APPENDIX

Q

Climate Change Risk Assessment Technical Report

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Inland Rail North Star to New South Wales/ Queensland Border

Appendix Q: Climate Change Risk Assessment Technical Report

Australian Rail Track Corporation

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Abbreviations

Abbreviation	Explanation
AEP	Annual exceedance probability
ARTC	Australian Rail Track Corporation Ltd
AS	Australian Standard
BOM	Bureau of Meteorology
CCRA	climate change risk assessment
DEH	Department of Environment and Heritage
FFDI	Forest Fire Danger Index
FFJV	Future Freight Joint Venture
GHG	Greenhouse gas
Inland Rail	Melbourne to Brisbane Inland Rail
IS	Infrastructure Sustainability
ISCA	Infrastructure Sustainability Council of Australia
km	kilometres
m	metre
NS2B	North Star to NSW/QLD Border
NSW	New South Wales
OEH	Office of Environment and Heritage
QLD	Queensland
RCP	representative concentration pathway
SEARs	Secretary's Environmental Assessment Requirements
SRES	Special Report on Emissions Scenarios
°C	Degrees Celsius

Executive summary

ARTC have rail infrastructure, including assets such as Inland Rail, that are susceptible to climate change. Current and projected climate events and trends pose a risk to rail infrastructure, by way of physical damage, reduced network capacity, accelerated deterioration of assets and potential risks to human health and safety.

The purpose of this report is to present the findings of a climate change risk assessment (CCRA) completed as part of the North Star to the New South Wales (NSW)/Queensland (QLD) Border section of the Inland Rail (the proposal). This report and corresponding CCRA serve to address the NSW Secretary's Environmental Assessment Requirements (SEARs) and address requirements outlined in version 1.2 (v.1.2) of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) Rating Scheme for Cli-1 and Cli-2. Cli-1 aims to reward the assessment of climate change risks, while Cli-2 aims to reward the assessment and implementation of climate change adaptation measures.

In line with the SEARs requirements, this report assesses risks and vulnerability related to climate change relevant to the proposal in accordance with current guidelines, utilises the NSW Government's climate change projections, and identifies and recommends specific adaptation actions.

In addition to satisfying the SEARs, in alignment with the ISCA Requirements for Cli-1 and Cli-2, this report identifies climate effects relevant to the proposal and provides an assessment to the potential climate change risks to the proposal. It further identifies appropriate risk management and adaptation measures to be incorporated into the construction and operation phases to build the resilience of the proposal to changing climate conditions.

For the risk assessment, climate variables were selected based on the following factors related to the broader context and nature of the proposal:

- The location of the proposal in an area projected for increased temperature and increased solar radiation
- The location of the proposal in an area projected for an increase in extreme rainfall.

As a result, the climate variables relevant to the proposal is listed in Table 1.

Table 1 Primary and secondary climate effects

Primary climate effect	Secondary climate effect
Mean surface temperature	Extreme temperature and heatwaves
Average annual rainfall	Bushfire weather
Solar radiation	Flood and flash flood events
Extreme rainfall	Drought
Increased CO_2	Storm events and wind speed

The impacts of climate change on these climate effects and the potential risks they may pose to the proposal were reviewed and assessed. Based on the risk assessment for the proposal, extreme rainfall events, flooding and extreme heat will present the highest risk in both the near future and far future. Risks associated with these events involve:

- Increased flooding resulting in inundation of track and trackside infrastructure (signalling/communications equipment and drainage basins)
- Increased incidents of extreme events (heat, rainfall and bushfire) on power supply and demand (both internal and external to the rail corridor) and network (communications) interruption
- Increased heat events leading to track buckling and subsequent disruption of service.

The risk assessment for this report (based on the ARTCs Risk Management Framework) identified a total of 34 climate change risks (both direct and indirect risks) relevant to the proposal, responding to each of the climate variables identified. Based on the initial risk assessment undertaken by a multi-disciplinary group who reviewed the selected climate variables, by 2030 the proposal will face 1 very high, 5 high and 9 medium risks related to climate change, which will increase to 3 very high, 7 high and 16 medium risks by 2090 and represent approximately 78 per cent of the total assessment with 9 per cent of risks recorded as very high, 22 per cent high and 50 per cent medium).

This risk assessment also documents the proposed risk treatment (adaptation) measures to reduce the identified risks and their residual risk ratings. Table 2 summarises the risk assessment findings. It should be noted, 2 risks were identified related to the design and construction of the proposal, given the timeline for the proposal, these risks were not considered for the 2090 timeframe.

Table 2 Summary of risk assessment over time

Risk rating	2030[1]	2090
Low	19	6
Medium	9	16
High	5	7
Very high	1	3
Total risks	34	32

As shown in Section 8, a residual risk assessment was conducted based on the adaptation measures identified with an appropriate scale and timing taken into consideration. Of the 1 very high risk, 5 high risks and 9 medium risks identified for 2030, applied adaptation measures have resulted in a residual risk rating of no ‘very high’ or ‘high risks and 8 medium risks. Furthermore, several of the risk management and adaptation measures can be applied to more than one projected climate impact and adaptation measures can be integrated at different phases. Opportunities to integrate adaptation measures into detailed design and consider during future phases have been highlighted where relevant.

The residual risk matrix also serves to detail compliance and ensure that risk management and adaptation measures identified in this report are carried forward into the next stages of design/construction to ensure that medium, high and very high risks to the works are considered and mitigated, where possible and practicable.

Compliance

In alignment with Cli-1, this risk and adaptation assessment for the proposal is aligned with the credit requirements of the category by demonstrating the following:

- The Climate Change Risk Assessment (CCRA) has incorporated and utilised two different climate change projections for two different years (2030 and 2090):
  - Representative Concentration Pathway (RCP) 8.5 from the CSIRO and BoM
  - Special Report on Emissions Scenario (SRES) A2 as per the NSW/ACT Regional Climate Modelling (NARCliM) results from AdaptNSW
- The CCRA has considered both direct and indirect risks posed to the proposal
- The CCRA has vetted and reviewed risks and adaptation measures with a multi-disciplinary internal (Australian Rail Track Corporation (ARTC) and Future Freight Joint Venture (FFJV)) stakeholder working group

[1] Given the expected design life of the rail infrastructure (around 20 years for signalling/electrical equipment and 100 years for track), the current construction timeframe for the proposed works (around 2024) and the available climate data, the time periods which were selected for assessment are 2030 and 2090. Climate change projections for 2030 were identified as appropriate for assessment of short term impacts of climate change on the proposed works (around 5 years after the rail line is operational).

- Modelling, in accordance with the Australian Rainfall and Runoff Guidelines (Geoscience Australia, 2016), was undertaken to help characterise impacts resulting from a projected changing climate including an increase of 10 per cent of current rainfall projections to account for climate change.

For Cli-2, the CCRA for the proposal demonstrates the following in accordance with the credit category:

- Adaptation options have been identified, assessed, and are in varying stages of implementation to treat the identified extreme (very high), high and medium risks for both the 2030 and 2090 time frames
- No residual extreme (very high) or high risks exist following the implementation of adaptation measures
- Adaptation options have been identified, assessed, and are in varying stages of implementation to treat medium priority risks.

1 Introduction

1.1 Purpose and structure

Australian Rail Track Corporation Ltd's (ARTC's) commitment to sustainability and climate resilience is evident through the Inland Rail Environment and Sustainability Policy. A main commitment for the program is to 'future-proof Inland Rail so it is efficient and effective in the long term'. As part of this commitment, ARTC will design the proposal to account for climate change and improve the resilience of their assets.

The purpose of this report is to present the findings of a climate change risk assessment (CCRA) completed as part of the North Star to the New South Wales (NSW)/Queensland (QLD) Border section of the Inland Rail program (the proposal). This report and corresponding CCRA serve to address the NSW Secretary's Environmental Assessment Requirements (SEARs) and align with the requirements outlined in version 1.2 (v.1.2) of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) Rating Scheme for Cli-1 and Cli-2. Cli-1: Climate Change Risk Assessment aims to reward the assessment of climate change risks, while Cli-2: Adaptation Measures aims to reward the assessment and implementation of climate change adaptation measures.

In line with the SEARs requirements, this report assesses risks and vulnerability related to climate change relevant to the proposal in accordance with current guidelines, utilises the NSW Government's climate change projections, and identifies and recommends specific adaptation actions.

In addition to complying with the SEARs, in considering the IS Rating Tool requirements for Cli-1 and Cli-2, this report identifies relevant climate effects and provides an assessment of the potential climate change risks to the proposal. It further identifies appropriate risk management and adaptation measures to build the resilience of the proposal to changing climate conditions.

Climate adaptation – action taken to help cope with a changing climate that leads to a reduction in harm or risk of harm, or realisation of benefits.

Climate resilience – is the ability and capacity of a system to withstand, recover and adapt form stress. It is a measure of how much disturbance from a changing climate a system can handle without losing functionality.

This report is structured as follows:

- This section (Section 1) outlines how this report addresses the SEARs and ISCA requirements
- Section 2 provides the international, national and local climate policy context
- Section 3 outlines the relevant guidelines and methodology used for the climate resilience assessment
- Section 4 provides the description of the proposal
- Section 5 provides the local climate exposure, climate change projections and detailed climate variables
- Section 6 presents the climate change risk assessment including a summary of key findings
- Section 7 provides the adaptation options developed to address relevant climate change risks
- Section 8 provides the residual risk assessment and details for SEARs and ISCA compliance
- Section 9 provides a summary and includes next steps.

1.2 Objectives

1.2.1 Secretary's Environmental Assessment Requirements compliance

The SEARs set out for the proposal include a key issue and desired performance outcome around designing, constructing and operating the proposal to be resilient to the future impacts of climate change. Table 1.1 identifies the two requirements and where within the technical report the requirement has been addressed.

Table 1.1 Secretary's Environmental Assessment Requirements compliance

Key issue and desired performance outcome	Requirement	Current guidelines	Where it has been addressed in the report
The proposal is designed, constructed and operated to be resilient to the future impacts of climate change.	The proponent must assess the risk and vulnerability of the proposal to climate change in accordance with the current guidelines.	▪ Australian Government's Climate Change Impacts and Risk Management – A Guide for Business and Government (2006) ▪ AS/NZS 3100:2009 Risk Management – Principles and Guidelines ▪ Technical Guide for Climate Change Adaptation for the State Road Network (RMS, in draft)	Current risk assessment guidelines described in Section 3 while the risk assessment is presented in Section 6.1.
	The proponent must quantify specific climate change risks with reference to the NSW Government's climate projections at 10 km resolution (or lesser resolution if 10 km projections are not available) or equivalent projection tool (such as the Climate Futures Tool from CSIRO and BoM (attenuated for project region)) and incorporate specific adaptation actions in the design.		Climate projections, including those at a 10km resolution, are provided in Section 5.3, while the climate change risk assessment is presented in Section 6.1. Adaptation actions are provided in Section 7.

1.2.2 Infrastructure Sustainability Council of Australia compliance

Table 1.2 provides an overview of the ISCA Rating Tool requirements for Cli-1: Climate Change Risk Assessment and Cli-2: Adaptation Measures. The proposal aims to pursue both Cli-1 and Cli-2 subject to future consideration during the design and construct phases. Section 9 summarises the consideration this report has given in addressing each of the credit categories.

Table 1.2 Infrastructure Sustainability Council of Australia compliance for Cli-1 and Cli-2

ISCA Credit	Aim	Level 1 Criteria	Level 2 Criteria	Level 3 Criteria
Cli-1: Climate Change Risk Assessment	To reward the assessment of climate change risks.	▪ A readily available climate change projection is identified and adopted for the asset region over the forecast useful life of the asset. ▪ Direct climate change risks to the asset over the forecast useful life are identified and assessed.	▪ The requirements of Level 1 are achieved. ▪ A number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset. ▪ The CCRA also considered indirect climate change risks to the asset. ▪ A multi-disciplinary team participated in identifying climate change risks and issues.	▪ The requirements of Level 2 are achieved. ▪ Modelling is undertaken to characterise the likely impacts of the projected climate change for all High and Extreme priority climate change risks. ▪ A comprehensive set of affected external stakeholders participated in identifying climate change risks and issues.

ISCA Credit	Aim	Level 1 Criteria	Level 2 Criteria	Level 3 Criteria
Cli-2: Adaptation Measures	To reward the assessment and implementation of climate change adaptation measures.	■ Adaptation options to treat all extreme and high priority climate change risks are identified, assessed and appropriate measures implemented. ■ After treatment there are no extreme priority residual climate change risks.	■ The requirements of Level 1 are achieved. ■ Adaptation options to treat 25 to 50 per cent of all medium priority climate change risks are identified, assessed and appropriate measures implemented.	■ The requirements of Level 2 are achieved. ■ The optimal scale and timing of options is addressed (which may be triggered by when a specific climate threshold is likely to be achieved). ■ Adaptation options to treat at least 50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented. ■ After treatment there are no high priority residual climate change risks.

2 Legislation and policy

2.1 International policy

In 2015 the Commonwealth government announced its commitment to a target of reducing greenhouse gas (GHG) emissions by 26 to 28 per cent below 2005 levels by 2030, building on its previous target of five per cent below 2000 emission levels by 2020, irrespective of what other countries do. The Commonwealth government submitted this new target as its intended nationally determined contribution to the United Nations Framework Convention on Climate Change for negotiation at the 21st Conference of the Parties (COP21) held in Paris in December 2015.

A global climate agreement was reached by all 196 countries in Paris on 14 December 2015. The Paris Agreement provides a framework for all countries to take action on climate change post 2020. Key outcomes of the Paris Agreement include (Department of Foreign Affairs and Trade 2016):

- A target to keep global temperature increase to well below 2°C and pursue efforts to keep warming below 1.5°C above pre-industrial levels
- All countries to set emissions reduction targets from 2020, with an agreement to review and strengthen targets every 5 years
- Transparency and accountability rules to provide confidence in countries' actions and track progress towards targets
- Promoting action to adapt and build resilience to climate impacts
- Financial, technological and capacity building support to help developing countries implement the Agreement.

2.2 National policy

The Commonwealth Government's Direct Action Plan sets out how the 2030 emissions reduction target will be achieved. The Emissions Reduction Fund, as part of the Direct Action Plan, aims to reduce Australia's GHG emissions by creating positive incentives to adopt better technologies and practices to reduce emissions.

The Commonwealth Government's National Climate Resilience and Adaptation Strategy was released on 2 December 2015 and provides a set of principles to guide effective adaptation and build the resilience of communities, the economy and the environment. The guiding principles include priorities for shared responsibility, climate change risks factored into decision making, a risk management approach based on the best available scientific data, assisting the vulnerable, collaboration with stakeholders, and the need to revisit decisions and outcomes over time.

2.3 State and local policy

The NSW Government's Climate Change Policy Framework for NSW (NSW Government 2016) aims to maximise the economic, social and environmental wellbeing of NSW in the context of a changing climate. The framework considers current and emerging policy settings both nationally and internationally.

The framework sets out two aspirational long-term objectives; achieve net-zero emission by 2050 and making NSW more resilient to a changing climate. In making NSW more resilient to a changing climate, the NSW Government role includes:

- Implementing policies to plan for climate change risks and provide targeted support
- Assessing and effectively manage climate change risk to government assets and services
- Advocating for action to support effective adaptation.

The draft Technical Guide for Climate Change Adaptation for the State Road Network (Roads and Maritime, 2015; unpublished) provides guidance for State Road Network projects which require climate change adaptation in response to changes in climate processes. While the Technical Guide has been developed considering existing Roads and Maritime processes, it aligns with the broader NSW Government initiatives and programs responding to climate change impacts and as a result been referenced within the SEARs for the proposal.

3 Climate change risk methodology

3.1 Risk assessment guidelines

The CCRA undertaken for the proposal follows the approach detailed within the draft Technical Guide for Climate Change Adaptation for the State Road Network (Roads and Maritime, 2015: unpublished). It is recognised that this technical guide is one of the current guidelines for assessing risk and vulnerability for infrastructure projects and is noted as such in the SEARs. While this guide was developed for use on motorway and road projects, the framework is applicable to all infrastructure projects (including freight rail), as the guide is focused on risk management and is closely aligned with Australian Standard (AS)/New Zealand Standard (NZS) 3100:2009 Risk Management – Principles and Guidelines. The guide references the identification of relevant climate variables and impacts, undertaking a risk assessment and identifying and evaluating various risk treatments (adaptation options) to address each risk. By using this technical guide, the NS2B will ensure consistency with other agencies approach to climate change adaptation across NSW.

In addition to the technical guide, the CCRA has been completed in line with the following relevant standards and current guidelines. These additional standards and guidelines serve to not only complement the technical guide, but also address various requirements outlined within the IS Rating Tool Cli-1 and Cli-2 credits.

- The ARTC risk assessment framework, in accordance with AS/NZS 3100:2009 Risk Management – Principles and Guidelines as well as International Standards Organisation (ISO)/International Electrotechnical Commission 31010 Risk Management – Risk assessment techniques
- AS 5334:2013 Climate change adaptation for settlements and infrastructure – A risk based approach, following ISO31000:2009
- Australian Government's Climate Change Impacts and Risk Management – A Guide for Business and Government (Department of Environment and Heritage (DEH), 2006)
- The ISCA Climate Change Adaptation Guidelines (Australian Green Infrastructure Council, 2011), which have been reviewed and used to guide, confirm and validate measures to mitigate and adapt to climate change risks.

3.2 Risk assessment methodology

The following steps were undertaken to complete the CCRA in line with both AS 5334:2013 and the Australia Government's Guide for Business and Government:

1. Identification of key climate variables (e.g. temperature, rainfall and extreme events) and the climate variability that differentiates regional climate zones
2. Development of potential climate change scenarios, based on the latest climate science, which describes how each variable may change over the design life of the proposal
3. Identification of broad climate-based risks that may impact on the proposal
4. Completion of a CCRA, with risk ratings evaluated using the ARTC risk management framework, including likelihood and consequence criteria (refer Section 3.2.1). Consequence ratings have been selected based on the highest rating for the risk categories
5. Identification of measures to mitigate and adapt to the identified climate change risks
6. Assessment of residual risks (vulnerability) to the proposal, considering specific adaptation measures to treat high and very high risks, which in turn will also help treat medium and low risks.

Figure 3.1 shows how risks to the proposal have been developed from an assessment of climate variables and projected climate change.

Figure 3.1 **Climate change risk assessment process**

Figure note: Adapted from DEH (2006)

3.2.1 Scope and limitations

For the purposes of this CCRA, the following scope of works were considered:

- Single track standard gauge rail line with one crossing loop and one maintenance siding
- Bridges to accommodate topography and crossings of waterways and other infrastructure
- The construction of associated rail infrastructure including signalling infrastructure to support the proposed signalling system; Advanced Train Management Systems.
- Rail crossings including level crossings, grade separations, occupational/private crossings and fauna crossing structures
- Ancillary works including road and public utility crossings and realignments
- Construction workspace, including camps and borrow pits, and access roads.

As ARTC do not own and/or operate rolling stock, nor have the proposal included rolling stock, consideration with regard to impacts resulting from climate change towards rolling stock has not been included in this report. In certain instances where impacts to rolling stock would have an impact on operation or maintenance of the proposal (indirect impacts), consideration was given in the risk assessment and through the identification of adaption responses.

This CCRA also represents a snapshot in time and should any aspects of the proposal design or proposed operation change, the identified risks and adaptation measures should be reviewed and updated, if required.

3.3 IS Rating Scheme Climate Change Risk and Adaptation Requirements

In accordance with the IS Rating Tool v.1.2, Cli-1 (climate change risk assessment) and Cli-2 (adaptation measures) credit requirements, this climate change risk and adaptation assessment for the proposal demonstrates considerations of requirements within the respective categories. A decision around the pursued level within each credit category would be determined in consultation with the preferred contractor.

For Cli-1 this is demonstrated by the following:

- The CCRA has incorporated and utilised two different climate change projections for two different years (2030 and 2090), representing the commencement of operations and the projections closest to the end of the service life of the proposal:
  - RCP 8.5 from the CSIRO and BoM
  - SRES A2 as per the NSW NARCliM results from AdaptNSW
- The CCRA has considered both direct and indirect risks posed to the proposal
- The CCRA has vetted and reviewed risks and adaptation measures with a multi-disciplinary internal (ARTC and FFJV) workshop representing designers, environmental specialists, and the asset owner who will have responsibility for operations and maintenance of Inland Rail
- Modelling, in accordance with the Australian Rainfall and Runoff Guidelines (Geoscience Australia, 2016), was undertaken to help characterise impacts resulting from a projected changing climate including an increase of 10 per cent of current rainfall projections to account for climate change.

For Cli-2 this is demonstrated by the following:

- Adaptation options have been identified, assessed, and are in varying stages of implementation to treat the identified extreme (very high), high and medium risks for both the 2030 and 2090 time frames
- No residual very high or high risks exist following the implementation of adaptation measures
- Adaptation options have been identified, assessed, and are in varying stages of implementation to treat medium priority risks.

3.3.1 Risk assessment criteria

Climate change risks identified for the proposal have been assessed using the ARTC risk management framework, including the following likelihood and consequence tables, to align with the Inland Rail programme risk register.

Table 3.1 Likelihood criteria

Likelihood	Description	Frequency of occurrence	Percentile
Almost Certain (A)	Is expected to occur in most circumstances	Once per month	>90%
Likely (B)	Will probably occur in most circumstances	Between once a month and once a year	60% to <90%
Possible (C)	Might occur at some time	Between once a year and once in five years	30% to <60%
Unlikely (D)	Could occur at some time	Between once in 5 years and once in 20 years	10% to <30%
Rare (E)	May occur in exceptional circumstances	Once in more than 20 years	<10%

Source: ARTC Environmental Assessment Procedure (2018)

Table 3.2 Consequence criteria

Risk category		Consequence				
		Not Significant (1)	**Minor (2)**	**Moderate (3)**	**Major (4)**	**Extreme (5)**
Safety	Impact to people	No medical treatment required	Lost time injury (LTI) results or medical treatment required	Serious injury occurs	Single fatality occurs	Multiple but localised fatalities occur
Assets	Engineering impacts(s) and satisfying objectives	Up to 6hrs track closure	>6hrs to 24hrs track closure	>24 hrs to 48 hrs track closure	>48hrs to 5 Days track closure	>5 Days track closure
Financial	Total outturn cost impact	Up to 0.05% of programme budget (i.e. to $5M in $10B)	>0.05% to 0.5% of programme budget (i.e.>$5M to $50M in $10B)	>0.5% to 1.5% of programme budget (i.e.>$50M to $150M in $10B)	>1.5% to 5% of programme budget (i.e.>$150M to $500M in $10B)	>5% of programme budget (i.e.>$500M in $10B)
		Up to 0.1% of project budget (e.g. to $100k in $100M)	>0.1% to 0.5% of project budget (e.g. >$100k-$500k in $100M)	>0.5% to 2.5% of project budget (e.g. >$500k-$2.5M in $100M)	>2.5% to 10% of project budget (e.g. >$2.5M-$10M in $100M)	>10% of project budget (e.g. >$10M in $100M)
Environment	Environment impact heritage, flora and fauna, archaeology and Indigenous, pollution and amenity (public)	Contained environmental damage - fully recoverable (no cost or ARTC action required)	Isolated environmental damage - minimal ARTC remediation required	Localised/clustered environmental damage - requiring remediation	Considerable environmental damage - requiring remediation	Widespread long term or permanent environmental damage - remediation required
Regulatory	Regulatory/legislation exposure non-compliance and our licence to operate	Minimal or no regulatory involvement	Notice to produce information	Improvement notice or threatened action	Prohibition notice or fine(s)	Prosecution of the company and/or its office holders
Reputation	Reputational exposure customer dissatisfaction, shareholder support, service quality and reliability, public image and stakeholder attitudes	Isolated event able to be resolved (up to 7 days)	Management intervention required (>7 days to 3 months)	Tactical (business unit/ divisional) intervention required (>3months to 18 months)	Strategic intervention required (>18 months to 3 years)	Corporate loss of shareholder and/or customer support (tangible business impact >3 years)
Schedule	Time based impacts	Influences schedule up to 1% of programme approved schedule period	Influences schedule >1% to 2.5% of programme approved schedule period	Influences schedule >2.5% to 5% of programme approved schedule period	Influences schedule >5% to 10% of programme approved schedule period	Influences schedule >10% of programme approved schedule period
		Influences schedule up to 2% of project approved schedule period	Influences schedule >2% to 5% of project approved schedule period	Influences schedule >5% to 10% of project approved schedule period	Influences schedule >10% to 20% of project approved schedule period	Influences schedule >20% of project approved schedule period

Source: ARTC Environmental Assessment Procedure (2018)

Table 3.3 Risk assessment matrix

Likelihood	Consequence				
	Not significant (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Almost Certain (A)	Medium – 1A	Medium – 2A	High – 3A	Very High – 4A	Very High – 5A
Likely (B)	Low – 1B	Medium – 2B	High – 3B	Very High – 4B	Very High – 5B
Possible (C)	Low – 1C	Low – 2C	Medium – 3C	High – 4C	High – 5C
Unlikely (D)	Low – 1D	Low – 2D	Low – 3D	Medium – 4D	Medium – 5D
Rare (E)	Low -1E	Low – 2E	Low – 3E	Low – 4E	Medium – 5E

Source: ARTC Environmental Assessment Procedure (2018)

3.4 Consultation

Considering the IS Rating Tool v.1.2. Cli-1 requirements, a CCRA workshop was undertaken on 20 September 2018 with a multi-disciplinary internal team representing the ARTC and FFJV team providing design and environmental services as well as the asset owner who will have responsibility for operations and maintenance of Inland Rail. The workshop sought to review:

- The validation of preliminary climate change risks informed by a desktop assessment
- The identification of new climate change risks
- The allocation of preliminary risk ratings
- The development of adaptation actions.

The following stakeholders were consulted in the development of climate change risk statements, risk ratings and adaptation options. Appendix A contains copies of the workshop presentation and materials.

Table 3.4 Workshop participants

Organisation and role
ARTC – Design manager
FFJV – EIS coordinator
ARTC – Design manager
SAJV – Sustainability technical advisor
FFJV – Hydrology lead
FFJV – EIS manager
FFJV – Hazard and risk lead
ARTC – Social performance advisor
SAJV – Traffic and transport technical advisor
ARTC – Project environmental advisor
ARTC – Sustainability manager
ARTC – Cultural heritage manager
FFJV – EIS manager
ARTC – Project environmental advisor
ARTC – Senior project manager
FFJV – Environment manager
FFJV – Climate change risk and adaptation lead
FFJV – Climate change risk and adaptation consultant

The key discussions points and outcomes from the workshop found:

- Extreme heat, flooding and extreme rainfall pose the most significant climate change risks to the proposal
- Many adaptation measures and responses have been accounted for and included in the basis of design. Modelling for specific criteria including temperature and flooding are considered as part of current standard operating procedures or have been identified for inclusion during updates to these procedures.
- There are several potential adaptation actions that would help increase the resilience of the proposal that should be carried forward for discussion.

4 Proposal description

The proposal is one of 13 sections of Inland Rail that will provide a continuous freight rail link between Melbourne and Brisbane. The proposal travels between the town of North Star and the NSW/QLD border (being the middle of the Macintyre River). The proposal and regional setting is shown in Figure 4.1.

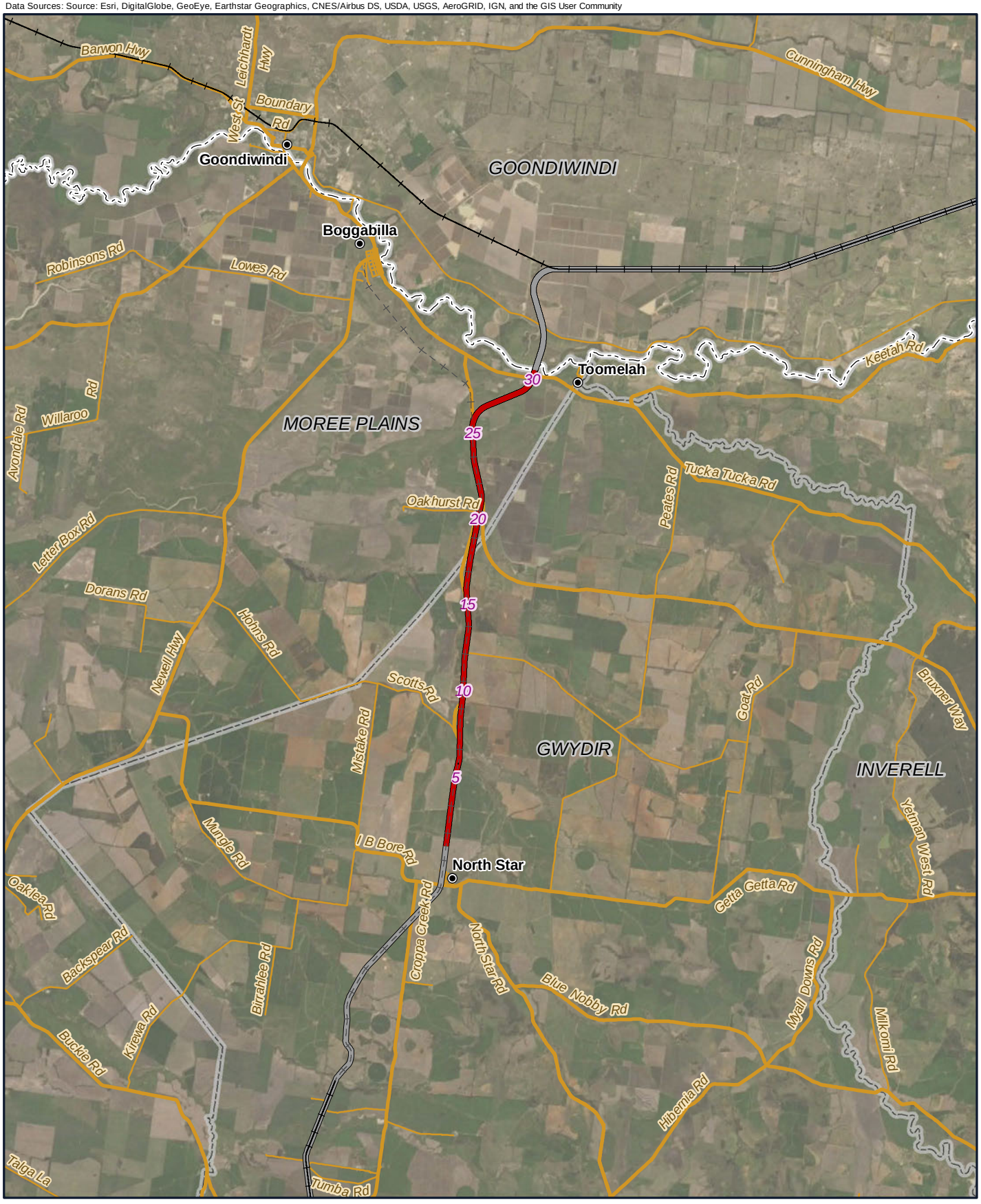
Key features of the proposal are as follows:

- Alignment commences at approximately 900 m north of North Star within the proponent's existing non-operational rail corridor and ends at the NSW/QLD border, being the middle of the Macintyre River
- Single track standard gauge rail line with one crossing loop and one maintenance siding to ultimately accommodate trains up to 3,600 m long based on business needs, but initially constructed for 1,800 m long train sets
- Bridges to accommodate topography and crossings of waterways and other infrastructure including one major rail crossing across the Macintyre River
- The construction of associated rail infrastructure including a maintenance siding and signalling infrastructure to support the proposed signalling system; Advanced Train Management Systems
- Rail crossings including level crossings, grade separations/road overbridges, occupational/private crossings and fauna crossing structures
- Ancillary works including road and public utility crossings and realignments
- Construction workspace, including construction camps and borrow pits, and access roads.

Ancillary work is to include level crossings, signalling and communications, signage, fencing, and services and utilities.

As ARTC do not own and/or operate rolling stock, nor has the proposal included rolling stock, consideration with regard to impacts resulting from climate change towards rolling stock has not been included in this report. In certain instances where impacts to rolling stock would have an impact on operation or maintenance of the proposal (indirect impacts), consideration was given in the risk assessment and through the identification of adaption responses.

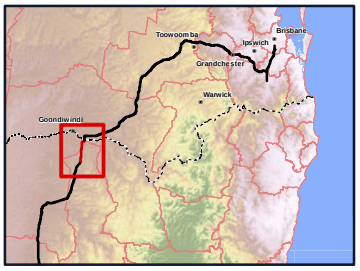
Data Sources: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: FFJV DTH LCT Z:\GIS\GIS_270_NS2B\Tasks\270-EAP-20190116\604_95p_figure_updates\270-EAP-20190116\604_Fig4.1_Regional_V6.mxd Date: 23/10/2019 11:04

Legend

- 5 Chainage (km)
- Localities
- North Star to NSW/QLD border alignment
- Adjoining alignments
- Major roads
- Minor roads
- NSW/QLD border
- Existing rail (operational)
- Existing rail (non-operational)
- Local Government



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0 1.25 2.5 5 7.5 10 12.5 Km

Future Freight
Integrating Community, Environment and Engineering

Date: 23/10/2019 Version: 6

Coordinate system: GDA 1994 MGA Zone 56

NORTH STAR TO NSW/QLD BORDER

Figure 4.1: Regional setting

5 Existing and future conditions

In 2016, for the first time, global temperatures had been confirmed to have risen by 1°C since pre-industrial levels. The Paris Climate Change Accord (effective 4 November 2016) seeks to limit climate change to under 2°C with a target of 1.5°C (UNFCCC 2016). Seeking to achieve these targets presents a significant challenge and even at 1°C we are already experiencing considerable changes with the earth's climate and weather systems.

The State of the Climate 2014 confirms the long term warming trend over Australia's land and oceans, showing that Australia's climate has warmed by 0.9ºC since 1910 (Ekström et al. 2015). The Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC 2013) states with high confidence that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. Other observed trends include an increase in record hot days, a decrease in record cold days and increases in extreme fire weather.

5.1 Local climate exposure

5.1.1 Climate variables

Climate differs from region to region due to changes in influencing factors such as geographical location, latitude, physical characteristics, variable patterns of atmosphere, ocean circulation and in some cases, human interaction (IPCC 2007). Consequently, climate change and the associated impacts can be expected to vary from region to region. The CCRA provided in this report is based on projections for the Central Slopes region and where possible, specific to the areas between North Star and the NSW/QLD border.

For the risk assessment, climate variables were selected based on the following factors related to the broader context and nature of the proposal:

- The location of the proposal in an area projected for increased temperature and increased solar radiation
- The location of the proposal in an area subject to decreased annual rainfall resulting prolonged periods of drought
- The location of the proposal in an area projected for an increase in extreme rainfall with subsequent flooding of local waterways.

As a result, the climate variables relevant to the proposal are listed in Table 5.1.

Table 5.1 Primary and secondary climate effects

Primary climate[1] effect	Secondary climate[2] effect
Mean surface temperature	Extreme temperature and heatwaves
Average annual rainfall	Bushfire weather
Solar radiation	Flood and flash flood events
Extreme rainfall	Drought
Increased CO_2	Storm events and wind speed

Table notes:

1 **Primary effects** – are those climate variables that are directly influenced or changed as a result of global warming/climate change. These include things such as air/sea surface temperature, precipitation, wind and solar radiation.

2 **Secondary effects** – are those variables that are derived from primary effects which are still influenced by a changing climate. These include things such as increased risk of bush fire weather and drought.

5.1.2 Observed local climate

The NS2B corridor is generally located within the New England North West region, characterised by a regional landscape varying from rolling hills to broad floodplains (including the west-flowing Macintyre River).

The region is generally dry and hot, with much of the region being semi-arid. Overall average rainfall is around 700 mm (400 to 800 mm on average) per year and generally higher in summer and fairly uniform across the other seasons. In summer, temperatures range between 26 to 28°C with January generally being the hottest month, while winter temperatures range between 12 to 14°C, with July generally being the coldest. According to AdaptNSW, the areas surrounding the NS2B corridor can experience over 50 days above 35°C per year.

In February 2017, temperatures across several days exceeded the 99th and 100th percentile for extreme heat including five straight days above 35°C (refer Figure 5.1).

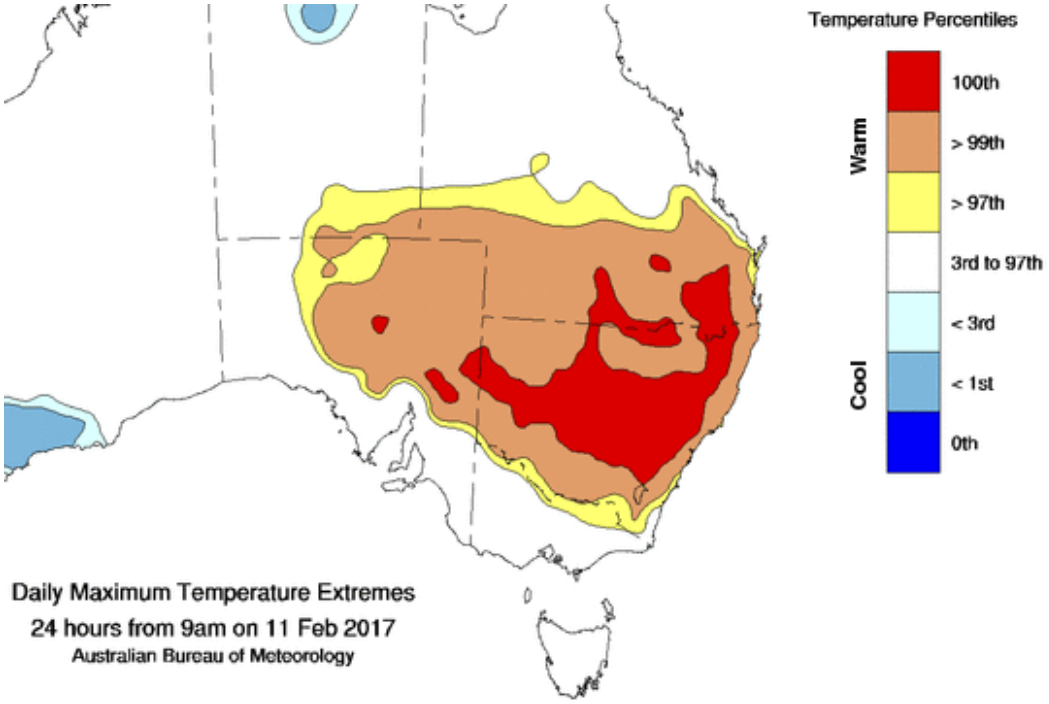

Figure 5.1 Extreme heat percentiles – February 2017

Source: BoM (2017)

The Forest Fire Danger Index (FFDI) is used across NSW to determine and quantify fire weather. This index takes into account observations of temperature, humidity and wind speed (as well as potential build-up of fuel sources). The nearest station to the Project is in Moree, where the average annual FFDI is 12.1, with the highest index values occurring in Spring. On average, there are around 3.3 days per year where conditions are classified as severe (FFDI >50).

Recent extreme events have highlighted the areas exposure to climate change including:

- A January 2011 extreme rainfall resulted in a flooding event (along the Macintyre and Dumaresq rivers) that caused the evacuation of nearly the entire towns of Boggabilla and Toomelah, which are located adjacent to the corridor (Sydney Morning Herald 2011). This event also resulted in the closure of the Bruxner Way (just outside of Boggabilla) and resulted in delays and cancellations for regional trains and regional coach services.
- A January 2013 extreme rainfall resulted in a flooding event that resulted in the closure of the Newell Highway near Boggabilla, with no access from either NSW or Queensland (Northern Star 2013). Furthermore, the Bruxner Way between Boggabilla and North Star was closed in both directions due to flood waters.

- A 2014 heat wave resulted in temperatures exceeding 45°C in Goondiwindi (45.9°C), while a 2017 event resulted in 3 day stretch of at least 43°C (Courier Mail 2018; The Chronicle 2017)
- In the summer 2016 to 2017, the town of Moree set a NSW record in experiencing 52 consecutive days of temperatures exceeding 35°C (Mashable 2017).

The period 2010 through today has already seen widespread, individual very-heavy rainfall events, particularly through the warmer months of the year. Figure 5.2 shows that the region experienced a 24-hour rainfall event greater than the 97th percentile in September 2016.

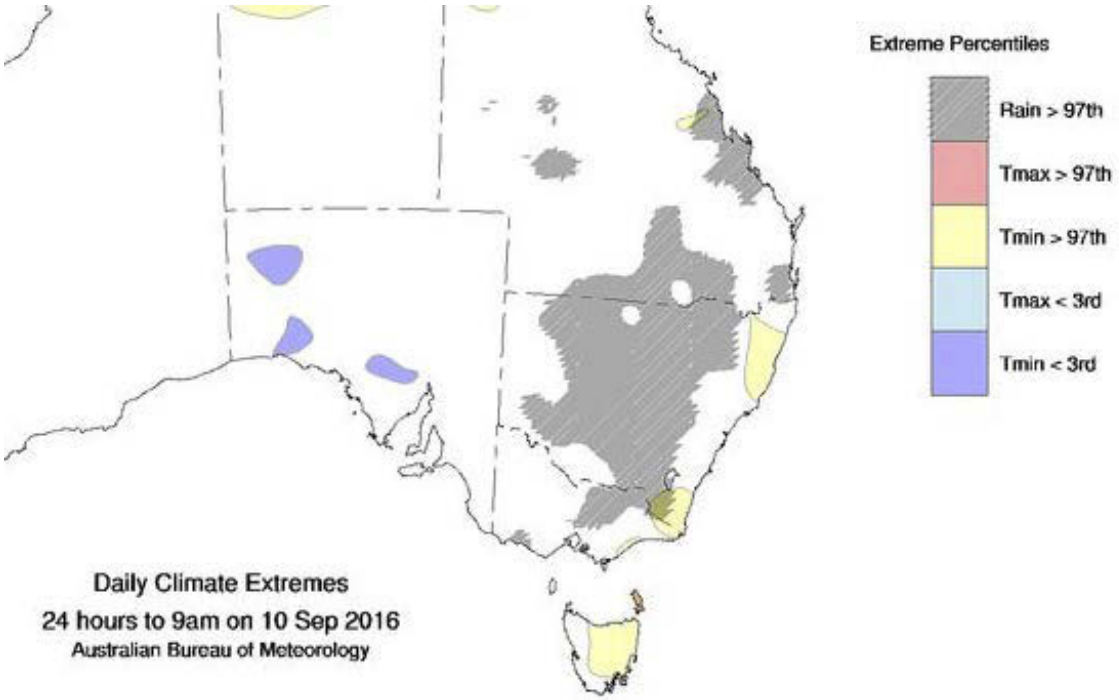

Figure 5.2 Daily rainfall extreme – 10 September 2016

5.2 Climate change data

The climate of northern NSW, as with global climate trends, is naturally variable. Climate change however, will lead to shifts beyond this natural variability. Risk assessment based on climate change requires an understanding of the current climate using historical data for comparison with future climate scenarios. Future climate scenarios are generated and prepared using data from Global Climate Models. Global Climate Models are tools used for understanding how the climate will respond to changes in GHG emission levels.

In order to assess the risk to the proposal posed by climate change, the current climate science and model projections have been investigated for the following parameters based on available data sources. Reflecting ARTC's commitment to future proofing Inland Rail, and the requirements of the Climate Change credits in the IS rating scheme, this CCRA has used two data sources for climate change projections:

- Adapt NSW and NARCliM developed by the Office of Environment and Heritage (OEH) (2014; 2015) which provides projections at the 10 km resolution
- CSIRO and Bureau of Meteorology (BOM) Climate Futures (CSIRO and BOM 2015) which supplements the information available from the NARCliM projections for a number of key climate variables.

The NARCliM project, undertaken by the NSW and ACT governments and presented through the OEH AdaptNSW web portal, presents regional downscaled climate projections (Climate Change Snapshots) for 12 regions within south-east Australia. Projections for the New England North West region have been used to inform this assessment for the area between North Star and the NSW/QLD border, in accordance with both the SEARs requirements (refer Section 1.2.1).

The CSIRO and BOM present climate data through the Climate Futures tool in the form of Cluster Reports, which are regional downscaled climate projects across eight regions in Australia. Based on the location of the project, the Central Slopes Cluster Report has been used to inform this assessment.

It is important to note the integrity of each climate data set as a whole, as the projections presented by each source represent a range of climate futures based on specific modelling parameters, scenarios and assumptions as described in the following sections. Care has been taken to consider each set of climate projections as a whole, to ensure an 'internally consistent climate future' approach. In accordance with the guidelines identified in Section 2, preference has been given to the CSIRO and BOM climate data.

5.2.1 Climate projection scenarios

As stated, the GHG emissions scenarios used to inform this CCRA are chosen based on the available climate projections from the following sources and include:

5.2.1.1 NARCliM

The SRES A2 scenario represents a high emissions pathway driven by economic growth and is projected to result in warming by approximately 3.4ºC by 2100. The SRES A2 emission scenario was selected for use in the NARCliM climate projections as a review of the global emissions trajectory suggests that we are tracking along the higher end of the A2 scenario (OEH 2014; OEH 2015).

5.2.1.2 Climate futures

Projections are presented for an emission scenarios or possible pathways, referred to as RCPs, each of which reflects a different concentration of global GHG emissions. While RCPs existing for low emission (RCP 2.5), medium emissions (RCP4.5), the RCP reported here is for high emissions (RCP8.5). The RCP8.5 pathway, which arises from little effort to reduce emissions and represents a failure to prevent warming by 2100, is similar to the highest SRES scenario and is used in this report. The RCP8.5 pathway is also closest to the current emissions trajectory. Where relevant, projections for the RCP4.5 pathway have been included for comparison. RCP4.5 projections have been included (refer Sections 5.3.2, 5.3.3 and 5.3.6) to provide a range of future projections to help inform potential actions to address risk as well as highlight the difference in projections based on various scenarios.

5.2.2 Time scales

Rail infrastructure has a varied expected design life depending on the particular component. For the purposes of this assessment, it has been assumed that the following design lives would be applied to rail components:

- Electrical, signalling and communications components – 20 years
- Earthworks – 50 years
- Concrete infrastructure (e.g. bridges, culverts, sleepers) and railway tracks – 100 years.

Based on these design lives, construction of the proposal being likely in the next several years (around 2020) and the latest available climate data, the time periods selected for assessment are 2030 and 2090. 2030 was considered appropriate for short-term impacts on construction of the proposal (assuming construction would be finished in mid-2020 with initial operation towards the end of 2020s). Climate change projections for 2090 are considered relevant to longer term operation and maintenance of the proposal given the expected design life. Projections, where available, for 2070 were included as a means of confirming long-term trends.

Climate projections for the selected time scales represent averages over a 20 year period:

- Projections for 2030 represent the average for the 20 year period between 2020 and 2039 (near future, as defined by AdaptNSW)
- Projections for 2070 represent the average for the 20 year period between 2060 and 2079 (far future, as defined by AdaptNSW)
- Projections for 2090 represent the average for the 20 year period between 2080 and 2099 (as projected by CSIRO and BoM).

5.3 Detailed projections

The IPCC Fifth Assessment Report (AR5 2013) states with high confidence, that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. As a result, it is especially important to understand the 'most likely' and 'worst case' implications of climate change on high-value infrastructure, including the proposal.

A summary of the current climate science available for the Central Slopes Cluster Report (CSIRO and BOM 2015) and the New England North West Climate Change Snapshot (OEH 2014) are provided below.

Table 5.2 Detailed climate change projections[1]

Climate variable	Baseline data[2]	NARCliM - AdaptNSW (OEH)		Climate Futures - CSIRO and BOM	
		2030	2070	2030	2090
		SRES A2[3] (high emissions)	SRES A2 (high emissions)	RCP 8.5 (high emissions)	RCP 8.5 (high emissions)
Average daily annual temperature	26 to 28°C summer 12 to 14°C winter	+0.7°C (0.5 to 1.0)	+2.2°C (1.8 to 2.6)	Average daily annual temperature	26 to 28°C summer 12 to 14°C winter
Average maximum temperature	36°C (summer)	+0.7°C (0.4 to 1.0)	+2.2°C (1.9 to 2.7)	Average maximum temperature	36°C (summer)
Average minimum temperature	4 to 6°C (winter)	+0.7°C (0.5 to 1.0)	+2.3°C (1.6 to 2.8)	Average minimum temperature	4 to 6°C (winter)
Extreme heat days (above 35°C)	50 to 60 days	+7 days (2 to 10 days)	+24 days (14 to 29 days)	Extreme heat days (above 35°C)	50 to 60 days
Average annual rainfall	400 to 800 mm	+1.6% (-9% to 13%)	+7.7% (-8% to 24%)	Average annual rainfall	400 to 800 mm
Extreme rainfall (>125 mm in 24 hours)	N/A	Extreme rainfall events to increase in intensity and severity			
Fire weather (number of days/year FFDI[5] > 50)	3.3 days/year	+0.2 (-0.8 to 1.0)	+0.9 (-0.6 to 2.5)	Fire weather (number of days/ year FFDI[5] > 50)	3.3 days/year
Drought[6]	N/A	Both time spent in drought and occurrence of drought are anticipated to increase in intensity and severity.			

Table notes:

1 Quantitative results presented as model median (50th percentile) value, with 10 to 90 percentile range in brackets.
2 NARCliM changes relative to 1990 to 2009 baseline, CSIRO and BoM changes relative to 1986 to 2005 baseline.
3 The SRES A2 is the high emissions trajectory resulting from the Intergovernmental Panel on Climate Change Fourth Assessment Report.
4 The RCP 8.5 is the high emissions scenario resulting from the Intergovernmental Panel on Climate Change Fifth Assessment Report
5 The Forest Fire Daily Index (FFDI) combines observations of temperature, humidity and wind speed. Fire weather is classified as severe when the FFDI is above 50.
6 As drought conditions are directly linked to corresponding rainfall projections, there is uncertainty regarding these projections. Rainfall is dependent on local climate drivers including topography with most models showing contrasting patterns and trajectories.

5.3.1 Mean temperature

Taking into consideration the strong agreement on the direction and magnitude of change among GCMs and downscaling results, and the robust understanding of the driving mechanisms of warming and its seasonal variation, there is very high confidence in substantial warming for the Central Slopes cluster for the annual and seasonal projections for daily mean, maximum and minimum surface air temperature.

Changes in mean temperature often play occur at the extremes, for instance increasing the duration of bushfire seasons and impacting heatwaves and days over 35ºC. Under RCP 8.5, mean temperatures are projected to rise by 1.1ºC by 2030 for the Central Slopes region, with the greatest change projected during spring months. Mean temperatures are projected to rise by 4.2ºC by 2090. Increases are expected to occur across the entire region in both the near future and far future (OEH 2014; OEH 2015).

There is a very high level of confidence in temperature projections as all models show increases in mean temperatures across the Central Slopes region for both 2030 and 2090, for a range of emissions scenarios (CSIRO and BOM 2015).

While mean temperature can impact upon elements of the proposal, it is the extremes that could result in the greatest impact to the proposal, including prolonged bushfire seasons impacting on service and extreme heat days affecting trackside equipment and operations/maintenance activities.

5.3.2 Extreme temperature and heatwaves

Heat related extremes are projected to increase at the same rate as projected mean temperature with a substantial increase in the number of warm spell days. Projections also indicate a marked increase in a warm spell index, which is defined as the annual count of days for events with at least six consecutive days where the daily temperature maximum averaged for the cluster is above the 90th percentile.

An increased frequency and duration of hot days and heatwaves is projected for the Central Slopes in general with very high confidence under RCP4.5 and RCP8.5 (CSIRO and BOM 2015). According to AdaptNSW, currently, areas in northern NSW experience 20 to 30 hot days on average.

As noted above, extreme temperature and heatwaves have the potential to reduce the efficiency of trackside equipment and impact upon operations and maintenance activities, resulting in potential disruption of service.

5.3.3 Mean rainfall and drought

Rainfall in the cluster has not shown any long-term trend over the 20th century, but has demonstrated intermittent periods of wetter and drier conditions. During much of the early part of the century, the cluster experienced extensive drying, including the Australia-wide Federation drought, and the World War II drought in the 1930s and 1940s. The latter part of the 20th century has seen more variable conditions with individual years of very high rainfall, and sequences of years with below average rainfall; notably in the early 1990s and 2000s. As a result, there is high confidence that natural climate variability will remain the major driver of rainfall changes by 2030 in this cluster.

To assess the implications of projected climate change for drought occurrence, the Standardised Precipitation Index was selected as a measure of meteorological drought. Duration of time spent in drought and changes to the duration and frequency of droughts were calculated for different levels of severity (mild, moderate, severe and extreme).

Projected changes to meteorological drought share much of the uncertainty of mean rainfall change, and there is no clear indication on changes to drought conditions in the cluster. Under RCP8.5, there is an increase in the proportion of time spent in drought through the century. However, the picture is less clear for RCP4.5. The 90th percentiles of the model range under RCP8.5 suggest that extreme droughts could become more frequent in some models and the duration could increase, but other models (see 10th percentile) show change in the opposite direction. Any increase in drought duration is likely to be related to the reduction in winter mean rainfall.

There is medium confidence that the time spent in drought will increase over the course of the century under RCP8.5.

Changes in precipitation and increased duration of drought can impact on the longer-life elements of the proposal including drainage infrastructure, bridges and track. Soil cracking and subsiding based on these changes in patterns can lead to instability and more frequent maintenance over the life of the proposal.

5.3.4 Extreme rainfall and flooding

In a warming climate, heavy rainfall events are expected to increase in magnitude mainly due to a warmer atmosphere being able to hold more moisture (Sherwood et al. 2010).

Based on the linear relationship between Southern Oscillation Index values and Australian rainfall, the El Niño Southern Oscillation remains the dominant driver of changes in rainfall extremes in Australia.

The CSIRO and BOM (2015) indicate with high confidence a future increase in the intensity of extreme rainfall events across the Central Slopes. However, given the natural variability of rainfall the frequency and magnitude of increases in extreme rainfall cannot be confidently projected.

The magnitudes of the simulated changes in extreme rainfall indices are strongly dependent on the emission scenario and time into the future. In summary, there is high confidence that the intensity of heavy rainfall events will increase in the cluster, but there is low confidence in the magnitude of change, and thus the time when any change may be evident against natural fluctuations, cannot be reliably projected.

Extreme rainfall can result in severe flooding which can directly impact the corridor, including inundation of track, damage to signalling infrastructure and malfunctioning of electrical equipment. In addition, flooding can impact the local road network, thereby restricting emergency access.

5.3.5 Bushfire weather

Studies suggest that climate change will have a significant impact on future fire weather (e.g. Hennessy et al. 2005; Lucas et al. 2007; Williams et al. 2009; Clarke et al. 2011; Grose et al. 2014). Suitable weather conditions (i.e. hot, dry and windy) must generally exist for fires to spread. Given the combination of factors required for increased bushfire conditions, the potential increase in the future will rely heavily on projected changes in the weather.

There is high confidence that climate change will result in harsher fire weather in the future. This is seen in the mean changes and when examining individual models and scenarios. However, there is low confidence in the magnitude of the change, as this is strongly dependent on the rainfall projection. It is also recognised that the actual variability of fire weather in this cluster may be underestimated as the baseline fire climate is poorly sampled due to the small number of stations.

Increased incidence of bushfire weather and the number of severe fire weather days could result in damage to trackside infrastructure as well as potentially delay service as a result of bushfire smoke.

5.3.6 Wind

Projected changes to seasonal surface winds for Central Slopes are overall small (less than 5 per cent seasonally) for the near future period (2030) under both RCP4.5 and 8.5. For late in the century (2090), changes are still small under RCP4.5 with medium to high agreement amongst models on little change. For RCP8.5 there is high agreement amongst models on increase in spring (about -2 to +10 per cent) and while there is medium agreement on little change in winter, some models suggest potential for substantial decrease. Possible winter reductions in wind speed are likely related to the southward movement of the storm track, which leads to a weakening of westerly winds in the Central Slopes cluster.

In the past five years, ARTC have had three incidents where double-stacked freight trains have derailed as a result of high winds. Any changes in wind, particularly increases, could potentially result in the additional derailment (as it is already known to occur) of trains which could substantially damage trackside infrastructure.

5.3.7 Extreme storms

The Central Slopes cluster is not often directly affected by tropical cyclones, with only one occurrence during the period since records were commenced in 1969/70 through to 2017/18 season. Cyclone Oswald January 2013, which passed approximately 50 km to the east of the proposal on the 28 January 2013.

Projections indicated decrease in the formation of tropical cyclones, however it is anticipated that the proportion of the most intense cyclones will increase over the century while the intensity of associated rainfall may increase further.

The region also experiences more than 25 extreme thunderstorms per year (on average). These storms result in high winds, hail, flash flooding and lightning strikes. Similar to extreme rainfall events, while there is high confidence that the intensity of these storms will increase, the magnitude and frequency cannot be accurately projected with high confidence.

As the intensity of cyclones and other extreme storms increase, potential impacts to the project include damage to track and trackside infrastructure from high winds and hail as well as from debris blowing onto the corridor.

5.3.8 Solar radiation

By 2030, models simulate little change in radiation (about -1 to +2 per cent) for both RCP4.5 and RCP8.5. For 2090, projected seasonal changes are generally less than +/- 5 per cent, with the exception for winter where there is some indication of increase in both RCP4.5 (about 0 to +7 per cent) and RCP8.5 (about 0 to +10 per cent). Projected increases in winter are likely to be related to decreases in cloudiness associated with reduced rainfall. Globally, several models appear to underestimate the observed trends in some regions due to underestimation of aerosol direct radiative forcing and/ or deficient aerosol emission inventories (Allen et al., 2013). Taking this into account, we have high confidence in little change for 2030. For 2090, there is medium confidence in increased winter radiation, and low confidence for the small changes projected for the other seasons.

Increased solar exposure could potentially result in the accelerated degradation of materials, particularly the less hardened materials (e.g. signalling and cabling). Given the low relative change in the future, solar radiation isn't considered likely to impact on the proposal.

6 Climate change risk assessment

Due to previous events experienced in and around the rail corridor and observed and projected trends (refer Section 5), risks to rail infrastructure, by way of physical damage, reduced capacity, the accelerated deterioration of assets and potential risks to human health and safety are likely. The increased frequency and intensity of extreme weather events, increased rainfall, bushfires and rising temperatures are already causing strain on existing rail networks and associated infrastructure. More extreme weather events are likely to damage rail infrastructure and, by 2030, design criteria for extreme events are very likely to be exceeded more frequently (Thom et al 2010).

Direct risks to the proposal and indirect risks from interdependencies with other infrastructure systems and organisations, as a result of climate change were identified and assessed using the ARTC Risk Management Framework (refer Section 3.1).

6.1 Summary of risk assessment

The preliminary climate risk assessment identified a total of 22 climate change risk statements for the proposal. During the course of the workshop, an additional 12 climate change risks were identified, bringing the total to 34 climate change risks for the proposal (both direct and indirect risks). Additional risks were largely identified for extreme heat and extreme rainfall (and associated flooding). Based on this revised risk assessment, there would be five (5) high risks and one (1) very high risk to the proposal by 2030, increasing to seven (7) high risks and three (3) very high risks by 2090, representing 31 per cent of the total assessment. Table 6.1 provides a summary of the revised risk assessment while Table 6.2 details the revised risk assessment.

Risks have been grouped by the following climate variables:

- Extreme rainfall/flood events – 14 risks
- Extreme heat – 8 risks
- Bushfire events – 7 risks
- Storm events and wind – 3 risks
- Mean rainfall change/drought – 2 risks.

During the course of the risk assessment process, two risks to the design and construction process were identified (R17 and R21). These risks relate to the uncertainty of projections impacting on the design of the proposal and the potential for extreme events to disrupt the construction of the proposal. Furthermore, as design and construction would be finished well in advance of 2090, risk ratings were only assigned for the 2030 timeframe.

Table 6.1 Summary of risk assessment

Risk rating	2030	2090
Low	19	6
Medium	9	16
High	5	7
Very High	1	3
Total Risks	34	32

The ISCA IS Tool V1.2, Cli-2 Criteria require adaptation options to be identified for all high and extreme (very high when using ARTC's risk framework) risks. Adaptation options are proposed in the Section 7 to reduce risks to a tolerable threshold of medium (at minimum), where possible and practicable. It is worth noting that adaptation options may also reduce risks that were identified as being low (e.g. asset protection zones).

Table 6.2 presents the CCRA for the proposal; with risk ratings evaluated first using the ARTC risk management framework and assessment criteria as well as in consultation with Project team members during the workshop. This combination allowed an appropriate determination of the consequence and likelihood of each risk.

Furthermore, in accordance with best practice and current design standards, operations and maintenance practices, risk management and adaptation measures are typically incorporated into the pre-concept and concept designs. In addressing climate change adaptation, these measures include:

- Consideration of climate change impacts associated with flooding as part of hydrology and drainage in accordance with Australian Rainfall and Runoff Interim Climate Change Guidelines[2]
- Assessment of floods larger than the 1 percent annual exceedance probability (AEP), including the consideration of AEP 1:2,000 for bridge design
- Material selection for infrastructure which considers future temperature changes such trackwork which responds to extreme temperature events
- Welded Track Stability Analysis [ARTC – ETM-06-09] to identify potential sources of track instability which may result in damage to the track in the event of extreme temperatures
- Temporary speed and/or load restrictions when extreme weather conditions increase the potential for buckling or misalignment of the track.

[2] Consideration of climate change impacts has also been undertaken to align with the RCP8.5 scenario, which assumes minimal effort to reduce global greenhouse gas emissions and projects a certain percentage increase in rainfall.

Table 6.2 Climate change risk assessment 2030 and 2090

Risk ID	Risk statement	2030			2090		
		Likelihood	Consequence[1]	Risk rating	Likelihood	Consequence	Risk rating
Extreme heat							
Direct risks							
R1	Risk to health and safety of staff working along the rail corridor through heat stress	Possible	Major	High	Likely	Major	Very high
R2	Risk to business continuity as a result of heat events (e.g. increased incidence of delayed service from trains breaking down and/or operational activities not being able to occur)	Likely	Minor	Medium	Almost certain	Minor	Medium
R3	Increase in hot days resulting in track twisting (buckling) which could lead to derailment of trains along the rail line	Likely	Moderate	High	Almost certain	Moderate	High
R4	Decreased efficiency and more frequent outages of electrical (track switches, signalling, etc.) and communication systems	Possible	Not significant	Low	Likely	Not significant	Low
R5	Accelerated degradation of materials and reduced life of structures (bridges, crossings, track) and specialist equipment (communications towers, signalling) resulting in increased capital cost due to the need for more frequent repairs and maintenance	Possible	Minor	Low	Likely	Minor	Medium
R6	Increased occurrence of extreme heat impacting the ability to maintain equipment (e.g. accessibility to water resources)	Likely	Minor	Medium	Almost certain	Minor	Medium
Indirect risks							
R7	Extreme heat leading to increased power demand and/or failure of power infrastructure (I.e. substations, LV/HV switchboards) resulting in interruptions to power supply with increased frequency and duration of power outages	Possible	Not significant	Low	Likely	Not significant	Low
R8	Increased incidence of extreme heat limiting the ability for ARTC to attract workers due to undesirable conditions	Possible	Minor	Low	Likely	Minor	Medium
Mean rainfall change/drought							
Direct risks							
R9	Structural deterioration, soil subsidence, erosion, movement and cracking as a result of increased variability of periods of wetting and drying causing reduced integrity of tracks, bridges and signalling infrastructure with potential structural failure	Unlikely	Moderate	Low	Possible	Moderate	Medium

Risk ID	Risk statement	2030			2090		
		Likelihood	Consequence[1]	Risk rating	Likelihood	Consequence	Risk rating
Indirect risks							
R10	Increased time spent in drought conditions impacting farmers (production of produce) reducing demand on rail services	Unlikely	Moderate	Low	Possible	Moderate	Medium
Extreme rainfall and flood events							
Direct risks							
R11	Risk to health and safety of staff (e.g. conductor, emergency crews) working along the rail corridor due to velocity and flow of flooding (e.g. flash flooding events)	Likely	Minor	Medium	Likely	Minor	Medium
R12	Inundation of tracks causing potential isolation of assets due to flooding	Possible	Major	High	Likely	Major	Very high
R13	Inundation of adjacent road network and signalling equipment causing potential isolation of assets due to flooding	Likely	Major	Very high	Almost Certain	Major	Very high
R14	Malfunctioning of electrical equipment, including signalling and communications	Unlikely	Minor	Low	Possible	Minor	Low
R15	Extreme rainfall leading to flooding/standing water resulting in the increased presence/risk of disease and water-borne pathogens which could pose a risk to rail operators or ARTC staff	Rare	Minor	Low	Unlikely	Minor	Low
R16	Changed rainfall patterns and resulting runoff impacting drainage including civil drainage (surface) and overland flow along the corridor	Possible	Moderate	Medium	Likely	Moderate	High
R17	Extreme rainfall and flooding resulting in delays to construction schedule and cost impacts	Possible	Major	High	-	-	-
R18	Extreme rainfall and flooding resulting in cost / time disruption to operation (increased frequency of repairs/outages/lost service revenue)	Unlikely	Major	Medium	Possible	Major	High
R19	Increased in extreme events resulting in increased maintenance costs (e.g. more frequent repairs)	Possible	Minor	Low	Likely	Minor	Medium
Indirect risks							
R20	Increase in extreme events increasing volume for runoff from catchment areas outside of the rail corridor	Possible	Moderate	Medium	Possible	Moderate	Medium
R21	Uncertainty of extreme rainfall events/flooding behaviour impacting on design conditions/requirements leading to a potential over or under design of infrastructure	Rare	Major	Low	-	-	-

Risk ID	Risk statement	2030			2090		
		Likelihood	Consequence[1]	Risk rating	Likelihood	Consequence	Risk rating
R22	Extreme rainfall leading to faults/failure of power infrastructure resulting in interruptions to power supply with increased frequency and duration of power outages (particularly signalling and communications equipment)	Possible	Moderate	Medium	Likely	Moderate	High
R23	Extreme rainfall leading to increased stormwater runoff, with potential damage and/or inundation of surrounding road infrastructure impacting the ability of emergency response/workers to reach the corridor	Possible	Moderate	Medium	Likely	Moderate	High
R24	Extreme rainfall and flooding causing damage to non-rail structures potentially impacting operations	Unlikely	Moderate	Low	Possible	Moderate	Medium
Bushfire events							
Direct risks							
R25	Smoke from bushfires limiting visibility resulting in increased risk of freight disruptions and/or cancellations	Unlikely	Moderate	Low	Possible	Moderate	Medium
R26	Bushfire damaging trackside infrastructure (e.g. signals, communications equipment requiring increased operational costs	Unlikely	Minor	Low	Possible	Minor	Low
R27	Risk to health and safety of staff working along the rail corridor due to inhalation of bushfire smoke and proximity to flames	Unlikely	Minor	Low	Possible	Minor	Low
Indirect risks							
R28	Bushfire events leading to damage to power supply infrastructure or a need to cut supply resulting in interruptions to power supply (particularly signalling and communications equipment) with increased frequency and duration of power outages	Unlikely	Moderate	Low	Possible	Moderate	Medium
R29	Bushfire event resulting in surrounding community using the rail corridor as access/egress	Unlikely	Moderate	Low	Possible	Moderate	Medium
R30	Bushfire events resulting in closure of surrounding road network, impacting emergency access, rescue, community evacuation or maintenance	Possible	Minor	Low	Likely	Minor	Medium
R31	Bushfire event along the Inland Rail corridor resulting in stoppage of freight along the rail and subsequent severing of community evacuation access/egress points	Unlikely	Moderate	Low	Possible	Moderate	Medium
Storm events							
Direct risks							
R32	Damage to tracks/siding, electrical, communications infrastructure and other structures due to higher wind speeds and falling debris requiring repair and/or replacement and an increase in capital costs	Possible	Major	High	Possible	Major	High

Risk ID	Risk statement	2030			2090		
		Likelihood	Consequence[1]	Risk rating	Likelihood	Consequence	Risk rating
Indirect risks							
R33	Storm events resulting in closure of rail line (due to damage to communications equipment, for safety purposes or loss of power supply/increased frequency and duration of power outages) with subsequent delays	Unlikely	Moderate	Low	Possible	Moderate	Medium
R34	Storm events and subsequent higher winds resulting in service disruption (loss of freight, rolling stock, cessation of operation) including damage to infrastructure	Unlikely	Major	Medium	Possible	Major	High

Table note:

1 Primary consequence driver noted on workshop materials located in Appendix A.

7 Adaptation options

The following outlines associated mitigation and adaptation measures to reduce the impact of climate change risk to the proposal. It is noted that in some instances, a changing climate can result in beneficial outcomes, including less impacts to track from rapid heating and cooling resulting from increased temperature changes. For the most part however, identified measures include a combined approach that addresses the avoidance of risk, designing out risk where possible and practicable, as well as procedures for the management of risks that may be unavoidable.

Table 7.1 outlines identified adaptation measures that have either been already considered as part of the design process, are currently underway, or will be undertaken prior to operation (planned). The identification of these adaptation measures have resulted from discussions with design leads and technical specialists, review of proposal information (including Basis of Design and flooding reports) and documentation of existing ARTC operating practices.

In terms of timing, a “current” Adaptation Action is considered to be an action which has already been or will be integrated into the design process, while “Planned” is considered to be an action that would be implemented during construction or operation specific to the proposal or require an organisational operation change. “Potential Actions” were also identified during the climate change risk workshop and have been identified as adding value and/or included as part of the Final Design Report. These actions are presented below, but have not yet have been programmed or incorporated and as such have not been assessed for the residual risk assessment and may not be feasible. Verification and feasibility of these measures would be confirmed by ARTC and/or FFJV prior to finalisation of the design and/or start of construction. The residual risk assessment will be updated periodically to account for any changes in the proposal design or to reflect changes in ARTC operating procedure.

The Potential Actions include:

- Providing educational resources to staff around extreme heat including heat stress, safe working conditions and risk to safety
- Accounting for soil erosion/cracking in the landscape management plan to be prepared
- Developing a procedure for ‘wagon stacking’ to reduce risk of containers derailing as a result of high winds
- Developing a ‘high-winds’ operating procedure to direct trains based on direction and intensity of wind
- Ensuring appropriate evacuation access is provided outside of areas of known natural hazard risk (e.g. before and after a known flood risk, alternative access/egress)
- Developing a recovery plan to account for potential impacts and proposed responses based on key risks
- Incorporating contingency in the works program (scheduling), tailor the construction methodology and provide additional budget for responding to extreme events
- Providing easy accessibility to trackside infrastructure including the development of an asset register to ensure locations are known during emergency response
- Providing weather monitoring equipment trackside and onboard to ensure real time understanding of local conditions, particularly for wind speed and temperature
- Considering the location of equipment stockpiling for repairs (e.g. having parts across various geographies) in case of extreme events shutting off access.

Table 7.1 Current and planned risk mitigation and climate adaptation options

Adaptation option	Applicable risk(s)	Timing
Mean temperature change/Extreme heat		
Maintenance program to be developed/operational policy updated to avoid outdoor works during hotter times (where practicable).	R1, R2, R8	Planned
Implement high temperature stop work threshold if not already considered within existing ARTC operational framework.	R1, R2, R8	Planned
Reduce train speeds during days where trackside temperature exceeds 35°C.	R3	Current
Ensure that design and procurement of trackside equipment (e.g. signals, communication relay points) account for an increase in ambient temperatures and extreme heat days beyond those required as the Basis of Design.	R4, R5, R6	Planned
Consider the use of elastic fasteners and/or heavier sleepers to account for potential track buckle.	R3	Current
Provide shade for trackside equipment (double ventilated signal boxes and/or double skinned enclosures) and/or specify material and colour selection to reduce heat load.	R4, R5, R6	Planned
Consider the use of lighter coloured ballast or painted rails to reduce trackside temperature.	R3, R4, R5, R6	Current, but infrequently applied
Bushfire		
Locate electrical equipment and supporting infrastructure outside of bushfire prone areas where reasonable and feasible to reduce risk of damage from bushfire.	R26	Current
Extreme rainfall and flooding		
Include allowance for climate change in the design criteria for flooding based on a 10% increase in rainfall event, particularly around track-side storage detention basins/stormwater infrastructure, in accordance with the NSW Office of Water (NOW) guidance Practical Consideration of Climate Change (25/10/2007).	R11, R12, R13, R15, R16, R20, R21	Current
Undertake sensitivity testing in line with climate change scenario planning for RCP 8.5 by reviewing implications of 20% and 30% increases in rainfall (in accordance with the Australian Rainfall and Runoff Guidelines, 2016).	R11, R12, R13, R15, R16, R20, R21	Planned
Implement flood mitigation measures along the rail corridor, including the locating of critical electrical systems (signalling, communications huts, etc.) above potential flood zones and increasing the design height of bunds.	R11, R12, R13, R14, R18	Current
Design site grading to direct flooding into on-site detention and other stormwater channels/drainage infrastructure.	R12, R13, R15, R16	Current
Design culverts and drainage to be concrete-lined to reduce potential for damage.	R16	Current
Incorporate additional drainage network features and flood protection measures (e.g. larger drainage network, additional pits, larger pipe diameters, larger sumps etc.) to mitigate a potential increase in flood risks.	R16	Current
Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding.	R11, R12, R13, R1, R16, R17, R18, R20	Planned

Adaptation option	Applicable risk(s)	Timing
General		
Develop or update emergency response procedures to respond to extreme weather events.	R8, R25	Planned
Establish vegetation clearance zones across the corridor to minimise vegetation (debris and bushfire risk).	R25, R26, R27, R32	Current
Backup power supply and/or built-in system redundancy (in case of substation failure) provided as standard to ensure continuous operation of electrical systems including signalling and communications equipment along the corridor.	R7, R28, R33	Current
Incorporate solar PV and battery storage as built in redundancy to ensure ongoing operation of signalling and communications equipment in the event of power failure.	R7	Current
Engage with local emergency services to discuss and coordinate emergency response procedures.	R29, R30, R31	Planned

8 Residual risk assessment

A residual risk assessment for the proposal was undertaken to apply the relevant adaptation measures identified in the above section for all ‘very high’ and ‘high’ risks and shown in Table 8.1. In addition, adaptation actions identified contributed towards treating all ‘medium’ risks, resulting in a number of those ‘medium’ risks having their corresponding residual risks revised to ‘low’. Based on the application of the adaptation measures, no residual ‘very high’ or ‘high’ risk ratings remain for the proposal, which satisfies both SEARs and ISCA requirements. As part of the residual risk assessment, individual, specific adaptation measures have been applied to multiple risks to help reduce the potential risks to the proposal. It is anticipated that as the proposal develops, this register will continue to be used to track compliance and progress against the adaptation measures to assist in reducing the risk exposure of the proposal.

Considering v.1.2 of the ISCA IS Rating Scheme Cli-2 criteria, adaptation options for all high and extreme (very high using the ARTC risk framework) risks and a percentage of medium priority risks are identified with appropriate measures implemented.

Table 8.1 Residual risk assessment 2030 and 2090

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R1	Risk to health and safety of staff working along the rail corridor through heat stress	High	Very high	▪ Maintenance program to be developed/operational policy updated to avoid outdoor works during hotter times (where practicable). ▪ Implement high temperature stop work threshold if not already considered within existing ARTC operational framework	ARTC	Review of ARTC operating procedures Temperature threshold Extreme heat events	Possible	Minor	Low	Likely	Minor	Medium
R2	Risk to business continuity as a result of heat events (e.g. increased incidence of delayed service)	Medium	Medium	▪ Maintenance program to be developed/ operational policy updated to avoid outdoor works during hotter times (where practicable). ▪ Implement high temperature stop work threshold if not already considered within existing ARTC operational framework.	ARTC	Review of ARTC operating procedures Temperature threshold Extreme heat events	Likely	Minor	Medium	Almost Certain	Minor	Medium
R3	Increase in hot days resulting in track twisting (buckling) which could lead to derailment of trains along the rail line	High	High	▪ Reduce train speeds during days where trackside temperature exceeds 35°C ▪ Consider the use of elastic fasteners and/or heavier sleepers to account for potential track buckle. ▪ Consider the use of lighter coloured ballast or painted rails to reduce trackside temperature	ARTC	Design Review	Likely	Minor	Medium	Almost Certain	Minor	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R5	Accelerated degradation of materials and reduced life of structures (bridges, crossings, track) and specialist equipment (communications towers, signalling) resulting in increased capital cost due to the need for more frequent repairs and maintenance	Low	Medium	▪ Consider the use of lighter coloured ballast or painted rails to reduce trackside temperature	ARTC	Design Review	Possible	Minor	Low	Likely	Minor	Medium
R6	Increased occurrence of extreme heat impacting the ability to maintain equipment (e.g. accessibility to water resources)	Medium	Medium	▪ Consider the use of lighter coloured ballast or painted rails to reduce trackside temperature	ARTC	Design Review	Likely	Minor	Medium	Almost Certain	Minor	Medium
R8	Increased incidence of extreme heat limiting the ability for ARTC to attract workers due to undesirable conditions	Low	Medium	▪ Maintenance program to be developed/operational policy updated to avoid outdoor works during hotter times (where practicable). ▪ Implement high temperature stop work threshold if not already considered within existing ARTC operational framework.	ARTC	Review of ARTC operation and maintenance procedures	Possible	Not Significant	Low	Likely	Not Significant	Low

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R9	Structural deterioration, soil subsidence, erosion, movement and cracking as a result of increased variability of periods of wetting and drying causing reduced integrity of tracks, bridges and signalling infrastructure with potential structural failure	Low	Medium	N/A	N/A	N/A	Unlikely	Moderate	Low	Possible	Moderate	Medium
R10	Increased time spent in drought conditions impacting farmers (production of produce) reducing demand on rail services	Low	Medium	N/A	N/A	N/A	Unlikely	Minor	Low	N/A	N/A	N/A
R11	Risk to health and safety of staff (e.g. conductor, emergency crews) working along the rail corridor due to velocity and flow of flooding	Medium	Medium	▪ Include allowance for climate change in the design criteria for flooding based on a 10% increase in rainfall event, particularly around track-side storage detention basins/stormwater infrastructure, in accordance with the NSW Office of Water (NOW) guidance Practical Consideration of Climate Change (25/10/2007).	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Likely	Not Significant	Low	Likely	Not Significant	Low

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
				▪ Undertake sensitivity testing in line with climate change scenario planning for RCP 8.5 by reviewing implications of 20% and 30% increases in rainfall (in accordance with the Australian Rainfall and Runoff Guidelines, 2016).Implement flood mitigation measures along the rail corridor, including the locating of critical electrical systems (signalling, communications huts, etc.) above potential flood zones and increasing the design height of bunds ▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding.								
R12	Inundation of tracks causing potential isolation of assets due to flooding	High	Very high	▪ Include allowance for climate change in the design criteria for flooding based on a 10% increase in rainfall event, particularly around track-side storage detention basins / stormwater infrastructure, in accordance with the NSW Office of Water (NOW) guidance Practical Consideration of Climate Change (25/10/2007).	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Likely	Minor	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
				▪ Undertake sensitivity testing in line with climate change scenario planning for RCP 8.5 by reviewing implications of 20% and 30% increases in rainfall (in accordance with the Australian Rainfall and Runoff Guidelines, 2016). ▪ Implement flood mitigation measures along the rail corridor, including the locating of critical electrical systems (signalling, communications huts, etc.) above potential flood zones and increasing the design height of bunds ▪ Design site grading to direct flooding into on-site detention and other stormwater channels/drainage infrastructure ▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding								

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R13	Inundation of adjacent road network and signalling equipment causing potential isolation of assets due to flooding	Very high	Very high	▪ Include allowance for climate change in the design criteria for flooding based on a 10% increase in rainfall event, particularly around track-side storage detention basins/stormwater infrastructure, in accordance with the NSW Office of Water (NOW) guidance Practical Consideration of Climate Change (25/10/2007). ▪ Undertake sensitivity testing in line with climate change scenario planning for RCP 8.5 by reviewing implications of 20% and 30% increases in rainfall (in accordance with the Australian Rainfall and Runoff Guidelines, 2016). ▪ Implement flood mitigation measures along the rail corridor, including the locating of critical electrical systems (signalling, communications huts, etc.) above potential flood zones and increasing the design height of bunds ▪ Design site grading to direct flooding into on-site detention and other stormwater channels/drainage infrastructure	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Likely	Minor	Medium	Almost Certain	Minor	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
				▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding								
R16	Changed rainfall patterns and resulting runoff impacting drainage including civil drainage (surface) and overland flow along the corridor	Medium	High	▪ Include allowance for climate change in the design criteria for flooding based on a 10% increase in rainfall event, particularly around track-side storage detention basins/stormwater infrastructure, in accordance with the NSW Office of Water (NOW) guidance Practical Consideration of Climate Change (25/10/2007). ▪ Undertake sensitivity testing in line with climate change scenario planning for RCP 8.5 by reviewing implications of 20% and 30% increases in rainfall (in accordance with the Australian Rainfall and Runoff Guidelines, 2016). ▪ Design site grading to direct flooding into on-site detention and other stormwater channels/drainage infrastructure ▪ Design culverts and drainage to be concrete-lined to reduce potential for damage.	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Likely	Minor	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
				▪ Incorporate additional drainage network features and flood protection measures (e.g. larger drainage network, additional pits, larger pipe diameters, larger sumps etc.) to mitigate a potential increase in flood risks. ▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding								
R17	Extreme rainfall and flooding resulting in delays to construction schedule and cost impacts	High	-	▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding ▪ Develop or update emergency response procedures to respond to extreme weather events.	ARTC	Construction	Possible	Moderate	Medium	-	-	-
R18	Cost and time impacts/disruption to operation (increased frequency of repairs/outages/lost service)	Medium	High	▪ Implement flood mitigation measures along the rail corridor, including the locating of critical electrical systems (signalling, communications huts, etc.) above potential flood zones and increasing the design height of bunds	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Unlikely	Moderate	Low	Possible	Moderate	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
				▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding								
R19	Increased in extreme events resulting in increased maintenance costs (e.g. more frequent repairs)	Low	Medium	▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding	ARTC	Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Likely	Minor	Medium
R20	Increase in extreme events increasing volume for runoff from catchment areas outside of the rail corridor	Medium	Medium	▪ Include allowance for climate change in the design criteria for flooding based on a 10% increase in rainfall event, particularly around track-side storage detention basins/stormwater infrastructure, in accordance with the NSW Office of Water (NOW) guidance Practical Consideration of Climate Change (25/10/2007). ▪ Undertake sensitivity testing in line with climate change scenario planning for RCP 8.5 by reviewing implications of 20% and 30% increases in rainfall (in accordance with the Australian Rainfall and Runoff Guidelines, 2016).	FFJV	Design Review Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Possible	Minor	Low

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
				▪ Investigate the inclusion and development of an early flood warning system (e.g. flood gauges, trackside monitors) to alert ARTC to impending flooding								
R22	Extreme rainfall leading to faults/failure of power infrastructure resulting in interruptions to power supply with increased frequency and duration of power outages (particularly signalling and communications equipment)	Medium	High	▪ Backup power supply and/or built-in system redundancy (in case of substation failure) provided as standard to ensure continuous operation of electrical systems including signalling and communications equipment along the corridor. ▪ Incorporate solar PV and battery storage as built in redundancy to ensure ongoing operation of signalling and communications equipment in the event of power failure.	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Likely	Minor	Medium
R23	Extreme rainfall leading to increased stormwater runoff, with potential damage and/or inundation of surrounding road infrastructure impacting the ability of emergency response/workers to reach the corridor	Medium	High	▪ Engage with local emergency services to discuss and coordinate emergency response procedures	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Likely	Minor	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R24	Extreme rainfall and flooding causing damage to non-rail structures potentially impacting operations	Low	Medium	N/A	ARTC	Budget Review	Unlikely	Moderate	Low	Possible	Moderate	Medium
R25	Smoke from bushfires limiting visibility resulting in increased risk of freight disruptions and/or cancellations	Low	Medium	▪ Develop or update emergency response procedures to respond to extreme weather events.	ARTC	Budget Review Review of ARTC operation and maintenance procedures	Unlikely	Minor	Low	Possible	Minor	Low
R28	Bushfire events leading to damage to power supply infrastructure or a need to cut supply resulting in interruptions to power supply (particularly signalling and communications equipment) with increased frequency and duration of power outages	Low	Medium	▪ Backup power supply and/or built-in system redundancy (in case of substation failure) provided as standard to ensure continuous operation of electrical systems including signalling and communications equipment along the corridor. ▪ Locate electrical equipment and supporting infrastructure outside of bushfire prone areas where reasonable and feasible to reduce risk of damage from bushfire. ▪ Incorporate solar PV and battery storage as built in redundancy to ensure ongoing operation of signalling and communications equipment in the event of power failure.	ARTC/ FFJV	Design Review Review of ARTC operation and maintenance procedures	Unlikely	Minor	Low	Possible	Minor	Low

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R29	Bushfire event resulting in surrounding community using the rail corridor as access/egress	Low	Medium	▪ Engage with local emergency services to discuss and coordinate emergency response procedures	ARTC/ FFJV	Review of ARTC operation and maintenance procedures	Unlikely	Moderate	Low	Possible	Moderate	Medium
R30	Bushfire events resulting in closure of surrounding road network, impacting emergency access, rescue, community evacuation or maintenance	Low	Medium	▪ Consider the location of equipment stockpiling for repairs (e.g. having parts across various geographies) in case of extreme events shutting off access ▪ Engage with local emergency services to discuss and coordinate emergency response procedures	ARTC/ FFJV	Design review Review of ARTC operation and maintenance procedures	Possible	Minor	Low	Likely	Minor	Medium
R31	Bushfire event along the Inland Rail corridor resulting in stoppage of freight along the rail and subsequent severing of community evacuation access/egress points	Low	Medium	▪ Engage with local emergency services to discuss and coordinate emergency response procedures	ARTC	Review of ARTC operational procedures	Unlikely	Minor	Low	Possible	Minor	Low
R32	Damage to tracks/siding, electrical, communications infrastructure and other structures due to higher wind speeds and falling debris requiring repair and/or replacement and an increase in capital costs	High	High	▪ Develop or update emergency response procedures to respond to extreme weather events. ▪ Establish vegetation clearance zones across the corridor to minimise vegetation (debris and bushfire risk).	ARTC	Budget review Review of ARTC operation and maintenance procedures	Possible	Moderate	Medium	Possible	Moderate	Medium

Risk ID	Risk statement	Risk rating		Adaptation options	Responsibility	Timing	2030			2090		
		2030	2090				Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
R33	Storm events resulting in closure of rail line (due to damage to communications equipment, for safety purposes or loss of power supply/increased frequency and duration of power outages) with subsequent delays	Low	Medium	▪ Backup power supply and/or built-in system redundancy (in case of substation failure) provided as standard to ensure continuous operation of electrical systems including signalling and communications equipment along the corridor. ▪ Incorporate solar PV and battery storage as built in redundancy to ensure ongoing operation of signalling and communications equipment in the event of power failure.	ARTC/ FFJV	Design review Review of ARTC operation and maintenance procedures	Unlikely	Minor	Low	Possible	Minor	Low
R34	Storm events and subsequent higher winds resulting in service disruption (loss of freight, rolling stock, cessation of operation) including damage to infrastructure	Medium	High	▪ Develop or update emergency response procedures to respond to extreme weather events. ▪ Engage with local emergency services to discuss and coordinate emergency response procedures.	ARTC	Review of ARTC operation and maintenance procedures	Unlikely	Moderate	Low	Possible	Moderate	Medium

9 Conclusion

9.1 Summary

With the implementation of adaptation measures, the residual risk assessment has resulted in no remaining extreme (very high) or high risks and has also treated a number of medium risks.

Based on the risk assessment for the proposal, extreme rainfall events, flooding and extreme heat will present the highest risk in both the near future and far future. Risks associated with these events involve:

- Increased flooding resulting in inundation of track and trackside infrastructure (signalling/communications equipment and drainage basins)
- Increased incidents of extreme events (heat, rainfall and bushfire) on power supply and demand (both internal and external to the rail corridor) and network (communications) interruption
- Increased heat events leading to track buckling and subsequent disruption of service.

It is anticipated that all high risks identified for the works can be reduced to a residual risk rating of at least medium through the implementation of the recommended risk management and adaptation measures through the proposal's design, construction and operation. As shown in Section 7 several of the risk management and adaptation measures can be applied to more than one projected climate impact.

Risk management and adaptation measures identified in this report have been previously considered as part of design and construction, planned for future phases (detailed design, operational procedures) or have been recommended as a potential action to ensure that risks to the works are considered and mitigated, where possible and practicable.

A residual risk assessment was conducted based on the adaptation measures identified in the above section with an appropriate responsibility and timing taken into consideration. A residual risk assessment for the proposal was undertaken after the relevant adaptation measures were identified for all 'very high' and 'high' risk. It is noted that 1, 5 and 9, respectively of the 34 identified risks for 2030 were rated as 'very high', 'high' and 'medium'.

While uncertainty regarding future climate projections exists, particularly to 2090, the adaptation measures identified as part of this CCRA would result in a lowering of residual risks to the rail corridor across future scenarios.

9.2 Recommendations

It is recommended that risk management and adaptation measures identified for medium, high or very high risks in this report should be carried forward into the next stages of design and construction to ensure that these risks are considered and mitigated, where possible and practicable, or where a suitable alternative measure can be considered in lieu of one of the previously identified actions (while maintaining a reduction in risk). Furthermore, in anticipation of future operation, ARTC should begin to review and update existing operations and maintenance procedures to account for extreme events.

From an ISCA perspective, the CCRA presented in this report has considered and addressed information that would be required for compliance with both the Cli-1 and Cli-2 credit categories, subject to approval and verification of adaptation measures. As part of the ISCA submission process however, evidence of initiatives and adaptation actions identified within this report must be provided including demonstration of how the adaptation actions have been and/or will be implemented. The ability to produce this information and address suggested adaptation actions (Potential Actions) should be considered during subsequent phases of the proposed works for feasibility.

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APPENDIX Q

Climate Change Risk Assessment Technical Report

Appendix A Workshop Materials

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Australian Rail Track Corporation

INLAND RAIL
North Star to Border

Climate Risk & Adaptation Workshop

20 September 2018

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Integrating Community, Environment and Engineering

SAFETY SHARE

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Safety Share – getting ready

- Impacts of climate change are set to increase the frequency and intensity of extreme events
- Do you know what to do in an emergency?
- Red Cross Australia's Emergency RediPlan provides a great baseline of what to prep and what to consider in case of emergency

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Agenda

1. Overview, purpose and introductions
2. Background, context and key drivers
3. Observed climate and projections
4. Preliminary climate risks for the projects
5. Activity 1 - Validation of climate risks

Break for lunch

6. Adaptation planning
7. Activity 2 - Identification of adaptation options
8. Wrap up and next steps

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Workshop purpose

- Present relevant climate projections for NS2B
- Review, revise and prioritise climate risks for NS2B and B2G
- Identify existing measures and additional design and operational measures to mitigate risks for NS2B and B2G
- Review opportunities to future proof the design and operation of the NS2B and B2G sections of track over its entire life

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Introductions

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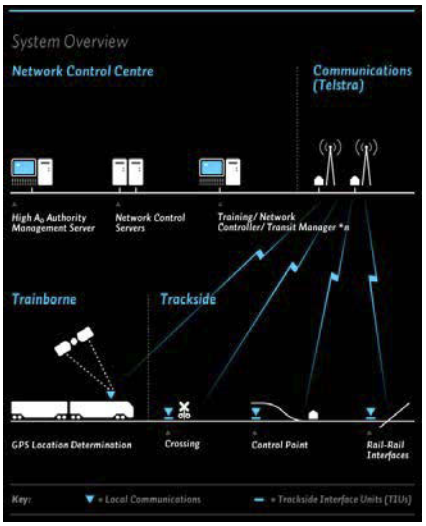
BACKGROUND AND CONTEXT

NS2B Overview

- New mainline single track to service freight operations with one crossing loop and one maintenance siding
- Signalling and communications infrastructure to support the Advanced Train Management Systems (ATMS)
- Alignment from just north of North Star to the NSW/QLD border (Macintyre River)

Communications & Signalling



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B2G Overview

- 220 km of single-track dual-gauge railway with five crossing loops and maintenance sidings
- Signalling infrastructure to support the Advanced Train Management Systems (ATMS)
- Will enable trains to travel between the QLD/NSW border near Yelarbon to Gowrie and provide connection between adjoining sections of Inland Rail
  - North Star to Border (NS2B) to the south
  - Gowrie to Helidon (G2H) to the north-east

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KEY DRIVERS

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Climate change context and drivers

PARIS2015 COP21-CMP11

ISCA Infrastructure Sustainability Council of Australia

IS Technical Manual Version 1.2

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ISCA v.1.2: Cli-1 and Cli-2

ISCA Credit	Aim	Criteria
Cli-1: Climate Change Risk Assessment	To reward the assessment of climate change risks.	The requirements of Level 1 are achieved. A number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset. AND The climate change risk assessment also considered indirect climate change risks to the asset. AND A multi-disciplinary team participated in identifying climate change risks and issues.
Cli-2: Adaptation Measures	To reward the assessment and implementation of climate change adaptation measures.	The requirements of Level 1 are achieved. AND Adaptation options to treat 25-50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented.

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OBSERVED CLIMATE

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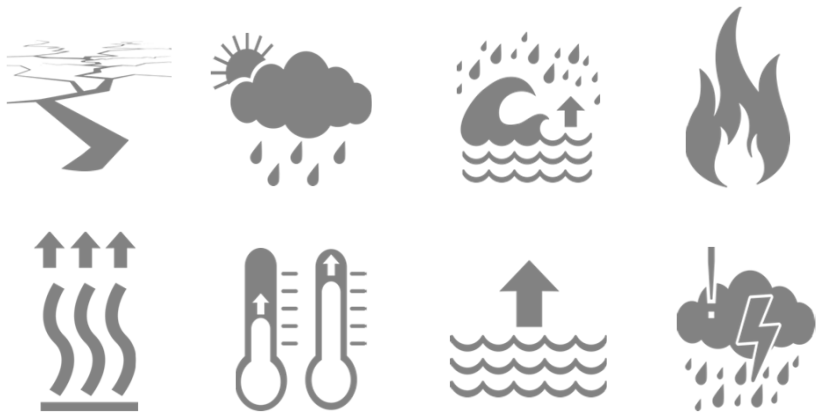
Climate Hazards



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Change is here

In the future it will happen more frequently

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Observed Regional Climate

- New England North West regional climate characterised by:
  - Dry and hot, semi-arid
    - Rainfall of 700mm/year – peaking during summer months
    - January the hottest month and July generally the coldest
- Extreme Rainfall events:
  - 2011: evacuation of Boggabilla and Toomelah
  - 2013: closures across Newell and Bruxner Highways
  - Extreme Heat events:
  - 2014 – close to 46°C in Goondiwindi
  - 2016-17: 52 consecutive days over 35°C

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Observed Climate

Hundreds evacuated, but threat easing south of the border

By Josephine Tovey
14 January 2011 – 3:00am

THE small border towns of Boggabilla and Toomelah in northern NSW were almost completely abandoned last night, as a small wall of water raced towards them.

NATURAL DISASTERS

Rain eases but roads closed and some river peaks yet to come

29th Jan 2013 7:22 AM | Updated: 8:26 AM

NEWS

UPDATE: Gwydir could be closed again due to bushfire

by JENNA THOMPSON, JARRARD POTTER and CAITLAN CHARLES

16th Aug 2018 7:10 AM

Global warming made Australia's record-breaking, sizzling summer 50 times more likely

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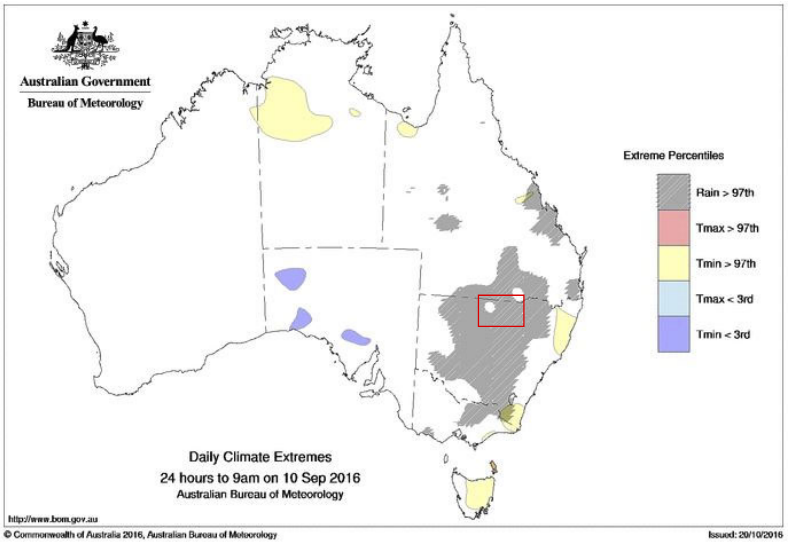
Observed Climate - Extreme Rainfall



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Observed Climate - Flooding (2011 & 2012)

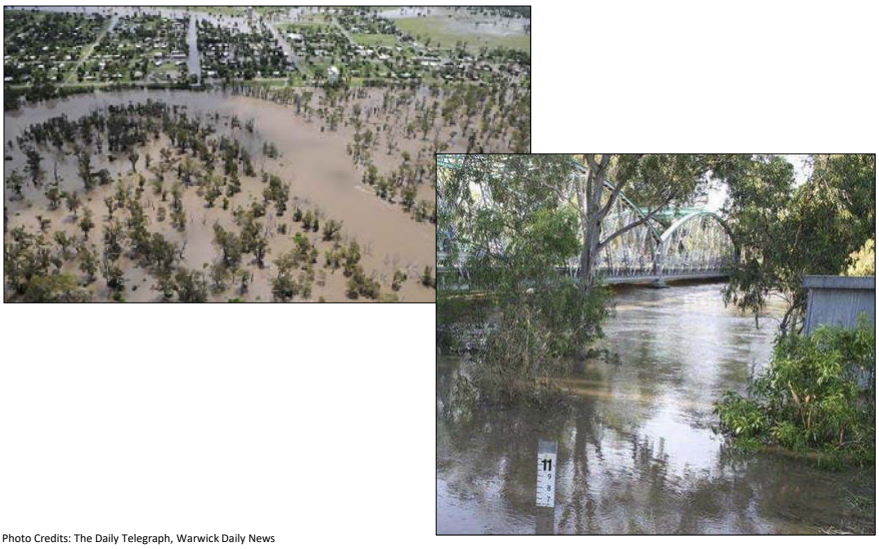

Photo Credits: The Daily Telegraph, Warwick Daily News

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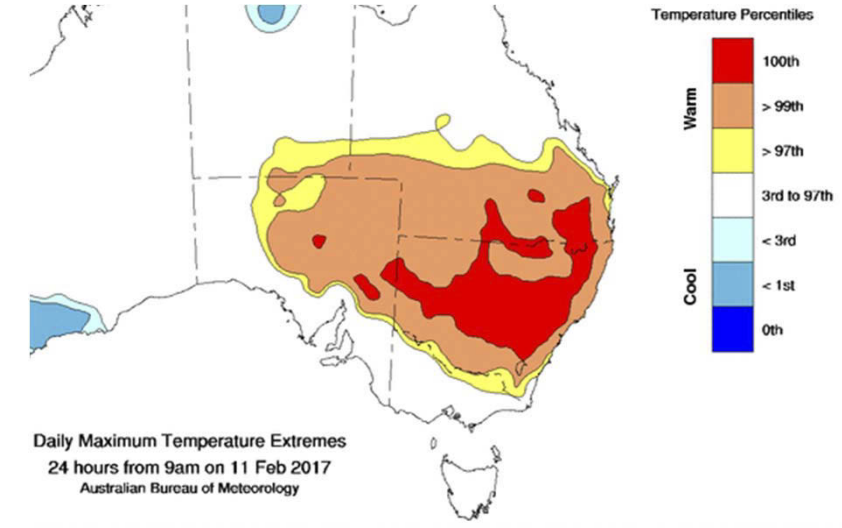
Observed Climate - Heat



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PROJECTED CHANGES TO THE CLIMATE

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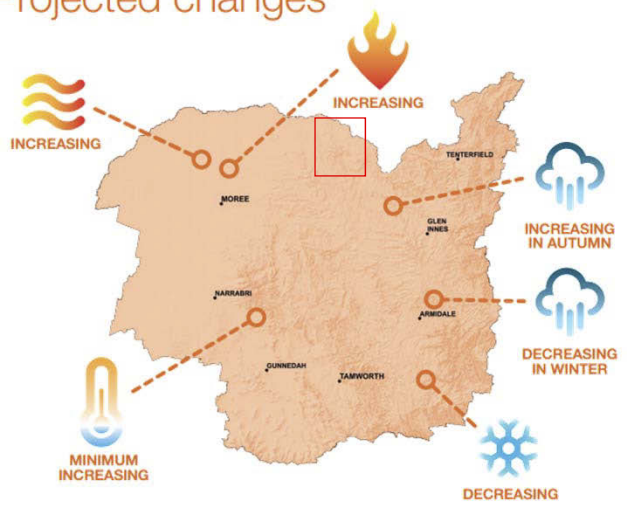
Projected changes



Adapt NSW, 2014 New England North West Climate Change Snapshot

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Projected changes

Projected temperature changes	
Maximum temperatures are projected to increase in the near future by 0.4 – 1.0°C	Maximum temperatures are projected to increase in the far future by 1.9 – 2.7°C
Minimum temperatures are projected to increase in the near future by 0.5 – 1.0°C	Minimum temperatures are projected to increase in the far future by 1.6 – 2.7°C
The number of hot days will increase	The number of cold nights will decrease
Projected rainfall changes	
Rainfall is projected to decrease over most of the region in winter	Rainfall is projected to increase in autumn
Projected Forest Fire Danger Index (FFDI) changes	
Average fire weather is projected to increase in summer, spring and winter	Severe fire weather days are projected to increase in summer and spring

Adapt NSW, 2014 New England North West Climate Change Snapshot

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Projected changes*

Climate Variable	2030	2090
Mean temperature change (°C)	Increase by 1.1°C (range of 0.6°C to 1.8°C)	Increase by 4.2°C (range of 3.0°C to 5.4°C)
Extreme Heat	Increase from 22 days (current) to 31 days (range of 26 to 37 days); RCP4.5	Increase from 22 days (current) to 65 days (range of 49 to 85 days); RCP8.5
Severe fire danger days per year (FFDI > 50)	Increased fire weather, with an increased number of severe fire danger days in the range of an additional 2.7 to 4.5 days per year (absolute change from a baseline of 2.0)	Increased fire weather, with increased number of severe fire danger days in the range of an additional 3.0 to 10.1 days per year (absolute change from a baseline of 2.0)
Solar radiation (%)	Minimal change of 0.6% (range of -0.7% to 2.1%)	Minimal change of 0.9% (range of -1.7% to 3.3%)
Relative Humidity	Minimal change of -0.8% (range of -2.8% to 1.6%)	Decrease on average by -2.4% (range of -7.4% to -1.1%)
Mean annual rainfall change (%)	Minimal change of -1% (range of -13% to 8%)	Decrease, with -6% change (range of -23% to 18%)
Extreme rainfall – inland flooding	Extreme rainfall events to increase in intensity and severity	
Drought	Both time spent in drought and occurrence of drought are anticipated to increase in intensity and severity.	

** Projected changes for the corridor based on the Central Slopes Cluster Report using the RCP8.5 high emissions scenario (BoM and CSIRO, 2015)*

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KEY CLIMATE RISKS AND IMPCTS

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Challenges for rail infrastructure

- Increased temperatures
  - Damage to metal / electrical components due to thermal expansi
  - Potential for track buckling
  - Risk to personnel operating in outdoor conditions
  - Increased bushfire risk and management
- Changes to rainfall
  - Risk of inundation of track and disruption of service
  - Increased flash flooding
  - Capacity constraints of storage and drainage systems
- More frequent intense storms
  - Physical damage to assets from wind, water or fire
  - Risk of inundation of assets

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Direct vs. indirect impacts

Direct Impacts

- The chance of an impact on an infrastructure system that causes damage, extra costs, accelerated deterioration or disruption of services.

Indirect Impacts

- The chance of an impact on another system, which disrupts the direct supply of services that your infrastructure system critically relies upon, thereby adversely impacting on your system.

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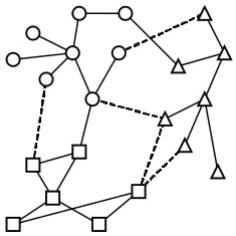
Considering interdependencies

Examples:

- Flooding and extreme rainfall leading to inundation of drainage infrastructure downstream of the project
- Increased frequency and intensity of bushfire leads to failure of power supply infrastructure due to direct fire damage to the transmission network



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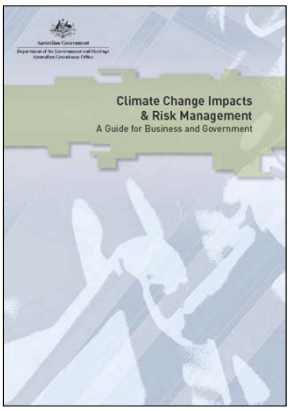
Climate risk assessment - Approach and standards



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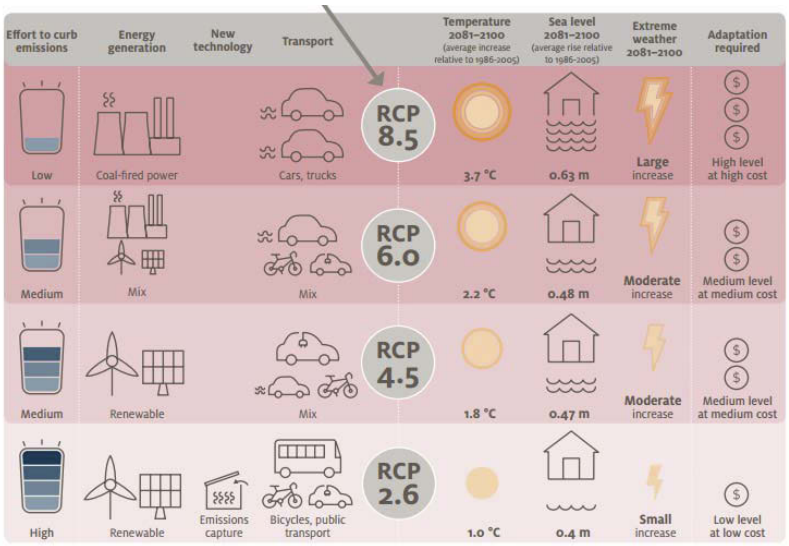
Climate scenarios



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Data sources

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Preliminary Climate Risk Assessment

- Preliminary findings:
- Key risk areas:
  - Extreme heat
  - Extreme rainfall and flooding
  - Extreme storms (including high winds and hail)

Risk Rating	2030	2090
Low	8	2
Medium	12	12
High	1	7
Very High	1	1
Total Risks	*22*	*22*

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Key climate risks

Risk ID	Risk	2030 Risk Rating
Extreme Heat		
Direct Risks		
R1	Risk to health and safety of staff working along the rail corridor through heat stress	Low
R2	Risk to business continuity as a result of heat events (e.g. increased incidence of delayed service or maintenance)	Medium
R3	Increase in hot days resulting in track twisting (buckling) which could lead to derailment of trains along the rail line	Low
R4	Decreased efficiency and more frequent outages of electrical (track switches, signalling, etc.) and communication systems	Medium
R5	Accelerated degradation of materials and reduced life of structures (bridges, crossings, track) and specialist equipment (communications towers, signalling) resulting in increased capital cost due to the need for more frequent repairs and maintenance	Low
Indirect Risks		
R6	Extreme heat leading to increased power demand and/or failure of power infrastructure (I.e. substations, LV / HV switchboards) resulting in interruptions to power supply with increased frequency and duration of power outages	Medium
Drought/Mean Rainfall Change		
R7	Structural deterioration, soil subsidence, erosion, movement and cracking as a result of increased variability of periods of wetting and drying causing reduced integrity of tracks, bridges and signalling infrastructure with potential structural failure	Low

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Key climate risks

Risk ID	Risk	2030 Risk Rating
Bushfire Events		
Direct Risks		
R8	Smoke from bushfires limiting visibility resulting in increased risk of freight disruptions and/or cancellations	Low
R9	Bushfire damaging trackside infrastructure (e.g. signals, communications equipment requiring increased operational costs	Low
R10	Risk to health and safety of staff working along the rail corridor due to inhalation of bushfire smoke	Low
Indirect Risks		
R11	Bushfire events leading to damage to power supply infrastructure or a need to cut supply resulting in interruptions to power supply (particularly signalling and communications equipment) with increased frequency and duration of power outages	Medium
Storm Events (including high winds and hail)		
Direct Risks		
R12	Damage to tracks / siding, electrical, communications infrastructure and other structures due to higher wind speeds and falling debris requiring repair and/or replacement and an increase in capital costs	Medium
Indirect Risks		
R13	Storm events resulting in closure of rail line (due to damage to communications equipment or for safety purposes) with subsequent delays	Medium
R14	Storm events leading to damage to power supply infrastructure or a need to cut supply resulting in interruptions to power supply (particularly signalling / communications equipment) with increased frequency and duration of power outages	Medium

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Key climate risks

Risk ID	Risk	2030 Risk Rating
Extreme Rainfall and Flood Events		
Direct Risks		
R15	Risk to health and safety of staff (e.g. conductor, emergency crews) working along the rail corridor due to velocity and flow of flooding	Medium
R16	Inundation of tracks, adjacent road network, and signalling equipment causing potential isolation of assets due to flooding	Very High
R17	Malfunctioning of electrical equipment, including signalling and communications	Medium
R18	Extreme rainfall leading to flooding / standing water resulting in the increased presence / risk of disease and water-borne pathogens	Low
R19	Changed rainfall patterns impacting drainage including civil drainage (surface) and overland flow along the corridor	High
Indirect Risks		
R20	Increase in extreme events increasing volume for drainage from catchment areas outside of the rail corridor	Medium
R21	Extreme rainfall leading to faults/failure of power infrastructure resulting in interruptions to power supply with increased frequency and duration of power outages (particularly signalling and communications equipment)	Medium
R22	Extreme rainfall leading to increased stormwater runoff, with potential damage and/or inundation of surrounding road infrastructure impacting the ability of emergency response / workers to reach the corridor	Medium

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GROUP ACTIVITY 1 - VALIDATION OF CLIMATE RISKS

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Group Activity 1 – Climate Risk Review

- **Part 1 - Validation of climate impacts:**
  - Can any of the risks be excluded?
  - Are there other relevant risks that need to be captured?
  - Are the risks consistent for B2G?
- **Part 2 – Rating/prioritising risks:**
  - Based on a 2030 time horizon – review and assign/confirm the risk rating
  - Prioritise the top risks for each of the climate impacts
  - Do they translate across both NS2B and B2G
- **Part 3 - Discuss key findings:**
  - Highlight key findings and discuss feedback to support resolution

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Activity 1 – Consequence Criteria

Risk Category		Consequence				
		Not Significant (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Safety	Impact to People	No Medical Treatment Required	Lost Time Injury (LTI) Results OR Medical Treatment Required	Serious Injury Occurs	Single Fatality Occurs	Multiple but Localised Fatalities Occur
Assets	Engineering impacts(s) and satisfying objectives	Up to 6hrs Track Closure	>6hrs to 24hrs Track Closure	>24hrs to 48hrs Track Closure	>48hrs to 5 Days Track Closure	>5 Days Track Closure
Financial	Total Outturn Cost impact	Up to 0.05% of programme budget (i.e. to $5M in $10B)	>0.05% to 0.5% of programme budget (i.e.>$5M to $50M in $10B)	>0.5% to 1.5% of programme budget (i.e.>$50M to $150M in $10B)	>1.5% to 5% of programme budget (i.e.>$150M to $500M in $10B)	>5% of programme budget (i.e.>$500M in $10B)
		Up to 0.1% of project budget (e.g. to $100k in $100M)	>0.1% to 0.5% of project budget (e.g. >$100k-$500k in $100M)	>0.5% to 2.5% of project budget (e.g. >$500k-$2.5M in $100M)	>2.5% to 10% of project budget (e.g. >$2.5M-$10M in $100M)	>10% of project budget (e.g. >$10M in $100M)
Environment	Environment Impact Heritage, Flora & Fauna, Archaeology & Indigenous, Pollution and Amenity (Public)	Contained Environmental Damage - fully recoverable (no cost or ARTC action required)	Isolated Environmental Damage - minimal ARTC remediation required	Localised/Clustered Environmental Damage - requiring remediation	Considerable Environmental Damage - requiring remediation	Widespread Long Term or Permanent Environmental Damage - remediation required
Regulatory	Regulatory/Legislation Exposure Non-compliance & Our Licence to Operate	Minimal or no Regulatory Involvement	Notice to Produce Information	Improvement Notice or Threatened Action	Prohibition Notice or Fine(s)	Prosecution of the Company and/or its Office Holders
Reputation	Reputational Exposure Customer Dissatisfaction, Shareholder Support, Service Quality & Reliability, Public Image and Stakeholder Attitudes	Isolated event able to be resolved (up to 7 days)	Management intervention required (>7 days to 3 months)	Tactical (Business Unit/ Divisional) intervention required (>3months to 18 months)	Strategic intervention required (>18 months to 3 years)	Corporate loss of Shareholder and/or Customer support (tangible business impact >3 years)
Schedule	Time Based Impacts	Influences schedule up to 1% of programme approved schedule period	Influences schedule >1% to 2.5% of programme approved schedule period	Influences schedule >2.5% to 5% of programme approved schedule period	Influences schedule >5% to 10% of programme approved schedule period	Influences schedule >10% of programme approved schedule period
		Influences schedule up to 2% of project approved schedule period	Influences schedule >2% to 5% of project approved schedule period	Influences schedule >5% to 10% of project approved schedule period	Influences schedule >10% to 20% of project approved schedule period	Influences schedule >20% of project approved schedule period

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Activity 1 – Risk Rating Criteria

Likelihood	Description	Frequency of Occurrence	Percentile
Almost Certain (A)	Is expected to occur in most circumstances	Once per month	>90%
Likely (B)	Will probably occur in most circumstances	Between once a month and once a year	60% - <90%
Possible (C)	Might occur at some time	Between once a year and once in five years	30% - <60%
Unlikely (D)	Could occur at some time	Between once in 5 years and once in 20 years	10% - <30%
Rare (E)	May occur in exceptional circumstances	Once in more than 20 years	<10%

Likelihood	Consequence				
	Not Significant (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Almost Certain (A)	MED – 1A	MED – 2A	HIGH – 3A	V HIGH – 4A	V HIGH – 5A
Likely (B)	LOW – 1B	MED – 2B	HIGH – 3B	V HIGH – 4B	V HIGH – 5B
Possible (C)	LOW – 1C	LOW – 2C	MED – 3C	HIGH – 4C	HIGH – 5C
Unlikely (D)	LOW – 1D	LOW – 2D	LOW – 3D	MED – 4D	MED – 5D
Rare (E)	LOW -1E	LOW – 2E	LOW – 3E	LOW – 4E	MED – 5E

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BREAK

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IDENTIFYING ACTIONS TO MITIGATE RISKS

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Risk mitigation – Adapting the design to a future climate

Influence and control:

- Location and design
- Operations and maintenance
- Community
- Emergency management
- Utilities and services.

Risk mitigation options:

- Spreading the risk
- Avoidance
- Structural and technological e.g. engineered solutions
- Policy e.g. regulatory and/or institutional
- Training and educational e.g. research and capacity building
- Triggers and thresholds for 2090 risks

Heat - Potential adaptation measures

- Works program to be developed / changed to avoid outdoor works during hotter times (where practicable).
- Consider the use of lighter coloured ballast or painted rails to reduce trackside temperature.
- Ensure that design and procurement of trackside equipment (e.g. signals, communication relay points) account for an increase in ambient temperatures and extreme heat days beyond those required as per Technical Note – TN 024: 2017 Ambient Environmental Conditions.
- Consider the use of elastic fasteners and/or heavier sleepers to account for potential track buckle.
- Provide shade for trackside equipment (double ventilated signal boxes and/or double skinned enclosures) and/or specify material and colour selection to reduce heat load.

Rainfall and flooding - Potential adaptation measures

- Implement flood mitigation measures along the rail corridor, including the locating of critical electrical systems (signalling, communications huts, etc.) above potential flood zones and increasing the design height of bunds.
- Incorporate additional drainage network features and flood protection measures (e.g. larger drainage network, additional pits, larger pipe diameters, larger sumps etc.) to mitigate a potential increase in flood risks.
- Prepare an emergency operations plan for personnel for flooding and storm events.
- Consider upgrading site drainage to account for projected increases in rainfall intensities (10, 20 and 30%).
- Design culverts and drainage to be concrete-lined to reduce potential for damage.
- Consider the use of solar PV and battery storage to ensure ongoing operation of signalling and communications equipment in the event of power failure.

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GROUP ACTIVITY 2 - IDENTIFICATION OF ADAPTATION OPTIONS

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Group Activity 2: existing and potential actions

Part 1 – Identifying existing measures:

- Are there any existing measures planned that address the key climate risks?

Part 2 – Identifying adaptation options:

- What additional adaptation options could be recommended to address gaps?
- Who is responsible for integrating these measures, and when?
- What triggers or thresholds need to be considered to address future risks?

Part 3 – Discussion on key findings:

- Highlight key findings and receive feedback / challenge from entire group.

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WRAP UP AND NEXT STEPS

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Wrap up and next steps

- Integrate measures into design
- Update and finalise risk assessment, consolidate and prioritise adaptation actions
- Document ISCA compliance and prepare evidence
- Finalise report for submission

Source: Parkes Champion Post

Future Freight
Integrating Community, Environment and Engineering

Prepared by Future Freight JV

Contact person:

Sjors de Kruijff
G2K Programme Delivery Manager

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E: Sjors.dekruijff@aecom.com

Risk ID	Risk Statement	2030					Priority Risk (Y / N)	Additional Comments	Applicability to G2B
		Preliminary Risk Rating	Revised Likelihood (L)	Revised Consequence* (C)		Revised Risk Rating			
			Rating (e.g. almost certain / likely/ possible)	Rating (e.g. Major, Moderate, Minor)	Category (e.g. Safety/ Assets / Financial)				
Extreme rainfall and flood events									
Direct Risks									
R8	Risk to health and safety of staff (e.g. conductor, emergency crews) working along the rail corridor due to velocity and flow of flooding	Medium (Likely / Minor)							
R9	Inundation of tracks, adjacent road network, and signalling equipment causing potential isolation of assets due to flooding	Very High (Likely / Major)							
R10	Malfunctioning of electrical equipment, including signalling and communications	Medium (Likely / Minor)							
R11	Extreme rainfall leading to flooding / standing water resulting in the increased presence / risk of disease and water-borne pathogens	Low (Possible / Minor)							
R12	Changed rainfall patterns impacting drainage including civil drainage (surface) and overland flow along the corridor	High (Moderate / Likely)							
Indirect Risks									
R13	Increase in extreme events increasing volume for drainage from catchment areas outside of the rail corridor	Medium (Moderate / Possible)							
R14	Extreme rainfall leading to faults/failure of power infrastructure resulting in interruptions to power supply with increased frequency and duration of power outages (particularly signalling and communications equipment)	Medium (Moderate / Possible)							
R15	Extreme rainfall leading to increased stormwater runoff, with potential damage and/or inundation of surrounding road infrastructure impacting the ability of emergency response / workers to reach the corridor	Medium (Moderate / Possible)							

*Consequence rating based on the highest / greatest impacted criteria

Risk ID	Risk Statement	2030					Priority Risk (Y / N)	Additional Comments	Applicability to G2B
		Preliminary Risk Rating	Revised Likelihood (L)	Revised Consequence* (C)		Revised Risk Rating			
			Likelihood rating (e.g. almost certain/ likely/ possible)	Consequence Rating (e.g. Major, Moderate, Minor)	Consequence Category (e.g. Safety/ Assets/ Financial)				
Extreme Heat									
Direct Risks									
R1	Risk to health and safety of staff working along the rail corridor through heat stress	Low (Possible / Minor)							
R2	Risk to business continuity as a result of heat events (e.g. increased incidence of delayed service or maintenance)	Medium (Possible / Moderate)							
R3	Increase in hot days resulting in track twisting (buckling) which could lead to derailment of trains along the rail line	Low (Unlikely / Moderate)							
R4	Decreased efficiency and more frequent outages of electrical (track switches, signalling, etc.) and communication systems	Medium (Possible / Moderate)							
R5	Accelerated degradation of materials and reduced life of structures (bridges, crossings, track) and specialist equipment (communications towers, signalling) resulting in increased capital cost due to the need for more frequent repairs and maintenance	Low (Rare / Moderate)							
Indirect Risks									
R6	Extreme heat leading to increased power demand and/or failure of power infrastructure (I.e. substations, LV / HV switchboards) resulting in interruptions to power supply with increased frequency and duration of power outages	Medium (Possible / Moderate)							
Mean rainfall change / Drought									
R7	Structural deterioration, soil subsidence, erosion, movement and cracking as a result of increased variability of periods of wetting and drying causing reduced integrity of tracks, bridges and signalling infrastructure with potential structural failure	Low (Rare / Major)							

*Consequence rating based on the highest / greatest impacted criteria

Risk ID	Risk Statement	2030					Priority Risk (Y / N)	Additional Comments	Applicability to G2B
		Preliminary Risk Rating	Revised Likelihood (L)	Revised Consequence* (C)		Revised Risk Rating			
			Rating (e.g. almost certain/ likely/ possible)	Rating (e.g. Major, Moderate, Minor)	Category (e.g. Safety/ Assets/ Financial)				
Bushfire events									
Direct Risks									
R16	Smoke from bushfires limiting visibility resulting in increased risk of freight disruptions and/or cancellations	Low (Unlikely / Moderate)							
R17	Bushfire damaging trackside infrastructure (e.g. signals, communications equipment requiring increased operational costs	Low (Unlikely / Moderate)							
R18	Risk to health and safety of staff working along the rail corridor due to inhalation of bushfire smoke	Low (Possible / Minor)							
Indirect Risks									
R19	Bushfire events leading to damage to power supply infrastructure or a need to cut supply resulting in interruptions to power supply (particularly signalling and communications equipment) with increased frequency and duration of power outages	Medium (Possible / Moderate)							
Storm events (including high wind and hail)									
Direct Risks									
R20	Damage to tracks / siding, electrical, communications infrastructure and other structures due to higher wind speeds and falling debris requiring repair and/or replacement and an increase in capital costs	Medium (Possible / Moderate)							
Indirect Risks									
R21	Storm events resulting in closure of rail line (due to damage to communications equipment or for safety purposes) with subsequent delays	Medium (Possible / Moderate)							
R22	Storm events leading to damage to power supply infrastructure or a need to cut supply resulting in interruptions to power supply (particularly signalling / communications equipment) with increased frequency and duration of power outages	Medium (Possible / Moderate)							

*Consequence rating based on the highest / greatest impacted criteria

Risk ID	Risk Statement	2030					Priority Risk (Y / N)	Additional Comments	Applicability to G2B
		Climate Variable (Extreme heat, bushfire, etc.)	Likelihood (L) rating (e.g. almost certain/likely/ possible)	Consequence* (C)		Risk Rating			
				Consequence Rating (e.g. Major, Moderate, Minor)	Consequence Category (e.g. Safety/Assets /Financial)				
Direct Risks									
Indirect Risks									

*Consequence rating based on the highest / greatest impacted criteria