Engineering Policy 170

Climate Change Risk Assessment Methodology

March 2020

Queensland Government

Feedback

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1 Purpose

The purpose of this policy EP170 *Climate Change Risk Assessment Methodology* is to provide advice on the minimum climate change information and assessments to be undertaken to incorporate climate change considerations into Transport and Main Road's standard Risk Management Framework.

This engineering policy is designed to be integrated into Transport and Main Road's Risk Management Framework, Risk Assessment and Ratings Matrix and Risk Context Profiles.

This engineering policy guides the risk assessment process. While this engineering policy does not provide specific advice on climate change adaptation methodologies, the engineering policy is supported by the *Climate Change Risk and Adaptation Assessment Framework for Infrastructure Projects* and provides guidance for operationalising climate change risk assessments.

2 Glossary

Term	Definition
Climate Change Mitigation	The actions taken to avoid or reduce release of greenhouse gas emissions including reduction of carbon footprint of construction materials.
Climate Change Adaptation	The planning, design and construction (including retrofitting) of infrastructure and services to accommodate influences on weather from climate change in order to avoid failure or impact from the weather.
Climate Change Resilience	The planning, design, management or construction of infrastructure and/or services to plan for failures due to climate change to ensure services are not interrupted or are able to be quickly re-established following failure (planning for failure).
RCP – Representative Concentration Pathways	The predicted concentrations of CO_2 in the atmosphere over the 21st century depending on different levels of global action to reduce greenhouse gas emissions.
Transitional Risks and Opportunities	The global economy is changing, and Queensland is substantially influenced by these global trends. 'Transition' refers to shifts in the Queensland economy and societal trends in response to the way the global economy is changing, and will continue to change, in response to an increasingly carbon constrained environment; from global trends such as automation, electrification, disruptive technologies, and information and communications technologies (ICT) innovation. These trends will be compounded by international and national measures to address climate change, as well as Queensland's commitment to action, which will drive structural economic change that will affect many of the state's industries. (Source: *Queensland Climate Transition Strategy*, 2017).

3 Background

In recent years, there has been a recognition and commitment across both government and industry that a response to climate change is required.

The Australian Government recognises that '*Climate change poses significant risks to our economies, communities and the natural environment*' (Commonwealth of Australia, 2015) and through Infrastructure Australia's *Assessment Framework*[1], mandates the consideration of climate change risks for projects seeking federal funding.

The Queensland Government policies and directions for considering and responding to climate change risk were documented in the 2018 *Climate Change Adaptation Strategy*[2]. The *Climate Change Adaptation Strategy* has a number of commitments for Transport and Main Roads including to '*manage risks to property, assets, infrastructure and services'.*

The Queensland *Climate Adaptation Strategy* and the *Climate Transition Strategy* are supported by climate data and projections documented on both the Bureau of Meteorology and the Queensland Climate Futures Dashboard. A summary of the key projected impacts is provided in Figure 3(a).

Engineers Australia have also formalised their stipulations for Professional Engineers to consider sustainability and climate change through the Code of Ethics and by publishing guidance *Implementing Sustainability: Principles and Practice*[3]*.*

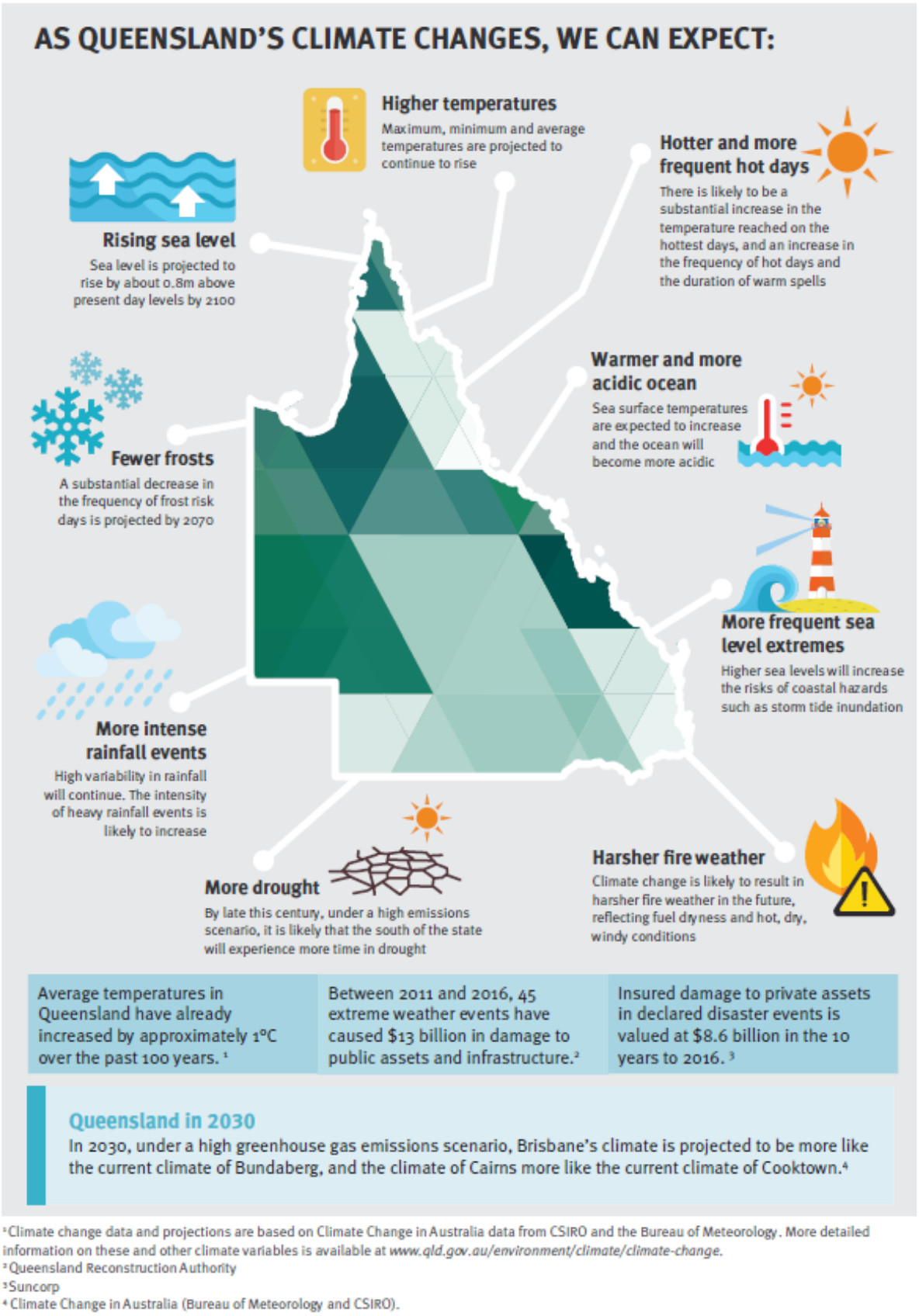
Climate change presents a risk to the organisation, its programs and the transport network in a number of ways. Infrastructure Australia groups the effects of climate change into three categories:

- **Direct** effects on an asset that alter its ability to deliver the intended services or its costs; these may be acute (for example, increasing disaster impacts from natural hazards such as flooding) or chronic (for example, trends towards higher average temperatures promoting faster corrosion).
- **Indirect** effects of climate that alter benefits flows even if the infrastructure itself is working as intended (for example, changing temperatures and rainfall altering demand for agriculture-related commercial transport).
- **Transitional** risks where changes in technology, policy or sentiment occur in response to climate change, altering the relevance of the services delivered by the infrastructure whether or not climate change itself eventuates (for example, changing fuel markets which reduce the demand for coal transport to export ports, driverless truck technology or improved telework which reduce the demand for transport[4].

Figure 3(b) depicts these direct, indirect and transitional effects on society.

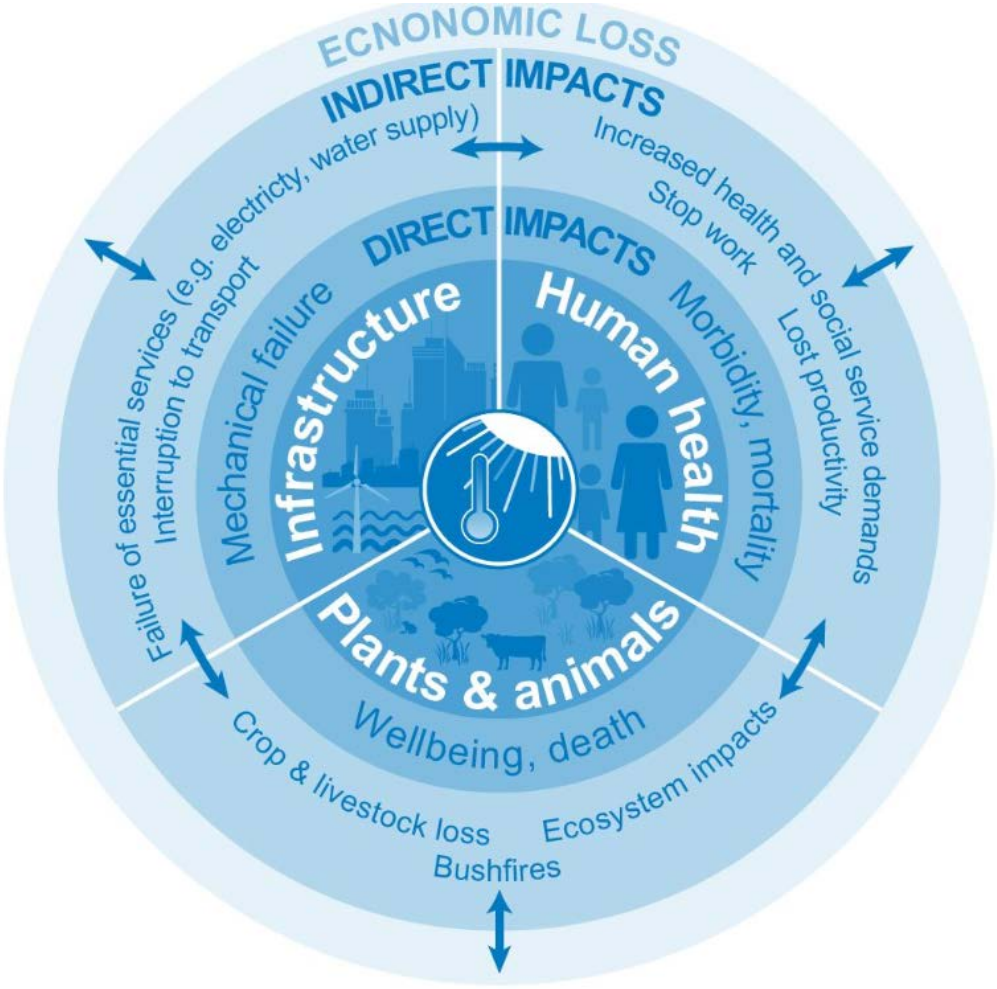
[1] Commonwealth of Australia, Infrastructure Australia Assessment Framework, March 2018
[2] Queensland Government, Climate Change Adaptation Strategy, 2018
[3] Engineers Australia, Implementing Sustainability: Principles and Practice
[4] Commonwealth of Australia, Infrastructure Australia Assessment Framework, March 2018

Figure 3(a) – The climate change hazards projected to impact Queensland



(Source: Queensland Government, *Climate Adaptation Strategy,* 2018).

Figure 3(b) - Climate change impacts on society



(Source: *Queensland Climate Adaptation Strategy*).

4 Infrastructure sustainability ratings

For major projects applying the Infrastructure Sustainability Council of Australia Infrastructure Sustainability Rating Scheme, consider the Cli-1 and Cli-2 credit requirements. This methodology has been developed to aid projects in addressing these requirements.

5 Integration of climate change into Transport and Main Road risk assessments

The Climate Change Risk Assessment should not be a stand-alone process. To identify maximum opportunities and achieve maximum benefits, climate change risk assessment should be integrated through:

1. Transport and Main Road's investment policies and programs
2. Transport and Main Road's specifications and standard drawings
3. Districts risk context profiles
4. Branch risk registers
5. Program risk registers
6. Project risk context profiles in accordance with EP153 *Risk Context Profiles*.

7. Projects seeking funding through Infrastructure Australia can integrate this methodology as part of the Infrastructure Australia's methodology for considering climate change risks (Section D4.6 of the Assessment Framework), and
8. Infrastructure projects over $100M applying a climate change risk assessment.

On infrastructure projects, the climate change risk assessment should form part of the overall project risk and opportunity workshops and registers.

6 Climate change risk assessment methodology

This engineering policy and the associated *Climate Change Risk and Adaptation Assessment Framework for Infrastructure Projects* has been developed in accordance with Australian Standard AS 5334 *Climate change adaptation for settlements and infrastructure – A risk-based approach*.

The process has also been developed to be consistent with Transport and Main Road's Risk Management Framework.

The overarching process follows:

1. Identification of key climate variables (temperature, rainfall, 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 describe how each variable may change over the design life of the proposed works.
3. Identification of broad climate-based risks that may impact on the proposed works.
4. Completion of a climate change risk assessment as part of the overall risk assessment process, with risk ratings evaluated using AS 5334 *Risk Management Framework*, including likelihood and consequence criteria.

   Consequence ratings have been selected based on the highest rating for the risk categories. This risk assessment should also identify the likely timing of particular risks and opportunities.
5. Identification of measures to mitigate, adapt or build resilience to the identified severe and high climate change risks.
6. Assessment of residual risks to the project, considering adaptation measures to treat all high and very high risks.

This overarching methodology for integration of climate change risk assessment and management into the existing Transport and Main Road risk management framework is prescribed in more detail in the steps below:

1. The person or team undertaking the risk assessment should review the forecasted climate impacts for the applicable region based on:
   a) the climate change projection, and
   b) the appropriate timeframe for the design life of the asset.

This information is available through a number of sources. It is recommended that for consistency Transport and Main Road utilise:

a) Queensland Future Climate Scenarios from the Long Paddock website[5]

b) CSIRO climate data available through the Climate Change in Australia website, and

c) Respective Local Government hazard mapping.

2. Describe the climate model and project data that applies for 2030, 2050, 2070 for the location.

3. Describe the design life and design standard of key infrastructure components (i.e. pavement, bridges, culverts, electrical / ITS, roadside and drainage).

4. Generate a list of direct climate change hazards for the applicable area at the 2030, 2050 and 2070 horizons.

   It is important to identify hazards at shorter timeframe and longer timeframes as this could present opportunities for delayed risk treatment.

   NOTE: For risk context profiling, the impacts from climate change on the branch / district, project should be considered as part of the weather risk category.

5. Consider the indirect impacts from climate change on the organisation, project or design. Consider how the direct and indirect climate change impacts may influence other risks identified (for example, increased rainfall intensity may increase the consequence of flash flooding events).

   Impacts should be considered in relation to:

   a) impact on the asset

   b) impact on the level of service

   c) impact to the public utilising the asset

   d) impact to the network operations and maintenance activities, and

   e) impact to the workforce.

6. Consider the influence on identified risks associated with interrelated infrastructure and the impacts on and from interrelated services failing (for example, if a road embankment is submerged more frequently due to sea level rise, if local government roads are also inundated the consequence of failure may be more significant).

7. Address climate change risks though Transport and Main Road's standard risk management practices.

8. Consider risk treatment options as per Transport and Main Road's Risk Management Framework. Adaptation treatments should be considered in association with Table 11 of the *Climate Change Risk and Adaptation Assessment Framework for Infrastructure Projects.*

9. Undertake a multi-disciplinary review (such as via a workshop) of the draft risk assessment outcomes to consider and validate the hazard likelihood, consequence and potential treatment methods.

[5] https://app.longpaddock.qld.gov.au/dashboard#responseTab1

10. Formalise the list of climate-related risk treatments by incorporating them into the overall project / program / district risk and opportunity register.
11. Obtain endorsement by the Program or Project Customer.

7 Guidance

7.1 Queensland climate summaries

For quick reference and background, the below links are to the Queensland Government's climate impact summaries for Queensland's regions.

The Queensland Government Future Climate Scenarios are presented in the Long Paddock website.

The Queensland Climate Futures Dashboard provides an interactive tool that can be used to identify the varying changes to climate across geographical areas, timeframes and climate change projection. https://app.longpaddock.qld.gov.au/dashboard/#responseTab1

The Queensland summaries are based on global climate models (GCMs):

- Queensland (https://www.qld.gov.au/environment/assets/documents/climate/queensland-climate-change-impact-summary.pdf)
- Cape York (https://www.qld.gov.au/environment/assets/documents/climate/cape-york-climate-change-impact-summary.pdf)
- Central Queensland (https://www.qld.gov.au/environment/assets/documents/climate/central-qld-climate-change-impact-summary.pdf)
- Central West Queensland (https://www.qld.gov.au/environment/assets/documents/climate/central-west-qld-climate-change-impact-summary.pdf
- Eastern Downs (https://www.qld.gov.au/environment/assets/documents/climate/eastern-downs-climate-change-impact-summary.pdf)
- Far North Queensland (https://www.qld.gov.au/environment/assets/documents/climate/far-north-qld-climate-change-impact-summary.pdf)
- Gulf Region (https://www.qld.gov.au/environment/assets/documents/climate/gulf-region-climate-change-impact-summary.pdf)
- Maranoa and District (https://www.qld.gov.au/environment/assets/documents/climate/maranoa-climate-change-impact-summary.pdf)
- North Queensland (https://www.qld.gov.au/environment/assets/documents/climate/north-qld-climate-change-impact-summary.pdf)
- North West Queensland (https://www.qld.gov.au/environment/assets/documents/climate/north-west-qld-climate-change-impact-summary.pdf)
- South East Queensland (https://www.qld.gov.au/environment/assets/documents/climate/seq-climate-change-impact-summary.pdf)

- South West Queensland (https://www.qld.gov.au/environment/assets/documents/climate/south-west-qld-climate-change-impact-summary.pdf)
- Whitsunday, Hinterland and Mackay (https://www.qld.gov.au/environment/assets/documents/climate/mackay-whitsunday-climate-change-impact-summary.pdf)
- Wide Bay-Burnett (https://www.qld.gov.au/environment/assets/documents/climate/wide-bay-burnett-climate-change-impact-summary.pdf)

The Commonwealth Government has also released climate projections through the Climate Change in Australia website. A Climate Futures overview: http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/

Local Governments have also undertaken a variety of climate change risk assessments and produced hazard mapping for their respective jurisdictions. Local hazard mapping commonly relates to sea level inundation and riverine flooding.

Guidance: it is recommended that Transport and Main Road projects, Branches, Divisions and Districts ensure a number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset.

7.2 Climate change projections

The predicted release of global greenhouse gas and aerosol emissions are modelled using four possible Representative Concentration Pathways (RCPs), initiated by the Intergovernmental Panel on Climate Change.

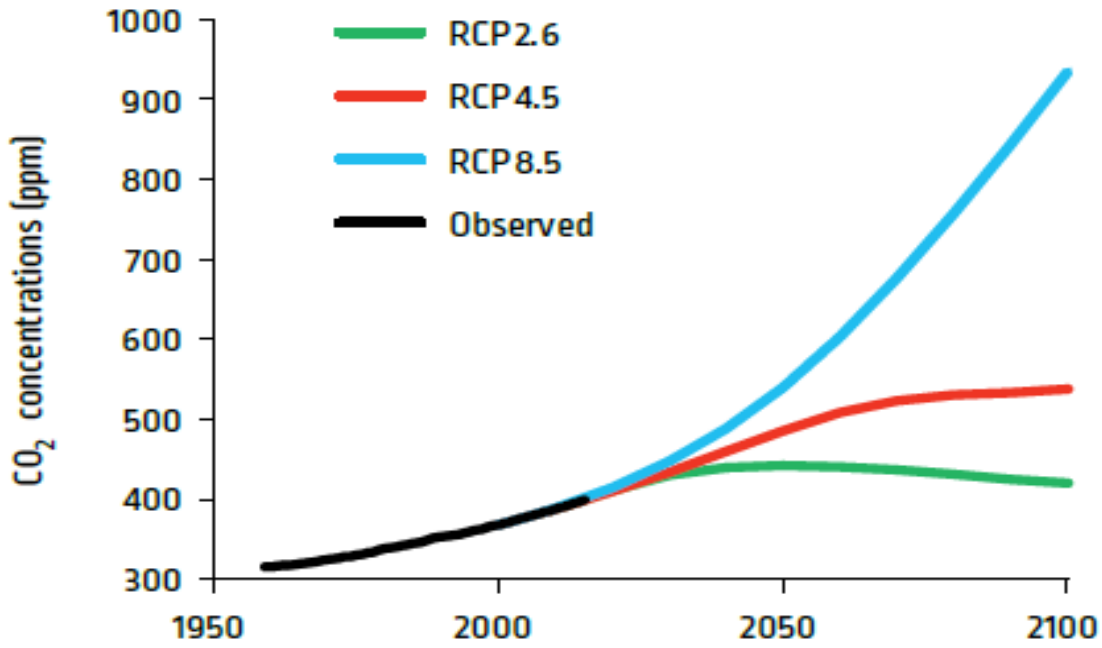
The RCP number refers to the amount of extra radiative impact on the climate system by the end of the century. The different RCP pathways are based on different assumptions on global greenhouse gas emissions.

Figure 7.2 demonstrates the predicted CO_2 concentrations in the atmosphere over time for each of the RCPs.

All the RCPs are quite similar up to 2030, but increasingly diverge after that time:

- RCP 8.5 (high) – little global action taken to reduce greenhouse gas emissions
- RCP 4.5 (medium) – strong global action taken to reduce emissions towards end of century
- RCP 2.6 (low) – ambitious global action.

Figure 7.2 - Carbon dioxide concentrations from global observations and for the three main RCPs across the 21st century



In June 2018 advice from the Australian Rainfall and Runoff Committee was that projections are showing that RCP 4.5 is no longer a likely scenario due to existing CO_2 concentrations.

Therefore, the committee advised that an RCP of 6.0 should be utilised. However, there is currently very limited modelling of RCP 6.0 and therefore confidence and availability of data is restricted.

Guidance: it is recommended that Transport and Main Road projects and units consider assessment under at least two RCP scenarios including RCP 4.5 and RCP 8.5 to develop a complete understanding of potential climate risks. The RCP 8.5 projection should be applied as a minimum for climate change risk assessment for critical infrastructure.

7.3 Climate projection timeframe

Generally, climate projections are considered over time frames of 2030, 2050, 2070 and 2090. The projection timeframe selected for a risk assessment should be based on the design life of the asset, project or corporate planning timeframe.

However, the impacts of climate change will be different across the different timeframes. In fact, the impacts could be considerably different trends (positive change versus negative impact) that may need to be considered for the asset.

For example, a bridge with a design life of 100 years should apply the longest timeframe available through the CSIRO projections (2090). However, if the asset has a shorter design life, such as for Intelligent Transport Systems, the projection timeline of 2030 is more appropriate. This will ensure cost-effectiveness of solutions.

Guidance: the timeframe for projecting climate impacts should correlate with the design life or the timeframe context of the risk assessment. It is also important to consider shorter term climate impacts as these may differ from the longer-term impacts and the asset may be exposed to both.

7.4 Climate hazards to be considered

Transport and Main Road's has an existing hazard prompt list[6]. In addition to the hazards on the prompt list Climate Change Risk Assessments completed on departmental networks and/or assets shall consider as a minimum, direct and indirect climate and weather hazards.

In addition, the risk assessment shall consider the variations in likelihood and consequence of those hazards depending on the projected climate changes.

The risk assessment should consider hazards across the lifecycle of the asset. This may include hazards to the asset, asset users, properties around the asset, essential services provided by the asset.

Table 7.4 – The minimum climate change hazards that should be considered as part of the department's risk assessment

Direct Impacts	Indirect Impacts
• Sea level rise and coastal inundation • Precipitation and rainfall intensity • Cyclones and storms • Flooding • Wind and hail • Air Temperature and humidity • Solar radiation • Heatwaves and droughts • Bushfire weather	• Water shortages • Disruptions to electricity supply • Inundation of coastal areas

7.4.1 Climate change transitional risks and opportunities

The potential risks and opportunities related to climate change transitional risks should also be considered by organisational units, districts, programs and projects. These transitional risks commonly have greatest consequence on transport trends and demands in future.

This would generally be best considered as part of strategic planning, service requirement identification and transport demand modelling.

7.5 Hazard likelihood and consequence

The likelihood and consequence climate hazards should be considered in accordance with AS 5334 *Climate change adaptation for settlements and infrastructure – A risk-based approach.* (see Risk matrices in Appendix A).

7.6 Risk treatment – Climate change risk mitigation, adaptation and resilience

Consistent with the ISO 31000 *Risk management standard*, once climate change related risks are identified and quantified as part of the risk assessment process, consideration of risk treatment measures shall be considered.

[6] https://intranet.tmr.qld.gov.au/corp/tmr/Documents/TMR%20Risk%20Prompt%20List%20v1.1.pdf

It is recommended that for climate change related risks, the following approach is applied:

1. Determine climate factors that influence project design and that are susceptible to climate change.
2. Assess the risk that these climate factors present for design life of the asset and the required level of service into the future.
3. Consider the design life of the design component impacted by the climate factor and likely impact during the lifespan of the component. (for example, pavement design life is up to 20 years and thus climate change influences beyond a 20 year horizon are not applicable).
4. Consider adaptation and resilience treatment options for project design, described in more detail in Table 7.6:
    a) build for end of design life scenarios
    b) planned adaptation
    c) progressive modification
    d) no adaptation or redundancy.
5. Secure funding for adaption treatment where this will require investment beyond the previously approved funding limit.

Table 7.6 – Description of adaptation treatment options for project designs

Adaptation Treatment	Description	Expected Financial Implication	Example
Build for end of design life scenario	Build to maintain standards and level of service for the climate change scenario expected at end of life.	Generally higher upfront costs, although lower addition costs through design life for adaptation. Provides a higher level of service for entire design life. Risk that actual climate change will exceed prediction	Bridge is designed and constructed with capacity for climate change.
Planned adaptation	Plan an upgrade program to progressively adapt the infrastructure as climate change occurs. Initial design considers predicted climate changes and provides functionality to adapt the infrastructure at another time. Consultation with program and asset managers required to secure investment program.	Moderate Upfront Costs expected, although further investment is required during infrastructure life cycle. Provides some increase in level of service.	Culvert is designed and constructed for mid-life span climate change conditions, but considerations made in current design for an upgrade in capacity i.e. second culvert can be installed in parallel.

Adaptation Treatment	Description	Expected Financial Implication	Example
Progressive modification (existing asset)	Redesign and reconstruct as required and as possible in response to verified climate change as part of existing maintenance regime or project upgrades. Future verified climate changes will be captured in investigatory criteria of audits.	Moderate upfront costs expected. Further climate changes will force re-design. Higher costs to adapt asset in long term. Maintains level of service.	Culvert is constructed according to current climatic conditions (assume standards may not be current). Culvert will be upgraded if needed in future.
No adaptation / redundancy	No adaptation or making the overall asset redundant as there are suitable alternatives, or the asset is not required.	No extra investment required.	Culvert is not constructed at all or not replaced when it fails.

(Source: Western Australia Main Roads, *Climate change risk assessment guideline*).

8 Key references

Australian Standard AS 5334:2013 *Climate Change adaptation for settlements and infrastructure – a risk-based approach*.

Queensland Government – The Long Paddock

https://longpaddock.qld.gov.au/qld-future-climate/

Queensland Government Climate Futures Dashboard

https://app.longpaddock.qld.gov.au/dashboard/#responseTab1

Queensland Government Interactive Map on Climate Change Risks and Impacts http://qgsp.maps.arcgis.com/apps/MapJournal/index.html?appid=1f3c05235c6a44dcb1a6faebad4683fc#

Climate Futures overview: http://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/

Selecting a region: http://www.climatechangeinaustralia.gov.au/en/climate-projections/about/modelling-choices-and-methodology/regionalisation-schemes/

Cluster reports: http://www.climatechangeinaustralia.gov.au/en/publications-library/cluster-reports/

Snapshot of selected Australian cities: http://www.climatechangeinaustralia.gov.au/media/ccia/2.1.5/cms_page_media/176/CCIA_Australian_cities_1.pdf

Summary of data available and sources: http://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/about-data/

Appendix A – AS 5334 Risk Matrices

Table A1 – Likelihood Criteria (Source: AS5334:2013 Climate change adaptation for settlements and infrastructure)

Likelihood	Description	Recurrent or Event Risks	Long Term Risks
Almost Certain	Could occur several times per year	Has happened several times in the past year and in each of the previous 5 years; or Could occur several times per year	Has a greater than 90% chance of occurring in the identified time period if the risk is not mitigated
Likely	May arise about once per year	Has happened at least once in the past year and in each of the previous 5 years, or May arise about once per year	Has a 60 – 90% chance of occurring in the identified time period if the risk is not mitigated
Moderate	Maybe a couple of times in a generation	Has happened during the past 5 years but not in every year, or May arise once in 25 years	Has a 40 – 60% chance of occurring in the identified time period if the risk is not mitigated
Unlikely	Maybe once in a generation	May have occurred once in the last 5 years, or May arise once in 25 to 50 years	Has a 10 – 30% chance of occurring in the future if the risk is not mitigated
Very Unlikely (Rare)	Maybe once in a lifetime	Has not occurred in the past 5 years; or Unlikely during the next 50 years	May occur in exceptional circumstances, i.e. less than 10% chance of occurring in the identified time period if the risk is not mitigated

Table A2 – Consequence Criteria (Source: AS5334:2013 Climate change adaptation for settlements and infrastructure)

Consequence	Adaptive Capacity	Infrastructure, Service	Social / Cultural	Governance	Financial	Environmental	Economy
Insignificant	No change.	No infrastructure damage, no change to service.	No adverse human health effects.	No changes to management required.	Little financial loss or increase in operating expenses.	No adverse effects on natural environment.	No effects on the broader economy.
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored.	Localised infrastructure service disruption. No permanent damage. Some minor restoration work required. Early renewal of infrastructure by 10 - 20%. Need for new/modified ancillary equipment.	Short-term disruption to employees, customers or neighbours. Slight adverse human health effects or general amenity issues.	General concern raised by regulators, requiring response action.	Additional operational costs Financial loss small, <10%.	Minimal effects on the natural environment.	Minor effect on the broader economy due to disruption of service provided by the asset.
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity.	Limited infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair. Early renewal of infrastructure by 20 - 50%.	Frequent disruptions to employees,customers or neighbours. Adverse human health effects.	Investigation by regulators Changes to management actions required.	Moderate financial loss 10 – 50%.	Some damage to the environment, including local ecosystems. Some remedial action may be required.	High impact on the local economy, with some effect on the wider economy.

Consequence	Adaptive Capacity	Infrastructure, Service	Social / Cultural	Governance	Financial	Environmental	Economy
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity.	Extensive infrastructure damage requiring major repair. Major loss of infrastructure service. Early renewal of infrastructure by 50 - 90%.	Permanent physical injuries and fatalities may occur. Severe disruptions to employees, customers or neighbours.	Notices issued by regulators for corrective actions. Changes required in management. Senior management Responsibility questionable.	Major financial loss 50-90%.	Significant effect on the environment and local ecosystems. Remedial action likely to be required.	Serious effect on the local economy spreading to the wider economy
Catastrophic	Capacity destroyed, redesign required when repairing or renewing asset.	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service. Loss of infrastructure support and translocation of service to other sites. Early renewal of infrastructure by 90%.	Severe adverse human health effects, leading to multiple events of total disability or fatalities. Total disruption to employees, customers or neighbours. Emergency response at a major level.	Major policy shifts. Change to legislative requirements	Extreme financial loss > 90%.	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems. Extensive remedial action essential to prevent further degradation. Restoration likely to be required.	Major effect on the local, regional and state economies.

Table A3 – Risk Rating Matrix (Source: AS 5334:2013 Climate change adaptation for settlements and infrastructure)

Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	Medium	High	Extreme
Moderate	Low	Low	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Very Unlikely (Rare)	Low	Low	Low	Medium	Medium