluate our projects and programs. It is designed to support users in developing business cases for projects and programmes by:

- Understanding the 6 Principles (1-6) of the SMART Buildings Framework (see Fig.3)
- Unpacking the 3 Objectives (A,B,C) that make up each Principle
- Mapping and developing projects according to an Indicator Scoring (0-4), with 0-3 drawing on the same indicators as the Genius of Place Wheel, with an additional score (4) for a more ambitious SMART approach (Fig. 4 below).

By working our way around these elements, we chart the added value our projects bring, creating a SMART ‘Compass’ (Fig. 5) to help us navigate towards our desired objectives. This can be achieved by charting first, our baseline - scoring how our assets are performing today - and second, our vision – scoring our proposed intervention and where it brings value. Overlaying the baseline and vision can help visualise a business case for the project, showing how it meets our targets and brings added value.

While this is currently a subjective assessment, it can be supported by additional documentation to justify scoring. For ease of reference, the Compass uses a code annotated as ‘Principle Objective – Indicator’ or ‘Number Letter – Score’ (e.g. 1A-2, or 5C-4). At the end of the document, interactive and printable template has been provided to allow project teams to note their assessments and draft compasses for their business cases. This can be printed on A4 pages or enlarged for workshops.

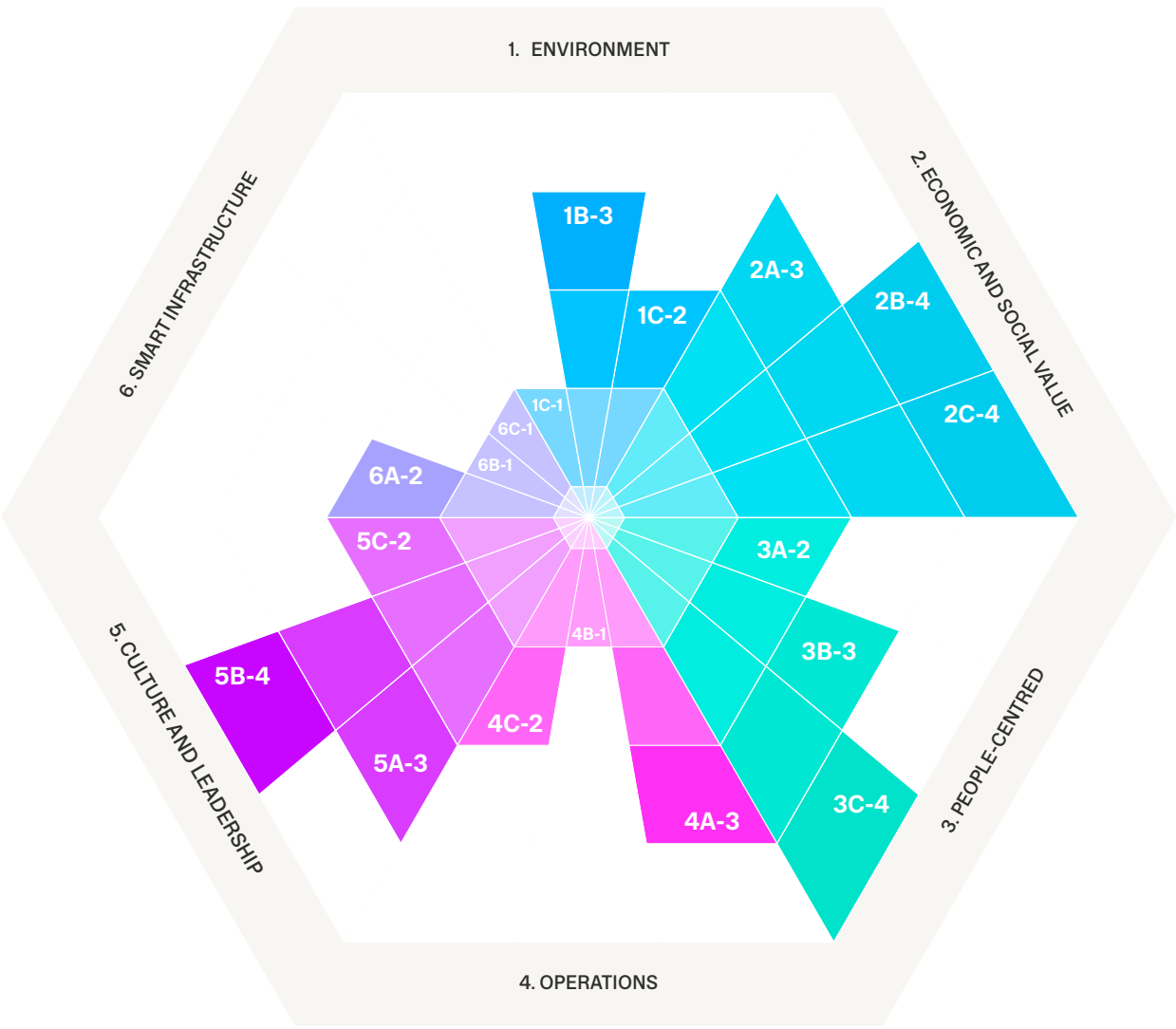


Figure 5: Smart Buildings Compass worked example

The following chapter is designed to support the use and application of the SMART Buildings Framework, by examining each Principle in a separate section that:

- Defines the Principle;
- Sets out 3 Objectives, detailing their relevance to our assets and our team;
- Demonstrates added value and benefits through potential return on investment under the Principle;
- Provides an ambitious case study demonstrating how this principle has been applied in a building context. We present a sample compass and explanation, to show how the project performs across all 18 Objectives and where it generates added value;
- Provides a more pragmatic case study to demonstrate more readily achievable interventions that meet the same objectives;
- Outlines a series of possible tactical moves that can be applied in existing buildings, often without major works or investment required.

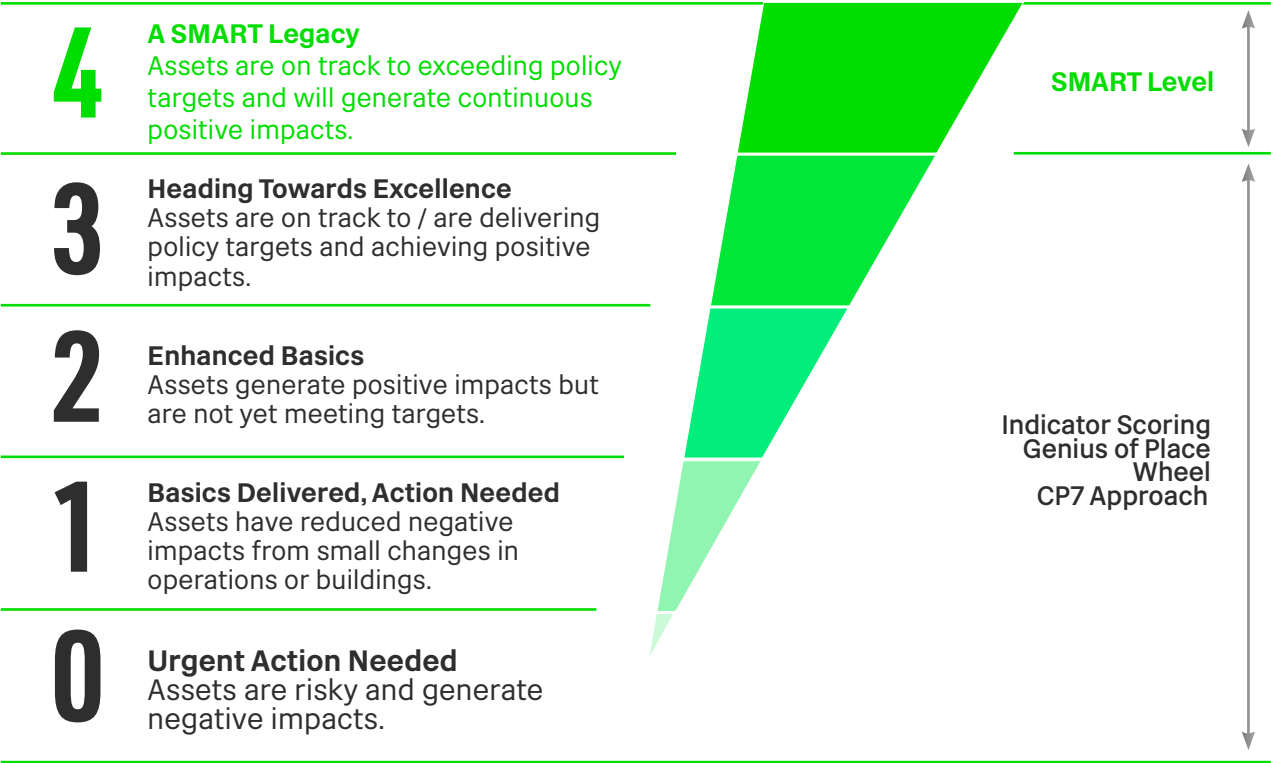


Figure 4: Indicator scoring key for SMART Buildings Compass

SMART BUILDINGS PRINCIPLES

Environment

Our buildings will actively nourish a healthy environment and generate positive ecological impacts for people and planet.

- 1
- A

Climate Resilience
- B

Towards Net Zero
- C

Regenerative Design

Economic and Social Value

Our buildings will create new opportunities for communities and businesses to thrive, highlighting distinctive local qualities and developing sustainable, long-term growth.

- 2
- A

Promote Investment
- B

Local Growth
- C

Long-Term Growth

People-Centred

Our buildings will create positive and seamless experiences for all passengers, staff and local communities.

- 3
- A

Inclusive
- B

Healthy
- C

Vibrant

Operations

Our buildings and practices will enable efficient, agile and forward-thinking operations to improve services and staff wellbeing.

- 4
- A

Adaptability
- B

Efficiency
- C

Wellbeing

Culture and Leadership

Our buildings and practices will foster innovation, collaboration and continuous learning to pilot new ideas and drive industry standards.

- 5
- A

Innovation
- B

Collaboration
- C

Feedback and Learning

Smart Infrastructure

Our buildings will form a network that integrates digital and physical infrastructure, gathering and using data across the estate to realise our ambitions.

- 6
- A

Connectivity
- B

Data-Processing
- C

Systems Thinking

1

Environment

Our buildings will actively nourish a healthy environment and generate positive ecological impacts for people and planet.

1 Environment

How do we reduce the vulnerability of our structures and users to extreme weather events?

Objective 1A

Climate Resilience

The evidence of climate change, its resulting extreme weather events and impacts on our spaces is overwhelming. Regardless of how quickly we decarbonise, studies show that some climate change is inevitable, owing to past and present carbon emissions.

Climate resilience is the capacity to cope with extreme events and recover from their impacts, with minimal damage to economic, environmental, and social fabrics. The aim is to anticipate and reduce our vulnerability to extreme weather across infrastructure, buildings, operations, and their users. This requires adapting our existing buildings, practices, and new-build strategies to increasing conditions of overheating, flooding, drought, and strong winds (amongst others).

Often, resilience constitutes a combination of three key capacities: (i) Coping; (ii) Adapting; and (iii) Transforming. Coping refers to increasing our building and operational capacity to manage risks; incorporating disaster preparedness and contingency plans, to ensure safety and operational continuity during a crisis. Adapting goes beyond our current 'coping' capabilities in extreme events. As these events become more frequent, we need to increase our capacity to respond to escalating conditions and reduce their negative impacts. Transformation requires large-scale and profound changes to how we build, renovate, and operate buildings, with significant shifts in how we plan for the future.

How can we play our part in averting the worst global impacts of climate change and maintaining liveability?

Objective 1B

Towards Net Zero

Our global average temperature increase must be limited to 1.5 °C above pre-industrial levels to avoid catastrophic changes to all aspects of society. The UK government and Network Rail have pledged to reach Net Zero by 2050, and 2045 in Scotland, and reduce emissions by 45% by 2030.

The UK is one of twenty countries that together, are responsible for about 76% of global greenhouse gas emissions worldwide. Buildings and their operations currently account for 30% of carbon emissions in the UK. We therefore have a critical role to play in tackling climate change by cutting greenhouse gas emissions, capturing emissions at the source, and removing carbon pollution from the atmosphere.

While Net Zero buildings may have once been a distant ideal, the industry is innovating extensively in this field, designing buildings with reduced whole-life carbon emissions, including direct and indirect emissions, with carbon neutral operations upstream and behaviours downstream. A Net Zero building looks to optimise passive design strategies to drive down energy demand in the first instance, avoid the use of fossil fuels and use materials, systems and equipment that are low carbon. It also looks to generate power through on-site or off-site renewables. Net Zero buildings apply integrated smart technologies to manage the use of resources, bring staff and stakeholders on board to change everyday behaviours and develop a robust system to collect data on emissions and offsetting.

What is the most innovative and comprehensive approach that we can apply to our future thinking?

Objective 1C

Regenerative Design

As the world struggles to reconcile the need for growth in the context of resource depletion and climate vulnerability, we need to push the boundaries of sustainability thinking towards replenishing resources for places and communities. We require buildings that will continue to deliver Net Positive impacts across their lifespan for people and nature.

Regenerative design is an innovative approach to our built environment, where we design our buildings to achieve circularity, biodiversity growth, and social wellbeing; maximising resource efficiency and increasing system adaptability to changing conditions. These buildings would generate energy, purify water, reduce, and reuse waste, use reclaimed materials, and create healthy and sustainable habitats for plant, animal, and human life.

While our industry may have the knowledge and technology to meet each of these objectives individually, we require innovative thinking and a place-based approach to achieve holistic regenerative development. Our challenge is to uncover what regenerative design can look like in the rail context, where we leverage our networks to enhance ecosystems, improve the flows and use of resources, and support sustainable lifestyles among our passengers and staff - to develop the performance of our natural and manmade systems in unison.

Added Value

£670m

Average annual damages to non-residential buildings from flooding, with expected increases of 27% by 2050, 40% by 2080 and 75% by 2080

224%

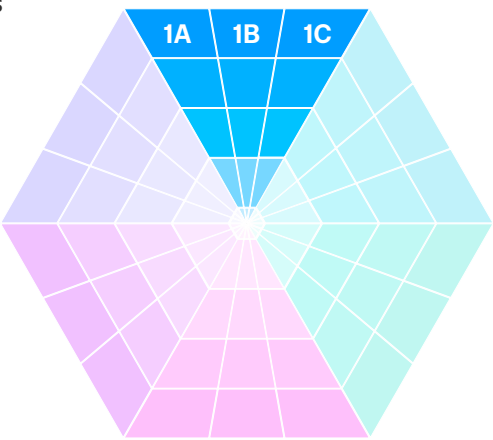
Return on investment from green roof insulation with extended life span, stormwater benefits and energy savings

80%

Reduction in carbon emissions from using low carbon heating with natural ventilation in offices

£111m

Estimated save by NHS from parks and green spaces on prevented GP appointments



Ambitious

Case Study: Zero energy and zero waste

Suzlon One Earth, Pune, India

Suzlon Energy | Christopher Charles Benninger, Ravi, Varsha Gagandi, Tao Architecture, Space Matrix | 45,392m² | 2009

Suzlon One Earth is one of the greenest corporate campuses globally, whose sustainable measures cut operating costs by 35%. Environmental sustainability is a core theme designed into the campus's life cycle, from site selection and design to engineering, construction, materials, and operations.



Figure 6: View of Suzlon One Earth with water garden and wind turbines

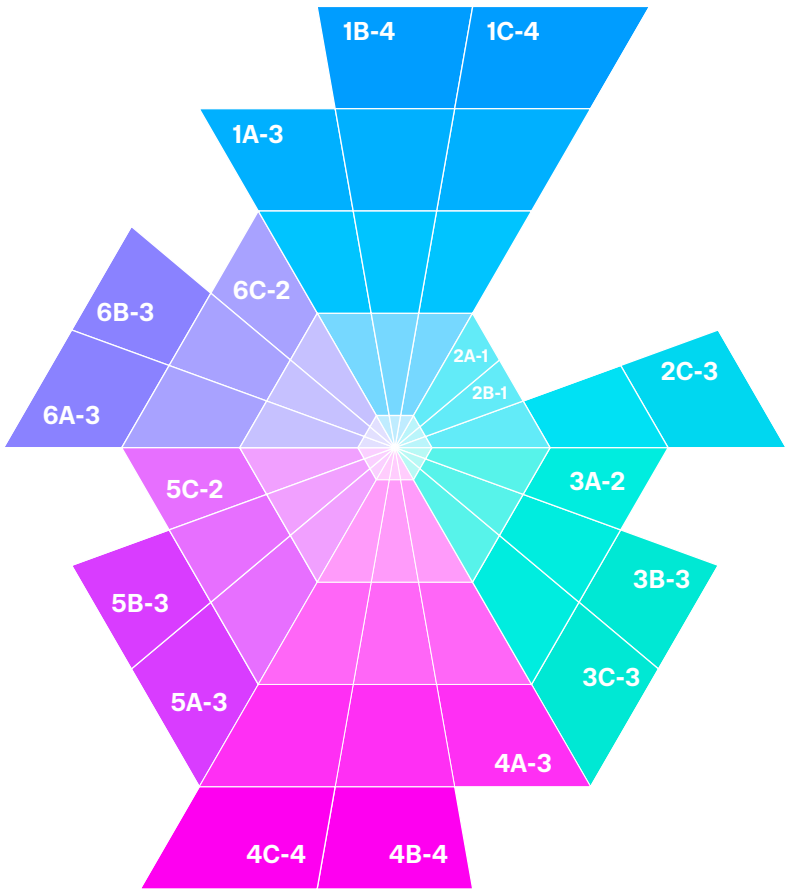


Figure 7: Suzlon One Earth Compass

1A Climate Resilience

The campus is designed to mitigate local climatic conditions including extreme heat, storms, and drought. The campus buildings have a central courtyard garden with a large water body, improving air quality and providing evaporative cooling. A stormwater harvesting and recirculation system accommodates up to three days' worth of rainfall. Treated sewage water is 100% reused in the air conditioning, landscape irrigation and flushing systems.

1B Towards Net Zero

Suzlon One Earth is a zero-energy project, maximising energy efficiency and generating sustainable energy. The campus produces 8% of its energy on-site with solar panels and windmills, with the remaining 92% generated sustainably off-site. The campus saves 65% of its energy by using dimmed LED open-air lighting systems. Net Zero is also considered through the life cycle and supply chain of Suzlon One Earth, with 80% of its built material sourced from within the region to reduce transportation needs and carbon footprint.

1C Regenerative Design

Resource efficiency and circularity are prioritised across all stages of the campus' lifespan, with 13.3% of building materials from recycled sources. Designed to maximise natural ventilation and daylight, the buildings are oriented so that 90% of building users do not require artificial lighting during the day, while Aluminium louvres on the façade provide a protective skin to reduce glare while letting daylight through. Suzlon One Earth also has a zero-waste policy, encouraging staff to change their behaviour to generate zero waste, and installing an onsite recycling and organic waste converter with an 85% recycling rate.

Compass Description

In addition to meeting its high environmental objectives, the Suzlon One Earth campus was designed to embody the holistic objectives of the company. Using occupancy sensors, the building is adaptable, optimising layout, and resource consumption, with changes in artificial light, heating and cooling, and automated water and recycling systems (4A, 4B, 5C). The architects looked to enhance wellbeing by designing zones for different emotions (4C), while including health measures such as maximizing daylight, improving air quality and providing access to green spaces (3B). Courtyards, multi-functional hallways and spaces encourage vibrancy, social engagement, innovation and collaboration (3C, 5A, 5B). Smart infrastructure was installed to connect their energy system to a network of renewable sources, both on- and off-site, while the data processing enables monitoring and evaluation (6A, 6B).

Pragmatic

Case Study: Green roof

Luchtpark (Air Park) Hofbogen, Rotterdam, NL

Municipality of Rotterdam, Dudok Group | De Urbanisten; DS landscape architects, De Dakdokters | 5,000m² | 2018

This elevated park in Rotterdam reuses disused train lines, platforms, and a station rooftop to create a nature inclusive and climate adaptive landscape. The green roof park incorporates a smart and regenerative circular water system that collects, naturally treats, and stores rainwater from the immediate surroundings. This water is reused for irrigation and passive cooling in times of heat stress and drought. It also improves building insulation, reducing energy costs and increasing the life span of the structure by protecting it from the elements. Native planting, fruit trees and a botanical garden offer shelter, food and migration spaces for birds, butterflies, hedgehogs, and bees. The Air Park has created a new identity for the area by repurposing the historic station infrastructure.



Figure 8: Aerial view of Air Park with public green roof developed on a repurposed train station

Tactical

Changeable landscapes

With growing risks of extreme storms and flooding, our built environment needs climate resilient water management strategies to reduce damage, maintain accessibility, and ensure safety. Copenhagen’s Cloudburst Management Plan applies a series of local drainage solutions that redirect flood water away from communities, buildings, and infrastructure. During dry weather, these concrete and nature-based floodable landscapes bring added value as local recreation spaces that also improve micro-climates and enhance biodiversity.

Heating from waste heat

Waste heat from the London Underground is being captured and used to heat homes, schools, and leisure centres. This is a cheaper and greener heat source for local communities, reducing carbon emissions, improving air quality, reducing heating costs to tackle fuel poverty, and taking significant steps towards local self-sufficiency. The system works across all seasons, providing cooler air for Underground passengers in summer.

Cool Microclimates

The Council of Paris is redesigning schoolyards as a network of small healthy microclimates open to the public outside of school hours. These green oases provide cool spaces for children and the wider community in summer, with drought-resistant plants, and rainwater infiltration and recovery measures. The grounds are play and education spaces for school children, community spaces for vulnerable populations and as a network, increase neighbourhood and building resilience.

Change of Material

By replacing standard paving with a photocatalytic material that has pollutant-trapping and self-cleaning properties, SEAT has improved air quality in their Martorell Plant by 40%. Ongoing improvements and innovations in construction and finishing materials are opening new avenues for reaching Net Zero targets and reducing long-term costs.



Figure 9: View of skatepark drainage design, Copenhagen Cloudburst Plan

2

Economic and Social Value

Our buildings will create new opportunities for communities and businesses to thrive, highlighting distinctive local qualities and developing sustainable, long-term growth.

2 Economic and Social Value

How can we continue to grow and enhance our services, amenities, and commercial offer in our buildings?

Objective 2A

Promote Investment

To continue to grow and provide a successful service to our millions of users and stakeholders, our buildings need to create opportunities for revenue streams that strengthen local economies and businesses while delivering social benefits to communities.

By identifying target markets, and developing a strategy around intended uses, our buildings can deliver aesthetic and functional properties that promote investment. In addition, where buildings achieve green building and wellbeing certifications with eco-friendly amenities, they can support our renters in reaching their Environment, Social and Governance (ESG) strategic targets. Ongoing and transparent communications with investors on building performance and operations build trust and confidence in the building as an investment.

Buildings across our estate have the potential to foster a thriving framework for investment within their spaces. Stations are often strategically located as transit hubs that bring assurances around seasonal and daily footfall, making businesses visible and offering a unique opportunity to serve as an amenity to travellers. Many buildings across the estate can also be key sites for wide-reaching advertising and marketing campaigns, capitalising on the high visibility of networks and spaces along the routes.

How can we understand and act upon local needs to generate local growth?

Objective 2B

Local Growth

Our buildings can be part of a wider ecosystem that promotes local growth and brings value to local communities. While each building is different, we can adopt practices across the network that celebrate distinct local character and context.

Generating local growth will mean different things in different places, and part of our role is to identify what type of growth and value would be most beneficial. Our buildings are situated in culturally and historically significant contexts - often embedded into their communities for generations, they can either contribute to or detract from the sense of place and identity. It is important to form partnerships with community groups, institutions, and agencies to support and discuss local needs and opportunities that our buildings can address, and continue to develop trust in our network by the diverse communities on the ground.

By collaborating with local groups, we can support educational programs, job training and other economic opportunities to empower residents and spark local growth. Our buildings can also serve as spaces for events, gatherings or cultural activities that promote social interactions, local stewardship of the space and enhance local cohesion. Often renovating and repurposing spaces in a locally sensitive approach can ensure that we revitalise neighbourhoods, support community initiatives however small, and foster inclusive growth.

How can we ensure that our legacy provides long-term value for future generations?

Objective 2C

Long-Term Growth

Our estate will be in use for generations to come. It is therefore critical that we ensure long-term and regenerative value from our investments. To allow for fluctuating economies and unknown changes in investment, we must embed several key attributes into our buildings - through design, operation and maintenance going forward.

Our buildings require an element of flexibility, where spaces can adapt to changing tenant needs, market demands and demographic characteristics. This will allow us to maximise occupancy and revenue generation over the building's lifespan.

We must reduce operating costs and demands by applying smart and efficient technologies. Investing in high-quality construction materials and techniques ensures the longevity of the building and its flexibility in the future - preserving its value as an asset, as a materials bank, and as an adaptable space. Long-term value also constitutes the value our buildings bring to local communities, providing accessible, mixed-use, integrated solutions to support people's health and wellbeing. Owing to their strategic geographic and social positions, our buildings retain opportunities to generate wide-ranging positive impacts and long-term value for years to come.

Added Value

£100 -

£300

Saved for every tonne of carbon reduced in the long term owing to carbon pricing

40%

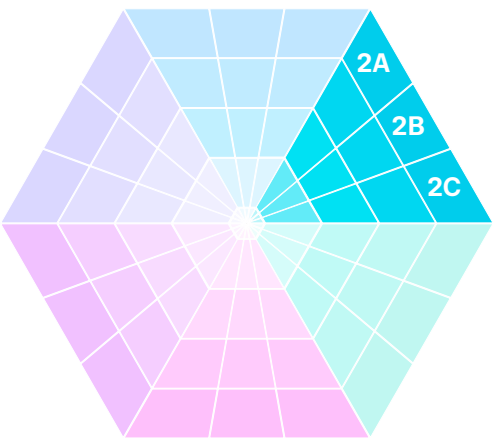
Increase in commercial trading and private sector investment following town centre public space improvements

30%

Increase in local footfall from pedestrianisation and public realm improvements

£5

Spent in town centres for every £10 spent in local destinations



Ambitious

Case Study: Meanwhile project made permanent

Pop Brixton, London, UK

Lambeth Council and 'The Collective' | Carl Turner Architects | 2,000m² | 2015

Pop Brixton, created as a meanwhile project on the site of a disused ice rink in 2015, has been made permanent due to its extensive positive impacts on the local economy and communities. It comprises 55 shipping containers that offer spaces for independent start-ups and businesses in food, beverage, music, film, education, and mental health. The project was set up with strong social and community objectives and has focused activities on delivering support to local enterprises, local employment opportunities, professional training, and providing space and support for local community groups.



Figure 10: Street view of Pop Brixton

2A Promote Investment

Opportunities for new revenue streams have been created by turning unused space into a functional place. The vibrancy of the area in and around the compound has increased footfall along the local high street by offering affordable work and leisure spaces, promoting investment in the area. The flexible programme of the building allows for investment in public spaces, events and nearby units.

2B Local Growth

Pop Brixton has created a new focal point and destination for the area, attracting visitors and businesses and encouraging local growth. The space empowers communities by offering affordable spaces for local start-ups and community events, purchasing 77% of its supplies locally while 70% of the members live locally.

2C Long-Term Growth

Pop Brixton is a building that uses recycled shipping containers to create a sustainable, efficient, and agile space. The building's flexible spaces are designed with a long-term vision, allowing them to evolve with changing needs and demands. These spaces can be used for various purposes, such as co-working and workshop spaces, a community garden, and a greenhouse for the local community to enjoy.

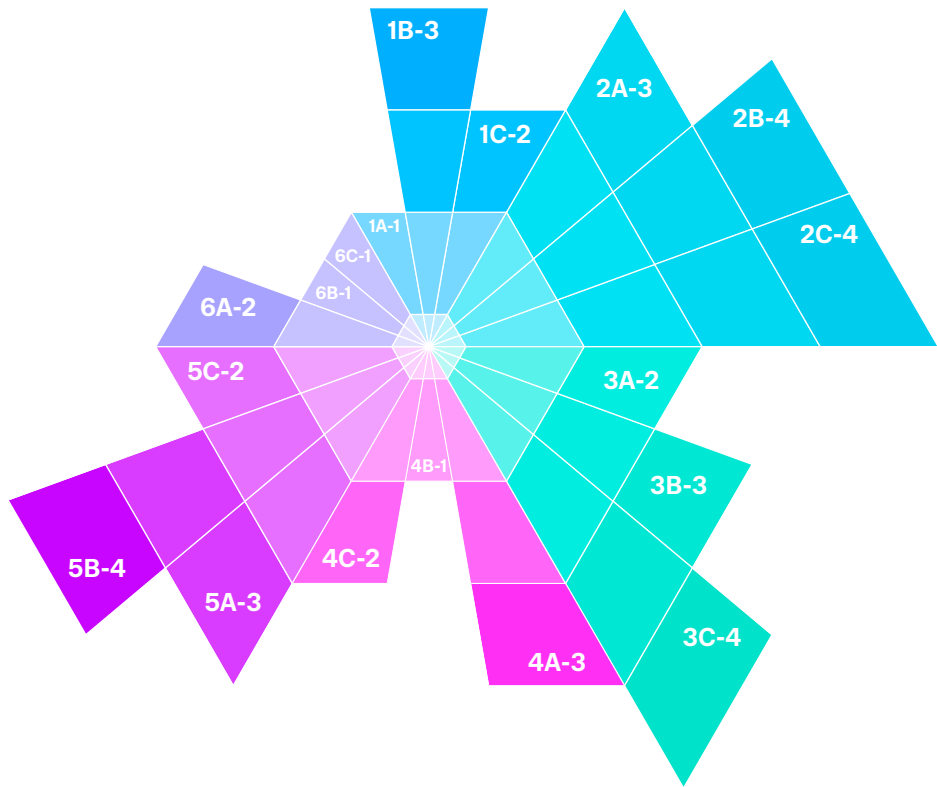


Figure 11: Pop Brixton Compass

Compass Description

While delivering on economic and social value, with an £18 million on-site turnover, an estimated £9 million annual contribution to the economy, and an increase in local spending, Pop Brixton also delivers on other objectives. Constructed with reused modular and local materials, and purchasing operational supplies from local vendors, the building seeks to reduce its carbon footprint while remaining adaptable to its users (**1B, 4A**). Its social programme of activities and events makes it a vibrant space for local communities, the expression of local identity and stewardship (**3C**), opening the space for community workshops, supporting local entrepreneurs, and developing new skills (**3A**). The programme also includes wellbeing classes, on-site green spaces and selecting suppliers according to their contribution to health (**3B**). The building and its programme establish ongoing opportunities to collaborate and innovate, acting as a centre and incubator for SMEs, social enterprises and community groups to come together (**5B**).

Pragmatic

Case Study: Activating Spaces

Pop-up Events, e.g. Tube 160 Treasure Hunt, UK

TfL Tube 160 Treasure Hunt. Rooftop Film Club, Luna Cinema, UK | 2024

Programming events and activities can generate new revenue streams that celebrate the legacy of rail and its heritage buildings. To celebrate its 160th anniversary, TfL organised an ‘architectural scavenger hunt’ across their heritage stations, encouraging people of all ages to engage with the history of places, and encouraging exploration across the network. Other events like pop-up cinemas and family raves have gained traction over the last few years as income generators. A diverse range of film choices can create an inclusive environment and creates opportunities for small businesses to thrive, for pop-up vendors to attend - particularly food and beverage vendors - and can be incorporated as part of a wider social and economic strategy.



Figure 12: TfL 160 anniversary logo

Tactical

Reclaiming unused spaces

Small spaces can be reclaimed and reimagined to activate spaces or make them more efficient. Community Brain, a community interest company, worked with residents and students around the entire Tolworth Station to reimagine how its vacant shop spaces could be reused as social spaces. Running local events celebrating cycling, music, and local nature reserves, they raised the site’s footfall, value, and community stewardship, leading to regular food stall popups that generate additional revenue.

Improving the view

Unused or undeveloped land and brownfield sites can visually deter investment in a community and give a negative perception, including safety concerns and anti-social behaviour. By redeveloping small sites and adding features such as community facilities, public art or planting, organisations can add significant economic and social value. While planning processes take time, interim measures can provide affordable and relatively rapid change. Outside a train station in Memphis, Tennessee, for example, artists were commissioned to paint famous song lyrics about the city on a plywood fence surrounding a disused site. This created a new landmark and gateway to the city reflecting local culture, heritage and identity.

Trip Chaining

Stations joined with retail create a one-stop-shop for passengers without needing to leave the transit hub. Delivery hubs, supermarkets and other retail can be provided, with successful cases often hosting unique services or facilities as its own destination. For example, CityPlaza in Hong Kong has a unique lifestyle cinema, an indoor ice rink (the only one in the region), and one of Japan’s most popular department store chain’s flagship location. To deliver local growth and social value, the mall’s developer has a Community Care Fund and Community Ambassador Programme. However, improving passenger experiences can also constitute smaller additions that bring more passive revenue streams, such as hosting parcel lockers, and vending machines – a growing and diverse industry that now includes pharmaceutical products, organic local food and milk, fresh pastries, warm snacks and drinks, among others.

Filling in Local Gaps

Network Rail buildings are often situated in strategic locations in communities and have significant potential to improve local quality of life by meeting both travel needs and local requirements. One method to assess opportunities to fill gaps in local services, amenities, and infrastructure is by conducting a local study such as the Scottish Government’s Place Standard tool, and 20-minute or complete neighbourhood studies. Digital mapping and engagement tools can help identify where a building can generate both social and economic value and contribute to local growth. It can highlight relevant revenue streams that improve passenger and visitor experiences. These facilities may include healthy food retailers, pharmacies and primary health services, leisure and recreation facilities, housing and hotels, among others.

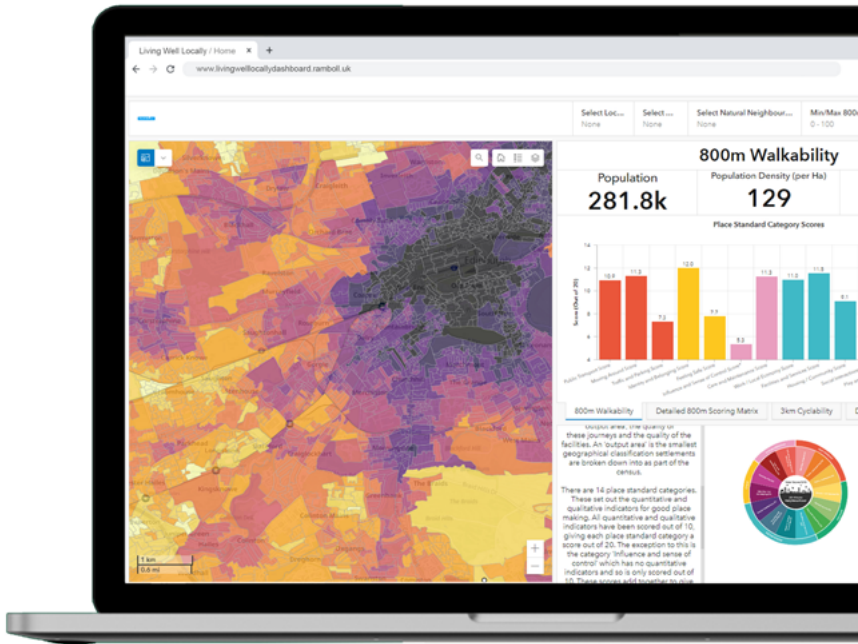


Figure 13: Example of 20-minute neighbourhood digital mapping tool

3

People-Centred

**Our buildings will
create positive and
seamless experiences
for all passengers,
staff and local
communities.**

3 People-Centred

How do we remove physical, social, and operational barriers for our diverse visitors, passengers, and staff?

Objective 3A

Inclusive

Our ability to move around, to see, hear and respond are largely enabled or restricted by the built environment. Our buildings, viewpoints and policies need to, as a minimum, ensure seamless and welcoming access to all.

As we serve a vast and diverse population, our assets must be designed for all abilities, ages, backgrounds, and identities - removing any barriers, disparities, and frustrations that people may experience. At an elementary level, inclusive buildings incorporate features such as ramps, wide thresholds, and visual and auditory cues for those with mobility and sensory impairments.

However, universal design goes beyond meeting minimum accessibility standards, catering to cognitive impairments and diverse life circumstances. Our network serves the entirety of Great Britain, with our staff and passengers coming from a multitude of diverse cultural, ethnic, and economic backgrounds. We will provide an empowering experience for all users, whether travelling alone or in a group. Our portfolio should create environments that support and encourage equitable participation in everyday activities, providing places for engagement, concentration, relaxation, and play. Community engagement, collaboration and co-design with diverse groups can help uncover their challenges and find solutions that deliver a more equitable, inclusive and universally accessible building.

How can we put people’s physical, mental, and social health at the heart of building design and operations?

Objective 3B

Healthy

To achieve long-term satisfaction and trust, part of our ethos must be rooted in health. Our buildings need to support the physical, mental, and emotional welfare of our passengers and staff.

Truly healthy places are composed of multiple interrelated elements that increase comfort and bring about a healthier experience overall. They may offer access to natural light and fresh air, and passive circulation that adapts to climatic conditions with temperature control. Our buildings may, for instance, incorporate biophilic design through the use of plants, natural materials, noise reduction, ergonomic design, and country, rural and city views – reducing stress and increasing safety for staff and passengers. Plants and air filtration technologies maintain indoor air quality, reducing respiratory concerns, while using non-toxic building materials can minimize exposure to harsh chemicals.

Beyond the design of our buildings, our spaces can influence healthy lifestyles and behaviours. They can provide healthy eating options, free hydration stations, and access to first aid supplies and emergency equipment. We can connect our buildings to local active mobility networks and provide bicycle storage, so people are encouraged to walk and wheel to our stations, and improve access to green spaces that promote physical, outdoor activities.

How can we create places where people want to come, spend time, and thrive?

Objective 3C

Vibrant

As part of our service, our buildings must be actively part of welcoming, vibrant and lively placemaking. This means giving identity to our buildings through the activities they promote, and the social behaviour patterns and relationships they create.

As our buildings are often located at the heart of local communities, we have opportunities to reimagine where people’s travel needs meet a local sense of belonging and long-term value, reducing the stresses of travel. We could achieve this using design elements that promote social interaction, visibility, gathering, rest, work or play. These can also generate alternate revenue streams, particularly with mixed-use strategies, combining retail and recreational spaces.

Community programming can bring people together around art, performances, events, and exhibitions to reflect and enhance local culture. Nursing spaces, play facilities or a variety of seating options for individuals, families and groups can generate different community draws throughout the day. Curating different activities throughout the day and night ensures that buildings continue to function as safe spaces for all - places that deliver positive experiences and help create long-lasting economic and social benefits.

Added Value

£100

Saved on renovations, complaints and hazards, for every £1 spent on inclusive design during the design phase

5%

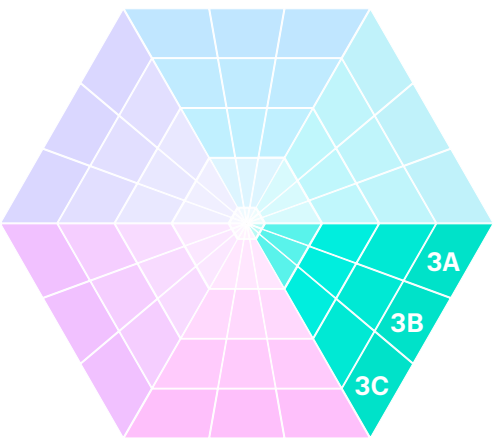
Increase in retail spending when extending visitor stay in a building for 5 extra minutes

30%

Increase in retail sales in US shopping malls with play areas

£1350

Estimated potential savings from every criminal damage incident avoided by incorporating inclusive and vibrant measures



Ambitious

Case Study: Making travelling a positive experience

Schiphol Airport, Amsterdam, NL

Royal Schiphol Group | Mijksenaar, Next Architects, Superuse Studios, Maurice Mentjens, NatuurCollege | 2002-2011

Schiphol Airport is known for its passenger-centric approach to travel and continues to make improvements to make travel a more positive experience for all.



Figure 14: Library space at Schiphol Airport

3A Inclusive

The Airport developed an innovative wayfinding strategy, using fewer signs with bigger and clearer letters, bold pictograms, bright colours, and easy-to-follow layouts to enable crowds to flow more easily through the terminals. The Schiphol app and interactive screens in the terminals provide tailored itinerary features for passengers to help them plan their time, explore options, and request additional help with scheduling and directions. A variety of public spaces cater to people from different cultural backgrounds and with diverse needs to reduce the stress and sensory overload that travel might bring. These include a Baby Care lounge, an interfaith space and meditation centre.

3B Healthy

The airport enables exercise and activity at predominantly sedentary locations, by providing bikes for passengers to recharge their phones. For those affected by travel's sensory overload, a variety of softly lit spaces to sit more quietly are also available. The airport has an integrated nature strategy, with a panoramic terrace, a green outdoor space, and an indoor airport park. This park houses real plants with a landmark 130-year-old tree at the entrance and integrates mixed reality technology to provide passengers with an embodied and immersive sense of being surrounded by nature.

3C Vibrant

Schiphol challenges the purely functional role of airport terminals, creating a sense of place and a range of activities beyond retail, food and beverage. These include multiple themed play and STEM activity areas for families with children, a library with books in 12 languages, and two museums for people whose flights have been delayed. The airport also has spotter spots from where passengers can enjoy watching planes on the runway.

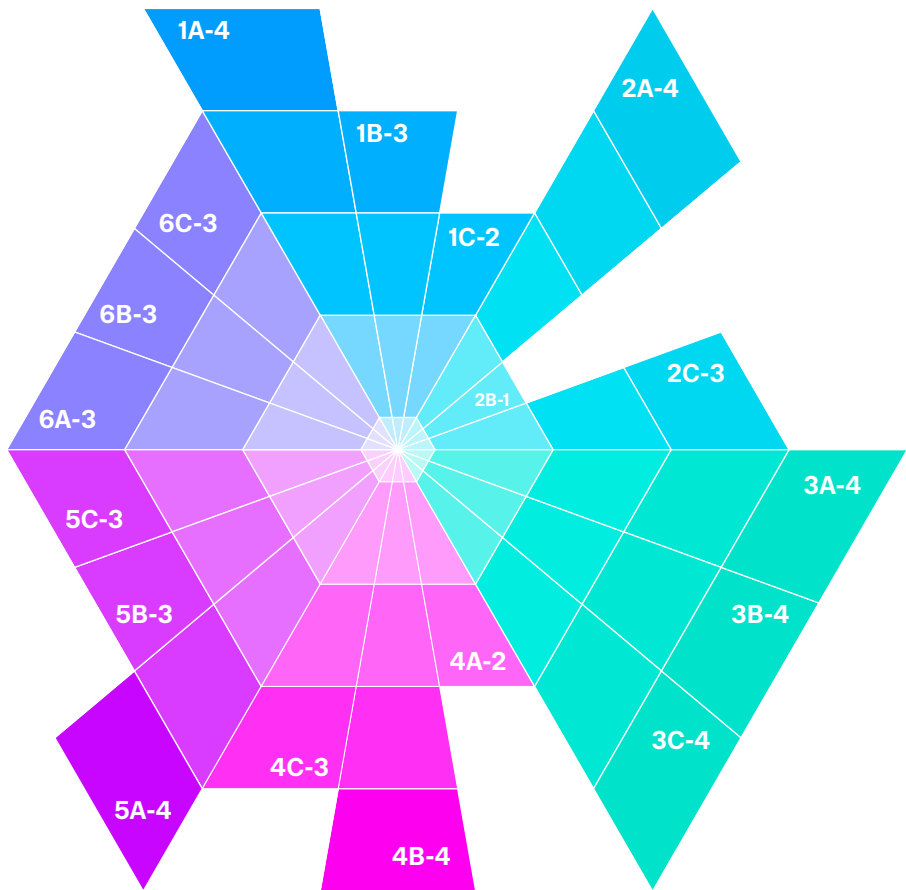


Figure 15: Schiphol Airport Compass

Compass Description

Schiphol Airport delivers not only people-centred objectives, but as an international multimodal transportation hub, meets multiple objectives on our compass. A green roof acts as a climate resilient, smart water storage solution ensuring that water is drained gradually during heavier rainfall (1A). The building is also 100% powered by offsite wind, and with an expanded electric fleet, is on-track to be a no-emission airport by 2030 (1B). The airport houses an array of retail units and open spaces for vendors, with a new strategy to establish a more Dutch offer with both well and lesser-known local brands, matched by popular international brands to create a unique experience (2A, 2B, 2C). The buildings are run efficiently in terms of sustainable heating and cooling, electricity, and mobility through the space (4B). A new smart buildings strategy is underway to increase connectivity, wellbeing and adaptability (6A, 6B, 4A, 4C).

Pragmatic

Case Study: Station of Art

Naples Art Station (Toledo), Naples, IT

ANM Azienda Napoletana Mobilità | Achille Bonito Oliva and various artists | 16 stations throughout Naples

Promoted by the Naples Metropolitan Council, Stations of Art makes public transportation environments more engaging and brings experiences of contemporary art to daily life. Working with artists to co-design underground stations removes the anonymity and homogeneity of stations, creates a sense of place, and reflects local identity within the historical and cultural context of the surrounding city. The use of art in stations creates a more attractive and user-friendly environment, creating new embodied experiences, often reducing anti-social behaviour, damage and long-term maintenance costs.

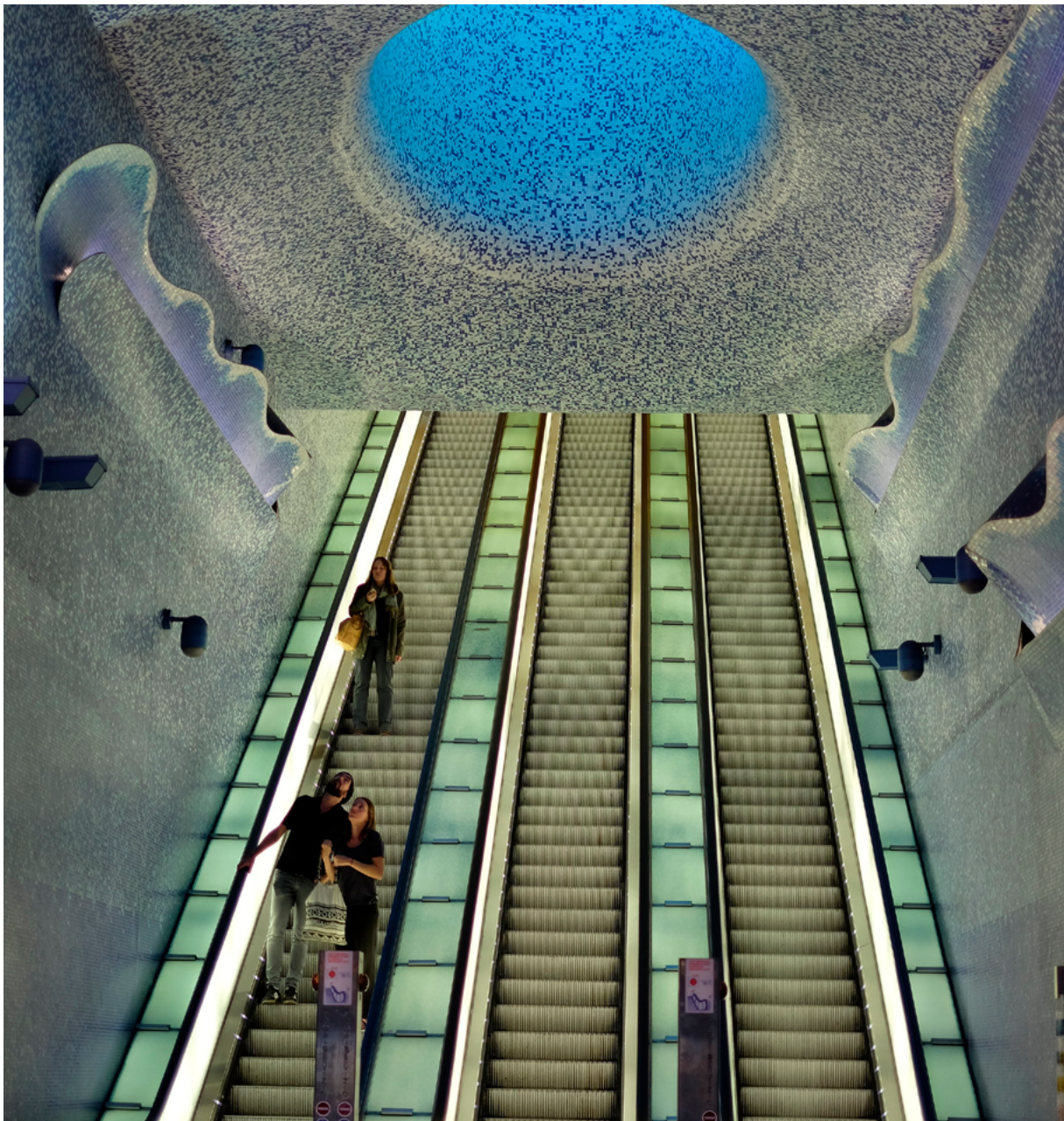


Figure 16: Users admiring the art installation at Toledo Station

Tactical

Digital Wayfinding

Inclusive and clear wayfinding is a way to build trust in a service, place and brand. With the use of mapping technology, digital wayfinding can empower passengers, offering real-time schedules, customisable directions, and revealing the mix of facilities on offer. It can help keep people moving and engaging in the place, decreasing congestion, reducing stress and confusion, and optimising routes based on distance, time, and accessibility. Beyond navigation, digital wayfinding captures insights into visitor behaviour and route popularity, boosting operational efficiency and revenue for clients. It can also be linked to facilities management and resource optimisation.

Inclusive public restrooms

To make the experience of public spaces more inclusive, designs can consider different cultures, identities, and lifestyles. The quality and offer of public restrooms are important for passengers, and while some may feel more welcome in gender-segregated restrooms, others may require multi-user facilities. The public restrooms at Gallaudet University include caregiving rooms equipped with changing tables, dry counters for medical procedures and showers which allow people of different cultures to perform ablutions. Taking a step beyond other gender-neutral bathrooms, it also includes a lounge, communal grooming and washing areas by the main path for everyone to feel safe.

Thinkscapes

Transforming small spaces into opportunities for children to play and learn, thinkscapes find ways to challenge minds. These STEM puzzles and activities stimulate cognitive development, and at the same time, helping children pass the time, converse, and interact with their carers. They can help with branding, making spaces more inclusive to young people.

Use of materials and patterns for inclusive design

Inclusive design for people with sensory impairments goes beyond visual detectors, automatic devices and signifiers. A more creative way to improve inclusivity can use colours, patterns and different materials in spatial design. Using contrasting materials can create visual stimulation and tactile cues while choosing colours and patterns that are comfortable for people with visual impairments can reduce stress when they navigate through the space.

Biophilic spaces

Biophilic design, or design that interacts with nature, can reduce the stress of travel and promote social interaction and gathering. This effect is evident at Singapore's Jewel Changi Airport where the world's largest indoor waterfall and indoor gardens create a vibrant attraction, a welcoming space for passengers and visitors, demonstrating the Airport's commitment to sustainability and biodiversity. In smaller buildings, pocket gardens can offer improved air quality and unique spaces for gathering and rest.



Figure 17: Child playing in an Urban Thinkscape, Philadelphia, USA

4

Operations

Our buildings and practices will enable efficient, agile and forward-thinking operations to improve services and staff wellbeing.

4 Operations

How can we plan for uncertain future conditions while ensuring continuous service delivery?

Objective 4A

Adaptability

Our buildings have a crucial role in meeting the demands of current and future transportation needs. To achieve this, our operations must be adaptable and responsive to changes such as population growth, technological advancements, resource depletion, economic shifts, expansion of services and evolving passenger behaviours.

While there are always unknowns we cannot predict, we can still take small steps today that will increase our adaptability in the long run. One way to achieve this is by designing or modifying buildings to include versatile spaces that can serve multiple purposes and host various events throughout the year. For instance, waiting areas can be used for events, and platforms can be utilized for temporary art exhibitions. Incorporating nighttime functions can also contribute to station finances and the local economy.

However, this can only be possible if our asset management is agile enough to address emerging operational needs. We have scope to increasingly apply predictive models in our decision making, installing sensors, and employing responsive systems to make our buildings more efficient. We can continue to lay the foundations to extend our digital and technological infrastructure in preparation for future modifications.

How can we save on costs, while increasing productivity, engagement, and satisfaction?

Objective 4B

Efficiency

Our buildings need to take a holistic approach to operational efficiency, considering customer needs, environmental sustainability, and financial stability. This means capturing needs and redundancies in everyday tasks, use of space, maintenance, and resource usage such as energy and water efficiency.

Our staff are key to the smooth and efficient running of all services and will understand better than most, what types of information are key to enabling more efficiency – be it through daily operations, maintenance, or design. Spatially, our stations require efficient circulation paths, crucial to handling the large volume of passengers moving in different directions. Alongside this, the access and maintenance requirements for all our assets are substantial. The more these are optimised, the more focus can be placed on smooth everyday operations and emergency planning – giving us breathing space to adapt and react to future unknowns.

Efficiency relies on both internal systems (crowd management, surveillance, communication systems, etc.), and external relationships (contracted partners, service and amenity offers, local communities and other infrastructure networks). Across all of these, integrating sustainable design principles can mitigate environmental impacts and reduce operating costs in the long term.

How do we improve staff wellbeing to support a happy, healthy, and productive workplace?

Objective 4C

Wellbeing

Promoting staff wellbeing goes hand in hand with some of the key considerations for people-centred design; to create a supportive, happy, productive, and healthy workplace. Making interventions in buildings that emphasise staff wellbeing fosters a supportive and inclusive workplace culture, encouraging a work-life balance that ultimately brings a wider added value.

Across our building types – whether customer-facing or back of house – our staff and their wellbeing are key to the running of our network. Personal comfort is closely linked to wellbeing, with ergonomic furniture, adjustable workstations and temperature control directly related to increased productivity and reduction in sickness and injury. Access to nutritious food, places to exercise, taking breaks and rest during the day help to reduce stress, allowing for enhanced cognitive function, improved mood and reducing the risk of accidents at work.

Relaxing communal spaces allow colleagues to decompress, gather and talk. Creating opportunities for staff to engage with one another can support better collaboration, improved efficiency, and increased performance by creating a social network. A holistic strategy that integrates these ambitions across all NR's buildings, culture, management, and community will embed wellbeing into the everyday business for all NR's staff.

Added Value

20%

Increase in employee productivity by having an accessible workplace

23%

Decrease in sick leave taken by employees with views of nature

12%

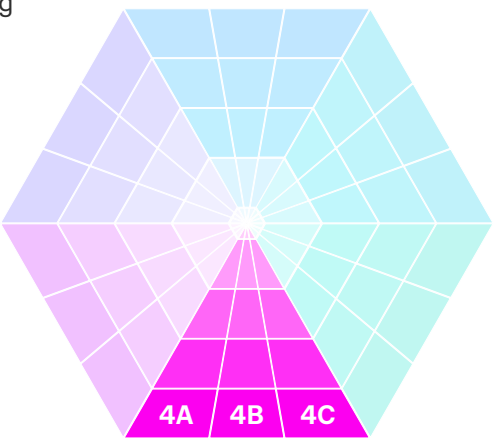
Improved cognitive function in buildings with better air flow and air quality

£2400

Annual productivity savings per employee where workplace has views and/or access to nature

87%

Employees consider health and wellness packages when choosing an employer



Ambitious

Case Study: Creating new ways of being together

Google Bay View Campus, Silicon Valley, USA

Google | Heatherwick Studio with BIG | 1.1 million sq ft | 2022

The Google Bay View Campus consists of three main buildings and is the first time Google has led the concept and construction of one of its office buildings. Google challenged the fundamental elements of a traditional office by prioritising human-centred and sustainable design to build a ‘canvas of creating new ways of being together.’



Figure 18: Interior view of Google Bay View Campus with spaces for informal conversations

4A Adaptability

The buildings were designed from the inside out to focus on employee experience and to create flexibility for the business. The main office has a flexible floor layout, using planter partitions, curtains, and transparent walls to create a ‘neighbourhood’ feel and allow teams to adapt the space to their needs. With the changing working mode and technological advancements, spaces for both physical collaboration and enhanced virtual collaboration have been built in.

4B Efficiency

The building houses the largest geothermal pile system in North America. The system is a more efficient way of heating and cooling buildings, reducing the amount of water typically used by 90%. The campus achieves water-positive performance by combining rainwater collection and wastewater treatment systems for on-site water recycling, and water retention ponds for nature restoration. The building uses dragon-scale solar roofing technology, where the angle and material of solar panels are designed and chosen to maximise energy efficiency. The building also uses automated window shading.

4C Wellbeing

One of the key aims for campus is employee health, happiness, and collective wellbeing, ensuring everyone has access to a healthy and productive environment. The building is designed to maximise indoor air quality, natural light, and thermal, visual, and acoustic comfort. Building materials are screened for toxicity to avoid any that are harmful to human and ecosystem health. To further improve employee wellbeing, ‘friction-free’ work experiences are created with places for quiet concentration and informal meetings.

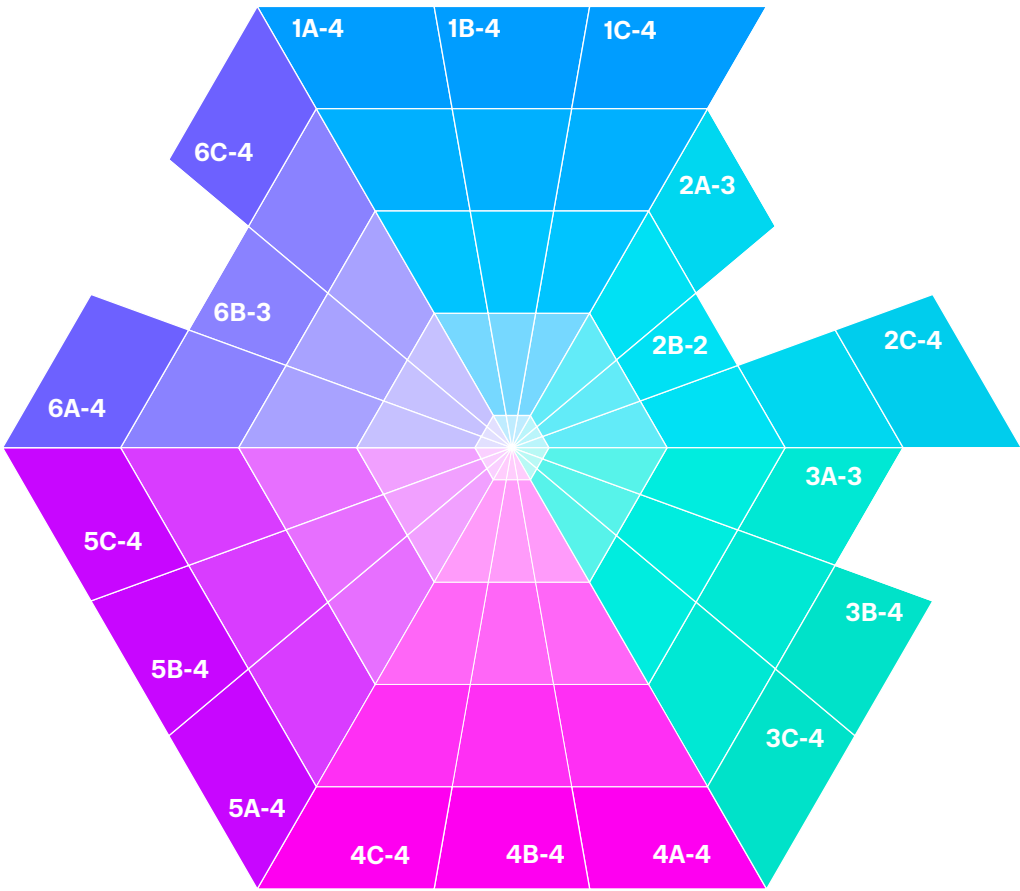


Figure 19: Google Bay View Campus Compass

Compass Description

Google Bay View is a flagship project for the company to push the boundaries of sustainable construction, operations, and company culture. The all-electric campus is also water-positive, establishing a restorative relationship with the adjacent San Francisco Bay, and has a geothermal pile system, unique solar panelled roof (1A, 1B), and has aimed to divert construction waste from landfills to create a circular building (1C). Inside, the building prioritises staff experiences, from the internal layout that promotes collaboration with a range of gathering spaces to foster inspiration and innovation (3C, 5A, 5B), to the use of healthy materials, with a sensitive approach to indoor daylight, acoustics, thermal comfort, and air quality (4C, 3B). The company is developing a supportive relationship with local communities by contributing to their infrastructure and quality of life while investing in local communities and schools to support local and long-term growth (2B, 2C). The entire building and its systems apply innovative smart infrastructure, actively collecting data on multiple operations and optimising resources, like their carbon-intelligent computing platform that automatically moves tasks to times when clean power sources are most plentiful (6A, 6B, 6C, 5C, 4A, 4B).

Pragmatic

Case Study: Staff Wellbeing Rooftop Garden Princess Anne Hospital, London, UK

Southampton Hospitals Charity, funded by Banksy Game Changer artwork donation | Strata Design | 690m² | 2023

In recognition of the sacrifices made during the pandemic to support the wellbeing of University Hospital staff, Southampton Hospitals Charity created a staff wellbeing rooftop garden. This garden offers all-hour access for staff to escape to a peaceful and calm green space. The garden features a sociable covered seating area with a refreshment kiosk, a more secluded area covered with grass, trees and plants and integrated seating for quiet reflection.

The roof also functions as a blue-green roof system through rainfall capture, storage, and reuse in an automated irrigation system. This increases the garden's resilience to drought events, reduces maintenance and manual watering requirements, and eliminates the need to use potable water for plant irrigation.



Figure 20: Staff Wellbeing Rooftop Garden, Princess Anne Hospital

Tactical

Efficient Waste Strategy

West One Shopping Centre, London, has achieved zero waste to landfill, by implementing a series of small but interlinked interventions including material choices, waste sorting, collection, recycling and reprocessing. By changing how they source everyday products, designing clearer labelling of public bins, offering customer discounts for recycling, and providing recycling training for tenant staff, they have increased mixed recycling by 118% in their first year, and improved their visitors' waste disposal behaviour overall. They have also increased separate food waste disposal by 96% and are using it to make compost on-site, distributed to tenants, team members and customers. The Shopping Centre has developed an educational network, sharing knowledge with local schools, and has ensured their waste collection fleet is certified carbon neutral.

Optimise Fresh Air

In the offices of the City of Hindmarsh Shire Council, initiatives to provide thermal and acoustic comfort, improve air quality and increase access to natural light have reduced the need for artificial heating and cooling. By designing an under-floor air distribution system that can be controlled by occupants, fresh air supply can be delivered closest to the user to maximise health benefits. Multiple studies have shown that increasing fresh air supply is a major contributor to enhancing the feeling of wellness, hence increasing productivity.

Wellbeing Initiatives

Studies show that 87% of employees consider health and wellness packages when choosing an employer. 67% of employees who work for organisations with wellness programmes tend to like their jobs more, remain driven and ambitious. Wellbeing programmes can include walking meetings, access to healthy snacks, wellness workshops and challenges. Where possible, bike storage, shower facilities, exercise facilities, and ergonomic designs can be provided in offices. It is important to tailor the initiatives and programmes to employee interests to maximise results.

Adapting to diversity

Creating a workplace that attracts diverse thinkers often brings creativity and innovative solutions to the workplace. It is important that a workplace welcomes neurodiversity and supports diverse needs for mental wellbeing. For some, enclosed or semi-enclosed spaces in the form of acoustic pods, privacy booths or shielded seating can provide respite from sensory overload. For others, better social spaces may be needed. Simple measures may include creating adaptive and multi-functional spaces, access to open spaces and ergonomic design.



Figure 21: City of Hindmarsh Shire Council Office

5

Culture and Leadership

Our practices and strategies will foster innovation, collaboration, and continuous learning to pilot new ideas and drive industry-leading standards.

5 Culture and Leadership

How can we apply new ideas and technologies to create the conditions where our teams can find solutions to the many pressing challenges we face?

Objective 5A

Innovation

As an organisation at the nexus of multiple challenges, while delivering continuous services to millions of people across the country, our role is to address problems with every intervention we make. To do that, we will need innovative thinking by enabling creativity in our practices and our buildings.

For our network to continue to be a successful service, we must pursue innovation through multiple modes – digital, material, and social – or a combination of these. We can achieve this by several means. First, our work environments can be designed to inspire our individuals and teams, accommodating different work styles, and fostering inspiration and communication. Studies show that integrating nature into the building design, natural lighting and flexible spaces contributes to stimulating everyday experiences that inspire creativity.

For these spatial applications to make a significant difference and shape creative thinking, we must identify how our leadership and management practices encourage our staff to think outside the box and empower them to explore and deliver new ideas. Furthermore, transparency concerning both our problems and successful solutions can encourage and inspire everyone to participate in driving innovation across the organisation.

How can we best leverage the different forms of knowledge in our teams and between our diverse stakeholders?

Objective 5B

Collaboration

Collaboration is both a means and an end. It is a salient element in improving problem-solving and innovation, raising morale and retention rates. It creates an overall more connected and efficient workplace, demonstrating to every employee the value they bring and the support they can receive.

Across our organisation, though we have many common goals, we also have different forms of expertise. Cross-disciplinary collaboration fosters the exchange of diverse perspectives and novel insights that lead to innovation. Collaboration with multiple stakeholders – across supply chains, local communities, industry partners, and academic institutions – can develop an ecosystem of different voices working together to drive holistic and integrated solutions.

Our buildings provide opportunities to bridge these differences by making social connections, both formally and informally. They can nurture collaboration in different spaces, such as open-plan areas, comfortable break-out rooms, lounges, and other spaces, where staff can share ideas. We can also seek collaborative efforts beyond our immediate work environments through online engagement.

How can we develop a culture of continuous improvement?

Objective 5C

Feedback and Learning

Creating feedback systems fosters a learning organisation that is continuously improving its operations, enhancing performance, supporting its talent, and achieving greater passenger and stakeholder satisfaction.

As a large organisation managing an extensive estate with multiple challenges, we are driven to increase our capacity to learn and develop from our staff, passengers, and stakeholders through loops of information exchange. Feedback from these different sources can drive a more agile and responsive service, identifying what we're doing right and where we need to improve in the future, to enhance our performance management.

Embracing feedback processes in our culture and leadership can reinforce staff confidence to speak up and act and encourage ongoing personal development. Across the organisation, it fosters open and transparent communication, developing a shared understanding of situations, aligning our drivers and objectives, and therefore improving decision-making on every level. When this extends outside of the organisation and reaches our many users, opportunities to give feedback and demonstrate its impacts improve satisfaction and loyalty.

Added Value

69%

Professionals prioritise working for an organisation seen as an innovation leader

50%

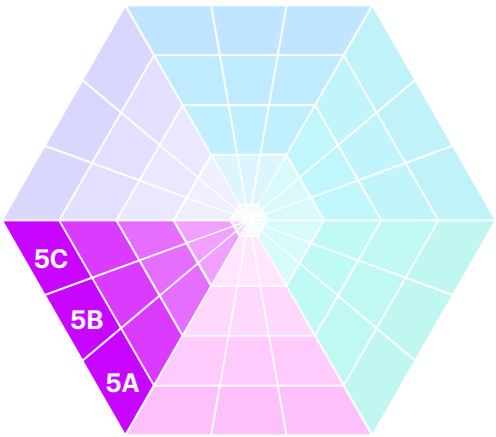
More effecient when staff complete tasks collaboratively rather than individually

80%

Time reduced in operational processes by implementing collaborative working and a culture of continuous improvement

73%

Global consumers believe brands have a responsibility to make a positive change in the world



Ambitious

Case Study: Embedding culture through value-driven leadership

Patagonia, USA

Patagonia

Patagonia is an outdoor clothing and gear company whose mission is to ‘protect our home planet’. In an industry known for its negative impacts, Patagonia is leading the way in environmental stewardship, a strategy that it carries across leadership, culture, and everyday practices, by achieving and reporting on sustainability targets, encouraging environmental activism and providing multiple learning and development opportunities.



Figure 22: A staff yoga class in the Patagonia office

5A Innovation

One of the company’s core values is developing new ways of doing things. This is embedded in their everyday practices and employee policies that promote curiosity, ambition, personal development, and growth. The company provides support for staff to ensure their wellbeing and drive, such as on-site childcare and 4-day work weeks every fortnight. Employees can access paid internships with environmental groups to pursue personal development and bring new knowledge to their teams. Everyone is encouraged to propose even risky responses to any problem and any opportunity to improve products.

5B Collaboration

Patagonia often rewards teams and team players on their performance, rather than individuals. They hold ‘town-hall’ type meetings in their open space offices, all employees can contribute and challenge ideas, and decisions are made by consensus. This creates a sounding board that holds the company accountable. In a sense, their corporate structure resembles a network so that everyone collaborates within and across teams. Collaboration extends to external stakeholders, as employees are encouraged to connect with change-makers and educators, among others, to act on pressing sustainability issues.

5C Feedback and Learning

Acknowledging they are part of an industry that does more harm than good, Patagonia seeks steady change to do better. They have replaced annual performance reviews with regular feedback through digital tools. They pursue a culture of generosity around feedback, ensuring that employees are asked for direct feedback, tending to result in more employees requesting feedback themselves. The wider company strategy shows a willingness to support the industry, openly sharing strategies and changing them when they receive negative feedback, while providing access to patented innovation for sustainable growth across the market.

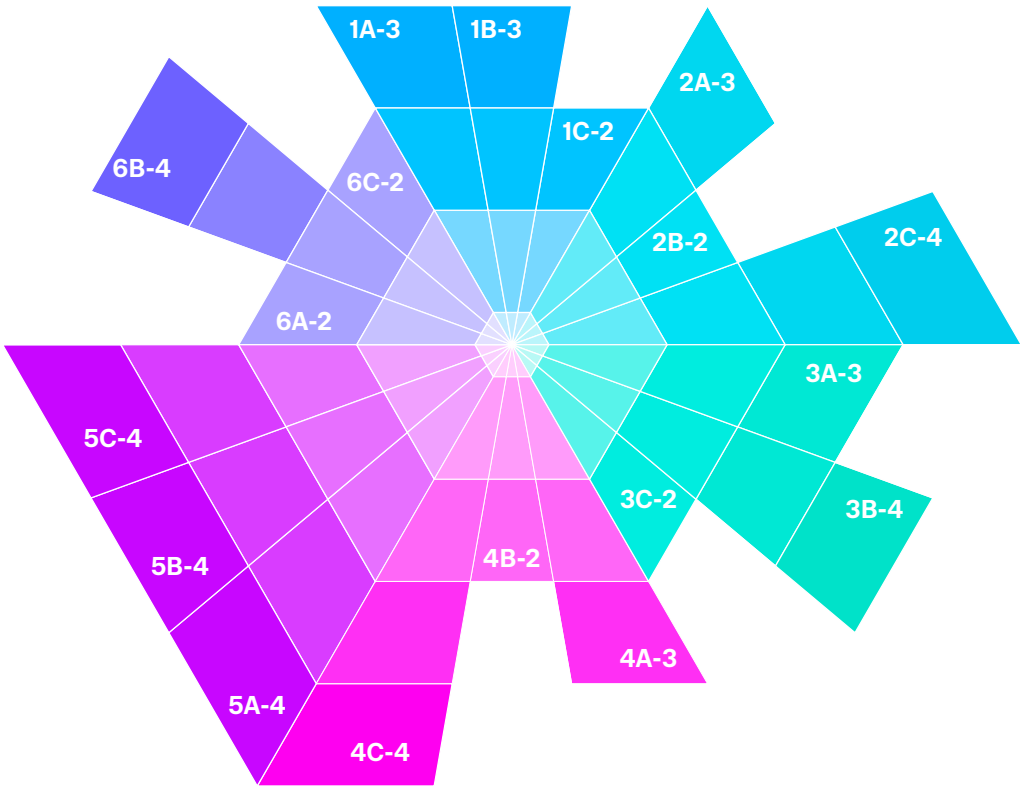


Figure 23: Patagonia Compass

Compass Description

As a mission-driven business, Patagonia focuses on certain key objectives that relate to our compass. Its buildings and production lines look to support communities and environmental groups to mitigate and reduce climate change, using 100% electricity from renewable sources, maximising recycled materials in their products, monitoring the chemicals and waste they produce to reduce quantity and ensure they are eco-friendly, and providing customers with online tutorials to enable at-home repairs of their products (1A, 1B). The company promotes investment by other companies and organisations to drive innovation, positive impacts in the market, and community development (2A, 2B, 2C). They promote adaptability by opening discussion spaces and reducing hierarchical practices in their company and do not prioritise efficiency over resilience, sustainability, and staff wellbeing (4A, 4B, 4C). Patagonia has installed a BlueSign system that gathers and analyses data on its supply chain to facilitate streamlined and transparent monitoring, evaluation, and reporting (6B).

Pragmatic

Case Study: Demonstrating commitment to learning and growth

Microsoft, USA

Microsoft

Microsoft achieves high levels of employee engagement by instilling a culture of growth mindset among staff. Their mission is to empower every individual to achieve more by valuing learning over knowing. The company offers learning opportunities through formal and informal training and encourages employees to actively seek on-the-job 'stretch' opportunities for both personal and career growth. Employees from all departments are welcome to join the annual collaborative Hackathon where new ideas are advanced and problems are solved. Microsoft believes potential can be nurtured by providing the right learning, at the right time and in the right way. 8.5 million people around the world have been trained and certified by Microsoft with in-demand skills for the digital economy over the past three years. In 2017, the Microsoft Hackathon had 18,000 participants from 75 countries. Since October 2021, Microsoft collaborated with 394 US community colleges (38% of all community colleges) across 49 states to advance cyber skilling.



Figure 24: Annual Microsoft Hackathon

Tactical

Connected Workspaces

Uniqlo offices are designed to create more connected spaces to inspire a creative, collaborative, risk-taking culture that fosters both individual thinking and group productivity. The objective is to provide employees a reason to leave their desks, with accessible social spaces, cafes, interior courtyards, and a library. Unlike standard office towers, Uniqlo City also has high ceilings and an abundance of windows. The new headquarters sees staff using every space, sofa and wall throughout the day to explore new ideas, collaborate and innovate.

Empowering Employees

Providing an internal whistleblowing channel builds a culture that empowers employees to raise concerns and builds brand loyalty. While whistleblowing has negative connotations, internal channels can empower staff to come forward anonymously and can help companies quickly respond to issues, understand employee experiences, and build trust through tangible responses. These channels can mitigate financial risks through brand protection, avoidance of theft and embezzlement, and lower legal fees.

Outdoor Meeting Spaces

Research shows that being in nature increases positive feelings, creativity, and focus, restoring the mind from the mental fatigue of work and time in front of screens. Microsoft built treehouses for outdoor meetings as part of a wider system of technology-enabled outdoor zones connected to office buildings and allowing employees to explore new ways of working to achieve more creativity and productivity.

Active Listening

Zara's approach to customer feedback is reflected across their business model, from supply chain to store development, product design to marketing. They have developed multiple modes through which to capture customer feedback and gather and process data to identify popular products, providing an evidence-base for business decisions to reduce risks and costs. Monitoring sales in real time allows them to monitor style, colour and fabric popularity by store, to remove and issue new products throughout the season. Customer engagement is further encouraged through newsletters and social media platforms to increase customer satisfaction, promote brand loyalty, and grow profits.



Figure 25: Microsoft Treehouse

6

Smart Infrastructure

Our buildings will form a network that seamlessly incorporates digital and physical infrastructure; gathering, measuring, and analysing data to inform and realise our future ambitions.

6 Smart Infrastructure

How can we optimise communications across our estate to support our ‘Mobility as a Service’ objectives?

Objective 6A

Connectivity

A crucial part of seamlessly enabling the flow of people, trains, information, and resources across our many buildings, lies in their interconnectivity. By creating digital systems to join the dots, we can optimise a building’s use, management, and maintenance in real-time.

Creating a virtual network that captures physical components and their condition, number, age, performance, and accessibility, can create significant short-term efficiencies, leading to long-term innovation. Furthermore, our passengers and stakeholders now expect more connectivity from us. With active travel schemes on the rise, more and more people are adapting their travel behaviour - moving between different modes of transport on a single route. Communicating changes in schedule or location with up-to-the-minute information through a connected network, can provide passengers with less stressful travel experiences, and build trust in our service as part of a wider travel network.

By applying intelligent systems, connected technologies can help to automatically regulate security, environmental conditions, communications, and accessibility to create a positive experience for passengers and optimise our operations.

How can we save on costs, while increasing productivity, engagement, and satisfaction?

Objective 6B

Data-Processing

For any organisation seeking to drive innovation, data is a strategic asset for understanding the ecosystem in which it operates and achieves its objectives. It enables organisations to monitor performance, track key metrics, and support data-driven decision-making.

Data processing refers to data collection, analysis, and translation into usable information. This process can support supervisors, managers, and other leadership teams in making effective decisions based on actual events and trends. Whether the objectives are to obtain customer insights or achieve regulatory compliance, data-processing practices can help to reduce risks, increase efficiencies, develop strategies, and facilitate reporting and distributing findings. By analysing and converting analysis into readable formats, data becomes a universal asset that can reach across the organisation to drive positive change.

Our organisation already generates and captures a great deal of data; however, we need to reflect on how it can best be operationalised for applied benefits. We need to increasingly question what data to gather and how advancing technologies such as artificial intelligence, should be used to process data, to lead to an increasingly informed decision-making system.

How can systems thinking change our business as usual?

Objective 6C

Systems Thinking

Systems thinking is a holistic approach to solving problems, focusing on inter-relationships and causality. It helps us to better understand why something is happening, and what strategic changes can be made to improve specific outcomes. A systems thinking approach can help us analyse problems, test new ideas and arrive at innovative, integrated solutions.

While there isn’t one single tool that constitutes systems thinking, there are workflows we can apply. Systems thinking is a diagnostic approach to examine problems in the round and understand their wider contexts, unpacking any assumptions we have. It can then challenge us to develop holistic solutions, with pathways of change that add value in multiple different ways simultaneously. Systems thinking encourages us to seek collaborative approaches across teams to achieve joined-up strategic objectives.

Systems thinking is at the core of addressing every principle in this document. It can help us better understand the connections between different aspects of our work, recognise dependencies between our objectives, and help unlock long-term value through smart decision-making.

Added Value

49%

Reduction in asset maintenance costs with predictive systems and smart infrastructure

55%

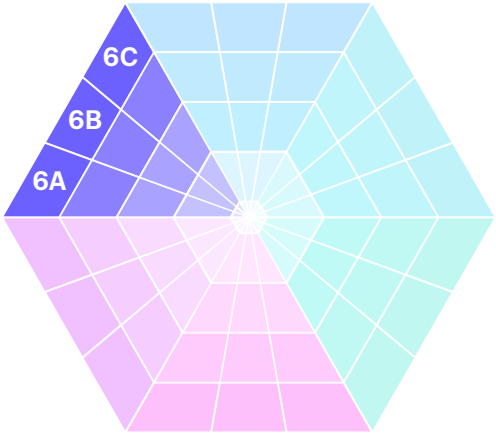
Increase in maintenance staff productivity with AI enabled system

41%

Energy cost savings per month from implementing a purpose-built smart infrastructure platform to streamline operational resources

85%

Potential improvement in downtime forecasting by using real-time data and insights



Ambitious

Case Study: AI-enabled predictive maintenance

Senseye Predictive Maintenance, Australia

BlueScope | Siemens | 2021 - ongoing

To enhance operational efficiency, Steel company BlueScope has implemented an AI-enabled predictive maintenance system, Senseye. It provides enhanced machine learning capabilities and streamlines human-machine interactions in their manufacturing plant to shift practices in industrial maintenance. This system enhances operational efficiency, reduces downtime, and lowers maintenance costs as it provides a way for machines not only to communicate, but collaborate with their human counterparts.



Figure 26: Integrated Senseye technology at a BlueScope plant

6A Connectivity

Connecting the digital network to the machines using Internet of Things (IoT) devices allows the system to monitor machine vibration and detect anomalies that could indicate damage before they break down. This allows preventative measures to be taken in advance and avoids or reduces often plant-wide downtime and associated financial losses. In addition, this connectivity enables BlueScope to manage resources and reduces in-person maintenance reviews.

6B Data-Processing

Senseye generates high-level statistical reports and assessments across key performance indicators and costs, informing investment and development decisions, and facilitating business case preparation. The software enables asset intelligence without the need for manual analysis. When combined with human insights and integrated with the data collected by other systems, Senseye can generate baseline models, allow fault detection, and direct resources to where it's needed the most.

6C Systems Thinking

Installing the Senseye platform caused a cultural shift within BlueScope towards preventative actions and streamlined, evidence-based decision-making. This smart infrastructure allows the individual and organisation to implement systems thinking, to think through challenges through a wider lens and to act upon dependencies in their system.

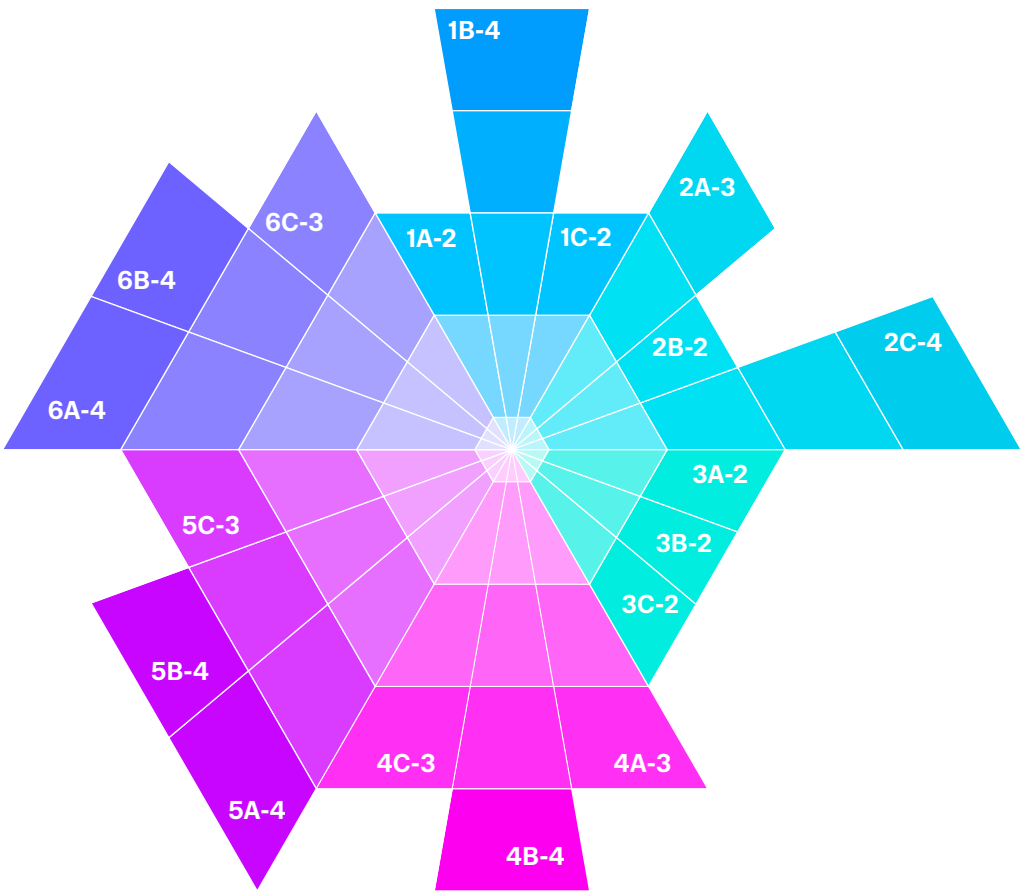


Figure 27: BlueScope Compass

Compass Description

Part of BlueScope's mandate is to develop sustainable innovation in the field of steel and metal coatings for construction. They therefore invest in decarbonisation, particularly low-carbon energy sources for steel production, and logistic monitoring and optimisation solutions (1B). As part of their environmental mandate and economic targets, they are looking to drive efficiency by managing daily operations (2C, 4B). They partner with stakeholders including their supply chain, competitors, regulatory bodies, and others to collaboratively challenge sustainability standards and drive innovation (5A, 5B), and have a culture of continuous improvement (5C). They have instituted an internal channel for employees to speak up and focus on inclusive hiring practices (3A) and have developed a health and wellbeing model to formalise commitments to their staff (3B, 4C). They also have programmes to encourage outreach and volunteering in local communities (2B).

Pragmatic

Case Study: AI-enabled Facilities Management Software

Louis Vuitton

Louis Vuitton | ServiceChannel | 2023

Louis Vuitton North America Division removed the burden of resolving repair and maintenance issues from stores and regional managers with AI-enabled Facility Management (FM) Software. The software speeds up and improves on the usual manual business analytic process which allows users to make intelligent, data-driven decisions. This is particularly useful for Louis Vuitton when selecting contractors, reviewing proposals, and scheduling maintenance. When integrated with other IoT networks, the software can predict faults, schedule preventative maintenance, and provide the company with a real-time benchmark on asset performance. Together with other FM improvement strategies, it has resulted in 96% reduction in daily time for employees spending on FM issues and reduced pricing concessions from vendors by 25-30%.



Figure 28: Louis Vuitton building exterior

Tactical

Remote monitoring

SMART digital systems are being increasingly applied to analyse and manage data obtained from infrastructure systems during their operation. IoT platforms provide real-time off-site monitoring, increasing reliability and reducing failures. In ROMEO, an innovative R&D project optimising operations and maintenance of offshore wind power facilities, intelligent solutions extend the lifetime of turbines and reduce the cost of operation and maintenance which reduces the cost of power generation. A digital twin model represents the behaviour of the structure as installed to apply predictive early fault detection. As data collection continues, it can be used to inform wind farm designs and further improve operation and maintenance strategies.

Digital Passport

A Digital Passport is an ID card for assets, listing their components and identifying their purpose, quantity, origin and location, technical and environmental characteristics, including the potential to recycle and reuse them. The Passport provides a green roadmap for buildings and infrastructure that helps monitor maintenance and replacements and understand whole-life impacts. It supports efficient operations including resource optimisation, mitigation of greenhouse gas emissions, waste reduction, and climate preparedness. It facilitates decision-making regarding the available use of materials considering cost, climate, and carbon impact, and tracks opportunities to recover residual value at the end of the asset's design life.

Optioneering Tech

Technology like Zero Emissions Building Roadmap Assessment tool (Zebrafish) can be used to decarbonise our built environment more efficiently by providing data-led insight and assisting decision-making. The software finds optimum pathways to achieving low and zero carbon solutions for existing buildings through comparative analysis of passive and active measures. This allows the user to make an informed decision, create cost-effective and sustainable strategies and prioritise their journey to Net Zero. The software has been used by Ramboll on the Sackville Building in Manchester to analyse over 7500 different options to decarbonise and achieve energy reduction in pursuit of Net Zero Carbon.

Workplace GPS

A smart workplace mobile app supports the development of McDonald's innovative and technology-enabled headquarters. The app enables a more efficient and personalised use of office space, including enhanced navigation, wayfinding support, and temperature control. The mobile app is connected to an indoor positioning system that enables location-based features, automatically booking desks and rooms via an internal GPS. Real-time occupancy, utilisation and comfort data are gathered, linking the mobile app, IoT and network sensors, to learn about and optimise operational efficiency.

Real-Time Twins

Seoul has implemented a digital twin system that connects its virtual and physical environment through an extensive landscape of sensors, the first of its kind at this scale. It allows cities to process data and respond to it in real-time using intelligent systems, ensuring seamless and safer service delivery and operational management. For example, air quality systems at schools measure fine dust and other harmful substances, temperature, and humidity, then automatically turn on air purifiers and ventilators when levels are exceeded. Traffic lights sense changes in light, humidity and congestion and adjust the length of green lights to make them safer for pedestrians. Crowd density detection systems alert district disaster prevention and emergency services to enable quick responses if needed. Water management sensors can respond to humidity and precipitation and take action to change drainage paths to reduce burdens on local systems. In addition, the Digital Twin system enables virtual community engagement to make the process more inclusive, cost-effective and efficient.



Figure 29: ROMEO project

This section provides interactive and printable templates for taking notes on baseline conditions and project priorities, intended to support thinking around the Compass. At the same time, we would appreciate any suggestions or feedback you have on the approach and its applicability, please contact the Buildings & Architecture team.

fill in template in PDF or on paper

Contents

Introduction

Smart Buildings Principles

Next steps

References

Applying the Compass

Business Case Formation

Business Case Formation

Project:

Year:

Name:

Type:

Baseline Assessment

Vision Development

Notes

0-4

1A Climate Resilience

0 1 2 3 4

1B Towards Net Zero

0 1 2 3 4

1C Regenerative Design

0 1 2 3 4

2A Promote Investment

0 1 2 3 4

2B Local Growth

0 1 2 3 4

2C Long-Term Value

0 1 2 3 4

3A Inclusive

0 1 2 3 4

3B Healthy

0 1 2 3 4

3C Vibrant

0 1 2 3 4

4A Adaptability

0 1 2 3 4

4B Efficiency

0 1 2 3 4

4C Wellbeing

0 1 2 3 4

5A Innovation

0 1 2 3 4

5B Collaboration

0 1 2 3 4

5C Feedback & Learning

0 1 2 3 4

6A Connectivity

0 1 2 3 4

6B Data-Processing

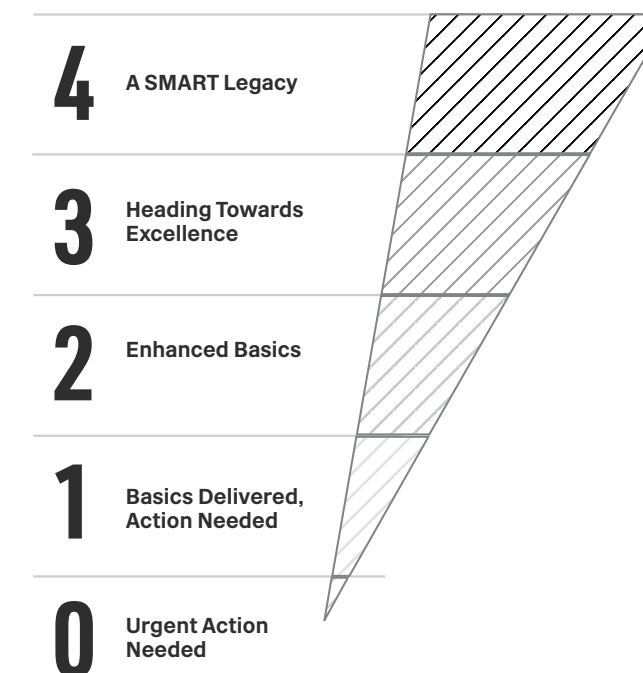
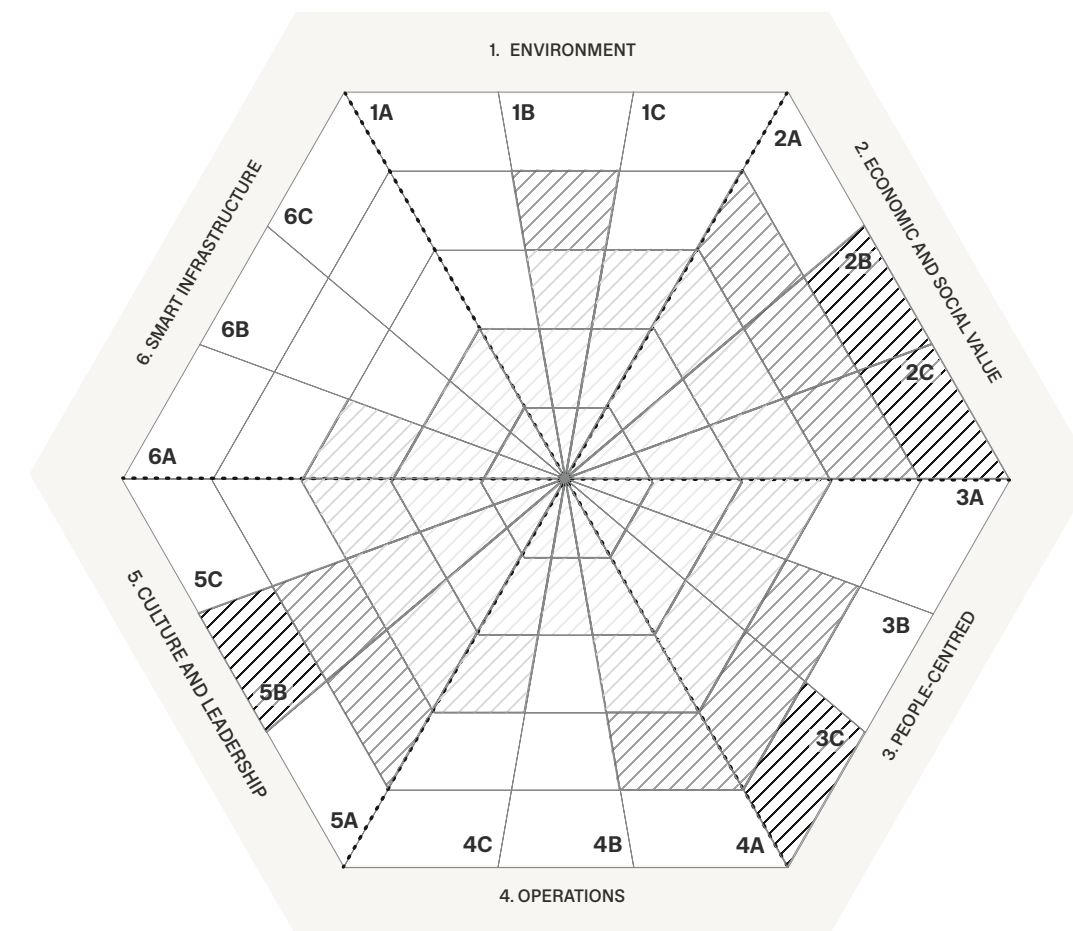
0 1 2 3 4

6C Systems Thinking

0 1 2 3 4

89

70



Business Case Formation

Project:

Year:

Name:

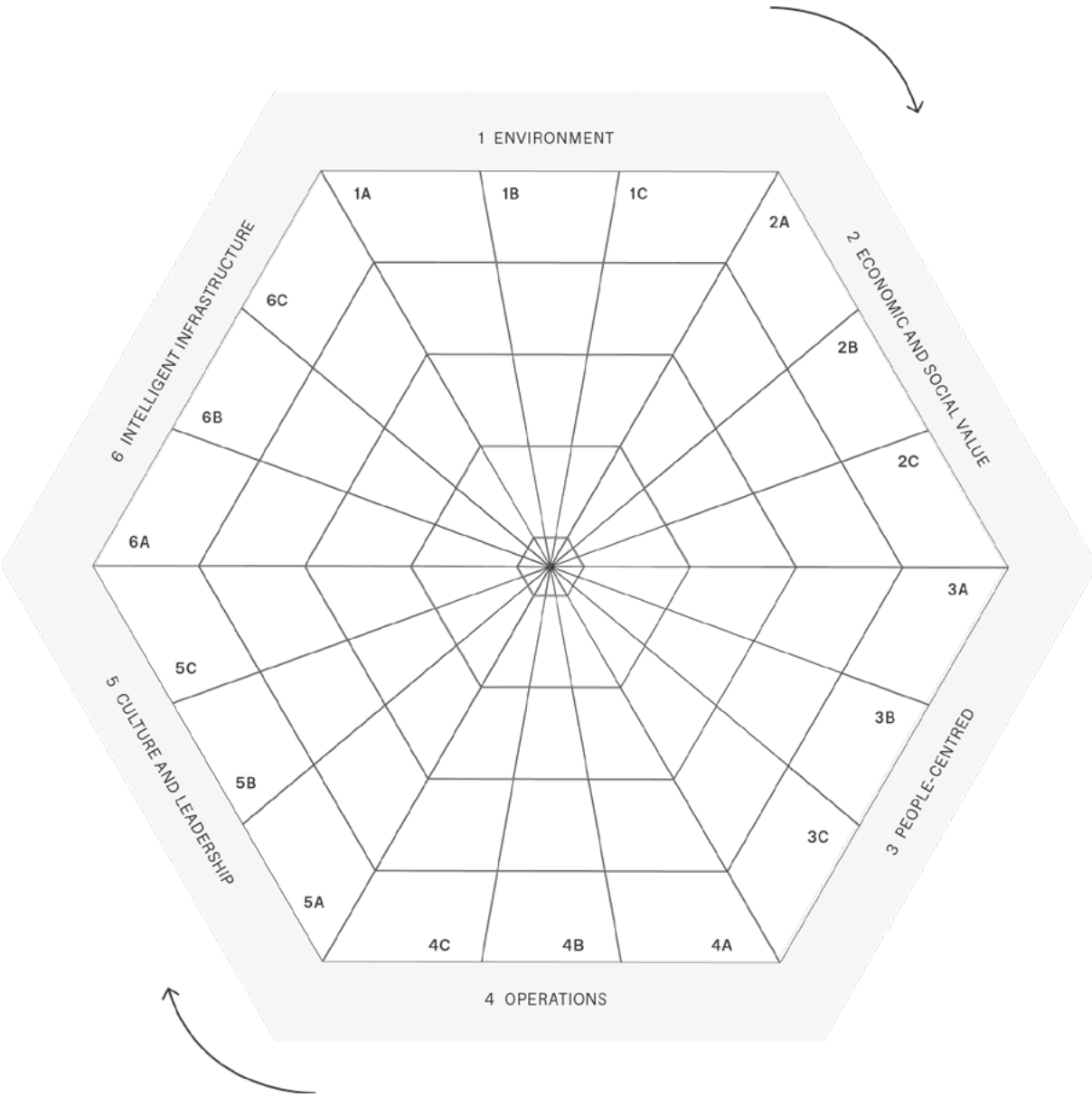
Type:

Baseline Assessment

☐

Vision Development

☐



	Notes	0-4
1A Climate Resilience		01234 ☐☐☐☐☐
1B Towards Net Zero		01234 ☐☐☐☐☐
1C Regenerative Design		01234 ☐☐☐☐☐
2A Promote Investment		01234 ☐☐☐☐☐
2B Local Growth		01234 ☐☐☐☐☐
2C Long-Term Value		01234 ☐☐☐☐☐
3A Inclusive		01234 ☐☐☐☐☐
3B Healthy		01234 ☐☐☐☐☐
3C Vibrant		01234 ☐☐☐☐☐
4A Adaptability		01234 ☐☐☐☐☐
4B Efficiency		01234 ☐☐☐☐☐
4C Wellbeing		01234 ☐☐☐☐☐
5A Innovation		01234 ☐☐☐☐☐
5B Collaboration		01234 ☐☐☐☐☐
5C Feedback and Learning		01234 ☐☐☐☐☐
6A Connectivity		01234 ☐☐☐☐☐
6B Data-Processing		01234 ☐☐☐☐☐
6C Systems Thinking		01234 ☐☐☐☐☐

REFERENCES

Added Value

Environment

UK Climate Risk (2021) *Flooding and Coastal Change: Findings from the third UK Climate Change Risk Assessment) Evidence Report 2021*. Available at: <https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Flooding-and-Coastal-Change.pdf> (Accessed: 8th April 2024).

U.S. General Services Administration (2021) *Green Roofs*. Available at: <https://www.gsa.gov/governmentwide-initiatives/federal-highperformance-green-buildings/resource-library/integrative-strategies/green-roofs> (Accessed: 12 February 2024).

Currie & Brown. (2019) *The costs and benefits of tighter standards for new buildings*. Available at: <https://www.theccc.org.uk/wp-content/uploads/2019/07/The-costs-and-benefits-of-tighter-standards-for-new-buildings-Currie-Brown-and-AECOM.pdf> (Accessed: 28 March 2024).

Field in Trust (2018) *Written evidence submitted by Fields in Trust (UGS0013)*. Available at: <https://committees.parliament.uk/writtenevidence/125517/pdf/#:~:text=Fields%20in%20Trusts%20own%20research,and%20offering%20social%20prescribing%20instead.> (Accessed: 4 April 2024).

Economic and Social Value

Allas T. (2021) *Opportunities for UK businesses in the net-zero transition*. Available at: <https://www.mckinsey.com/capabilities/sustainability/our-insights/opportunities-for-uk-businesses-in-the-net-zero-transition> (Accessed 28 March 2024).

Lawlor E. (2014) *The pedestrian pound - The business case for better streets and places*. Available at: <https://www.justeconomics.co.uk/uploads/reports/Just-Economics-Pedestrian-Pound-Living-Streets.pdf> (Accessed: 12 February 2024).

Tasker M. et al. (2018) *The pedestrian pound - The business case for better streets and places (Updated)*. Available at: <https://www.livingstreets.org.uk/media/2t0hyzcm/pedestrian-pound-2018.pdf> (Accessed 28 March 2024).

Love Lambeth (2018) *Positive impact of Pop Brixton leads to two-year lease extension by Lambeth Council*. Available at: <https://love.lambeth.gov.uk/pop-extension/>. (Accessed: 6 March 2024).

People-Centred

Faragher J. (2024) *How can inclusive building design support all people at work?* Available at: <https://dileaders.com/blog/how-can-inclusive-building-design-support-all-people-at-work/> (Accessed: 7 March 2024).

Brinded L. (2015) *This is the science behind how shopping centres make Britons spend £55 million in one minute*. Available at: <https://www.businessinsider.com/intu-ceo-david-fischel-shopping-centre-spending-trends-and-technology-2015-6?r=US&IR=T> (Accessed: 26 February 2024).

Soft Play (2018) *Soft Play brings a Jersey shore play area to life at Westfield Garden State Plaza*. Available at: <https://www.softplay.com/blog/playground-economics-grow-brick-and-mortar-business.> (Accessed: 26 February 2024).

Trotter L. et al. (2014) *Measuring the Social Impact of Community Investment: A guide to using the wellbeing approach*. Available at: <https://hact.org.uk/publications/measuring-the-social-impact-of-community-investment-a-guide-to-using-the-wellbeing-approach/> (Accessed: 26 February 2024).

Operation

The World Bank (2022) *The World Bank Technical Note on Accessibility*. Available at: <https://www.worldbank.org/en/topic/disability/publication/technical-note-on-accessibility> (Accessed: 23 February 2024).

Workman (2021) *The benefits of nature to health and wellbeing at work*. Available at: <https://www.workman.co.uk/nature-mental-health-wellbeing/>. (Accessed: 23 February 2024).

Selincourt K. and Palmer J. (2023) *Health, wellbeing and people performance*. Available at: <https://www.passivhaustrust.org.uk/UserFiles/File/research%20papers/Benefits%20technical/Health%20wellbeing%20and%20people%20performance%20v1.1%20230810.pdf> (Accessed: 23 February 2024).

Business in the Community (2021) *The power o nature for employee wellbeing*. Available at: <https://www.bitc.org.uk/wp-content/uploads/2021/05/bitc-toolkit-environment-ignition-thepowerofnature-may21.pdf> (Accessed: 23 February 2024).

Wein D. (2018) *Win With Wellness -- Attract And Retain Talent*. Available at: <https://www.forbes.com/sites/forbesbusinessdevelopmentcouncil/2018/08/27/win-with-wellness-attract-and-retain-talent/?sh=46681dd01648> (Accessed: 23 February 2024).

Culture and Leadership

Slaski C. (2018) *Innovation can make or break employee retention*. Available at: <https://www.forbes.com/sites/forbeshumanresourcescouncil/2018/09/04/innovation-can-make-or-break-employee-retention/?sh=34d89b0e2d27>. (Accessed: 7 March 2024).

Vitasek K. (2022) *Why collaboration yields improved productivity (and the science behind it)*. Available at: <https://www.forbes.com/sites/katevitasek/2022/03/08/why-collaboration-yields-improved-productivity-and-the-science-behind-it/?sh=26ba9aa5d559> (Accessed: 7 March 2024).

Dewar C. (2019) *How continuous improvement can build a competitive edge*. Available at: <https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/the-organization-blog/how-continuous-improvement-can-build-a-competitive-edge>. (Accessed 7 March 2024).

Rogers K. (2021) *The CEO Imperative: Make sustainability accessible to the consumer*. Available at: https://www.ey.com/en_uk/consumer-products-retail/make-sustainability-accessible-to-the-consumer. (Accessed: 24 February 2024).

Smart Infrastructure

JLL (2024) *London Workspace Reduced Electricity Consumption by 31.20% In 5 Months*. Available at: <https://www.jll.co.uk/en/case-studies/london-workspace-reduced-electricity-consumption-by-31-20-in-5-months> (Accessed: 16 February 2024).

Siemens (2023) *Senseye Predictive Maintenance*. Available at: <https://www.siemens.com/global/en/products/services/digital-enterprise-services/analytics-artificial-intelligence-services/predictive-services/senseye-predictive-maintenance.html> (Accessed: 16 February 2024).

Tactics: Project Details

Environment

Changeable landscapes

Cloudburst Management Plan
Copenhagen, Denmark
Ramboll and Ramboll Studio Dreiseitl

Heating from waste heat

Bunhill 2 Energy Centre
London, UK
Islington Council, TfL and Ramboll

Cool Microclimates

Paris Oasis School Yard Programme
Paris, France
Council of architecture, urbanism and environment of Paris

Change of Material

SEAT Martorell Plant
Barcelona, Spain
SEAT

Economic and Social Value

Reclaiming unused spaces

Tolworth Station
UK
Community Brain and SHEDx

Improving the view

The Memphis Poetry Panels
Tennessee, USA
UrbanArt Commission

Trip Chaining

CityPlaza
Hong Kong, China
Swire Properties

Filling in Local Gaps

Living Well Locally strategy and tool
UK
Ramboll

People-Centred

Digital Wayfinding

King's Cross Redevelopment
London, UK
King's Cross Central Limited Partnership (KCCLP),
Living Map

Inclusive public restrooms

Gallaudet University
Washington, USA
MIXdesign and Stalled!

Thinkscapes

Urban Thinkscape in Temple University
West Philadelphia, USA
Kaboom!

Use of materials and patterns for inclusive design

Boarding School for the Deaf
Gradignan, France
Pierre Goutti Karine Louilot Architects

Biophilic spaces

Changi Airport
Singapore
Safdie Architects and Butterfly House Consultancy

Operation

Efficient Waste Strategy

West One Shopping Centre
London, UK
Grundon Waste Management

Optimise Fresh Air

City of Hindmarsh Shire Council Offices, Hindmarsh,
Hindmarsh, Australia
K20 Architecture

Wellbeing Initiatives

Forbes Business Development Council

Adapting to diversity

N/A

Culture and Leadership

Connected Workspaces

Uniqlo City
Tokyo, Japan
Fast Retailing, parent company of Uniqlo
Allied Works Architecture

Active Listening

Zara
Arteixo, Spain
Inditex, parent company of Zara

Empowering Employees

Winningtemp
Gothenburg, Sweden

Outdoor Meeting Spaces

Microsoft Treehouse
Washington, USA
Microsoft and Nelson Treehouse and Supply

Smart Infrastructure

Remote monitoring

ROME0
Teesside, UK; East Anglia, UK; Wikinger, Germany
Consortium with 12 key players from 6 countries,
including Ramboll and University of Strathclyde

Digital Passport

British Antarctic Survey
Antarctic
Ramboll

Optioneering Tech

Zero Emissions Building Roadmap Assessment tool
(Zebrafish)
UK
Ramboll

Workplace GPS

McDonald's Headquarters
Chicago, USA
JLL

Real-Time Twins

Metaverse Seoul and other systems
Seoul, South Korea
Seoul Metropolitan Government

Images

Adobe Stock

1, 28

Network Rail

2

Ramboll

3, 4, 5, 7, 9, 11, 13, 15, 19, 23, 27, 29

ArchDaily

6, 18, 21, 25

de Architect

8

DepositPhotos

10

TfL

12

Schiphol

14

Girl From Naples

16

All Things Urban

17

FAAC Entrance Solutions

20

Visit Ventura

22

CNET

24

Siemens

26

Bibliography

General

Design Council (various years) Resources. Available at: <https://www.designcouncil.org.uk/our-resources/> (Accessed: 13 February 2024).

Enoch M. (2018) ‘Mobility as a Service (MaaS) in the UK: Change and its implications’, Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766759/Mobilityasaservice.pdf (Accessed: 13 February 2024).

National Infrastructure Commission (2020) Design Principles for National Infrastructure, Available at: <https://nic.org.uk/app/uploads/NIC-Design-Principles-Final.pdf> (Accessed: 18 August 2023).

Network Rail (various years) Strategy and Policy Documents. Available at: <https://www.networkrail.co.uk/industry-and-commercial/supply-chain/existing-suppliers/buildings-and-architecture-design-guidance/> (Accessed: 13 February 2024).

Steer (2020) ‘The Value of Station Investment’, Available at: <https://www.raildeliverygroup.com/about-us/publications/12843-2020-08-value-of-station-investment/file.html> (Accessed: 18 December 2023).

Environment

ArchDaily (2014) Suzlon One Earth Global Corporate Headquarters. Available at: <https://www.archdaily.com/466958/suzlon-one-earth-global-corporate-headquarters-christopher-benninger> (Accessed: 1 March 2024).

deArchitect (2021) The battle for the city roof (De strijd om het stadsdak) Available at: <https://www.dearchitect.nl/268082/de-strijd-om-het-stadsdak> (Accessed: 1 March 2024).

Holmes D. (2021) Hofbogenpark Rotterdam De Urbanisten. Available at: <https://worldlandscapearchitect.com/hofbogenpark-rotterdam-de-urbanisten/?v=79cba1185463> (Accessed: 26 February 2024).

Suzlon Energy Limited (2021) Suzlon One Earth. Available at: <https://www.suzlon.com/in-en/careers/one-earth> (Accessed: 1 March 2024).

Economic and Social Value

DepositPhoto (2019) Space that showcases the most exciting independent businesses from Brixton and Lambeth. Available at: <https://depositphotos.com/editorial/london-july-2019-pop-brixton-space-showcases-most-exciting-independent-298160372.html> (Accessed: 2 April 2024).

Transport for London Press Room (2023) Happy birthday, London Underground! Available at: <https://tfl-newsroom.prgloo.com/news/tfl-press-release-happy-birthday-london-underground-the-worlds-first-underground-railway-the-tube-celebrates-160-years-of-serving-the-capital> (Accessed: 15 March 2024).

Turner Works (2015) Pop Brixton. Available at: <https://turner.works/works/view/pop-brixton/> (Accessed: 26 February 2024).

People-Centred

Borbonica G. et al. New art stations of Naples Metro. Visit Naples. Available at: <https://www.visitnaples.eu/en/neapolitanity/discover-naples/new-art-stations-of-naples-metro> (Accessed: 24 February 2024).

Danin V . (2018) Architecture and Neuroscience collide to design conscious cities. All things Urban. Available at: <https://www.allthingsurban.net/blog/Architecture-And-Neuroscience-Collide-To-Design-Conscious-Cities> (Accessed: 6 March 2024).

Girl from Naples (2018) Underground Napoli: The Metro. Available at: <https://www.girlfromnaples.com/new-blog/2018/4/23/underground-napoli-the-metro> (Accessed: 1 March 2024).

Lisa. A (2011) Fun and fanciful Eco-Park sprouts up in Amsterdam Schipol Airport. Available at: <https://inhabitat.com/fun-and-fanciful-eco-park-sprouts-up-at-amsterdam-schipol-airport/maurice-mentjens-amsterdam-schipol-airport-park-5/> (Accessed: 24 February 2024).

Schiphol (2024) Experiences at Schiphol. Available at: <https://www.schiphol.nl/en/at-schiphol/discover/facilities/> (Accessed: 24 February 2024).

Operation

ArchDaily (2015) City of Hindmarsh Shire Council's new Civic Centre. Available at: https://www.archdaily.com/620282/city-of-hindmarsh-shire-council-s-new-civic-centre-k20-architetcure?ad_medium=gallery (Accessed: 24 February 2024).

Florian M. (2022) Google's Bay View Campus Designed by BIG and Heatherwick Studio Opens in Silicon Valley, California. ArchDaily. Available at: <https://www.archdaily.com/982121/googles-bay-view-campus-designed-by-big-and-heatherwick-studio-opens-in-silicon-valley-california> (Accessed: 1 March 2024).

Google (2022) Bay View and Gradient Canopy. Available at: <https://realestate.withgoogle.com/bayview/> (Accessed: 24 February 2024).

FAAC Entrance Solutions (2023) Princess Anne Hospital. Available at: <https://www.faacentrancesolutions.co.uk/our-projects/princess-anne-hospital/> (Accessed: 1 March 2024).

NHS Forest (2023) NHS Forest Awards Winners 2023. Available at: <https://nhsforest.org/blog/nhs-forest-awards-winners-2023/> (Accessed: 13 February 2024).

Strata (2022) Princess Anne hospital staff roof garden. Available at: <https://www.strata-design.co.uk/princess-anne-hospital-staff-roof-garden/> (Accessed: 13 February 2024).

Culture and Leadership

Martin J. (2018) Microsoft's mission to code for all. CNET. Available at: <https://www.cnet.com/pictures/microsofts-mission-to-code-for-all/> (Accessed: 1 March 2024).

McAlpine K. (2018) For 45 years and counting, Patagonia and Ventura continue to grow together. Visit Ventura. Available at: <https://visitventuraca.com/blog/for-45-years-and-counting-patagonia-and-ventura-continue-to-grow-together/> (Accessed: 1 March 2024).

Patagonia (2024) Business Unusual. Available at: <https://eu.patagonia.com/be/en/business-unusual/> (Accessed: 24 February 2024).

Rajagopal A. (2018) How Microsoft is making data-driven decisions to craft its new workplace design language. ArchDaily . Available at: https://www.archdaily.com/889448/how-microsoft-is-making-data-driven-decisions-to-craft-its-new-workplace-design-language?ad_medium=gallery (Accessed: 1 March 2024).

Ray S. (2017) Artificial intelligence eclipses cloud and mobile projects to win the day at Microsoft 2017 Hackathon. Available at: <https://news.microsoft.com/features/artificial-intelligence-eclipses-cloud-mobile-projects-win-day-microsoft-2017-hackathon/> (Accessed: 1 March 2024).

Smart Infrastructure

ROMEO Project (2024) Reducing the cost of offshore wind energy and boosting the renewables industry. Available at: <https://www.romeoproject.eu/> (Accessed: 24 February 2024).

ServiceChannel (2023) Case Study: Louis Vuitton. Available at: <https://servicechannel.com/case-studies/louis-vuitton/> (Accessed: 24 February 2024).

Siemens AG (2023) Blue Scope: Increased operational efficiency. Available at: https://assets.new.siemens.com/siemens/assets/api/uuid:22961a8f-d2c0-455c-b3f2-f934d19a2fa5/BLUESCOPEV2_original.pdf (Accessed: 28 March 2024).

Siemens AG (2024) Welcome to the Senseye Predictive Maintenance resource hub. Available at: <https://www.siemens.com/global/en/products/services/digital-enterprise-services/analytics-artificial-intelligence-services/predictive-services/senseye-predictive-maintenance/resources-hub.html> (Accessed: 1 March 2024).

Meet the Team

Project lead



Dr. Garry Bosworth
Principal Engineer - Technical Authority, Buildings and Architecture, Network Rail

Garry is an expert in the built environment with a proven track record of programme management including delivery of award-winning sustainable buildings, retrofit energy efficiency programmes and cutting-edge innovation.

Authors



Dr. Shira de Bourbon Parme
Urban Innovation Lead
Ramboll, Regenerative Cities

Shira is an urban development planner and social anthropologist with over 20 years of experience merging design with social science. She embeds wellbeing-focused, life centred strategies into projects, and develops systems thinking to create regenerative solutions for the built environment and its communities.



Amanda Chan
Digital Urbanism Lead
Ramboll, Regenerative Cities

Amanda has seven years of environmental consultancy experience with a focus on impact assessment and digital solutions. She leads on delivering integrated digital tools to support cities in tackling their most complex challenges, and meet their interdependent objectives.



Greg Perkins
Visual Design Consultant
Ramboll

Greg has 10 years' experience of graphic design output in the engineering consultancy sector. His work across digital and print formats focus on concise communication and accessibility. He has previously assisted with production of Network Rail Design Manuals.



Aimee Jones
Senior Economist
Ramboll

Aimee is an economist with six years of experience. Aimee uses economic tools to incorporate climate considerations, nature and social value impacts on strategic and project-level decision-making. Aimee manages innovation projects that seeks to better capture the value of place.

Steering group



Anthony Dewar
Buildings and Architecture
Network Rail

Anthony is a chartered engineer with over 20 years' experience. Managing Network Rail's extensive built portfolio, and as a member of the National Infrastructure Commission Design Group, he elevates design quality and innovation within Network Rail and the wider industry.



Dean Timms
Director
Ramboll

Dean is a chartered engineer with over 20 years' experience. As Head of Department for Services South in Ramboll, Dean led the NR low/zero carbon plant room design guide. Dean's ability to see the bigger picture and interest in sustainability allows solutions that are innovative whilst still being practical.



Stefanie O'Gorman
Director
Ramboll

Stefanie is the Director of Sustainable Economics in Ramboll with 20 years' experience. Stefanie is a member of the Scotland Climate Emergency Response Group and an expert in strategic sustainable development and decision-making guidance.



Kosh Kar
Director
Ramboll

Kosh is a chartered architect leading Ramboll's Regenerative Cities Team. Kosh is passionate about the value of good design and driving a collaborative approach that incorporates all aspects of diverse communities.



Catherine Gray
Director
Ramboll

Catherine is a Director in the Building Services Team in Ramboll with 19 years' experience in the consulting and construction industry. Catherine has previously led the Electric Vehicle Charging Points and Associated Infrastructure Design Manual.



Michael Toher
Head of Rail UK
Ramboll

Michael is a chartered engineer with 31 years' experience. Michael operates at a strategic level and leads the Network Rail Account in Ramboll. Michael has been working with Network Rail since 2001 and is currently working to support Network Rail's modernisation of rail system.



Appendix E WRCCA Maturity Evaluation

Benchmarking WRCCA Maturity across regions		Eastern Region	North West and Central Region	Wales and Western Region	Southern Region	Scotland Region
1. Governance		Achieved	Achieved	Achieved	Achieved	Achieved
1.1 Strategy						
No strategic overview described, no overall targets for climate resilience	0	3	1	3	2	3
Limited strategic overview provided, no overall targets for climate resilience	1					
Sufficient overview of strategic plan and brief mention of targets for climate resilience	2					
Good overview of strategic plan, targets for climate resilience provided	3					
Very clear overview of strategic focus, clear and measurable climate resilience targets provided	4					
1.2 Leadership		Achieved	Achieved	Achieved	Achieved	Achieved
No governance or leadership structure described	0	3	3	3	1	3
Little mention of governance or leadership structure	1					
Sufficient description of leadership and governance structure	2					
Governance structure described, decision making process outlined	3					
Governance structure fully described, clear decision making process outlined	4					
2. Methodological alignment		Achieved	Achieved	Achieved	Achieved	Achieved
2.1 Best Practice Alignment						
Not aligned or never aligned	0	2	2	3	2	3
Little alignment or aligned in only a few occasions	1					
Sufficient alignment and aligned frequently	2					
Good alignment, most of the time	3					
Best practice alignment, always	4					
2.2 Standards applied		Achieved	Achieved	Achieved	Achieved	Achieved
No codes or standards discussed	0	3	1	2	1	1
Some codes for climate resilience discussed	1					
Most codes for climate resilience discussed	2					
Most important codes for climate resilience and buildings discussed	3					
All relevant codes for climate risks and buildings applied and discussed	4					
3. Integration		Achieved	Achieved	Achieved	Achieved	Achieved
3.1 Systems, Processes & People						
No evidence of collaboration	0	2	3	3	1	2
Limited description of collaboration	1					
Some description of collaboration, future plans mentioned	2					
Interaction with relevant stakeholders described, future plans discussed	3					
Full description of interactions with stakeholders with evidence, future plans discussed	4					
3.2 Mainstreaming		Achieved	Achieved	Achieved	Achieved	Achieved
No integration of climate resilience into a BAU approach	0	1	3	2	3	2
Limited integration of climate resilience into a BAU approach	1					
Some progress in integrating climate resilience into BAU	2					
Good progress in integrating climate resilience into BAU	3					
Assessing and improving climate resilience has been mainstreamed into BAU	4					
4. Capability		Achieved	Achieved	Achieved	Achieved	Achieved
4.1 Ability to Understand						
No metrics for monitoring climate impacts, no understanding of asset condition, or risks to buildings	0	3	3	2	1	3
Some metrics to monitor climate impacts, little understanding of asset condition, limited discussion of risks to buildings	1					
Detailed climate risk metrics and targets for railway and buildings, some knowledge of asset condition, good discussion of risks to buildings	2					
Good description of metrics for railway and buildings, good understanding of asset conditions, detailed risks to buildings	3					
Detailed metrics and targets for railway and buildings, full understanding of asset condition, thorough examination of risks to buildings	4					
4.2 Ability to Implement		Achieved	Achieved	Achieved	Achieved	Achieved
No technical capability demonstrated and no targets presented	0	2	3	2	1	3
Limited technical capability demonstrated, basic targets outlined	1					
Sufficient technical capability demonstrated, no building specific adaptation targets	2					
Good technical capability demonstrated, targets outlined for railway and buildings	3					
High technical capability demonstrated, clear and measurable targets for improving resilience of buildings	4					
5. Resources		Achieved	Achieved	Achieved	Achieved	Achieved
No mention of resources available	0	2	2	2	1	3
Limited resources and significant gaps in most areas	1					
Sufficient resources but no consideration of risk to buildings	2					
Most resources in place for implementing climate adaptation and strengthening resilience	3					
Good resources in place for continual improvement and innovation	4					

Appendix F Good Practice case studies

Network Rail Adaptation Pathways

The adaptation pathways approach, which is part of NR's approach, is considered to be global best practice in adaptation planning as it supports strategic, robust, flexible and structured decision-making. In the context of NR, it enables each region to identify the most appropriate risk management option for a particular risk or area. To create a pathway, the methodology (NR/GN/ESD41 Issue 2)³³ identifies three key questions that must be considered:

1. Are there climate change impacts that render current assets or services inefficient, ineffective, unsafe or redundant (i.e., the climate threshold beyond which the asset or service does not function)?
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?

This structure allows each region to identify and prioritise adaptation measures to manage climate change impacts effectively and helps align to long-term strategic challenges.

Department for Transport's 'Fit for Changing Climate? Adapting the UK's transport system'

Over the next five years, the Department of Transport (DfT) has identified policies and actions as part of a long-term strategy to encourage adaptation action across the transport sector. These policies and actions are grouped into three themes including 'Culture – Embedding Climate Risk', 'Economics – Making the case for adaptation', and 'Regulatory – Setting-the long-term direction'. Collaboration and sharing knowledge underpin each of these themes, as the DfT has identified that bringing transport operators together to share best practice will help to address independencies within transport and wider infrastructure. The key policies that will enable knowledge sharing across transport operators include:

1. Utilise forums to drive industry collaboration, including Infrastructure Operators' Adaptation Forum (IOAF), Transport Research Innovation Board and the UK Roads Leadership Group.
2. Transport infrastructure operators to identify and map their interdependencies across all sectors.
3. Transport infrastructure operators to enhance their adaptive capacity by providing training to relevant staff.

Sustainable Rail blueprint

The Sustainable Rail Blueprint³⁴ developed by the Rail Safety and Standards Board is the industry-wide blueprint for a sustainable rail sector and includes the industry's preparation for climate change. The five elements enabling climate change preparation are presented and explained in the next paragraphs.

³³ [Climate Change Adaptation Pathways](#)

³⁴ [Sustainable Rail Blueprint](#)

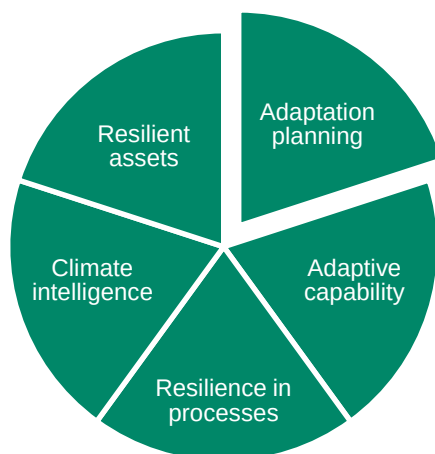


Figure 20: Five elements contributing to being prepared for climate change (adapted from the Sustainable Rail Blueprint).

- **Adaptation planning:** Develop long-term, flexible adaptation pathways to guide strategic investment, enhance resilience of infrastructure and rolling stock, and integrate nature-based solutions for sustainability benefits.
- **Adaptive capability:** Build skills, guidance, and conduct regular climate maturity assessments to ensure staff can embed climate considerations into decision-making.
- **Resilience in processes:** Integrate adaptation into core business processes, standards, and supply chains, and establish metrics to measure operational resilience.
- **Climate intelligence:** Use technology and data for monitoring, modelling, and risk analysis to improve understanding and management of weather impacts.
- **Resilient assets:** Shift from reactive repairs to proactive investment in infrastructure, buildings, and rolling stock to withstand extreme weather.

Adaptation and resilience in HS2

The Climate Change Adaptation and Resilience Adaptation Reporting Power Fourth Round³⁵ shares valuable experience on processes, initiatives and activities related to the HS2's climate adaptation and resilience strategies. The HS2 organisation embedded climate adaptation and resilience in multiple ways, including working with their supply chain, as well as with industry and academia.

HS2 has implemented a bespoke climate change adaptation and resilience process to ensure railway designs can withstand future climate risks. This includes a dedicated design standard, evidence-based assessments and mandatory reports from contractors. The Climate Change Design Impact Assessment assesses the suitability of HS2 design standards to future climate change and identifies where additional allowances may be required. The Climate Change Resilience and Interdependencies Assessment categorises, assesses and prioritises risks arising from climate change impacts on HS2's interdependent infrastructure. The Climate Change Adaptation and Resilience Reports demonstrate that climate change has been considered in design, including requirements for further analysis of specific risk and asset combinations.

HS2 also collaborates with transport industry partners, standards bodies, and academia to advance climate change adaptation and resilience in infrastructure. These partnerships enable knowledge sharing, research, and development of best practices. Key initiatives include stakeholder collaboration through forums like the Infrastructure Operators Adaptation Forum (IOAF) and the Rail Safety and Standards Board (RSSB) to promote cross-sector resilience and work with the RSSB and Department for Transport to help standardise climate scenarios for risk assessments.

One of the most significant aspects of delivering adaptation is about having an action plan that allows HS2 to measure progress and links actions at different levels, with a variety of stakeholders. **Table 22** presents HS2's

³⁵ [HS2 Climate Change Adaptation and Resilience Report - Fourth Round / APR4 submission - HS2](#)

adaptation action plan, taken from its Fourth Round of Climate Change Adaptation and Resilience Adaptation Reporting Power.

Table 22: HS2 Adaptation action plan (adapted from the Climate Change Adaptation and Resilience Adaptation Reporting Power Fourth Round).

Action	Action to address risks
1. Governance and risk management	Ensure climate risks are managed throughout the project with governance and risk management.
2. Collaborations	Host regular meetings to bring together engineers, designers and environmental managers including the HS2 Climate Change Adaptation and Resilience Forum and HS2 Collaboration Group.
3. CCARRs	Ensure designers and contractors develop and submit CCARRs.
4. Adaptation Reporting Power (ARP) reporting	Provide updates on the adaptation progress across the project in future ARP reports.
5. Task Force on Climate-related Financial Disclosure (TCFD)	Provide annual disclosures covering climate adaptation in HS2's Annual Reports and Accounts, in line with the requirements for TCFD reporting for arm's-length bodies, as set out in HM Treasury sustainability reporting guidance.
6. Metrics	Develop metrics for climate adaptation and resilience for the construction and operation phases of HS2.
7. Construction	Ensure the impacts of climate change on construction are assessed and monitored, meeting the requirements in the Phase One HS2 Code of Construction Practice.
8. Operational planning	Undertake operational planning to ensure resilient HS2 operations including risk management of weather and climate change as well as extreme weather and seasonal changes. This includes the ability to monitor performance during operation to provide insight and allow further adaptation of HS2 assets to climate change.
10. Adaptation pathways	Develop adaptation pathways guidance for HS2 assets and case studies, including monitoring requirements. Support industry-wide initiatives to develop pathways and provide feedback and learnings from implementation experience.
11. Interdependencies	Work with partners, supply chain and stakeholders to achieve our climate change adaptation and resilience objectives, including managing interdependent climate risks.
12. Innovation	Engage in industry and academic partnerships to develop understanding of climate change adaptation and resilience. Seek opportunities to innovate and share knowledge.
13. Engineering design standards	Continue to embed climate change considerations in engineering design standards where practicable given HS2 design stage, and share lessons learned to improve industry standards.

San Diego International Airport climate resilience plan

The San Diego International Airport climate resilience plan establishes a structured approach to strengthening climate resilience by adapting current infrastructure and operational practices while integrating future climate considerations into upcoming projects. The strategy is centred on three key focus areas:

- Governance: how climate-related decisions are managed
- Awareness: how knowledge and understanding are built
- Infrastructure: how facilities are designed and constructed to withstand changing conditions.

The climate resilience plan defines a long-term vision for creating a more resilient airport, setting clear goals, targets, and metrics for 15 to 20 years. These objectives are supported by a comprehensive set of initiatives designed to minimize disruptions caused by future climate impacts. To ensure effective execution, the plan includes a robust monitoring and implementation framework that serves as an operational tool for tracking progress and maintaining alignment with the San Diego County Regional Airport Authority's resilience strategy.

The plan begins with a vision to guide long-term resilience, followed by an impact assessment to identify vulnerabilities. Goals were then set to define desired outcomes, each supported by measurable targets. Initiatives were developed to address vulnerable assets, alongside identifying funding opportunities and creating a monitoring and implementation plan to ensure progress and successful execution.

Identifying and securing funding was highlighted as a critical element for implementing the initiatives in the plan. The San Diego County Regional Airport Authority committed to monitor grant opportunities and leverage funds from their operating budget and capital improvement programs. Climate resilience was expected to be increasingly integrated into all capital projects as a design requirement; nevertheless, there was a level of uncertainty on whether traditional funding sources would cover the added costs of ensuring resilience.

Adaptation of Melbourne's Metropolitan Rail Network in response to climate change

The Adaptation of Melbourne's Metropolitan Rail Network in response to climate change³⁶ presents a good practice example, linking operational considerations of the rail network to climate change induced hot weather events. One of the key purposes of this was to identify a performance indicator which would enable the modelling of the likely impact of future weather events on the train network. Although this study is not building-focused, it provides a good practice example of quantifying historic and future weather events, modelling climate change with and without adaptation and thus identifying the optimum adaptation options based on a cost-benefit analysis for different climatic scenarios.

Figure 22 shows a summary of the process followed to identify and prioritise adaptation measures for Melbourne's Metropolitan Rail Network through a robust and quantifiable approach.

³⁶ Adaptation of Melbourne's Metropolitan Rail Network in Response to Climate Change [Adaptation of Melbourne's Metropolitan Rail Network in Response to Climate Change](#)

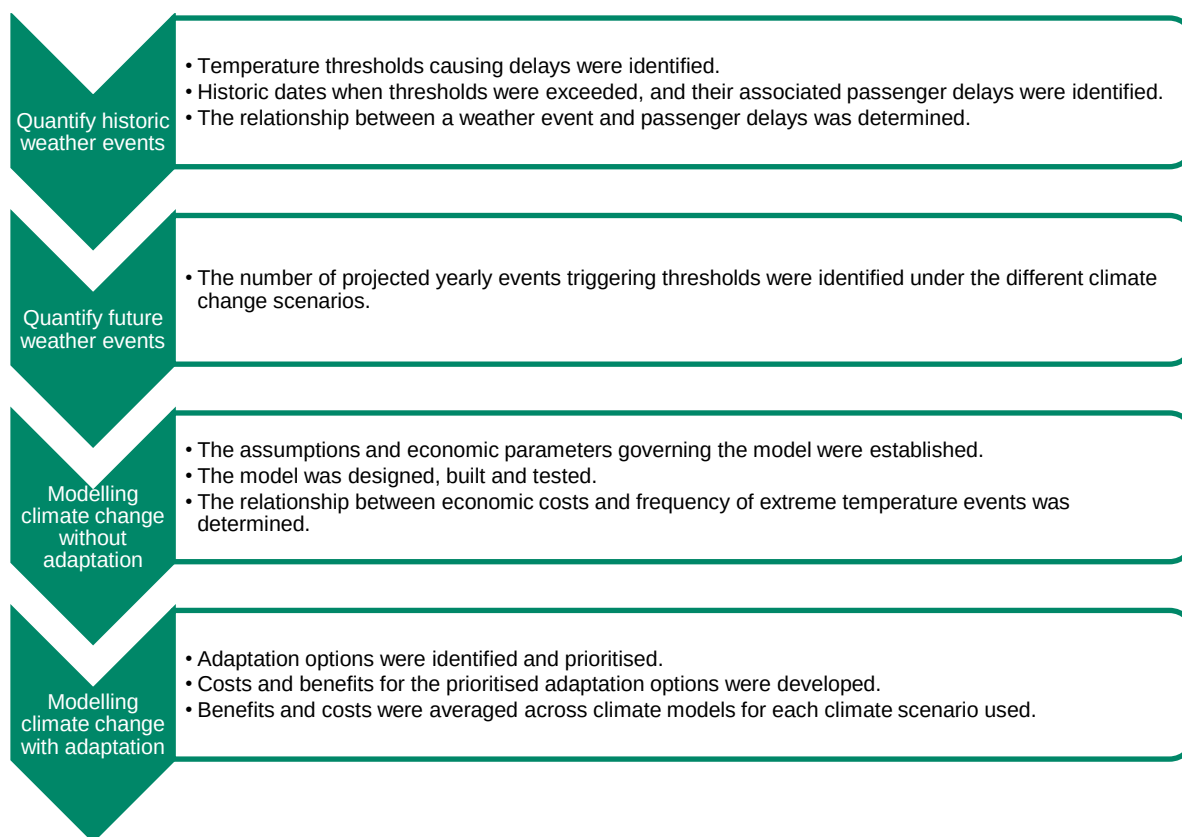


Figure 21: Study methodology and key outcomes per stage.

Association of University Directors of Estates Climate Change Adaptation and Resilience Guide

AUDE's Climate Change Adaptation and Resilience Guide provides a good practice example recently developed for University stakeholders. The guide is structured based on the following five dimensions:

- **Physical:** Direct damage to buildings and infrastructure from flooding, storms, and extreme heat.
- **Operational:** Disruptions to core functions like teaching, research, and campus services.
- **Health and Safety:** Increased risks to wellbeing from heat stress, poor air quality, and related health issues.
- **Economic:** Financial impacts including repair costs, insurance, reduced student mobility, and adaptation investments.
- **Reputational:** Effect of climate response on public image, stakeholder trust, and global rankings.

A catalogue of adaptation measures has been developed focusing on the following:

- Drought and dry weather.
- Heat/high temperatures.
- Flood and sea level rise.
- Heavy rainfall and storm.
- Wildfires.
- Ground movement.
- Low temperatures / frost and ice.

There are brief descriptions of adaptation measures for each one of the above hazards, as well as a separate section on multiple hazards which addresses broader, operational aspects, such as power supply resilience, adverse weather plans and early warning plans.

Section 4.4.1 has brought together Several good practice examples, highlighting the following:

- The importance of collaboration and sharing knowledge and best practice.
- The need to identify and map interdependencies across sectors.
- The significance of adaptation planning and developing long-term, flexible adaptation pathways to guide strategic investment.
- The need to build skills and to empower staff to embed climate considerations into decision-making.
- The importance of integrating adaptation into core business processes, standards, and supply chains, and establishing metrics to measure operational resilience.
- The importance of having an action plan that allows measuring progress and linking actions at different levels, with a variety of stakeholders.
- The importance of including risk management of weather and climate change as well as extreme weather and seasonal changes into operational planning. This includes the ability to monitor performance during operation to provide insight and allow further adaptation of assets to climate change.
- The need to integrate climate change adaptation and resilience into all capital projects and lifecycle investments, rather than considering it as an added cost.

Appendix G Digital Survey Responses and Analysis

The survey questions that were sent to stakeholders are listed below.

How do you provide information about weather and climate related events to building and service users?

A range of methods appear to be used to provide information across the regions, including in-person communications, via the website, social media, and email correspondence.

How often do you provide weather and climate related updates to service users?

A couple of responses indicated that they only provide updates when required, whereas one response specified that this is done periodically on an ad-hoc basis around extreme weather events, approximately 4-6 times per year.

What specific information do your building or service users seek during a weather or climate related event?

A range of information is sought across the regions during specific events, including health and safety, information about service cancellations, and those specific to hazards.

Have your building or service users been affected by a weather or climate related hazard (building)?

A range of hazards have affected regions differently, including those associated with precipitation, wind speed, high temperatures, drought, flooding and snow and ice. Again, as the results are limited, it is different to ascertain if particular hazards are affecting one region compared to others.

How were your building and service users impacted by weather and climate related hazards?

Two responses indicated that their users had lower satisfaction with building, stress of repeated building hazards and building feels less safe or secure. A few responses indicated that inability to access the building itself or associated infrastructure that provides access was a significant impact for users impacted by weather and climate related hazards.

How you were affected by the weather or climate related hazard?

Specific instances were mentioned, such as concourse flooding at Nottingham station, which impacted passengers and tenants. Another response indicated a range of examples such as thermal comfort, risk of slips, trips and falls in wet weather and/or icy weather, windblown debris on bridge decks or striking bridge soffit leading to outage, damage to utilities and services such as lighting, electricity, and telecoms, and surface water flooding in areas of staff and customer footfall.

Provide a rating for how well maintenance plans & service agreements include monitoring, risks, and incentives for weather and climate-related performance? Where 0 = not at all and 5= extremely well

A range of ratings were provided between 0 and 5, and due to a limited number of responses, it is difficult to indicate how well maintenance plans and service agreements are adept at monitoring risk and incentives for weather and climate-related performance.

How well do Heritage and premodern buildings cope with climate hazards that affect the users' experiences? How warm, dry, protected from wind, not exposed to surface flooding, not vulnerable to slip-trip hazards from wet surfaces are they? Where 0 = Not very well and 5= Excellent

A range of ratings were provided between 0 and 5, and due to a limited number of responses, it is difficult to indicate how well heritage and premodern buildings cope with climate hazards, and how this affects the users' experiences.

How well do Modern buildings cope with climate hazards that affect the users' experiences? How warm, dry, protected from wind, not exposed to surface flooding, not vulnerable to slip-trip hazards from wet surfaces are they? Where 0 = Not very well and 5= Excellent

Three responses provided a '3' rating, which suggests that compared to heritage and premodern buildings, there is a greater sense of agreement that modern buildings are more adept to coping with climate hazards.

Are there any differences in the building or service user experience of weather-related hazards in heritage and postmodern buildings? Please describe the key differences

Constraints and limitations were mentioned in four responses, and performance and capacity were mentioned in two responses. This suggests there is general agreement about the differences in building and service user experience when comparing heritage and postmodern buildings.

Please provide case studies, good practice, lessons learned or performance-based outcomes in your region that illustrate your points

Only one response provided a summary of good practice and lessons learnt:

“Our lessons learned have been to embed health & safety considerations in our climate change risk assessments for building management and operation; including staffed-station areas. This is in tandem with asset health monitoring and transport serviceability (punctuality and frequency of train services). Good practice for us has been to consider the risk of adverse weather impacts in station management routines; including asset maintenance checklists and incident response routines. This also links to adaptation & resilience metrics around reducing the frequency, severity and scale of adverse weather impacts - we're working on quantifying these metrics.”

Prepared for: Office of Road and Rail