# TfNSW Climate Risk Assessment Guidelines

9TP-SD-081/3.0

Supporting Document – Applicable to Infrastructure and Services

## Divisional Management System

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# Document History

| Version | Date of approval | Doc. control no. | Summary of change |
|---|---|---|---|
| 1.0 | 1 Mar 2016 | DS#4910686_1 | Document created to assess climate risk |
| 2.0 | 15 Nov 2016 | DS#4910686_5 | Rebranded to I&S |
| 3.0 | | | • Document is updated to better enable climate risk decision-making to inform the earlier stages of a project's delivery<br>• A pre-screening tool to support the consideration and assessment of climate risk from pre-feasibility stage is added |

# Table of Contents

# 1. Introduction

Meteorological records show that since the 1950s the duration, frequency and intensity of heatwaves have increased across many parts of Australia including NSW. Seven of Australia's ten warmest years on record have occurred in the 13 years from 2002, with 2014 marking the warmest year on record for NSW. (BoM, 2015[1]) In parallel with rising temperatures, over the past 30 years the number of fire days has also continued to rise across NSW. Throughout the state, the fire season is starting earlier and lasting longer with fire weather often extending into spring and autumn. (Climate Council, 2014[2]) In addition to temperature related risks, impacts from flooding and sea level rise have the capacity for widespread damage and disruption. Across Sydney, flooding events became three times more frequent during the 20th century as a result of sea-level rise. By 2100 it is likely that today's 1-in-100 year flood will occur every day or so. (Climate Council, 2014[3])

Transport for NSW (TfNSW) aims to provide a world class sustainable transport system that meets customer expectations and optimises the economic development of the state.

Recognising that the impacts from climate change pose a significant risk to its business, infrastructure assets, and the communities it serves, TfNSW is committed to building climate resilience across its network of current and future projects.

Addressing climate risk is highlighted within a number of TfNSW's guiding strategic documents including:

- **NSW Long term Transport Masterplan**: The plan identifies responding to climate change as a state-wide action of priority, with Action 8.8.3 focussed on boosting our resilience to climate change and natural disasters by assessing climate resilience.
- **TfNSW's Environment and Sustainability Policy Statement**: A key theme within the Policy's is, *"to plan and deliver transport infrastructure and operations that are resilient to the effects of climate change."*
- **Sustainable Design Guidelines**: The delivery mechanism for implementing TfNSW's sustainable project delivery requirements, the SDG require the completion of a climate risk assessment as a mandatory initiative for all projects with a capital value over $15 million.

## 1.1. Scope

The following guide has been updated and expanded from version 1 (released in March 2016) to provide guidance on how climate risk might be addressed across influential stages of the asset lifecycle for TfNSW projects. Additionally, the guide provides support on how to complete a Climate Risk Assessment (CRA) in line with TfNSW's latest Sustainable Design Guidelines (SDG) requirements.

There are several stages across an asset's project lifecycle where the timely consideration of climate risk can meaningfully contribute to a project's planning and decision-making (refer Figure 1). This guide focuses on the earlier stages of project delivery (Stage 1- Needs Analysis; Stage 2 – Investment Decision; and, Stage 3 and beyond relating to detailed design) this reflects the fact that the most significant opportunity to influence the delivery of an infrastructure asset is in the earlier stages of planning and development. **It is designed for application on all TfNSW projects over $15 million**.

[1] *State of the Climate, 2014* Bureau of Meteorology and CSIRO
[2] *Be Prepared: Climate change and the NSW bushfire threat.* 2014. Climate Council
[3] *Counting the costs: climate change and coastal flooding. 2014. Climate Council*

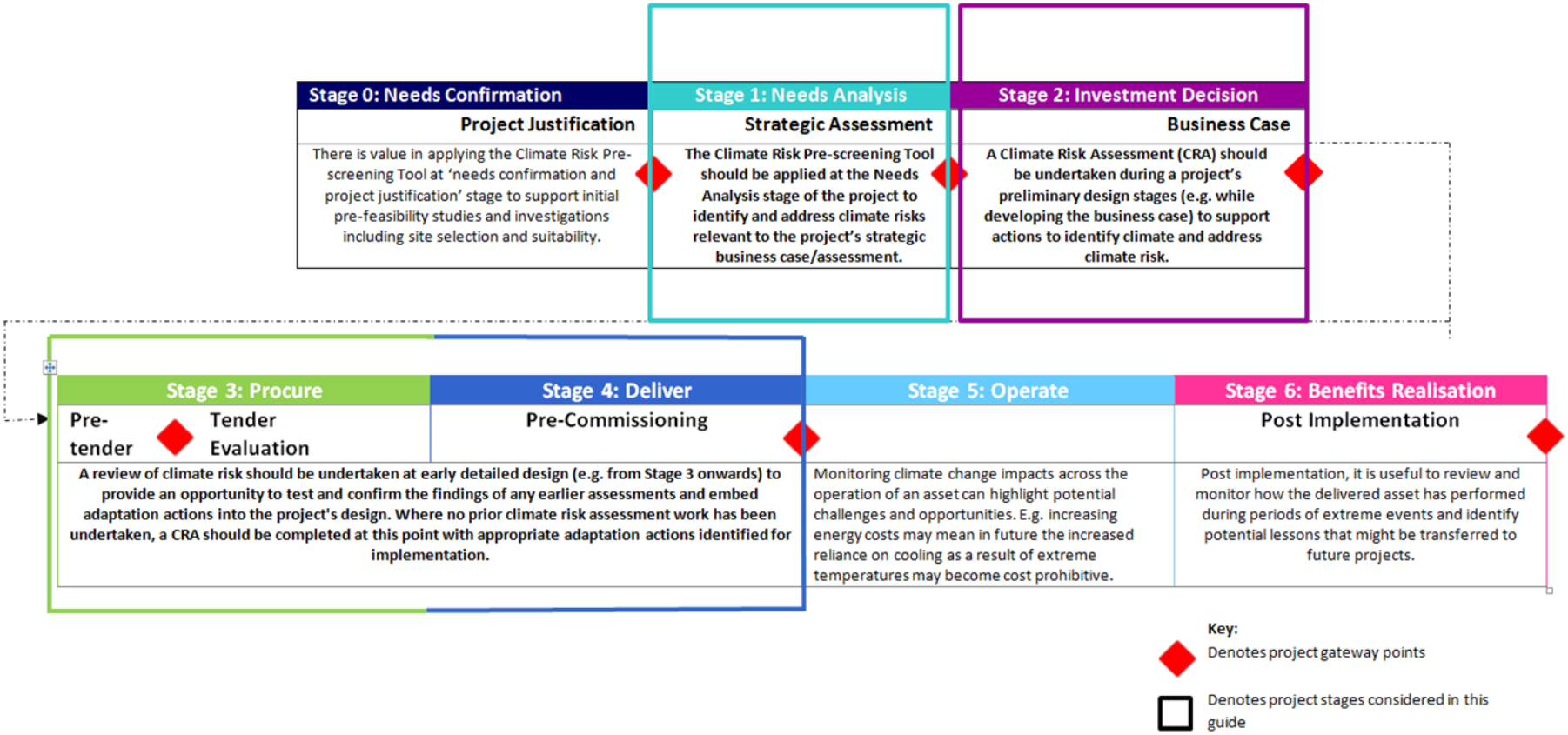


**Figure 1 Opportunities to address climate risk across the project lifecycle**

## 1.2. Developing the guide

A number of documents and standards have informed development of this guide. These include:

- Australian Standard, 2013, *AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach*
- Australian Greenhouse Office, 2006, *Climate Change Impacts & Risk Management A Guide for Business and Governmen*t
- Infrastructure Sustainability Council of Australia (ISCA), 2015, *Infrastructure Sustainability Rating Tool Technical Manual: Cli 1 – Climate Risk Management*
- *Australian Rainfall and Runoff Guidelines: A Guide to Flood Estimation*, 2016, Geoscience Australia
- *NSW Climate Change Policy Framework*, 2016, Office of Environment and Heritage
- Green Buildings Council of Australia, 2015, *Green Star Communities v1 Submission Guidelines: Credit 04: Adaptation and Resilience*
- Asia Development Bank, 2009, *Climate Risk Screening Tool*
- World Bank, 2016, *Climate and Disaster Risk Screening Tool*

In addition, consultation has been undertaken with key stakeholders from the following organisations to support alignment with existing industry standards and requirements:

- Sydney Trains
- ISCA
- Office of Environment and Heritage
- Sydney Metro North West
- Roads and Maritime Services
- Asset Standards Authority

# 2. Abbreviations and definitions

All terminology in this document is taken to mean the generally accepted or dictionary definition with the exception of the following terms which have a specifically defined meaning:

| Abbreviation | Definition |
|---|---|
| AR4 | The Intergovernmental Panel on Climate Change Fourth Assessment Report – published in 2007 |
| AR5 | The Intergovernmental Panel on Climate Change Fifth Assessment Report – published in 2014 |
| CRA | Climate Risk Assessment |
| EIS | Environmental Impact Statement |
| FFDI | Forest Fire Danger Index |
| I&S | Infrastructure and Services Division |
| IPCC | Intergovernmental Panel on Climate Change |
| ISCA | Infrastructure Sustainability Council of Australia |

| Abbreviation | Definition |
|---|---|
| NARCliM | NSW / ACT Regional Climate Modelling project |
| OEH | NSW Office of Environment and Heritage |
| REF | Review of Environmental Factors |
| SDG | Sustainable Development Guidelines |
| TERM | Transport for NSW Enterprise Risk Management |
| TfNSW | Transport for NSW |
| TSR | Transport for NSW Standard Requirements |

# 3. Considering climate risk

There is broad scientific consensus that the climate is changing. Historical models which have long been used to inform project designs are increasingly being found to be inadequate at helping understand the level of risk and potential impact resulting from climate change. Increasingly unpredictable extreme weather events are already posing a challenge to our transport assets and network. Damage estimates for the storms that occurred along the east coast of Australia over April and May 2015 are estimated at approximately $1.55 billion[4]. Work undertaken by Sydney Trains to quantify the local impact of those storms over the three day period in which they hit Sydney (20 - 23 April 2015), estimate nearly 200 significant incidents to Sydney Trains and NSW Trains, and approximately 585 peak and non-peak services were affected during the 3-day period.

One way of addressing these risks and uncertainties is by identifying measures to adapt and build resilience at relevant stages of project development and delivery. As stated, there are a number of opportunities to address climate risk across a project's life cycle (refer Figure 1), the following guide provides specific guidance on how climate risk should be considered during key stages associated with project definition, concept design and detailed design specifically. While it is relevant to consider climate risk during construction and operation phases, the most significant opportunity to address climate risk meaningfully is during the earlier stages of an asset's project lifecycle when there is still a degree of flexibility and opportunity for change.

To maximise opportunities for embedding the adaptation actions identified through the risk assessment, it is a requirement of the TfNSW Standard Requirements (TSR) that the CRA is undertaken during the preliminary stages of detailed design (at System Design Review stage or equivalent.

Development of this guide has been prepared to align with a minimum of Level 1 compliance with the Infrastructure Sustainability Rating Tool Technical Manual Version 1.2 requirements for 'Design' and 'As Built' projects. Further, ongoing collaboration with ISCA has enabled considerations regarding future revisions to the climate categories and credits to be factored into the preparation of this guide.

## 3.1. Stage 1: Needs Analysis

Considering climate risk during the needs analysis stage of the project can help with the early identification of those challenges and opportunities likely to have a longer term impact on the project across the lifecycle of the asset. At this preliminary stage it is most relevant to consider those climate risks associated with extreme events (e.g. bushfires, heatwaves,

[4] http://www.theguardian.com/world/2015/jun/02/storms-that-hit-sydney-and-nsw-coast-leave-155bn-damage-bill

flooding, storms etc.) to provide a high-level appreciation of impacts that might have a material impact on the project.

Using the Climate Risk Pre-screening Tool (refer Figure 2) to identify areas of exposure and impact will assist in understanding the key risks requiring further exploration and closer examination. **Application of the pre-screening tool should be undertaken by an appropriate member of the project team (e.g. Environment and Planning Manager**) **and accompanied by a short report outlining responses to the questions below.** On finalisation, the report should be submitted to the Project Director for review and issued to the Project Control Group (or project equivalent) for approval. Following sign off the report should be issued to the project team for action as appropriate.

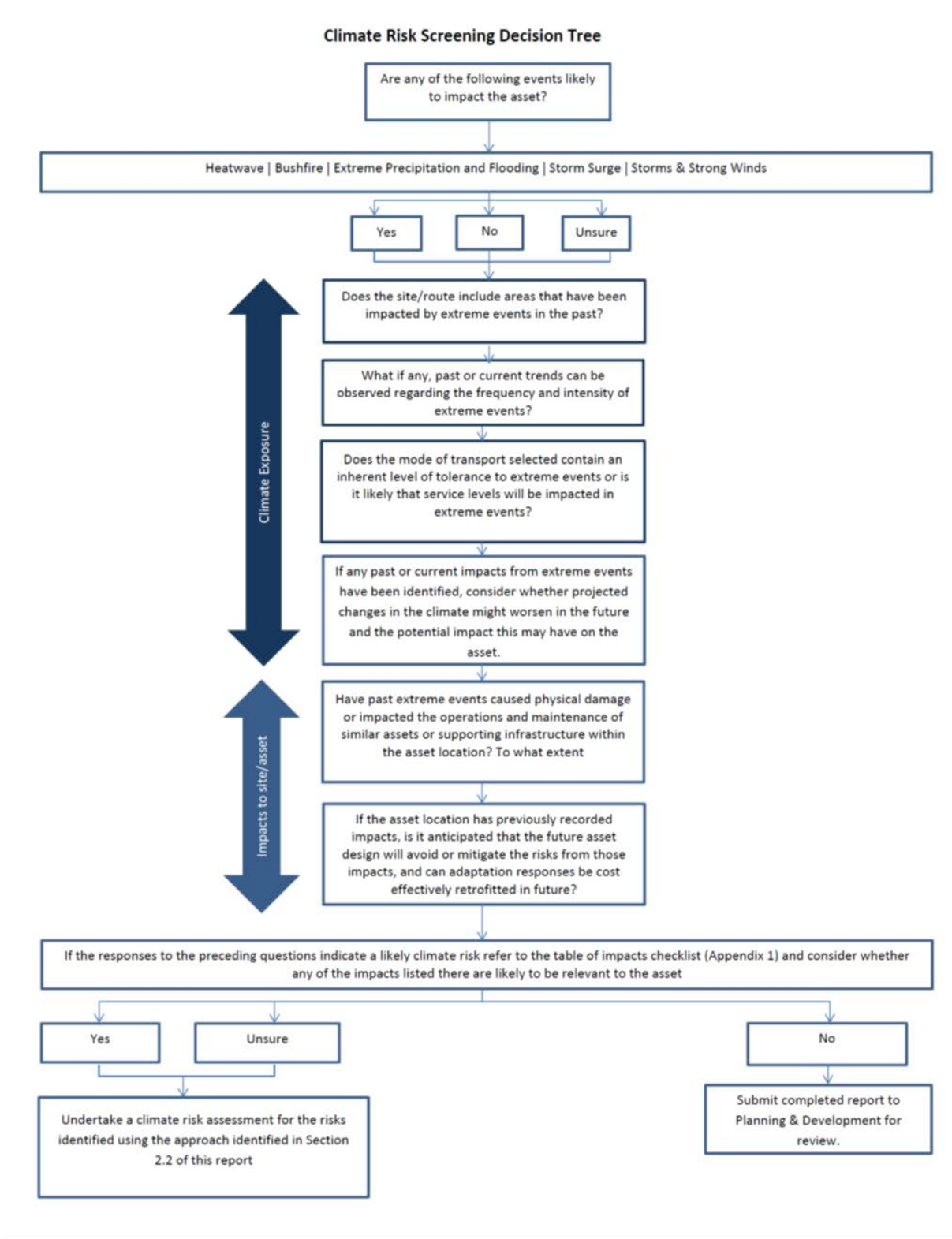


**Figure 2 Climate Risk Pre-screening Tool**

### 3.1.1. Impacts and data exposure

The first step in applying the pre-screening tool is to consider whether any of the extreme events listed are likely to have an impact on the project. As the ability to answer this question requires knowledge of the project location; previous events that may have impacted the site; and, an understanding of how future climate may compound any risks, it is recommended that a review of past or current trends regarding extreme events is undertaken. Ideally the TfNSW I&S Sustainability, Planning and Development team would be responsible for completing the pre-screening assessment in collaboration with the project team.

**Note**: While research suggests using historic data to inform future decision making regarding climate change is flawed, identifying the occurrence of past/current extreme events can be useful as the science is showing a likely increase in the intensity and frequency or extreme events in the future.

At the climate risk pre-screening stage the information and data needed to form an assessment is easily accessible and readily available. Table 1 provides a summary of data sources and supporting information to respond to each question.

**Table 1 Climate Risk Pre-screening data and information sources**

| Relevant Pre-Screening Question | | Data Sources/ Supporting information |
|---|---|---|
| **Exposure** | **Impact** | |
| Does the site/route include areas that have been impacted by extreme events in the past? | Have past extreme events caused physical damage or impacted the operations and maintenance of similar assets or supporting infrastructure within the project location? To what extent? | Consideration should be given to whether the project site has been impacted by extreme events previously and the frequency of these occurrences. Useful information may include:<br>Media (including social media) reports and or alerts such as those provided by news agencies; emergency response organisations; government agencies etc.<br>Warnings and updates provided by the relevant local government authority.<br>Any preliminary modelling or technical studies that may have been undertaken e.g. flood modelling, bushfire risk, drainage designs etc.<br>Additionally, if available and/or appropriate consultation with local stakeholders (e.g. council) can be useful in providing historical context for a site regarding past and current impacts. |
| Does the mode of transport selected contain an inherent level of tolerance to extreme events or is it likely that service levels will be impacted in extreme events? | - | Different modes of transport have varying tolerances to extreme events. For instance light rail services can be impacted by minimal flooding e.g. 50mm, whereas heavy rail is able to maintain service at much higher levels of inundation and buses present arguably the most versatile mode of transport as they are able divert and change routes to maintain service. |
| What past or current trends can be observed | If any past or current impacts from extreme events have | A summary of high-level climate risk data including impacts from extreme events are easily accessible through the following resources: |

| Relevant Pre-Screening Question | | Data Sources/ Supporting information |
|---|---|---|
| **Exposure** | **Impact** | |
| regarding the frequency and intensity of extreme events? | been identified, consider whether projected changes in the climate might worsen in the future and the potential impact this may have on the project | Adapt NSW:<br>http://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map<br>Using an easy to navigate clickable map, climate data regarding heatwaves, bushfire risk, extreme precipitation can be accessed.<br>CoastAdapt:<br>https://coastadapt.com.au/how-to-pages/use-national-mapping-help-understand-flood-and-erosion-risk<br>Web portal providing graphs and tables on future sea-level rise caused by climate change for each coastal local council. Data is also available that explores the characteristics of the Australian coast at the present-day and provide a guide to the sensitivity and vulnerability of the coast to inundation and erosion now and in the future.<br>Regional Hazard Mapping: local councils have readily available hazard mapping data related to extreme events such as flooding, bushfire, storm surge which can be easily accessed. |
| - | If the project location has previously recorded impacts, to what extent is it anticipated that the future project design will avoid or mitigate the risks from those impacts, and can adaptation responses be cost effectively retrofitted in future? | Based on available project information is there confidence that the project will be able to avoid or mitigate the risks from extreme events in future? Identify the processes and/or procedures that will be implemented to enable effective climate risk mitigation and/or identify the mechanisms that will enable cost effective adaptation measures to be retrofitted at a future stage of project delivery. |

The final section of the pre-screening tool advises that where the responses to the preceding questions indicate a likely climate risk, a table of impacts checklist (Appendix 1) should be reviewed and completed. The checklist presents a summary of high and/or extreme priority risks resulting from extreme events relevant to TfNSW's projects. If any of the risks from the check list are selected, a full CRA should be undertaken (for those specific risks/extreme events) in accordance with the methodology outlined in Section 2.2. Where none of the risks listed in the checklist apply to the project, the pre-screening report should make reference to this finding.

**Required deliverable:** submission of a climate risk pre-screening summary report to be developed by a member of the Sustainability, Planning and Development Team and provided to the Project Director and Project Control Group for review and approval A copy of this report should be sent to the Associate Director Sustainability, Planning and Development and will form part of a centralised.

## 3.2. Stage 2: Investment Decision

Undertaking a CRA during the formation of the investment decision (e.g. when the concept/reference design is being developed to support the business case) provides a critical project input. It presents a valuable opportunity to address key climate risks likely to shape the project's development.

At this stage it is advised a full CRA is prepared by a relevant professional with a formal tertiary environmental science or engineering qualification or with a minimum five years' experience in climate risk and adaptation assessments. **As a minimum, the qualifications and suitability of the person leading the CRA should be submitted through a memo to the relevant TfNSW Sustainability Manager for approval prior to undertaking the assessment.**

### 3.2.1. Undertaking a Climate Risk Assessment

Resilience refers to the ability and capacity to withstand, recover and adapt from stress. As such, it is a measure of how much disturbance from a changing climate can be absorbed without impairing functionality.

The following identifies the steps required when undertaking a CRA (refer Figure 3). Central to the task is identifying and assessing the risks climate change poses to TfNSW projects, and prioritising those risks that require appropriate actions for adaptation.

A total of 5 steps have been identified and form the basis of this guide:

- Step 1: Assessing risk exposure
- Step 2: Develop risk statements
- Step 3: Undertake risk assessment
- Step 4: Identify adaptation initiatives
- Step 5: Reassessing risk

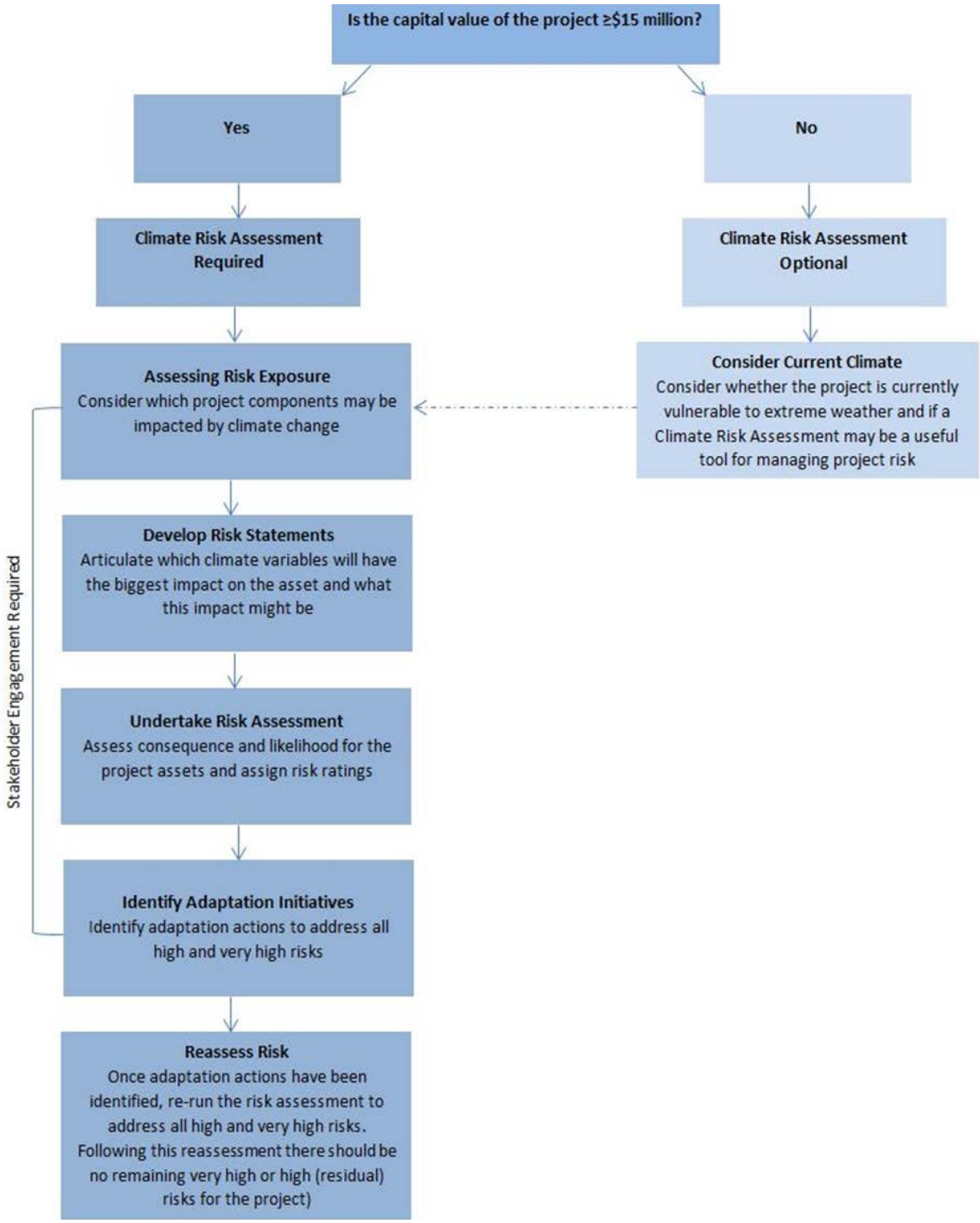


**Figure 3 Steps to undertaking a Climate Risk Assessment**

### 3.2.2. Assessing exposure

As with the guidance provided in Section 2.1.1, the first step in a CRA is confirming the nature of climate risk posed to the project. A necessary component of this is identifying those climate variables (temperature, rainfall, storminess etc.) likely to have an impact on the project and establishing the project context to be assessed.

### Past and current climate risks

In order to gain an appreciation of future risk, it is beneficial to establish an appreciation of past and current risk. Determining the extent to which the project site may have already been affected by weather and climate will assist with selecting relevant climate variables (refer Section 2.1).

Consideration should be given to whether the project site has been impacted by natural disasters or extreme weather events previously (e.g. storms, heat waves, flooding etc. and the frequency of these occurrences).

Useful information may include:

- Any modelling undertaken for the project during early project planning e.g. flood modelling, bushfire risk, and drainage designs etc.
- TfNSW can assist in providing this information including technical studies undertaken as part of an Environmental Impact Statement (EIS); Review of Environmental Factors (REF) etc.
- Media reports
- Warnings and updates provided by the relevant local government authority.

An additional baseline step is considering the climate-related thresholds and limits already applied to the project. For example establishing what thresholds and/or limits have already been considered and applied to the project during business case development.

Understanding this baseline information will be useful for informing decisions related to future risks to project assets and selecting relevant climate variables.

### Project scope

As a general rule, all project components included within the project boundary and scope of works should be considered within the CRA (e.g. rail track, signalling components etc.).

### Climate data

Recent advances in climate science, and the release of the Intergovernmental Panel on Climate Change (IPCC) Fourth and Fifth Assessment Reports (AR4 and AR5) have given rise to a wealth of climate data being made publically available.

Figure 4 provides a hierarchy of data sources to be referenced as part of the climate risk assessment process and includes a list of useful resources that may be helpful in sourcing relevant data.

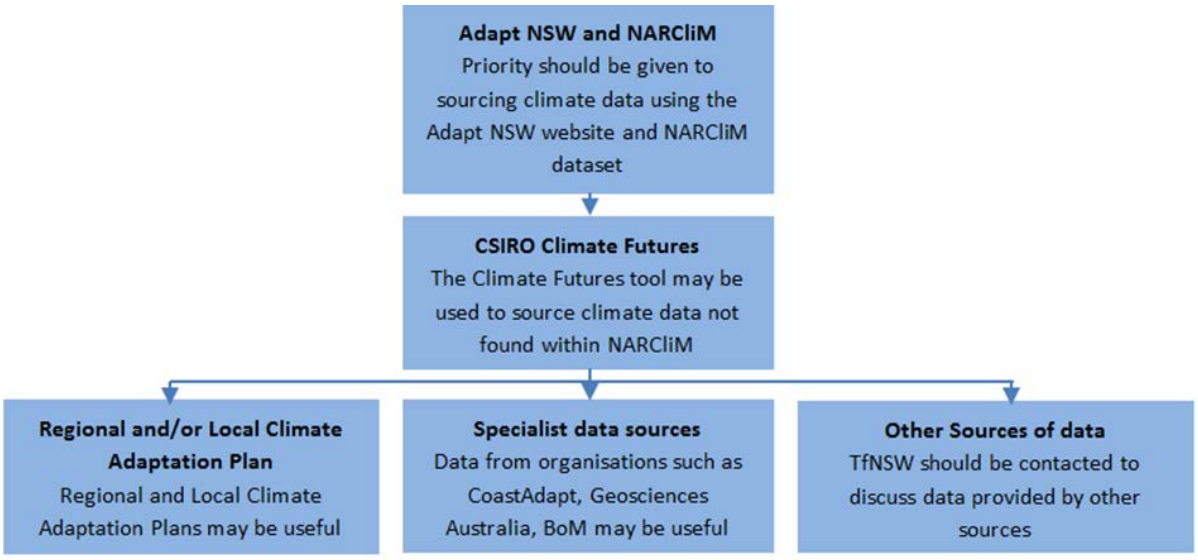


**Figure 4 Hierarchy of climate data sources**

- **Adapt NSW and NARCliM**: The NSW Office of Environment and Heritage (OEH) has developed a range of information and tools to help government, businesses and communities build resilience in the face of future extreme events and hazards by helping them understand and minimise the impacts of climate change. NARCliM data (NSW/ACT Regional Climate Modelling project) produces an ensemble of regional climate projections for south-east Australia designed to provide robust projections that span the range of likely future changes in climate.
- **CSIRO - Climate Futures**: provides a selection of both AR4 and AR5 projections that enables users to explore, and obtain data for, projected monthly, 3-monthly, 6-monthly and annual changes in up to 14 climate variables (extreme temperature, precipitation, sea level rise etc.).
- **Specialist data sources**: organisations such as CoastAdapt, Geosciences Australia and the Bureau of Meteorology contain useful datasets that may prove helpful in identifying specific climate projections and considering natural hazard risk for projects.
- **Regional/Local Climate Adaptation Plan**: Where an overarching Climate Adaptation Plan has been developed at a regional or local authority level, climate projections from this may be used.
- **Other sources** of climate projections may be used following consultation and confirmation from TfNSW.

**Useful resources** (note, this list is not exhaustive)

Adapt NSW:

- About NARCliM: http://www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM
- Help on where to start: http://www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Need-some-help-on-where-to-start
- NSW climate change snapshot and climate projections for each of the regions: http://www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/NSW-Climate-Change-Downloads
- Interactive maps: http://www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map
- Accessing and downloading datasets: http://www.climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Download-datasets
- To obtain further information and support accessing data and projections contact OEH's Adapt NSW team at narclim@environment.nsw.gov.au

Climate Futures:

- 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/

### Which climate variables should be modelled

Identifying the relevant climate variables to model is an essential step in understanding the level of climate exposure. Exposure refers to changes in essential climate variables such as temperature, precipitation, wind and solar radiation. The potential impact is the change in conditions that often result in natural hazards such as heat waves, drought, flooding, wind, hail, bushfires and coastal inundation. Figure 5 provides an overview of the climate variables to be considered.

Data is available for a multitude of climate variables, however not all of them will be relevant for all projects. For example, modelling the impacts of sea level rise and storm-tide inundation is unlikely to be relevant for projects located inland. Similarly, considering bushfire risk may not be relevant for projects located in an urban, coastal setting.

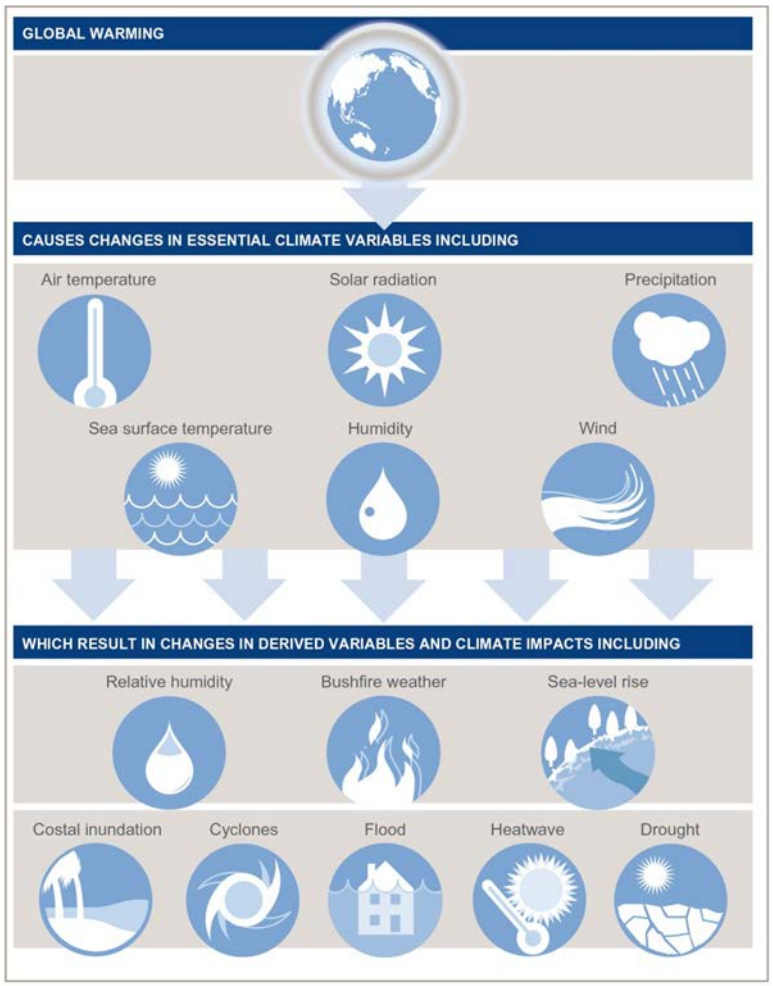


**Figure 5 Relationship between climate variables and impacts**

The following table lists both the primary and secondary climate effects that should be considered as part of the CRA where relevant.

**Table 2 Primary and Secondary Climate Effects to be considered**

| Primary Effects | Secondary Effects |
|---|---|
| Air Temperature | Relative Humidity |
| Solar Radiation | Bushfire Weather |
| Precipitation | Sea Level Rise |
| Sea Surface Temperature | Coastal Inundation |
| Humidity | Cyclones and Storms |
| Wind | Flood |
| | Heatwave |
| | Drought |

### Selecting a time series

When selecting a time series it is important to consider the lifespan of the asset. A bridge for example, is likely to have a longer design life than pavement or a culvert. Establishing these differences will affect the climate projections used and the level of climate risk the asset is exposed to. For example, it is not necessary to use 2070 climate change projections for an asset with a 20 year lifecycle; similarly if a project design life is 100 years, it will be important to use at least two different time periods (e.g. 2030 and 2070) to understand the future climate impacts across the asset's life.

The aim of the climate risk assessment is to classify key areas of risk and categorise adaptation actions to build resilience across the life of the asset (not just for the construction period). For this reason, it is imperative the broader implications of risk to areas such as maintenance, operations, workforce, customer services etc. are recognised.

### Identifying a scenario

Recognising the degree of uncertainty that exists regarding future climate, the latest IPCC report (AR5) introduced a series of Representative Concentration Pathways (RCPs) to help provide parameters around varying greenhouse gas (GHG) emission trajectories. The RCPs represent four plausible climate futures that may eventuate over the coming years. The most conservative scenario is represented by RCP 8.5 which assumes a high emissions pathway with global GHG emissions continuing to rise throughout the 21st century. Currently, RCP 8.5 represents not only the worst case emissions scenario, but also the most likely case. As such, until further climate data revises this prediction, it is recommended that a RCP 8.5[5] is used when sourcing relevant climate projections (e.g. when using the CSIRO Climate Futures portal).

### Required deliverable:

- List of any relevant recent and/or historical weather events that have impacted the project site.
- List of relevant climate variables including appropriate data sources for at least two different time periods (refer Appendix 2, Table A1)
- Note: Depending on the project design life TfNSW accepts there may be justifiable circumstances where only one time series is appropriate.
- Tabulated breakdown of major project components and associated project time periods/design life (refer Appendix 2, Table A2)

## 3.2.3. Develop risk statements

**Managing Australia's climate risks**

"Australia is among the developed countries most vulnerable to climate change. Our climate is highly variable and predisposed toward extreme weather events, and our ecosystems are finely balanced and often unique. Most of the country's population lives in coastal cities exposed to rising sea levels and connected by infrastructure exposed to the full range of weather conditions. Climate change will have direct economic costs for Australia that need to be managed."

- Coming Ready or Not: Managing climate risks to Australia's infrastructure, The Climate Institute, 2012)

[5] Note: within the 2007 IPCC 4th Assessment Report (AR4) RCPs are not used, instead reference is made to different Special Report Emissions Scenarios (SRES), the AdaptNSW NARCliM software uses AR4 data and is predicated on the application of the high emissions A2 scenario http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=98

Once the relevant climate variables have been identified, associated climate risks will need to be identified for the project. In order to develop the project's climate risk statements, the risks should address all relevant climate change variables and their associated project impacts.

For example, if assessing climate variables associated with extreme heat, specifically, days over 35°C, an appropriate climate risk statement might be as follows.

[Event that has an effect on objectives] caused by [cause/s] resulting in [consequence/s]

An increase in the number of extreme heat days (over 35°C) caused by climate change resulting in heat stress of passengers and reduced capacity of staff and disruption to services.

In line with good practice climate risk assessment, risk statements (and risk ratings) should be developed in consultation with key members of the project team. Collaboration with key stakeholders better enables a comprehensive assessment of key project risks associated with climate change. As a minimum, TfNSW requires the following representatives to participate in the development of the CRA: a staff member of the TfNSW Sustainability, Planning and Development team, Manager, Project Sustainability Officer, Project Design Manager, Project Engineer, and Technical Manager.

**Required deliverable:**

- Clear identification of the project boundary and scope of works considered as part of the assessment
- List of project team members consulted in the development of the risk statements. As a minimum the following should be included in stakeholder engagement: TfNSW a staff member of the Sustainability, Planning and Development team, Project Sustainability Officer, Project Design Manager, Project Engineer, Technical Manager.

### 3.2.4. Undertake risk assessment

Risk is generally defined as the effect of uncertainty on objectives. (ISO, 2009) Once a project's climate risks have been identified, their corresponding risk ratings will need to be allocated. Ideally this task will also be done as part of a collaborative approach with key internal and external stakeholders present (Refer Section 2.2.3).

Risk assessments rely on the allocation of both consequence and likelihood ratings to determine the overall level of risk. While an example is provided for use (refer Table 3), **to ensure all 'very high' and 'high' risks are considered across the project lifecycle it will be critical that the climate risks are incorporated into the broader project risk register**. For this reason, it is recommended that the risk matrices used align with the project's broader risk assessment process. The consequence and likelihood tables outlined in Sections 2.2.5 align directly with the TERM approach and correspond directly with TfNSW's considerations of risk tolerance and acceptability (refer to TERM, Transport Enterprise Risk Management Standard) Consequence

Assessing a risk's consequence explores what the magnitude of impact would be if the risk were to occur. For example, if train stations, tracks or signalling equipment were to be impacted by a flood what would the consequence of this impact be? Table 3 outlines the suggested consequence criteria for use.

Note: the consequence category may change when assessing the project's residual risk. E.g. the implementation of proposed adaptation actions are likely to result in a reduced level of impact. However, depending on the adaptation action identified, the event likelihood may

also change. For example if a larger sized culvert is specified for a project to reduce impacts from flooding, this would subsequently reduce the likelihood of flooding impacting the project/asset.

**Likelihood**

Risk likelihood seeks to categorise the probability of the risk occurring. Refer to the TERM Risk Standard for risk matrix and evaluation.

**Risk Rating**

Once the likelihood and consequence ratings have been identified, the project's climate risks can be assessed using the TERM Risk Standard for risk matrix and evaluation.

A climate risk assessment template has been provided in Appendix 3. All risks should be assessed for the corresponding time series and ratings should include the consequence and likelihood criteria assigned to the associated risk rating.

**Risk Tolerance and Response**

It is important all risks are considered in the context of tolerance and acceptability. TERM Risk Standard for risk matrix and evaluation

Required deliverables:

- A statement summarising which risk assessment parameters have been applied. E.g. has the TfNSW TERM assessment criteria been used? If not, summarise the approach applied to the project and include a copy of the relevant consequence, likelihood and risk matrices in the report appendices.
- Summarise the total number of climate risks identified for the project including a breakdown of 'very high', 'high', 'medium' and 'low' risks.
- Discussion regarding the risk tolerance and level of acceptability to be provided for all 'high' and 'very high' risks.
- A copy of the project's climate risk statements must be included in the report appendix (refer Appendix 3)

### 3.2.5. Identifying adaptation actions

Once the project's climate risk ratings have been applied, adaptation actions must be identified for all risks rated 'high' or 'very high' (unless otherwise indicated by TfNSW). Any projects seeking to pursue the higher performance levels outlined in SDGv.4 will need to address the corresponding proportion of medium risks. These actions should comprise actual or proposed adaptation initiatives rather than aspirational, potential actions. Further the identified adaptation actions should enable the climate risk rating to be reduced on reassessment[6]. I.e. TfNSW should feel confident the associated climate risk will be reduced as the identified adaptation actions will be incorporated into the project. TfNSW reserves the right to request evidence of how adaptation actions have been incorporated into the project.

Actions may fall into a range of categories including:

- **Mutually beneficial**: reflects worthwhile actions that deliver a net socio-economic benefit regardless of the level of climate impact. These types of measures include those justified under current climate conditions (including those addressing its

[6] Following treatment of medium risks, the residual risk rating should be reduced to 'low'.

variability and extremes) and are further justified when their introduction is consistent with addressing risks associated with projected climate changes.

- **Cost Effective**: actions for which the associated costs are relatively low and for which future benefits are comparatively large.
- **Co-benefit**: actions which will contribute to the minimisation of climate risk but will also deliver other social, environmental, or economic benefits for the project.
- **Flexible or Adaptive Management**: rather than undertaking large-scale adaptation in one fell swoop, adaptive management involves introducing incremental adaptation options. This approach reduces the risks associated with uncertainty, since it allows for incremental adaptation. Measures are introduced through an assessment of what makes sense today, but are designed to allow for incremental change (including changing tack) as knowledge, experience and technology evolve.

It is also noted, that in some instances an engineered solution may be appropriate, for example if culverts, sea walls and similar infrastructure are required. While these options typically represent a less desirable project solution as they often require additional capital expenditure, they also deliver significant benefit in reducing the likelihood of high or very high risk. It will be important to engage with the project's detailed designers and TfNSW project manager to discuss and recommend substantive design changes resulting from the CRA. Similarly, there may be exceptional circumstances where the tolerability of high and extreme risks may need review should the cost to reduce the risk be considered unfeasible and/or unreasonable in the context of broader public value considerations. In these instances it will be critical to liaise directly with TfNSW as per the response protocols listed in Figure 6.

Required deliverables:

- Summary of the adaptation actions identified for all high and very high risks
- Inclusion of adaptation actions within the risk assessment table included in the report appendices. (Refer Appendix 3).

### 3.2.6. Reassess risk

Once relevant adaptation actions have been identified for all 'very high' and, 'high' risks, the risk assessment process should be re-run to identify the revised level of risk associated with the project (residual risk). Where 2 different time series have been assessed for the project (e.g. 2030 and 2070) the identified adaptation measures should ensure the risk rating is reduced across both time series. Note: following the application of the identified adaptation actions the highest level of residual climate risk across the project must be 'medium'.

Following completion of concept design a summary report must be provided to TfNSW outlining how the adaptation actions identified will be implemented.

Required deliverables:

- Summary of the how the adaptation actions identified for all high and very high risks will reduce the residual risk ratings for all projects to no higher than 'medium' for all time periods assessed
- Inclusion of residual risk rating with the risk assessment table included in the report appendices (Refer Appendix 3)

**Project Example – Wickham Transport Interchange**
*The following provides a case study example summarising how a CRA has been undertaken for a recent TfNSW project during the early stages of detailed design.*

The Wickham Transport Interchange Project comprises a new train station and stabling yard at Wickham, Newcastle. It includes a transport interchange for local buses, taxis and private vehicles (short term parking for passenger pick up and drop off).

To support a comprehensive risk assessment process, the project's key assets and components were categorised based on their design life. For example, cabling and support systems were identified to have a design life of 25 years; track support and fastening systems will have a design life of 50 years; and, the project's inaccessible permanent structures including bridges, retaining and deflecting walls, platforms, aerial concourses, pedestrian bridges and substructures will have a 100 year design life. Based on the variance of these design life projections, 2030 and 2070 were selected as the time series under which to model the project's climate risk.

Relevant climate change variables for a selection of primary and secondary climate effects were obtained using a range of data sources. CSIRO data based on the IPCC Fourth Assessment Report, Special Report on Emissions Scenarios was used assuming an A1FI storyline. The A1F1 storyline describes a future world of very rapid economic growth, global population peaks mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income.

The A1FI scenario is distinguished by a high level of reliance on fossil fuels and assumes a stronger rate of global warming, i.e. a rate corresponding to a global warming of 4.2˚C for a doubling of $CO_2$ from 280ppm to 560ppm by the end of the century (IPCC, 2007).

The risk assessment categorised project impact categories i.e. infrastructure and assets; environment; customer service etc. and identified a total of 28 climate risk statements responding to each of the climate variables identified for the project. Based on the initial risk assessment, by 2030 the project will contain 5 high risks, which will increase to 12 high risks by 2070 and represent approximately 39% of the total assessment.

| Risk Rating | 2030 | 2070 |
|---|---|---|
| **Low** | 7 risks | 3 risks |
| **Medium** | 16 risks | 12 risks |
| **High** | 5 risks | 12 risks |
| **Very high** | 0 risks | 0 risks |
| **Total Risks** | 28 risks | 28 risks |

Four key climate variables are responsible for the project's 'high' risk ratings:

- Storms and sea level rise
- Increase in daily mean temperatures
- Increase in humidity

- Increase in precipitation events

In order to reduce all high risks to a tolerable threshold of 'medium' risk, appropriate adaptation actions have been identified for the project. An example of these actions is provided below (note this is an extract only, not the definitive list of actions provided).

| Climate risk statement | Initial Risk Rating | Adaptation Actions | Revised risk rating |
|---|---|---|---|
| **Increase in daily mean temperature** | | | |
| An increase in the number of extreme heat days could lead to heat stress and solar exposure of the staff, resulting in increased illness and/or dehydration-related illness possibly resulting in hospitalisation. | High | Implement measures for protecting customers/staff from extreme weather – this can include shading (natural and man-made), HVAC solutions, or changed working schedules. | Medium |
| **Storms/Sea Level Rise** | | | |
| An increase in incidents of storms could lead to impacts on the ICT networks – in turn this may affect communication, emergency response management, intruder alarm reporting. | High | Review of affected systems; implement backup systems and measures for protecting ICT equipment from wind and rain during storm events. | Low |
| **Increase in precipitation** | | | |
| An increase in rainfall and runoff could lead to localised flooding resulting in reduced activity in affected area (access and egress). | High | Develop/expand flood management plan to incorporate 2070 climate related metrics. | Medium |
| **Increase in humidity** | | | |
| Humidity impacts on electrical equipment results in higher risk of failure and material fatigue. | High | Engineered redundancy in electrical systems to reduce the impact of humidity on electrical equipment. | Medium |

Based on the application of these measures, there will be no residual risks for the project rated higher than 'medium' risk which is considered to be tolerable for the project.

## 3.3. Stage 3 and beyond: detailed design

While the preferred stage to complete a CRA is to inform the concept design, there remains value in assessing climate risk during the early stages of detailed design,[7] particularly if no prior CRA work has been undertaken. In these instances, the methodology outlined in Section 2.2 should be applied.

In line with SDGv.4 *Compulsory Requirement 3 (CR 3) –Climate Change Risk*, a CRA is required for all projects with a capital value over $15 million. Projects under this value threshold are not required to complete a CRA but may find it beneficial to do so depending on the project's location.

[7] For example at SDR stage – System Design Review representing 20% completion of detailed design

For projects that have previously undertaken a CRA, a review and gap analysis of prior findings should be done. A key driver for updating the CRA at this stage to review and consider the outcomes of the detailed design process for instance at this stage of the project lifecycle information will be available regarding types of equipment, materials etc. that may require specific assessment in the context of climate risk and resilience (e.g. operating thresholds for plant and equipment).This work should be undertaken by a suitably qualified professional (refer Section 2.2) and include the following tasks:

- **Review climate change projections for relevant time series**: This will be relevant if new climate projections have been released by sources such as AdaptNSW, CSIRO and/or the IPCC since the initial climate risk assessment as it will inform the risk ratings and improve understanding around the likelihood and severity of climate impacts. If no new climate data has been released any previously used information may be applied.
- **Review climate change risk statements and ratings**: A gap analysis to identify any additional climate risks not captured during earlier design stages for the project should be undertaken including a revision of the attributed risk ratings.
- In particular, consideration should be given for instances where prior assessments only considered extreme events or specific climate risks. Additionally, a more comprehensive review of climate risks likely to play out during construction and operations should be considered.
- **Review climate adaptation actions and mitigation review**: A review of prior climate adaptation actions should be completed and should include investigation of how previously identified risks have been mitigated as appropriate (e.g. Extreme, High and Medium risks as relevant). In addition, relevant adaption actions should be identified as required (refer Section 2.2) for any newly identified climate risks.
- **Review residual risk ratings:** As a final check the residual risk ratings for associated risks should be completed, including attributing a residual risk rating for any new climate risks and adaptation measures identified at this stage.

As consistent with good climate risk assessment practice, any review work should also seek to engage with members of a multidisciplinary project team. TfNSW requires the following representatives to participate in this process as a minimum: TfNSW Sustainability Manager, Project Sustainability Officer, Project Design Manager, Project Engineer, and Technical Manager.

**Required deliverables:**

- For projects where no prior CRA has been undertaken, deliverables should comply with those outlined in Section 2.2 of this guide.
- For projects undertaking a review of prior CRA work, a summary report should be provided to the TfNSW Sustainability Manager presenting the findings of the gap analysis review. This should include:
    - data and commentary on any new climate data identified as relevant to the project;
    - newly identified climate risks and risk mitigation actions;
    - revisions to risk ratings for previously identified climate risks;
    - revision to residual risk ratings as appropriate; and, assignment of residual risk ratings to any new climate risks and associated mitigation actions; and,

- confirmation of how the project will address Compulsory Requirement (CR) 3 – Climate Change Risk as outlined in TfNSW's SDG v.4.

# 4. Beyond climate risk assessment

The focus of this guide is to support a consistent approach for how climate risk should be assessed across key delivery stages for TfNSW projects. It is important to note that the climate adaptation and resilience space continues to grow and evolve and this guide offers a baseline from which to progress and advance how climate risk and resilience is considered on a project.

While not a SDG requirement, those wishing to adopt a more holistic approach to climate risk, are encouraged to think beyond completing a CRA, and consider climate risk more broadly in relation to resilience, vulnerability and, in particular, interdependencies. The analysis of risk interdependence explores an expanded remit of climate impacts to consider the knock-on effects borne out of a particular event. For example a power outage resulting from a heatwave event may affect train signalling, which may affect passenger services, which in turn may have an economic impact resulting from stranded commuters being unable to get to work. This approach requires an enhanced level of stakeholder engagement and consultation to enable the consideration of risks arising from interdependencies between the project asset, as well as the assets and services provided by other stakeholders.

# Appendix 1: Pre-screening climate risk checklist

As future changes to the climate are expected to increase the frequency and intensity of extreme events, a common finding when reviewing climate risk is for risks ranked medium (or tolerable) in the short to medium term, to progressively escalate further into the future (particularly from 2070 onwards).

For the purpose of this checklist, the preselected risks denote impacts that are commonly ranked as high or extreme in a CRA over various time horizons e.g. current, 2030 and/or 2070+ across a range of TfNSW asset types.

If any of the following are identified as being a likely risk to the future delivery of the project a comprehensive exploration of those risks should be undertaken using the CRA methodology outlined in Section 2.2 of the Guideline. *Note: the CRA methodology need only apply to the associated extreme event/s identified not for the full spectrum of climate variables commonly explored during a detailed CRA.*

| Climate Risk | Relevant to Project (Y/N) |
|---|---|
| **Heatwave resulting in…** | |
| 1. Delays, cancellations & reliability implications to network due to speed restrictions | |
| 2. Heat stress impacts to staff and passengers, leading to dehydration and/or illness resulting in possible hospitalisation and/or fatality | |
| 3. Overload and/or interruption to mains power impacting service provision and the customer experience e.g. signal failure and/or reduced functionality | |
| **Bushfire resulting in…** | |
| 1. Delays and cancellations due to bushfires or bushfire warnings | |
| 2. Direct heat and fire damage to supporting infrastructure e.g. wiring, electrical equipment etc. | |
| **Extreme Precipitation & Flooding resulting in…** | |
| 1. Flooding/scour of stabling/maintenance yards, tracks, depots, bridges, tunnels, stations, stops, electrical/signalling, car parks, etc. | |
| 2. Landslides, slope failures and embankment instability/failure / collapse or failure of rock cuttings / collapse or failure of earth cuttings | |
| 3. Delays, cancellations & reliability implications due to inundation of supporting infrastructure e.g. tracks, stations, stops, roads, wharves etc. | |
| 4. Increased localised flooding resulting in reduced activity in affected areas [access and egress] | |
| **Storm Surge resulting in…** | |
| 1. Inundation of low-lying track, erosion and effects on coastal defences | |
| 2. An increase in erosion of shorelines and damage to near shore assets | |
| 3. Storm water drain inundation leading to increased pressures on drainage capacity and impacting operations | |
| **Storms and Strong Winds resulting in…** | |
| 1. Delays, cancellations, safety & reliability implications due to storm impacts including wind and lightning | |
| 2. Impact to substations, electronic and communication systems and other equipment vulnerable to storm and lightning damage impacting energy supply, communications and emergency response management etc. | |
| 3. An increase in frequency of extreme wind above thresholds known to correspond to damage to assets, electricity network and overhead cables (usually from flying debris)resulting in asset damage and power failure | |

# Appendix 2: Climate Variable and Asset Tables

The following tables provide an example of how information regarding climate variables and project assets should be presented. This table and the climate variables listed is for illustrative purposes only, different variables may also be appropriate for consideration e.g. single day over 35°C, days with Forest Fire Danger Index (FFDI) over 50 etc.

**Table A1 Climate Variables for 2030 and 2070**

| | | Climate Projections | |
|---|---|---|---|
| **Climate Effect** | **Baseline** | **2030** | **2070** |
| Mean temperature change (ºC) | | | |
| Extreme heat (single day over 40ºC) | | | |
| Heatwave (3 consecutive days over 35ºC) | | | |
| Mean rainfall change | | | |
| Extreme rainfall (125mm in 24 hours) | | | |
| Sea surface temperature | | | |
| Wind (high wind events) | | | |
| Cyclones | | | |
| Bushfire weather<br>(Cumulative Forest Fire Danger Index [FFDI]) | | | |
| Sea level rise | | | |
| Coastal Inundation | | | |
| Fluvial flooding | | | |
| Local catchment (flash) flooding | | | |
| Drought (e.g. days without rain) | | | |
| Relative Humidity | | | |
| Solar Radiation (MJ/m$^2$/day) | | | |

*** Note: only complete projections for those climate variables relevant to the project. Refer Section 3.1.4 of the guide regarding how to select the relevant time series.**

**Table A2 Asset design life summary**

| Project Component | Design Life (years) |
|---|---|
| Road pavements (asphalt) | 20 |
| Rail track | 50 |
| Road pavements (concrete) | 50 |
| Signalling Structures | 50 |
| Drainage structures and inaccessible pipe systems | 100 |

***Note: this table is provided for illustrative purposes only. The table should be tailored to reflect the key project components for each CRA (it is important to note the design life for certain project components may vary between projects).**

# Appendix 3: Risk Assessment Template

The following template provides a recommendation of how a project Climate Risk Assessment should be completed. The example here is for reference only. Other time series may be used if deemed to be of greater relevance to the project e.g. 2030 and 2050; 2050 and 2100 etc, and all climate risks for the project should be included.

| | | | 2030 | | | 2070 | | | | 2030 | | | 2070 | | | Summary of how measures reduce risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Climate Variable** | **Asset/s Impacted** | **Climate Risk** | **C** | **L** | **Rating** | **C** | **L** | **Rating** | **Proposed Adaptation Actions** | **C** | **L** | **Rating** | **C** | **L** | **Rating** | |
| **Extreme heat – days over 35°C** | Station | An increase in the number of extreme heat days could lead to heat stress of passengers and reduced capacity of staff | C4 | L3 | M | C4 | L1 | H | - Improved station and concourse facade design incorporating performance glazing and external shading to mitigate impacts<br>- Use of materials that reduce heat load impacts for shelters and outdoor furniture e.g. avoid the use of metal furniture.<br>- Provision of water bubblers | C6 | L3 | L | C6 | L1 | M | Implementing the measures outlined will reduce the impact and consequence experienced at the station on extreme heat days. Improved passive design, material selection and the provision of water bubblers will reduce the risk posed to passengers and staff. |
| | Signalling | An increase in extreme heat days may lead to a decrease in energy network capacity and increases in power outages causing signalling and transport system interruptions | C3 | L3 | H | C3 | L1 | VH | - Backup generator to be provided for signalling energy supply to avoid disruption from power outages | C6 | L3 | L | C6 | L1 | M | The use of a generator to provide backup power supply if and when needed will reduce the impact of power outages on the signalling network and reduce the likelihood of delays to service. |

**Note: Please include the consequence and likelihood rankings in addition to the risk rating.**

# Appendix 4:Climate Risk Assessment Checklist

The following provides an at-a-glance summary of the report inclusions Transport for NSW (TfNSW) requires as part of a Climate Risk Assessment report submission.

| Report Components | Included [✓] |
|---|---|
| **Climate Data and Project Assets** | |
| List of any relevant recent and/or historical weather events that have impacted the project site to inform the project baseline. | |
| List of relevant climate variables including appropriate data sources for at least two different time periods (refer Appendix 2, Table A1).<br>Note: Depending on the project design life, TfNSW accepts there may be justifiable circumstances where only one time series is appropriate. | |
| Tabulated breakdown of key project components relevant to the project time periods/design life (refer Appendix 2, Table A2). | |
| **Scope and Engagement** | |
| Clear identification of the project boundary and scope of works considered as part of the assessment. | |
| List of project team members consulted in the development of the risk statements. As a minimum the following should be included in stakeholder engagement: TfNSW Sustainability Manager, Project Sustainability Officer, Project Design Manager, Project Engineer, and Technical Manager. | |
| **Risk Assessment Approach and Assessment** | |
| A statement summarising which risk assessment parameters have been applied. E.g. has the TfNSW Enterprise Risk Management (TERM) assessment criteria been used? If not, summarise the approach applied to the project and include a copy of the relevant consequence, likelihood and risk matrices in the report appendices. | |
| Summarise the total number of climate risks identified for the project including a breakdown of 'very high', 'high', 'medium' and 'low' risks for all time periods assessed. | |
| Discussion regarding the risk tolerance and level of acceptability to be provided for all 'high' and 'very high' risks (refer Figure 5). | |
| A copy of the project's climate risk statements should be included in the report appendix (refer Appendix 3). | |
| **Adaptation and residual risk** | |
| • Summarise the adaptation actions identified for all high and very high risks. | |
| • Inclusion of adaptation actions within the risk assessment table to be included in the report appendices. (Refer Appendix 3) | |
| • Summarise how the adaptation actions identified for all 'high' and 'very high' risks will reduce the residual risk ratings for all projects to no higher than 'medium'. | |
| • Inclusion of residual risk rating with the risk assessment table included in the report appendices. (Refer Appendix 3) | |