**Guidelines**

Climate Change Risk Assessment

Version 2

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# Purpose

Main Roads is proactively looking to protect our asset and against the potential risks of climate change. In doing so, Main Roads is seeking to ensure the future integrity of the road network by minimising economic disruption, ensuring road user safety and working with our community stakeholders to assist with the overall resilience to the impacts of climate change and natural hazards.

Main Roads is committed to continue to play a leading role in responding to the challenges and opportunities associated with climate change and will progressively review its Standards, Guidelines and Policies to address these. Fundamentally our response will be to employ a ‘what if’ scenario approach to decision making, to better appreciate risks that might be placed on current and future infrastructure, and to incorporate greater flexibility to accommodate change where appropriate to do so.

This document outlines the considerations that should be given during the planning, design, construction, operation and maintenance of road and bridge infrastructure, associated with climate change and natural hazard risks to the asset.

#  Scope

Climate change considerations are applicable to all stages of planning, developing, constructing and maintaining a Main Roads asset and assets that Main Roads is delivering on behalf of other government agencies.

## Deliverables and outcomes

When applied, following this guideline will assist in:

* undertaking climate change and natural hazards risk assessments
* Identifying a range of planning, design, construction and operational treatment options
* Stages and priority at which those treatment options should be assessed.

During planning, an initial assessment of the climate change and natural hazard risks should be as part of the options assessment, route selection and concept design development processes.

For projects which are in design and construction, the consideration and implementation of options is expected to be integrated into the detailed design and the inclusion of treatments documented in design reports.

Where residual risks remain or treatment options require implementation post practical completion of the asset or network are proposed, review and acceptance of the risk and treatment options must be accepted by the asset owner prior to being approved by the Main Roads’ Representative on the project. These requirements must be included in the project risk register, the climate change report and in handover documentation.

The consideration of climate change and natural hazard risks during the planning, design and construction of new projects and upgrade works, as well as part of reviews of operations, will assist Main Roads to manage current and future risks and improve the ability for our network and assets to meet service and accessibility demands in the future. It will also assist the communities we service become more resilient to shocks and stresses by maintaining a safe, operational network which can be used to service their needs.

# Roles & Responsibilites

## Who should use this document?

This guidance document should be referred to and implemented by those involved with the planning, design, operation and maintenance of Main Roads’ infrastructure, including Main Roads staff and service providers involved in:

* Strategic Planning;
* Road Planning;
* Road Designing;
* Project Management;
* Asset Management;
* Network Operations; and
* Contract Management.

The use of this document manages corporate risk by assisting to identify climate change and natural hazard risks relevant to projects leading to the development of appropriate treatments.

## Responsibilities

Project Managers are responsible for ensuring that the implications of a changing climate have been assessed as part of project development and that the risks are both understood and have been discussed with the relevant Asset Manager for their input.

# Current Context

Climate change poses risks to health, livelihoods, food security, water supply, human security and economic growth. Current research indicates that 1.5 degree warming is inevitable and we are already observing climate changes that include less rainfall, increased temperatures, increased intensity of storms and increased intensity of heatwaves. Sea level rise is expected to be between 0.26-0.77m by 2100. To keep warming at 1.5 degrees would require rapid and far-reaching transitions in all economic activities, and Global emissions would need to fall by 45% from 2010 levels by 2030.

While changes in climate are set to continue throughout this century and beyond, the key impacts are of concern are those which coincide with the anticipated service life of projects currently in planning, design and operation.

Climate change is predicted to have a significant impact on transportation, affecting the way we plan, design, construct, operate, and maintain our infrastructure. Decisions taken today, related to the redesign and retrofitting of existing infrastructure, or the location and design of new infrastructure, will affect how well our network is able to adapt to climate change into the future.  Focusing on the problem now will help reduce the likelihood of costly future investments and disruptions to operations to accommodate climate change.

Until recently, infrastructure design was based on historical weather records, assuming that the climate will remain the same. Climate change means that this assumption is no longer valid, so that long lifespan infrastructure now needs to be designed, constructed and operated to cope with projected much hotter, drier and stormier climatic conditions, with higher sea levels. Climate projections released by Australia’s CSIRO and Bureau of Meteorology in 2015 indicate that under all future emissions scenarios:

* average temperatures will continue to increase (very high confidence in this outcome) and Australia will experience more heat extremes (very high confidence) and fewer frosty days (high confidence)
* extreme rainfall events are likely to become more intense (high confidence)
* the number of tropical cyclones is projected to become less frequent with a greater proportion of high intensity storms (medium confidence) and a greater proportion extending beyond the southern latitude of 25 degrees (low confidence).

The ability for communities, government agencies and businesses to adapt to changing climate conditions and natural disasters is also a key aspect of the United Nations [Sustainable Development Goals](https://www.un.org/sustainabledevelopment/sustainable-development-goals/). [Goal 13: Climate Action](https://www.un.org/development/desa/disabilities/envision2030-goal13.html) also includes a target for integrating climate change considerations into policies, strategies and planning as well as building capacity to mitigate, adapt, reduce impacts and identify early warnings for climate related and natural hazards.

# Climate change Projections

The CSIRO and Bureau of Meteorology (BoM) are nationally responsible for producing projections of key climate variables at regional levels which are called clusters, as shown in Figure 1.



Figure Climate change regional super clusters (CSIRO and Bureau of Meteorology, n.d.)

Western Australia is made up of three super clusters, Southern and South-Western Flatlands, Rangelands and the Monsoonal North. The alignment of these superclusters with the CSIRO and BoM regions is provided in Table 1.

Table Main Roads Regions and climate change superclusters

|  |  |
| --- | --- |
| **Main Roads Region** | **Super Cluster(s)** |
| Metro | Southern and South-Western Flatlands |
| Kimberley Region | Monsoonal North |
| Pilbara Region | Rangelands |
| Goldfields-Esperance Region | Southern and South-Western Flatlands for:* Shire of Esperance areas including South Coast Highway
* Great Eastern Highway west of SLK 500

Rangelands * All other assets
 |
| Mid West-Gascoyne Region | Southern and South-Western Flatlands* All assets within the city of Greater Geraldton
* Assets up to the northern boundary includes Shire of Northampton
* Assets out to the eastern boundary includes Shires of Morawa, Perenjori

Rangelands* All other assets
 |
| Great Southern Region | Southern and South-Western Flatlands |
| South West Region | Southern and South-Western Flatlands |
| Wheatbelt Region | Southern and South-Western Flatlands |

# State Wide Climate and Natural Hazards

Although there are some differences between the anticipated climate changes across each of the super clusters, as a state, we face five broad key climate change risks:

* generally higher temperatures and increased frequency of bushfires
* increases in the frequency, duration and magnitude of extreme heatwaves
* more rainfall in the north and less rainfall in the south
* increased intensity of storms and flood events
* sea level rise, including increases in the level of estuarine and river systems which are influenced by tides.

Although infrequent, Western Australia also has the potential to be affected by earthquakes across the state and tsunami’s which originate from earthquakes originating in more active geological areas such as Indonesia are also possible.

These risks can impact our network in several ways:

* Inundation of coastal and estuarine assets
* Increased fatigue rates of pavement due to increasing temperature and moisture fluctuations
* Threat of asset failure such as material displacement from earthquakes and flooding
* Reductions in asset demand in drying areas such as the Wheatbelt changing the economic profile of our regions
* Increases in asset demand in the areas getting wetter, particularly in the Kimberley region
* Changes to the occurrence of events that diminish the road networks performance
* Changes to the occurrence of events that reduce the road networks safety
* Changes to the occurrence of events that alter the road networks demand profile

Table Applicability of climate change variables to Main Roads (adapted from AS5334)

|  |  |  |
| --- | --- | --- |
| **Element** | **Climate change variable** | **General hazard impact on Main Roads assets** |
| Marine, river and estuarine waters | Sea, estuarine and riser level rise | Inundation of alignment, Bridges, Walls, Base, Sub-base |
| Storm surge, storm tides and tsunami | Inundation or flooding of Alignment, Bridges, Walls, Base, Sub-base |
| Surface temperature | Durability of Alignment, Bridges, Walls, Base, Sub-base |
| Currents and waves | Durability of Alignment, Bridges, Walls, Base, Sub-base |
| Atmospheric salt | Durability of Alignment, Bridges, Walls, Base, Sub-base |
| Rainfall | Average annual rainfall | Drainage sizing inappropriate (oversized or undersized), death to revegetation |
| Extreme rainfall events | Floodways, Bridges, Tunnels, Abutments, Drainage, revegetation |
| Drought | Changes to asset demand  |
| Temperature | Average annual temperature | Degradation or damage to expansion joints, sprayed seal, revegetation |
| Extreme temperature events and heatwaves  | Damage to Expansion joints, sprayed seal, revegetation success |
| Wind | Storms, cyclones and extreme wind events | Safety impacts for users of exposed road, bridges or structures |
| Prevailing wind direction | Changes to wind flows around structures  |
| Relative humidity | Average annual relative humidity change  | Changes to asset demand, revegetation |
| Soil | Moisture, saltwater intrusion, salinity, ground stability, groundwater levels, acidity (pH) | Durability of Alignment, Bridges, Tunnels, Walls, Base, Sub-base |
| Runoff | Erosion of exposed areas along Alignment, Drainage and Revegetation |
| Surface and ground water  | Water levels | Degradation or damage to Base, Sub-base, Drainage, revegetation success |
| pH | Durability of Bridges and Structures which are in contact with water |
| Solar Radiation | Frequency, intensity and duration of sunlight | Degradation of sun exposed components of assets such as seal, paint |
| Bushfire | Frequency, intensity, duration or location  | Damage to assets, Service interruption without damage to asset |
| Fog | Frequency, intensity, duration or location | Safety impacts for users of exposed road, bridges or structures |
| Hail and lightning | Frequency, intensity, duration or location | Damage to sensitive assets, fire |
| Evapotranspiration | Evaporation rates | Changes to surface water availability and revegetation success |
| Earthquake | Frequency, intensity, duration or location | Damage to assets, Service interruption without damage to asset |

# Standards, Specifications And Requirements

A number of Main Roads standards, specifications and contractual requirements include consideration of climate change and natural hazards as discussed below.

## Climate change assessments

* For Design and Construction projects greater than $20M, there is a requirement for climate change and natural hazard risk assessments to be undertaken by the contractor as part of the Sustainability requirements in the SWTC.
* For disaster response and upgrade works projects which are exposed to natural hazard or climate change risks due to proximity to bushfire prone areas, floodplains or waterways, an **Initial Assessment**to identify risks must be undertaken. Where the initial assessment identifies very high or very high risks a **Detailed Assessment** must be undertaken.
* Main Roads representatives must be invited to participate in Initial Assessment, Detailed Assessment and Treatment Options workshops. For contracts where the requirement to undertake a climate change and natural hazard assessment are included in the Sustainability requirements, a risk assessment undertaken in accordance with this guideline is deemed to satisfy that requirement, subject to participation from Main Roads representatives.
* Australian Standard AS5334: 2013 *Climate Change Adaptation for Settlements and Infrastructure – a risk based approach* which is based on ISO31000:2009 *Risk Management* is widely referenced for Australian infrastructure projects, including:
* WA Planning Commission’s [Coastal hazard risk management and adaptation planning guidelines](https://www.dplh.wa.gov.au/getmedia/76fb800f-07ad-479a-8efc-50dc2d812448/GD_CST_coastal_hazard_risk_management)
* WA Planning Commission’s [State Coastal Planning Policy Guidelines](https://www.dplh.wa.gov.au/getmedia/dfa403eb-8488-454a-ad26-198ccbd8754d/GD_CST_State-coastal_planning_policy)
* WA Department of Transport’s [Coastal Management Local Coastal Hazard Assessment: Generic scope](https://www.transport.wa.gov.au/mediaFiles/marine/MAC_P_Local_Coastal_Hazard_Assessment_generic_scope.pdf)
* Infrastructure Sustainability rating scheme Climate Change (Cli-1, Cli-2) for projects assessed against version 1.2 and Resilience credits (Res-1, Res-2) for projects assessed against version 2.0.

## Sea level rise

* A 300mm sea level rise (450mm for structures) is required to be considered as part of planning, design and construction considerations for all rehabilitation and expansion projects near coastal areas. Documentation of how this has been assessed and adopted on projects is required in Design Reports. Reference - Standards & Technical / Roads and Traffic Engineering / [Climate Change](http://standards.mainroads.wa.gov.au/Internet/Standards/RTems/climate_change.asp)
* Projects should also consider higher levels of sea level rise where relevant Coastal Hazard Risk Management and Adaptation Planning guidelines prepared for the location indicate that this is required.
* Consideration of the physical and chemical properties or sea, river and estuarine waters as a result of climate change which influence the durability of the asset should be included in durability reports, as appropriate.

## Rainfall

* Main Roads Drainage guidelines include consideration of *Australian Rainfall and Runoff 2016*, which includes consideration of climate change based on 5% increase in rainfall for every degree increase in temperature based on representative concentration pathway 4.5.
Reference - MRWA-Supplement-to-Austroads-Guide-to-Road-Design -[Part-5](https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/RoadandTrafficEngineering/GuidetoRoadDesign/Pages/MRWA-Supplement-to-Austroads-Guide-to-Road-Design---Part-5.aspx), section 3.2.3.
* Representative concentration pathway (RCP) 4.5 is now recognised as being below the likely emissions pathway and for modelling the anticipated changes to rainfall and representative concentration pathway 8.5 has been identified by the [National Climate Change Adaptation Research Facility](https://coastadapt.com.au/sites/default/files/infographics/15-117-NCCARFINFOGRAPHICS-01-UPLOADED-WEB%2827Feb%29.pdf) as the pathway indicated by current emissions.
* Updates to Australian Rainfall and Runoff (ARR) in 2016 and the 2019 update have included consideration of climate change impacts associated with changes to rainfall. The 2019 version recommends consideration of RCP4.5 and RCP 8.5.
* Standard Scope of Work and Technical Criteria issued for Infrastructure Delivery Directorate projects include requirements for the design to ensure that no lanes become untrafficable for longer than one hour during the 100 year ARI storm event for freeways and highways. Reference – SWTC Drainage (typically clause 4.7)

## Temperature

* Consideration of temperature increases are most likely to impact on shorter service life components, such as expansion joints and spray seals as well as revegetation activities.
* Work undertaken by Main Roads and ARRB indicates that impacts of increased temperatures due to heatwaves or increases in temperature are unlikely to affect the service life of 14 mm chip seal. Reference – Standards & Technical / Roads and Traffic Engineering / [Climate Change](http://standards.mainroads.wa.gov.au/Internet/Standards/RTems/climate_change.asp)
* It is common practice in Main Roads to require consideration of climate during plant selection as part of the Scope of Work and Technical Requirements for new projects and upgrades.
* Main Roads currently doesn’t have consideration within the existing standards for the possible effects due to increases in frequency, duration and magnitude of extreme heat waves.

## Ground water

* Development and agreement with regards to design groundwater levels has been included as part of the Scope of Work and Technical Criteria requirements for a number of projects, particularly those where groundwater is close to the surface.
* There are currently no predictions on the anticipated changes to groundwater levels for Western Australia and these are dependent on a range of factors, including groundwater extraction and replenishment in the area.

## Other elements

* Main Roads currently don’t have explicit requirement beyond those which are included in Australian Standards, operational management, durability and or safety in design requirements for the other elements.

# Level of Risk Assessment

Climate change and natural hazard risk assessments typically have different levels of detail which are used to assess the risks relative to the level of detail for the project.

*Initial Assessment*

An initial assessment consists of a first pass assessment and a risk assessment. The first pass assessment is used to identify what hazards may be present within the project area based on the location of the asset. This includes review of existing risk assessments conducted by the local government or other infrastructure projects in the area and identification of the presence or absence of key hazards including, but not limited to:

* water bodies, including the ocean, river, estuarine areas
* floodplains
* drought affected areas
* areas prone to extreme temperatures
* bushfire prone areas
* fault lines or past earthquake events
* areas prone to severe weather events including cyclones, dust storms, thunderstorms, tornadoes

Based on the first pass assessment, an initial, high-level risk assessment using the methodology described in Section 7 is performed. For an initial assessment, the intention is to identify the most obvious potential risks associated with the project, the surrounding community and environment as well as the identification of high-level treatment options.

*Detailed Assessment*

Detailed risk assessments are undertaken to identify the less obvious and more complex climate change and natural hazard risks. These assessments require inputs from external stakeholders, with suggested participants identified in the Assess Risk subsection of Section 7.

The outcomes of detailed assessments must document:

* the specific direct and indirect risks identified
* an assessment of the likelihood and consequence of the risks
* treatment options identified to address the risks, with a focus on high and very high priority risks
* prioritisation of the treatment options to be implemented
* optimal timing for implementation of the treatment
* justification of why options were not feasible
* for treatment options which are to be implemented in the future or associated with operation of the network/asset, details of the handover including:
	+ details of the timing, or occurrence of an event, in which treatment should be implemented
	+ identification of the responsible discipline/region or asset owner responsible for future implementation of treatment options
	+ confirmation from the discipline/region or asset owner of acceptance of responsibility
	+ monitoring requirements used to assess the condition of the asset associated with the risk
	+ reporting requirements associate with managing and treating the risk

# Approach to Climate Change and natural hazard Risk Assessments

Main Roads has adopted a five step process reflecting the processes in AS5334, PIARC’s *International Climate Change Adaptation Framework* and the Infrastructure Sustainability Council of Australia’s rating scheme Technical Manual and supporting documentation as shown in Figure 2.



Figure Main Roads climate change and natural hazard risk assessment process

This approach should be adopted for all planning, design and construction as part of the project establishment for new and upgrade projects. The depth of the assessment depends on the phase of the project:

* All projects must undertake an Initial Assessment
* Projects in design and construction should complete an Initial Assessment if one has previously not been undertaken and then commence a Detailed Assessment, including seeking external stakeholder input, to determine what precise form of treatment to adopt.
* The assessment of risks associated with operational assets should be undertaken to enable the risks to inform the risk for the asset.

It is recommended that all assessments are facilitated by specialists with experience in the identification and treatment of climate change risks. Where project teams do not have a specialist with experience in climate change assessments engaged in the delivery team, the Principal Advisor Sustainability should be advised.

For projects with a contractual requirement with regards to a self assessment or a formal rating under the Infrastructure Sustainability rating scheme, additional guidance which must be considered and adopted during the assessment is presented later in this guideline. This additional guidance should be read in conjunction with the IS Technical Manual applicable for the stage of the project and any IS Rulings which may have been issued by ISCA in relation to the relevant credits.

## Identify and Review

Establishing the scope, collating and reviewing existing information and identifying data to be used for the risk assessment is fundamental to the success of the assessment. It consists of:

* Defining the scope of the assessment, including the asset(s), design life of the components, potential impact locations and sensitive receivers.
* Reviewing the suitability and currency of the assessment for the asset(s), location and receivers where previous assessments have been undertaken.
* Identifying and reviewing known climate and natural hazard risks based on the elements identified in Table 2.
* Identify opportunities to avoid or mitigate risks associated based on responses or lessons learnt from past weather and natural disaster events.
* Review local government natural hazard or climate change risk assessments, where available.
* Identify, review and update potential vulnerability of the asset(s) to the potential risks.
* Select the most current and readily available climate change and natural hazard information for time horizons representing mid-design life of the asset and the end of design life.
* It may be more appropriate to use a timeframe which coincides with planned future upgrades (for example the construction of the Ultimate Design) or the timeframe which aligns with the design life of short life components of the asset.
* Where climate change data is not available for the entire design life of the asset, use the furthest time horizon available, for example 2090 for assets which have a 100-year design life.
* The use of projections based on the CSIRO/BoM high emissions scenario (currently RCP 8.5) and either RCP 4.5 or 6.0 are required.

## Assess Risk

The Transport Portfolio, including Main Roads, have adopted a common framework for the assessment and management of risks within the Portfolio. The current version of the Risk Management Process (D11#208987) and supporting Transport Portfolio Risk Reference Table (D15#699153) must be applied to risk assessments, including climate change risks on projects. This includes the adoption of the Risk Register format which is provided in Appendix 9 of the Risk Management Process (D11#208987).

When considering the likelihood, the occurrence of the event should assess the potential for the risk occurring after normal design and operation tolerances are considered. When considering the consequences, consider when the:

* level of service is likely to fall below acceptable economic limits;
* asset could be expected to incur significant damage; and
* risks to the safety of the community or damage to the environment as a result of the asset could occur.

Major projects or critical infrastructure may also consider using the consequence matrix used in Appendix B of [Western Australia’s Natural Hazards Risk Profile](https://semc.wa.gov.au/Documents/Resources/ReportsandReviews/WesternAustraliaNaturalHazardsRiskProfile2017.pdf), although this may not meet the requirements for projects seeking Infrastructure Sustainability ratings.

When conducting the risk assessment direct risks to the asset and indirect risks to others as a result of the asset must be considered.

* Direct risks are those where there is damage, disruption, or loss to the asset or the asset results in risks to property or the environment.
* Indirect risks are those where the availability or level of service of the asset is impacted because of an impact to a critical service which the asset relies on (such as power) or the area surrounding the asset.

Seeking inputs from a broad range of disciplines and asset phases, is key to the identification of potential hazards as well as the consequence and likelihood of those risks occurring given Main Roads existing practices, guidelines, Standards and Specifications. Participants in the risk assessment must include:

* Project team members from disciplines associated with the risks such as:
* Drainage
* civil and structural engineering
* durability or materials engineering
* environmental management and
* stakeholder engagement
* Main Roads representatives as nominated by the Main Roads Project Manager.

Where possible, representatives from the regional maintenance and operation of the asset should be included or their post workshop input sought and documented.

Opportunities to engage with external stakeholders, including representatives from local government and State agencies potentially impacted by interruption to the service provided by the network should be approved by Main Roads.

## Manage the Risk

Once the risks are assessed, the identification of treatment options to manage, reduce or eliminate the risk are to be identified as part of the risk assessment process. Treatments, often called adaptation or management options, are generally be considered as being additional measures when compared to standard planning design, construction and operation options. In some cases, existing approaches may be considered as treatments either as a result of Main Roads’ integrating climate change into planning documentation, Standards, Specifications, Technical Criteria or contracts.

In general the principle of ‘as low as reasonably practicable’ for risk control should be applied. It is likely that options to treat or manage the risk may not be able to be committed to during the risk assessment process and the process to document the review. The identification of treatment options is expected to include:

* Identify design, construction and management approaches for to reduce the consequence and likelihood of the risk (see the **Treatment Approaches** section for further information).
* Prioritisation of the management and treatment options for very high and high risks.
* Assess the feasibility of options, considering decision making or options assessment processes adopted for the project.
* Implement feasible options for all very high and high risks.
* Where resources or funding is required beyond those already approved for the project, seek approval in accordance with established processes.
* When considering options more extensive probabilistic investment analyses and design approaches may need to be considered by Network Managers, strategic and project planners and designers to consider the costs of making the infrastructure more resilient to the risk against the economic costs of disruption or failure.
* Where additional funding is required, or No Adaptation/Redundancy options are identified, this should include consultation between the project manager and the project team, asset managers, key decision makers and external stakeholders assess the proposed treatment option(s) against life cycle cost, value for money, budgetary constraints and social and environmental aspects.

## Assess Residual Risk

Following the identification of preferred treatment options, re-assessment the consequences and likelihood of the risk based on the identified treatment and management options must be recorded using the Treatment Plan format which is provided in Appendix 8 of the Risk Management Process (D11#208987).

Where very high or high risks exist, identify additional options to reduce the residual risk in accordance with the ALARP principle.

## Implementation

Once the treatment option(s) are agreed and approved the adoption of these as part of the planning, design or operational iteration process begins. This should include:

* Implementation of feasible options in planning, design, construction or operation and documentation of how this has been assessed and adopted on the project as part of design reports, environmental or sustainability documentation, handover documents or similar.
* For planned adaptation, progressive modification, non-structural management, no adaptation or redundancy option document requirements in asset management plans.
* For emergency response planning options, engage with local emergency management organisation and document consultation outcomes.
* If a hazard event occurs, monitor and evaluate the effectiveness of the treatment options.

## Monitoring and Review

Monitoring and review of the effectiveness of climate change and natural hazard risk management on projects must be managed in accordance with Section 5.8 Monitoring and Review of the Risk Management Process (D11#208987).

# Indirect and Direct Risks

Direct risks are the most obvious risks to identify. They are the risks which, when they occur, result in damage, disruption of services, increased maintenance or degradation of Main Roads assets or the network.

Indirect risks are risks are more complicated because they generally do not cause physical damage or disruption to the asset or network which is the focus of the risk assessment. They are generally considered as being risks where the asset is dependent on, or causes impacts to, services, assets, communities or the environment which are not part of the project:

* Upstream
where the risk is experienced by a service, asset, communities or the environment which impacts on the asset’s serviceability or operation
* Downstream
where a risk to the asset changes the consequence or the likelihood of risks to another service, asset, community or the environment
* Internal
where there are dependencies between the asset and the operation of the broader Main Roads network

Depending on the scale of the climate change or natural hazard event, direct risks and indirect risks may be identified for the same hazard.

Examples of direct risks to Main Roads assets include:

* Pavement failure due to premature wearing and/or deterioration of asphalt
* Accelerated degradation of assets (structures and roadside furniture)
* Bushfire resulting in damage to asset including timber bridges, light poles, signage and pavement
* Flooding of the asset or gutter spread
* Death to revegetated areas

Examples of indirect risks associated with Main Roads projects include:

* Upstream
	+ Disruption to grid connected power supply causing electrical assets or services associated with the usual operation of the project to fail (streetlights, VMS)
	+ Fire, smoke, fog or flood beyond the project boundary which poses increased safety risks or interrupts the ability for the asset to operate as intended.
	+ Damage to non-Main Roads’ assets, such as freight rail, ports and airports used by the supply chain associated with repairs
* Downstream
	+ Flooding, damage or negative impacts on community, residents or the environment as a result of changes to the consequence or likelihood of a hazard occurring as a result of construction of the asset.
	+ Certain classes of water traffic being unable to pass under bridges
	+ Damage or disruption to Main Roads’ assets which is relied upon by regional communities, preventing the supply of food, water and medical services.
* Internal
	+ Major climate or natural hazard event which results in prioritisation of asset repairs to other assets within the Main Roads network above that of the project.

Indirect risks often require collaboration between Main Roads, other state government agencies and the community to identify and implement treatment options.

# Treatment approaches

In general, there are five broad approaches for considering the timeframe at which treatments are most appropriate. The first four are described as structural management as they are based on the designed asset, the last is non-structural as it manages the risk through changes to practices or management planning:

* Build for end of design life scenario
* Planned adaptation
* Progressive Modification
* No Adaptation or Redundancy
* Non-Structural Management

Table Description of treatment approaches

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| **Adaptation Treatment** | **Description** | **Expected Financial Implication** | **Example** |
| Avoidance (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 against standard Main Roads design lives. Avoid locations where climate change impacts are expected to be significant | Potentially high upfront costs, although no further costs for adaptation are required. Provides a higher level of service for entire design life. Risk that actual climate change will exceed prediction | Bridge is designed and constructed to consider increased flood risk for climate change.Alignment is moved to avoid coastal hazard zones. |
| 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. | Bridge components are selected and integrated into the designed and constructed based on having a shorter design life than is usual and can be replaced when required.  |
| Progressive Modification or Redundancy (existing asset) | Realign, redesign and/or 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. | Bridge is designed and constructed in such a way that adaptation responses, such as the height of the deck can be elevated and undertaken as part of based on increased risk or opportunity such as upgrade works being planned.Road alignment is changed such that bridge over waterway is no longer required and can be decommissioned. |
| Contingency Asset Planning | Identify and implement alternative assets to meet service requirements such providing multiple entry and exits to locations or alternate access arrangements such as construction of emergency landing strips  | Potentially high to moderate up-front costs depending on existing assets and need for new or upgraded assets.Where emergency response planning is undertaken, minor upfront and ongoing costs may be required where this is currently not within the operational services of the region. | Design of the road has included identification of suitable areas which operate as emergency landing strips or the provision of remote airstrips in areas away from hazard zones.  |
| No Adaptation / Designing for reduced service life | No adaptation or reducing the service life due to the life of the asset being shorter than typical design lives or as there are suitable alternatives  | No extra investment required. | Bridge design and construction does not include potential adaptation options where they are beyond Standards and Specifications. Bridge may be deconstructed or designed to fail safely. Rebuild is dependent on the current or future demand for the asset.  |
| Non-Structural Management | Changes to operations and or asset management and maintenance arrangements to respond to events Collaborative emergency response planning to document roles and responsibilities of Main Roads within broader emergency response plan. | Minor upfront costs expected associated with changes to the scope, frequency of surveillance and preventative maintenance of assets. Preparation of emergency response plans for assets which are not already covered by an existing plan developed by Main Roads, local government authority or the State Emergency Management Committee  | Asset management and preventative maintenance programs for bridge includes consideration of observed climate or weather data to identify where risk of damage to, or operation of, the asset has increased.Active engagement with stakeholders involved in emergency management planning where the bridge’s serviceability is at risk. Clear articulation of roles, responsibilities and approval requirements where Main Roads assets are included in emergency response planning by DFES or local government agencies. |

# Additional Guidance

## Project Management

The Project Management Team, including the Project Director and the Project Manager represent the Main Roads during the delivery of projects and are responsible for the identification and assessment of risks, including those associated with climate change and natural hazards.

### Project risk register

The integration of climate change risks must be included in the project’s risk register. Whilst it may not be practical or useful to include all risks identified through the risk assessment process, all pre-treatment very high or high risks must be included into the project risk register. Reference to climate change and natural hazards risk assessments may be acceptable for medium and low risks.

### Tender documentation

Where **Initial Assessments** and/or **Detailed Assessments** have been undertaken prior to the release of tender documentation for the delivery of the phase, these should be finalised or reviewed and included in the tender documentation.

Inclusion of requirements associated with the consideration of climate change and natural hazard risks should be in accordance with the guidance provided in **Standards, Specifications and Requirements**. Where uncertainty exists about the requirement for inclusion of climate change and natural hazard considerations this should be discussed with the relevant discipline(s) identified in the **Further Support** section of this guide.

### Delivery

During the delivery of the project, the Project Management Team are expected to be involved with the identification, assessment and evaluation of treatment options as well as ensuring that the outcomes are documented and reviewed in accordance with this Guideline and contractual requirements. This may also include assisting with the delivery of the climate change and natural hazard risk assessment through the identification of, and promotion of attendance by, attendees from relevant disciplines across the Main Roads and delivery team partners.

Monitoring and review of climate change and natural hazard risks, including the effectiveness of the treatment options should be considered throughout the life of the project. This includes consideration for each of the IMS Certified Processes identified in Table 3 of the Risk Management Process (D11#208987). Where risks are identified which may have impacts beyond the project, these should be reported for consideration by the relevant Directorate.

### Handover Processes

At the conclusion of the project, the climate change and natural hazards risk management documentation, including reports, modelling, risk register and risk treatment plan must be included into the handover documentation provided to the asset owner. This should be undertaken once acceptance of the responsibility for managing the risk, including implementation of future treatment options and monitoring of the controls identified in the Risk Treatment Plan has been documented. Where this not finalised at handover, a process for resolving the issue must be agreed.

## Planning Projects

Planning phase projects should, where appropriate, consider the high level climate change and natural hazard risks early on in the planning phase, and integrate climate change into the options assessment process. This should include consideration during, route selection and infrastructure solution.

### Strategic Options Assessment

When considering strategic options, early in the planning phase the following questions could assist with the identification of risks or opportunities associated with the strategic alternatives.

For improvements to existing assets:

* Could climate change or natural hazard risks impact on the:
	+ demand, viability, safety, serviceability or performance of the road network?
	+ ability for Main Roads to implement demand management?
* Could improvement to the asset address climate change or natural hazard risks whilst maintaining demand, safety, serviceability and performance of the road network?

For new assets:

* Are there climate change or natural hazard risks which could influence the solution, such as the use of tunnels or viaducts in place of surface roads?
* Can the timing of project and ultimate designs consider optimal scale and timeframe of potential adaptation options?

For the no build/do minimum option:

* Could the increases to climate change and natural hazard risks guide when the asset becomes redundant?
* Could consideration of climate change and natural hazard risks identify the optimal timeframe for consideration of other strategic alternatives becomes practical?

### Route and infrastructure selection

When considering the route alignment for a new or significantly upgraded asset the following questions could assist with identifying high level risks and opportunities resulting from climate change and natural hazard risks:

* Is the route selected optimal to minimise risks to the asset from the natural hazard and climate change risks?
* Is the route selected optimal to minimise climate change and natural hazard risks to the road user considering impacts on demand, safety, serviceability or performance of the road network?
* Does the route selection increase the risk of negative impacts to the community and environment in the event of a climate change or natural hazard risk event?
* Does the timing of a future ultimate design, such as grade separation, consider the optimal timing for responding to increased risk from climate change impacts?
* Does the proposed infrastructure and route change the risk profile of the region?
* Could treating for climate change and natural hazards create positive or negative consequences for Main Roads, the community or the environment?
* Will the anticipated climate change or natural hazard risks significantly change the demand profile of the network?

## Infrastructure Sustainability Registered projects

Main Roads has considered the requirements of the *Res-2 Climate Change and Natural Hazard Risks* credit of version 2.0 in the Planning and Design and As-Built ratings and rulings which are applicable to the credit.

The guideline has adopted a risk assessment approach based on AS5334: 2013 *Climate change adaptation for settlements and infrastructure – a risk based approach*, considering AS/NZS ISO31000 *Risk Management* and Main Road’s Risk Management Procedure*.*

The following additional guidance has been prepared to support projects seeking a rating and using this guideline.

* The requirements for Planning ratings correspond to the **Initial Assessment** as described in this guideline and for Design and As-Built ratings the requirements are aligned to the**Detailed Assessment.**
* At least RCP 8.5 must be used for projects seeking a formal rating.
The use of RCP 4.5 is not an acceptable alternative for meeting Res-2 requirements.
* The assessment of risks must align with the Lea-2 credit requirements, which may result in the adoption of a different consequence and likelihood matrix that is provided in this guideline.
* The assessment of treatment options for must align with credit requirements, where applicable, to:
	+ Ecn-1 Options assessment
	+ Ecn-2 Valuing and considering externalities
	+ Ecn-3 Equity and distributional impacts
	+ Ecn-4 Economic and financial sustainability.
* Engagement with stakeholders as part of the risk assessment and treatment options assessment may a;so assist with providing evidence for the Sta-1 credit.

The risk assessment and treatment option identification must be facilitated by a Suitably Qualified Professional (SQP). Names and contact details of people who are expected to meet the requirements of the SQP can be suggested by the Principal Advisor – Sustainability, but no guarantee with regards to the suitability, availability or experience of the SQP can be assumed.

* The word vulnerability has been used to identify the *tolerances* as defined in Res-2 Planning phase in this guideline (PL.1.1)
* When using the outcomes from the assessment aligned to this guideline to demonstrate the *Res-1 Resilience Plan* credit it is noted that additional considerations, such as interdependency of assets would be required. Reference to the Res-1 credit requirements applicable for the rating phase is recommended.

# References and related Documents

The following resources, beyond those included in the Risk Management Process (D11#208987) have been identified to assist projects with the planning, delivery and reporting of a climate change and natural hazard risk assessment.

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| **Resource** | **Description** |
| [Climate change impact and risk management – a guide for business and government](https://www.environment.gov.au/system/files/resources/21c04298-db93-47a6-a6b0-eaaaae9ef8e4/files/risk-management.pdf) | may be referred to where projects do not have access to AS5334. It should be noted that this document may use terminology and scenarios which have been updated or redefined since the publication was released in 2006. |
| ISv2.0 Climate and Natural Hazard Risk Guideline | available to Infrastructure Sustainability Accredited Professionals |
| [State Emergency Management Committee](https://semc.wa.gov.au/home) resources | including [The Hub](https://semc.wa.gov.au/thehub) information portal |
| [Climate Change in Australia](https://www.climatechangeinaustralia.gov.au/) | for projections and data as well as regionalised impacts and adaptation options associated with natural resources. |
| [CoastAdapt](https://coastadapt.com.au/) | which provides a range of resources, including risk assessment templates and details of modelling tools available focused on coastal assets. |

Main Roads NM Branch is currently finalizing an Asset Management Resilience and Sustainability Framework with the purpose of integrating resilience and sustainability principles and practice within the organisations’ asset management system and activities. The scope of the framework includes all asset life cycles (creation, construction, operation, improvement, maintenance and disposal) and a whole range of natural events such as cyclones, flooding, earthquake, bushfires, extreme temperature and humidity, sea level rise and salinity. A Resilience and Sustainability interactive ArcGIS tool is also being developed in-conjunction with the Framework.

The content of the current Climate Change Risk Assessment Guideline v2 will be incorporated into the Asset Management Resilience and Sustainability Framework, which upon completion will replace the current Guideline.

# Further Support

| Question relating to… | Contact | Intranet site / TRIM document |
| --- | --- | --- |
| Risk Management Procedure | Manager Legal and Commercial Services, or Manager Business Performance | [Online Documents](http://cms2002/nr/mrwa/frames/onlinedoc/) |
| Climate Change | Manager Road Traffic Engineering, or Principal Advisor Sustainability | [Sustainability](http://cms2002/nr/mrwa/frames/sus/)  |
| Sea Level Rise | Manager Road Traffic Engineering | D11#301668 |