25 Climate change risk and adaptation

The NSW Government has acknowledged that, despite efforts to reduce greenhouse gas emissions, some climate change is now inevitable. The Government aims to minimise the impacts of climate change on natural and built environments, communities and the economy.

Road networks and infrastructure assets are exposed and vulnerable to climate change because of their long design life, during which many impacts of climate change may become more significant.

Roads and Maritime determined that the assessment of the potential impact of climate change on the project is warranted due to the significant investment required for the project, the long design life of the project, and its exposure to potential flooding impacts.

This chapter outlines the methodology adopted to assess the impacts of climate change on the project and adaptation measures that could be implemented.

The assessment addresses the requirements of the Secretary of the Department of Planning and Environment 9SEARs (**Table 25-1**).

Table 25-1 SEARs – climate change risk and adaptation

SEAR	
Identification of potential impacts of the proposal on existing flood regimes demonstrating consideration of the changes to rainfall frequency and/or intensity as a result of climate change…	Changes to rainfall frequency and / or intensity as a result of climate change are discussed in **Appendix W** (Climate change risk assessment framework) and **Section 25.4**.

During detailed design, a detailed Climate Change Risk Assessment would be undertaken in accordance with the Australian Standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure - A risk based approach*, and would be informed by this initial Climate Change Risk Assessment.

25.1 Assessment methodology

Roads and Maritime Services (Roads and Maritime) is currently in the process of finalising a Technical Guide for Climate Change Adaptation for the State Road Network. The Guide is aligned with existing Roads and Maritime processes and broader NSW Government initiatives and programs responding to climate change impacts. This assessment adopts the approach of the latest draft to ensure consistency with Roads and Maritime's approach to climate change adaptation.

Further, this assessment considers the impact of future climate change on the project, rather than the impact of the project on the future of climate change. Impacts of the project on climate change relate to greenhouse gas emissions generated from the construction and operation of the project, which have been assessed in **Chapter 22** (Greenhouse gas). Greenhouse gas calculations are provided in **Appendix U**.

The climate change risk assessment has been carried out in line with the following relevant standards and current guidelines:

- The risk assessment approach set out in AS/NZS ISO 31000:2009 *Risk Management – Principles and Guidelines* and ISO/IEC 31010 *Risk Management – Risk assessment techniques*
- Australian Standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure - A risk based approach* - follows the International Standard ISO 31000:2009 *Risk Management – Principles and guidelines*
- *Australian Green Infrastructure Council, Guideline for Climate Change Adaptation, Revision 2.1* (2011)
- *Draft Technical Guide for Climate Change Adaptation* (RMS (unpublished), 2015d).

The overall approach is focused on risk management and is closely aligned with *AS/NZS 31000:2009 Risk Management* and complements Roads and Maritime's *Guidelines for Risk Management*. The approach comprises the following steps:

- Pre-screening
- Screening
- Detailed risk assessment
- Risk evaluation
- Adaptation (risk treatment).

Each of these steps is described in the following sections.

25.1.1 Pre-screening

A pre-screening process was undertaken by Roads and Maritime before the climate change risk assessment was carried out to determine whether the project is likely to be impacted by climate change. As previously mentioned, it was determined that the assessment of the impact of climate change on the project is warranted due to the significant investment required, the long design life of the project, and exposure of the project to potential flooding impacts.

25.1.2 Screening

Screening aims to identify potential exposure to relevant climate change impacts. Each roads project has a range of engineering components and service provisions and is subject to different climate change impacts, and therefore different risks. As a result, it is not appropriate to consider a generic list of climate change risks.

For the project, specific risks were identified using a screening matrix, which plots relevant elements of the project on one axis and key climate change variables relevant to the region on the other axis. By identifying the intersection between the climate change variables and the elements of the project, relationships can be identified and used to form the basis of potential risk scenarios for further analysis. This step forms part of the 'risk identification' of a typical risk management process as described in Roads and Maritime's *Guidelines for Risk Management* (Roads and Maritime, 2014d).

The climate change risk screening for the project is provided in **Appendix W** (Climate change risk assessment framework).

25.1.3 Detailed risk assessment

The first step of the detailed risk assessment is the formulation of risk scenarios for each of the relationships identified in the screening stage. Each risk scenario is then analysed in detail by assigning a likelihood and consequence rating. The criteria used for likelihood and consequence (following the Roads and Maritime *Guidelines for Risk Management*) are shown in Table 1-1 and Table 1-2 of **Appendix W** (Climate change risk assessment framework). The consequence rating considers the potential consequence of climate change on the project in terms of the physical asset (damages) and in terms of service provision (loss).

By combining the likelihood and consequence rating for each risk scenario, using the risk ranking matrix in **Table 25-2** the level of risk can be determined. These are the original risk levels before any mitigation measures are applied. For example a risk with medium likelihood and low consequence results in a risk level of low.

The detailed risk assessment for the project is provided in **Appendix W** (Climate change risk assessment framework).

Table 25-2 Risk level matrix

Likelihood	Consequence					
		Negligible	**Low**	**Medium**	**High**	**Extreme**
	Extreme	Medium	High	Extreme	Extreme	Extreme
	High	Low	Medium	High	Extreme	Extreme
	Medium	Negligible	Low	Medium	High	Extreme
	Low	Negligible	Negligible	Low	Medium	High
	Negligible	Negligible	Negligible	Negligible	Low	Medium

25.1.4 Risk evaluation

The purpose of risk evaluation is to identify which of the risks require treatment. Treatments designed to mitigate the risks should be applied to those risks evaluated as extreme or high. Risks evaluated as negligible or low do not require any further consideration. As this is a preliminary climate change risk assessment and a subsequent detailed risk assessment will be undertaken, medium risks have been retained for consideration.

The risk evaluation for the project is provided in **Section 25.3.2**.

25.1.5 Adaptation (risk treatment)

This step involves the development of risk treatments that can reduce the original unmitigated risk rating. Some adaptation options have been presented **Section 25.4** for consideration during detailed design.

25.2 Existing environment

An increase in global concentrations of greenhouse gases has led to an increase in the Earth’s average temperature (surface temperature) (IPCC, 2013). The most recent Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2013) states that ‘human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system’.

In 2015, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Bureau of Meteorology (BoM) released an assessment of observed climate change and projected future changes in Australia over the 21st century (CSIRO and BoM, 2015a). This recent assessment confirms the long term warming trend: showing that in Australia, the average surface air temperature has increased by 0.9 degrees Celsius (degrees Celsius) since records began in 1910, with most of the warming occurring since 1950. Australia’s warmest year since 1910 was in 2013 (CSIRO and BoM, 2015a).

The AR5 states with high confidence that Australia is already experiencing impacts from recent climate change. Observed trends include changes in the frequency of air temperature extremes, changes in mean and extreme rainfall, changes in the frequency and intensity of storm events, ocean warming, ocean acidification and sea level rise.

Due to the long lag times associated with climate processes, even if greenhouse gas emissions are mitigated and significantly reduced, the warming trend and associated impacts of climate change are expected to continue for centuries (IPCC, 2007).

Key projected trends include:

- Increase in atmospheric carbon dioxide concentrations
- Increase in mean temperature
- Increase in heat extremes
- Decrease in cold extremes
- Changes in mean rainfall
- Changes in the intensity and frequency of extreme rainfall and storm events
- Increase in sea level
- Increase in extreme sea levels (eg storm surges)
- Increase in ocean acidity
- Increase in bushfire weather.

The magnitude of these projected changes will vary both spatially and temporally (IPCC, 2013).

Road networks and infrastructure assets are exposed and vulnerable to climate change because of their long design life, during which many impacts of climate change are likely to become more significant.

The main impacts to road networks and infrastructure assets as a result of climate change are associated with an increase in extreme rainfall intensity and frequency (which can exacerbate flooding or landslides risks, and damage to pavement) and from sea level rise (which will worsen damage from coastal erosion, storm surge and coastal flooding and may even eventually lead to long-term inundation and loss of land). The largest impacts are likely to be borne by roads in upland areas with steep topography, and by coastal roads in areas exposed to coastal erosion and storm surge.

Appendix W (Climate change risk assessment framework) provides information regarding the existing climate and historical climate trends of the project area.

25.2.1 Future climate

This section presents climate projections relevant to the project. The climate projections are based on information published by CSIRO and BoM in 2015. As the project has been designed for a 100 year design life, projections modelled for 2090 (an average of the period 2080-2100) have been selected for the assessment, which are the available projections for the time horizon closest to the end of the project's design life.

Projections for south-east Australia have also been published by the NSW / ACT Regional Climate Modelling (NARCliM) project (2014) in collaboration with the NSW Office of Environment and Heritage (OEH). However, NARCliM projections are not yet available for a number of key climate variables (extreme rainfall, sea level rise, storm surge, wind speed). This presents limitations when considering climate change impacts in road planning.

Projections provided by CSIRO and BoM are considered most appropriate for this project and are recommended in the Roads and Maritime Climate Change Adaptation Practice Note (Roads and Maritime, unpublished, 2015d). It is important that only a single source of projections is used for a climate change risk assessment. This ensures an 'internally consistent climate future' approach is used, whereby a consistent set of assumptions, scenarios, and modelling method is applied to each projection. As such, a combination of NARCliM and CSIRO and BoM projections has not been used.

Projections are presented for two emission scenarios or possible pathways, referred to as 'representative concentration pathways' (RCPs), each of which reflects a different concentration of global greenhouse gas emissions. The two RCPs reported here are intermediate emissions (RCP4.5) and high emissions (RCP8.5). Intermediate emissions projections are only provided in this report for context; the assessment is based on high emissions projections, to account for a worst case scenario based on the precautionary principle (refer to **Chapter 28** (Sustainability) for more information).

The ensemble of projections published by CSIRO and BoM (2015b) are spatially broken down into eight natural resource management 'clusters', which largely correspond to broad-scale climate and biophysical regions of Australia. Projections at this scale are considered appropriate for the consideration of future climate for road projects. The project falls within the east coast cluster. This cluster forms the central part of the eastern seaboard of Australia, straddling the Queensland−NSW border immediately east of the ridgeline of the Great Dividing Range. It extends from south of Sydney in NSW to north of Rockhampton in Queensland.

A summary of projections for the east coast cluster for 2090 for both the Intermediate and high emissions scenarios is provided in **Table 25-3** followed by a description of each climate variable.

Table 25-3 Projections for the East Coast Cluster for 2090

Climate variable		
Mean surface temperature	Increase of 1.3 degrees Celsius to 2.5 degrees Celsius	Increase of 2.7 degrees Celsius to 4.7 degrees Celsius
Extreme temperature (days per year, Sydney)	Increase of 6.0 (over 35 degrees Celsius) Increase of 0.9 (over 40 degrees Celsius)	Increase of 11 (over 35 degrees Celsius) Increase of 2.0 (over 40 degrees Celsius)
Mean annual rainfall (per cent)	Decrease by 5 per cent to 15%	Decrease by at least 15 per cent
Extreme Rainfall (one in 20 year, per cent)	Increase by 10 per cent to +30 per cent	Increase by +10 per cent to +30 per cent
Mean annual wind speed (per cent)	Between a decrease of 1% and increase of 1%	Between a decrease of 1% and increase of 1%
Bushfire weather (annual cumulative forest fire danger index (FFDI) / number of days with a fire danger rating of severe and above)	Increase of annual cumulative FFDI by 13 per cent Increase of number of days with a fire danger rating of severe and above by 45 per cent	Increase of annual cumulative FFDI by 30% Increase of number of days with a fire danger rating of severe and above by 130 per cent
Sea level (metres) (compared to 1986-2005)	Increase of 0.30 metres to 0.65 metres	Increase of 0.44 metres to 0.88 metres

Source: CSIRO and BoM, 2015b

Mean surface temperature

Mean surface temperature is projected to continue warming during the 21st century, at a rate that strongly reflects the increase in global greenhouse gas emissions (CSIRO and BoM, 2015b). By 2090 mean surface temperatures are projected to increase by 1.3 degrees Celsius to 2.5 degrees Celsius under RCP4.5 and by 2.7 degrees Celsius to 4.7 degrees Celsius under RCP8.5. There is very high confidence in these projections (CSIRO and BoM, 2015b).

Extreme temperature

The trend of increasing extreme temperatures is projected to continue, with increases in the annual number of days over 35 degrees Celsius and 40 degrees Celsius projected for Sydney. The current number of days over 35 degrees Celsius in Sydney is 3.1 and the current number of days over 40 degrees Celsius in Sydney is 0.3. By 2090:

- under intermediate emissions, the annual number of days over 35 degrees Celsius is projected to increase for Sydney by 2.9 days, and the annual number of days over 40 degrees Celsius is projected to increase by 0.6 days (CSIRO and BoM 2015b)

- under high emissions the annual number of days over 35 degrees Celsius and 40 degrees Celsius is projected to increase by 11 and 2.0 days respectively (CSIRO and BoM 2015b). There is very high confidence in these projections (CSIRO and BoM, 2015b).

Mean annual rainfall

By 2090, under intermediate emissions, the change in mean annual rainfall is projected to range from a 15 per cent decrease to a five per cent increase (CSIRO and BoM 2015b). The direction of trend is more clear under high emissions, projecting a drying by more than 15 per cent by 2090 (CSIRO and BoM 2015b).

Despite the projected drying trend for mean rainfall under RCP8.5, it is projected that extreme rainfall events will become more frequent and intense (refer to discussion of extreme rainfall below).

There is generally a high degree of uncertainty in rainfall projections due to the fact that mean rainfall in Australia is influenced by a number of climate drivers and there is no consensus on how these drivers will be affected by and respond to climate change. As such, there is a low confidence in mean rainfall projections (CSIRO and BoM, 2015b).

Extreme rainfall

Projections of extreme rainfall events (wettest day of the year and wettest day in 20 years) are projected to increase in intensity across Australia. By 2090, one in 20 year extreme rainfall events are expected to increase by 10 per cent to 30 per cent under intermediate emissions and high emissions scenarios respectively (CSIRO and BoM, 2015b). There is high confidence that the intensity of extreme rainfall will increase in the east coast cluster. However, the magnitude of the change cannot be reliably projected (CSIRO and BoM, 2015b).

Mean annual wind speed

Projections of annual mean wind speed for the east coast cluster do not indicate much change for 2090. Under both intermediate emissions and high emissions, the projected change in mean wind speed is between plus and minus one per cent (±1%) (CSIRO and BoM, 2015b). There is low to medium confidence in these projections (CSIRO and BoM, 2015b).

Bushfire weather

Projections of fire weather show that projected warming and drying will lead to fuels that are drier, with increases in the average Forest Fire Danger Index (FFDI) and a greater number of days with a severe fire danger rating and above (CSIRO and BOM 2015b). By 2090, under RCP4.5, cumulative FFDI is projected to increase by 13 per cent, and the number of days with severe fire danger is projected to increase by 45 per cent. Under RCP8.5, cumulative FFDI is projected to increase by 30 per cent and the number of days with a fire danger rating of severe and above is projected to increase by 130 per cent. There is a high confidence that climate change will result in a harsher fire weather climate in the future, however there is low confidence in the magnitude of the change, largely due to the uncertainty associated with rainfall projections (CSIRO and BoM 2015b).

Sea level rise

CSIRO and BOM (2015b) state that there is very high confidence that sea levels will continue to rise during the 21st century. By 2090, projections differ significantly between RCPs. Sea levels along the east coast cluster shoreline are projected to rise by 0.30 metres to 0.65 metres under RCP4.5, and by 0.44 metres to 0.88 metres under RCP8.5. The continued increase in sea levels along the east coast is projected with very high confidence (CSIRO and BoM, 2015).

Extreme sea level

For 2090, under RCP8.5 and RCP4.5, CSIRO and BoM (2015b) have calculated an ‘allowance’ which is the minimum distance required to raise an asset to maintain the current frequency of breaches under projected sea level rise. The allowance takes into account the nature of extreme levels along the coastline. This is the parameter which should be used in planning along the coastline. For 2090, along the east coast cluster coastline, the vertical allowance ranges from 0.55 metres to 0.63 metres under RCP4.5 and 0.78 metres to 0.89 metres under RCP8.5.

Increase in atmospheric carbon dioxide

The current concentration of atmospheric carbon dioxide (CO_2) is approximately 400 parts per million (ppm) (National Oceanic and Atmospheric Administration, 2015). RCP8.5 represents a future with little curbing of emissions, with CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100. Under RCP4.5 concentrations peak at around 2040 and CO_2 concentrations reach 540 ppm by 2100.

25.3 Assessment of potential impacts

25.3.1 Construction

The potential impacts of climate change would be negligible during the construction phase due to its relatively short timeframe. These potential impacts are therefore not considered further in this assessment and the focus of the chapter is on potential operational impacts.

25.3.2 Assessment of potential operational impacts

Operation Risk Evaluation

As discussed in **Section 25.1.4**, high and extreme risks identified in the detailed risk assessment should be treated. The detailed risk assessment carried out for the project (refer to **Appendix W** (Climate change risk assessment framework)) did not identify any risks rated as high or extreme. Of the 28 risks that were analysed for the project, 13 were identified as having a medium risk. These risks rated as medium are listed in **Table 25-4** for consideration in the subsequent detailed risk assessment to be undertaken during detailed design.

Table 25-4 Climate change risks ranked medium

Risk scenario
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated localised flood risks the crossings over Alexandra Canal.
Increase in atmospheric CO_2 and the frequency and intensity of extreme heat events leads to accelerated deterioration of bridge structures due to corrosion and thermal expansion of steel reinforcement in concrete and thermal expansion of steel, protective cladding, and coatings on bridges.
Increase in the intensity and frequency of extreme rainfall adversely affects performance of the surface drainage system(s) at the western surface works as a result of increased runoff, leading to localised flooding of surface roads, and potential flooding of ancillary infrastructure, substations, landscaped areas and within the main alignment tunnels.
Increase in the intensity and frequency of extreme rainfall combined with sea level rise (and increased extreme sea levels during storm surges) adversely affects performance of the surface drainage system at St Peters interchange and local road upgrades as a result of inundation, leading to localised flooding of surface roads, ancillary infrastructure, substations, landscaped areas and within the main alignment tunnels.
Sea level rise causes reduced performance or failure of water treatment system(s) as a result of increased water levels at the location of the submerged discharge infrastructure in Cooks River and deterioration from saline intrusion.
Increased frequency and intensity of bushfire events due to increased bushfire weather adversely affects performance of tunnel ventilation system as a result of smoke pollution.
Decrease in mean rainfall combined with an increase in mean surface temperature and the frequency and intensity of extreme heat events, leads to exacerbated risk of dust storms adversely impacting the performance of tunnel ventilation system.
Increase in frequency and intensity of extreme heat events causes higher temperatures within the tunnel.
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated risk of flooding of Alexandria Landfill Leachate Treatment System.

Risk scenario
Sea level rise causes failure of the underground cut-off wall at Alexandria Landfill due to raised water table.
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated risk of flooding of Alexandria Landfill gas capture system.
Increase in the intensity and frequency of extreme rainfall leads to exacerbated risk of road incidents.
Increase in frequency and intensity of extreme heat events increases the risk of heat stress conditions for operational personnel.

25.4 Environmental management measures

Table 25-5 provides environmental management measure to be implemented to reduce the risk from climate change on the project during operation.

During detailed design, a detailed Climate Change Risk Assessment would be undertaken (in accordance with the standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure - A risk based approach*). The assessment would identify and implement adaptation measures to comprehensively address high and extreme risks. The decision to implement adaptation measures for medium risks would also be considered during detailed design. **Table 25-6** provides a list of adaptation options which are available for consideration during detailed design and the subsequent detailed climate change risk assessment.

Table 25-5 Environmental management measures – climate change risk and adaptation

Impact	No.	Environmental management measures	Timing
Construction			
The impacts of climate change to the project during construction are negligible.			
Operation			
Climate change impacts	CC01	The risk associated with future climate change on the project would be further considered during detailed design.	Pre-construction
	CC02	Implement adaptation measures (refer to **Table 25-6**) to address high and extreme rated risks identified in the subsequent detailed climate change risk assessment.	Pre-construction
	CC03	Where extreme, high or medium risks have been identified in this assessment or subsequent climate change risk assessments, a review of the existing design policies, specifications or practices would be undertaken to consider the impacts of climate change.	Pre-construction

Table 25-6 Adaptation options for consideration during detailed design

Impact	Adaptation option	Timing
Increase in atmospheric CO_2 leads to accelerated deterioration of concrete structures due to corrosion of steel reinforcement in concrete.	In the detailed design of concrete structures, if reasonable and feasible, consider options to mitigate the potential impacts to concrete from increasing atmospheric CO_2 (eg thicker concrete, sacrificial layers and protective chemical layers etc).	Detailed design
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated localised flood risks for bridge crossings over Alexandra Canal.	Apply a minimum of 10 per cent sensitivity testing (as required by the draft Roads and Maritime Technical Guide) to hydrological / hydraulic modelling on detailed design, combined with extreme sea level scenario incorporating projected sea level rise by 2090. Consider applying 25 per cent sensitivity testing to this model, which is the recommended sensitivity test value (as per the draft Roads and Maritime Technical Guide) for the projected temperature increases and the design life of the asset. During detailed design, consider incorporating 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.	Detailed design
Increase in the intensity and frequency of extreme rainfall adversely affects performance of surface drainage system at western surface works.	Apply a minimum of 10 per cent sensitivity testing (as required by the draft Roads and Maritime Technical Guide) to hydrological/hydraulic modelling on detailed design, including drainage design. Consider applying 25 per cent sensitivity testing to this model, which is the recommended sensitivity test value (as per the draft Roads and Maritime Technical Guide) for the projected temperature increases and the design life of the asset. In the detailed design of drainage systems, consider the incorporation of additional drainage network features and flood protection measures (e.g. larger drainage network, additional pits, larger pipe diameters, larger sumps etc.) into drainage systems to mitigate a potential increase in flood risks.	Detailed design
Increase in the intensity and frequency of extreme rainfall combined with sea level rise (and increased extreme sea levels during storm surges) adversely affects performance of surface drainage system at St Peters Interchange and upgraded local roads, and leads to exacerbated risk of flooding of Alexandria Landfill Treatment System and gas capture system.	Apply a minimum of 10 per cent sensitivity testing (as required by the draft Roads and Maritime Technical Guide) to hydrological/hydraulic modelling on detailed design, including drainage design, combined with extreme sea level scenario incorporating projected sea level rise by 2090. Consider applying 25 per cent sensitivity testing to this model, which is the recommended sensitivity test value (as per the draft Roads and Maritime Technical Guide) for the projected temperature increases and the design life of the asset. In the detailed design of drainage systems, consider the incorporation of 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.	Detailed design

Impact	Adaptation option	Timing
Sea level rise causes inundation of Arncliffe, St Peters and / or Burrows Road motorway operations complexes.	The potential for inundation due to sea level rise would be considered during detailed design to determine the climate change related flood risks to the project.	Detailed design
Sea level rise causes failure of the underground cut-off wall at Alexandria Landfill due to raised water table.	In the detailed design of the Alexandria Landfill cut-off wall, consider the potential impacts from sea level rise.	Detailed design
Sea level rise causes reduced performance or failure of water treatment system due to increased water levels at the location of the submerged outfall diffuser system in Cooks River, and deterioration from saline intrusion.	In the detailed design of the outfall diffuser system in Cooks River, consider the potential impacts from sea level rise.	Detailed design
Increased risk of bushfire smoke and dust affecting the performance of tunnel ventilation system.	Consider the implementation of operational procedures for emergency planning and management, in consultation with emergency management services, local governments and other relevant agencies, during bushfire and dust storm events, and other extreme climate events.	Operation
Increase in frequency and intensity of extreme heat events increases the risk of heat stress conditions for operational personnel, and causes higher temperatures within the tunnel.	In the refinement of Work Health and Safety Management Plans further consider the increased potential for heat stress among operational personnel (eg a stop work threshold could be implemented for operation and maintenance activities).	Operation
	Consider the implementation of operational procedures for management when tunnel temperatures are high.	
Increase in the intensity and frequency of extreme rainfall leads to exacerbated risk of road incidents.	Consider the implementation of operational procedures to increase safety during extreme rainfall events, such reduced speed limits.	Operation

Note: During the consideration of any the above adaptation options, analyses of costs and benefits should be undertaken.