M1 Pacific Motorway extension to Raymond Terrace

Environmental impact statement – Chapter 21: Climate change risk

Transport for NSW | July 2021

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21. Climate change risk

This chapter describes the potential climate change risk impacts that may be generated by the construction and operation of the project and presents the approach to the management of these impacts.

The desired performance outcome for the project relating to climate change risk, as outlined in the SEARs, is to:

- Ensure the project is designed, constructed and operated to be resilient to the future impacts of climate change.

Table 21-1 outlines the SEARs that relate to climate change risk and identifies where they are addressed in this EIS. The full assessment of climate change risk impacts is provided in the Climate Change Risk Working Paper (**Appendix U**).

Table 21-1 SEARs (climate change risk)

Secretary's requirement	Where addressed
9. Climate Change Risk	
1. The Proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines.	**Section 21.1** outlines the relevant legislation, policy and guidelines that were used to assess potential impacts **Section 21.4** assesses the risk and vulnerability of the project to climate change
2. The Proponent must quantify specific climate change risks with reference to the NSW Government's climate projections at 10 km resolution (or lesser resolution if 10 km projections are not available) and incorporate specific adaptation actions in the design.[1]	**Section 21.4** assesses the specific climate change risks associated with the project and **Section 21.5** outlines specific measures which will be used in future stages of the project.

[1] The proponent has also received permission from The Department of Planning and Environment (as was) to use the Climate Futures Tool from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BoM) (attenuated for the project region), to assess climate impacts (letter dated 26/3/2018, Ref IRF18/1522)

21.1 Policy and planning setting

The climate change risk assessment was prepared to assess the potential impacts of the project in accordance with the following relevant legislation, policy and guidelines:

- Legislation:
  - *National Greenhouse and Energy Reporting Act 2007*
- Plans and policies:
  - Paris Agreement
  - The Greenhouse Gas Protocol (World Business Council for Sustainable Development and World Resources Institute)
  - NSW Net Zero Plan Stage 1: 2020 – 2030 (DPIE 2020f)
  - NSW Climate Change Policy Framework (OEH 2016b)
  - National Climate Resilience and Adaptation Strategy (DoE 2015)
  - NSW Future Transport Strategy 2056 (Transport for NSW 2018a)
  - Environmental Sustainability Strategy 2019 – 2023 (Roads and Maritime Services 2019)

- Guidelines:
  - Climate Change Impacts and Risk Management – A Guide for Business and Government (DoEH 2006)
  - Technical Guide for Climate Change Adaptation for the State Road Network (Roads and Maritime Services in draft).

Further detail on the above legislation, policies and guidelines, and how they apply to the project, is provided in the Climate Change Risk Working Paper (**Appendix U**).

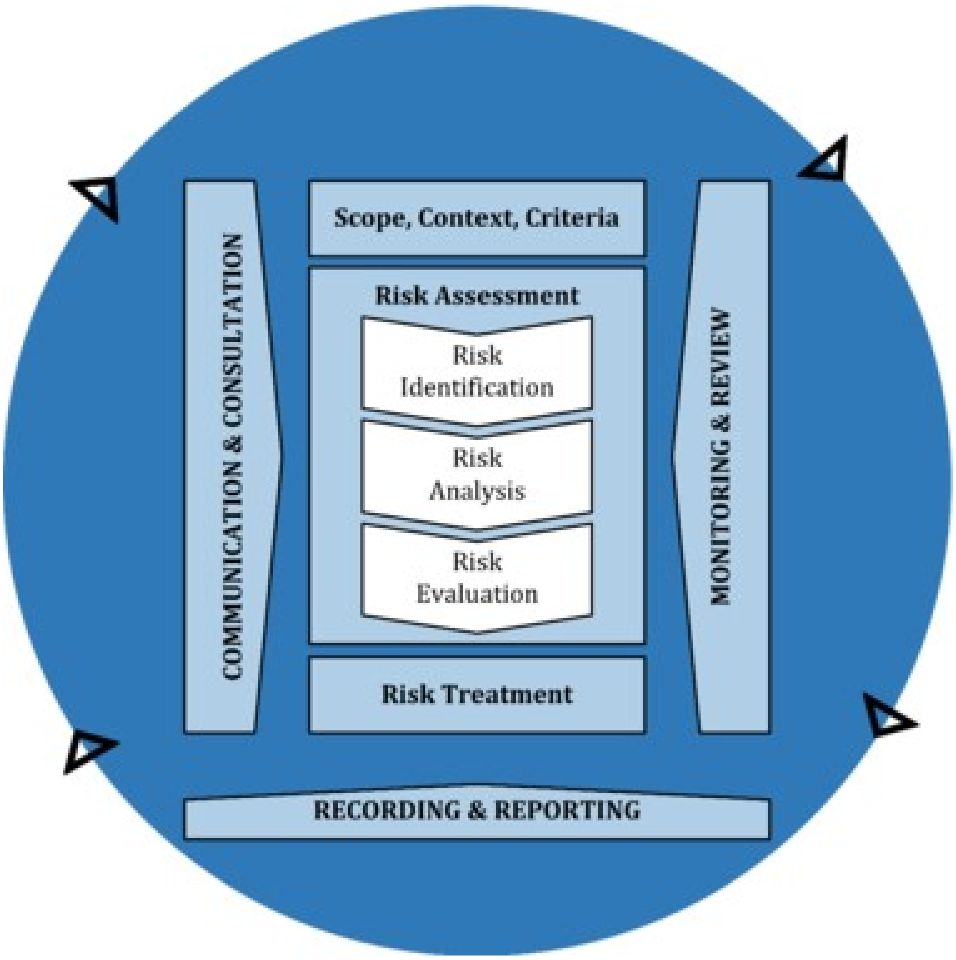
21.2 Assessment methodology

21.2.1 Climate change risk assessment

The methodology for conducting the climate change risk assessment was based on the Australian Standard AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach. The standard follows the International Standard ISO 31000:2018, Risk management – Principles and guidelines (adopted in Australian and New Zealand as AS/NZS ISO 31000:2018), which provides a set of internationally endorsed principles and guidance on how organisations can integrate decisions about risks and responses into their existing management and decision-making processes.

The risk assessment forms part of a risk management process that would be carried out throughout the different project stages. This would involve communication and consultation between the design team, Transport and relevant stakeholders, as well as regular monitoring and review of the risk assessment plan as shown in **Figure 21-1**.

It is noted that while the SEARs for the project (refer to **Table 21-1**) require modelling with reference to the NSW Government's climate projections at a resolution of 10 kilometres, Transport has received permission from the NSW Department of Planning, Industry and Environment (formerly Department of Planning and Environment) to instead use the Commonwealth Scientific and Industrial Research Organisation's Climate Futures Tool to assess climate impacts.



Source: Reproduced from AS/NZS ISO 31000

Figure 21-1 Risk management process

Risks to the operation and maintenance of the project that might be influenced by climate change were identified using the hazard-receptor pathway model and are listed in **Section 21.4**. This model is outlined below:

- Hazard: climate or climate-influenced attributes with potential to influence the project's operation and maintenance
- Receptor: the component of the project's operation and/or maintenance impacted by the hazard; this may also include users of the project and affected elements of the surrounding environment
- Risk Rating: utilising the likelihood and consequence rating system, including an assessment of the way hazards influence the project receptors and a risk rating awarded.

Within the risk assessment process, the risk resulting from the projected change in climate is assessed, whether this is a newly identified or elevated existing risk. For example, some risks are already present (flooding) but the frequency and intensification of these are projected to change. Other risks (such as migration of pests and weeds) may not be expected to happen in the absence of a changing climate.

21.2.2 Greenhouse gas assessment

The greenhouse gas (GHG) assessment was carried out by first determining the GHG assessment boundary, then determining the quantity of GHG emissions generated by each emission source.

The following six GHGs are covered under international climate change agreements and were considered in this assessment:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HCFs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6).

It is common practice to aggregate the emissions of these gases into the equivalent emission of carbon dioxide. This provides a simple, single figure for the comparison of emissions against targets. The aggregation is based on the potential of each gas to contribute to global warming relative to carbon dioxide and is known as the global warming potential. The resulting number is expressed as carbon dioxide equivalents (CO_2e).

Under the Greenhouse Gas Protocol, the direct and indirect GHG emission sources of a development can be classified into three 'Scopes' for GHG accounting and reporting purposes. The GHG scopes are presented in **Figure 21-2** and are described as follows:

- Scope 1: Direct emissions from sources that are owned or operated by a reporting organisation
- Scope 2: Indirect emissions associated with the import of energy from another source
- Scope 3: Other indirect emissions (other than scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them.

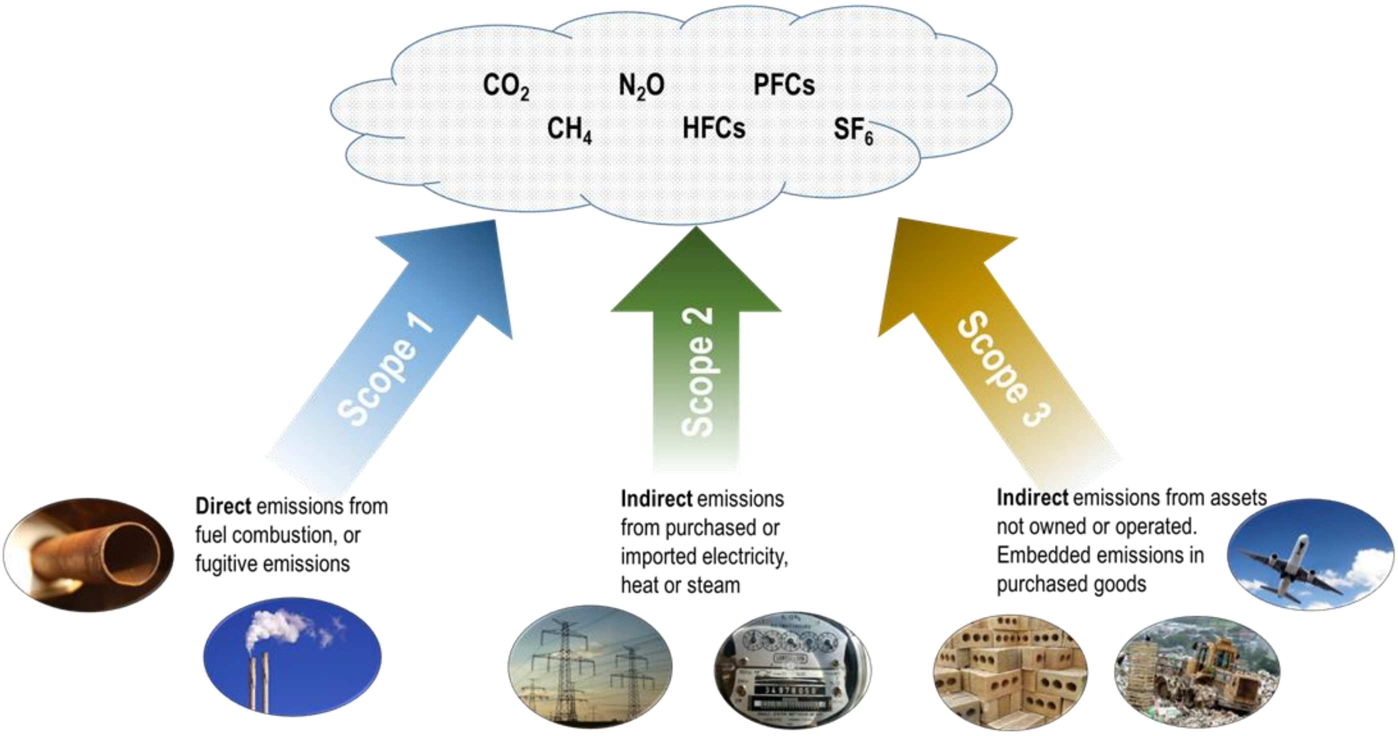


Figure 21-2 Sources of GHGs – Adapted from World Business Council for Sustainable Development – Greenhouse Gas Protocol

The results of this assessment are presented in terms of the above-listed 'scopes' to help define and understand the direct and indirect sources of the GHG emissions generated by the project. All three 'scopes' have been assessed for this project. The initial action for a GHG inventory is to determine the potential sources of GHG emissions. This is done in order to assess their likely significance and set a provisional boundary for the assessment. Following this, data are collected to represent the activities being carried out for the project and converted to GHG emissions typically using emissions factors (a published figure for the particular activity representing the aggregated GHG emissions per unit of the activity).

GHG assessment boundary

The assessment boundary defines the scope of GHG emissions and the activities to be included in the assessment. **Table 21-2** summarises the emission sources and activities considered within the project's assessment boundary for construction and operation, according to scope. Note that some emission sources are accounted for in more than one scope. This is typically the case where there are direct emissions (e.g. combustion of fuel in a vehicle operated as part of the project) as well as indirect emissions (extraction and processing of the fuel before it is used).

Table 21-2 GHG emission sources

Emission source	Included	Scope 1	Scope 2	Scope 3
Construction				
Fuel use – diesel consumption in plant and equipment during construction	✓	●		●
Construction materials	✓			●
Fuel use – transport of construction materials	x (Materials are likely to be sourced from less than 50km away*)			
Fuel use – transport of construction waste, spoil or dredged material	x (Materials are likely to be taken less than 50km away from site*)			
Vegetation removal	✓	●		
Operation				
Road use by vehicles (differential between 'without project' and 'project' scenarios)	✓			●
Electricity consumption – lighting	✓		●	●
Maintenance activities – fuel	✓	●		●
Maintenance activities – materials	✓			●

* The assessment methodology does not consider emissions associated with the transportation of material/waste less than 50 kilometres to be material

Quantity of GHG emissions generated

The GHG emissions that may result from the construction of the project were estimated using the Transport Authorities Greenhouse Group's (TAGG) Carbon Gauge GHG assessment tool (Carbon Gauge). The tool was also used to:

- Determine the fuel combustion, material requirements and vegetation clearance associated with the construction of the project
- Determine the embodied emissions, a Scope 3 emissions source associated with the extraction of raw materials, processing, manufacturing and transportation of materials for construction
- Calculate the projected electrical energy during operation
- Calculate the maintenance fuel and materials required during operation (with emissions factors updated from other sources as required).

Emissions associated with the change in traffic resulting from the road alignment have been calculated in the Tool for Roadside Air Quality (TRAQ). TRAQ was used to determine emissions associated with current and future operational road use, both with and without the project. The tool calculates air quality and GHG emissions based on a number of factors, including:

- The type of roads in the scope of the project
- Road length and grade
- Daily traffic count on the road
- Peak and average speeds on the road
- Traffic composition
- The year of the assessment.

Figure 21-3 shows the roads in the project scope and how they relate to the assessment scenarios described in **Section 21.4**.

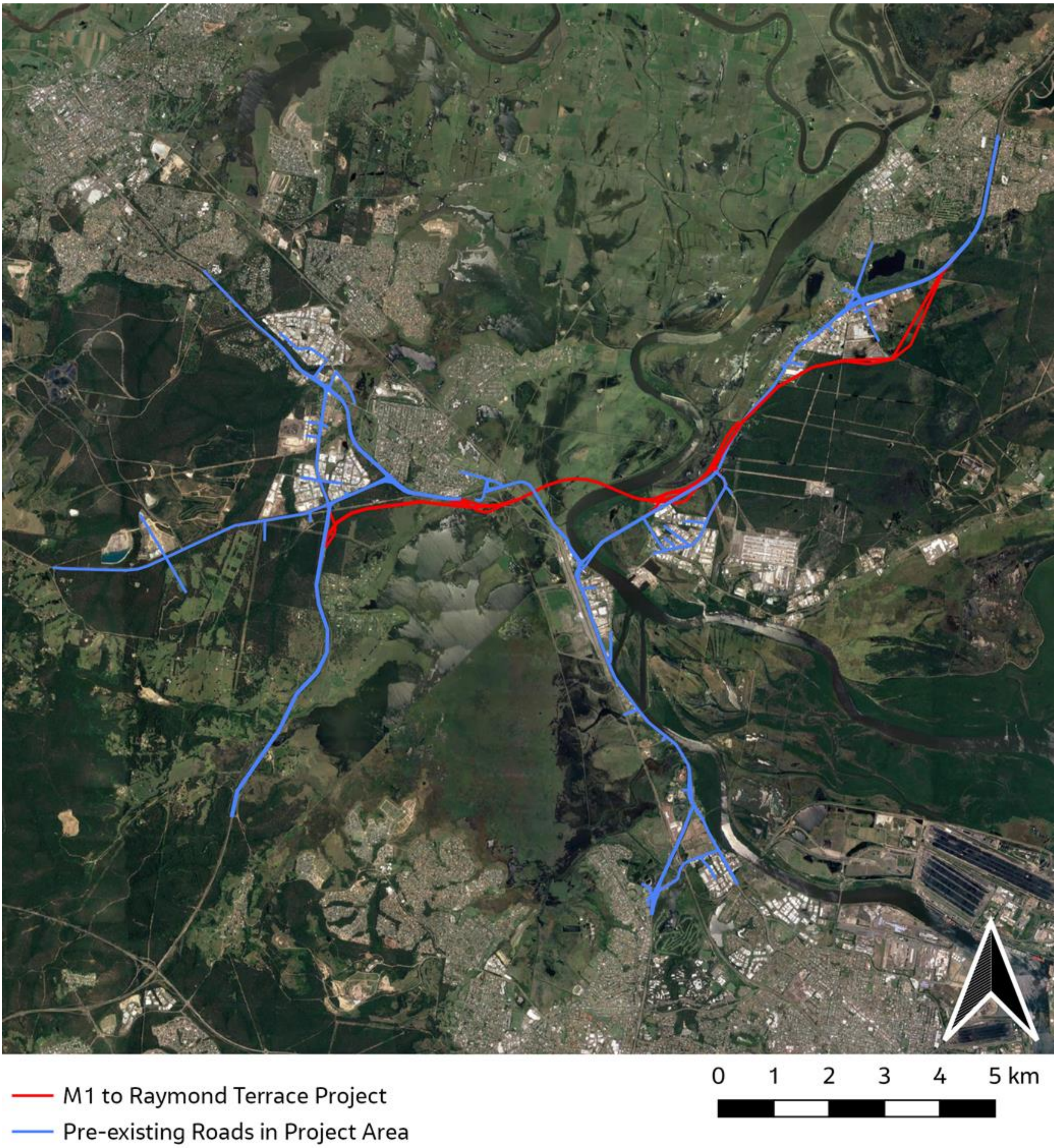


Figure 21-3 Extent and division of roads within the project scope

21.3 Existing environment

GHGs are gases that when released into the atmosphere effectively trap heat, influencing global temperatures. The release of GHGs into the atmosphere is caused by both natural processes (such as bushfires) and human activities (such as burning fossil fuels and land clearing).

Since the industrial revolution, the concentration of GHGs in the atmosphere, has been rapidly increasing. This has led to an increase in the earth's average surface temperature and has contributed to the phenomenon of climate change.

The term 'climate' refers to the typical weather conditions for a specific geographical area, usually averaged over at least 30 years. Climate variability represents the normal day to day, seasonal, and year to year variability of the different climate components (e.g. temperature, rainfall). This climate variability may also generate extreme conditions, such as flooding, heatwaves and hail, which require management.

Among some of the key findings presented by the world's leading climate scientists in the Intergovernmental Panel on Climate Change Fifth Assessment Report (AR5) (IPCC 2014) was the finding that surface temperature is projected to rise over the 21st century under all assessed emission scenarios, meaning that it is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. In urban areas, climate change is projected to increase risks for people, economies, and ecosystems, making building adaptive capacity crucial for effective selection and implementation of adaptation options.

Historical climate in the vicinity of the project

The historical climate for the project area is based on meteorological observations from Bureau of Meteorology (BoM) station 061078 located at the Royal Australian Air Force Base (RAAF) Williamtown (operating from 1942 until present). This BoM station was selected to be representative of the Lower Hunter region which comprises the City of Newcastle, Lake Macquarie, Cessnock, Maitland and Port Stephens local council areas. RAAF Williamtown is located about 10 kilometres east of the project but is the nearest BoM station with a substantial level of historical climate data available. Rainfall observations are available for the years 1960-2025 and temperature observations are available for the years 1951-2020. There are some data gaps in the rainfall record between 2010 and 2015.

Rainfall

The project would be located in the Lower Hunter region. Annual rainfall for this region over the full period of record is 1,120 millimetres, with a high level of year-to-year variability.

Average monthly rainfall in the region ranges between 61 millimetres in September and 130 millimetres in June. Average monthly rainfall during late winter and early spring is considerably lower than the average for autumn, where rainfall almost doubles. The pattern in extreme monthly rainfall indicates that the potential for very wet months is highest during January to June.

Maximum recorded daily rainfall totals are typically greater during summer-autumn than at other times of year.

Temperature

There are consistent trends for increased maximum temperatures since about 2000. This trend is most obvious for maximum and minimum recorded temperatures. Average temperatures over the 1976 – 2015 climate change projection reference period are 0.1 degrees Celsius to 0.2 degrees Celsius warmer than over the entire period of record.

Monthly average and average maximum temperatures for the climate change projection reference period are typically higher than those for the full period of record. Average monthly minimum temperatures are generally the same.

Days in which maximum temperatures exceed 35 degrees Celsius are reasonably common in the Lower Hunter, while days during which minimum temperatures are 2 degrees Celsius or less are less common.

Over the period of record there has been an annual average of 23.8 heatwave days and 2.2 severe heatwave days. The average incidence of heatwave days and severe heatwave days during the climate change projection reference period was 24.8 days per annum and 1.9 days per annum respectively.

Wind

Wind speeds in the Lower Hunter typically increase through the day. During summer months, the wind speed increases by about 10 kilometres per hour from 9am to 3pm, while in the winter months this is lower, ranging from an increase of two to four kilometres per hour from 9am to 3pm. Maximum recorded wind gusts in the Lower Hunter range between 98 kilometres per hour in February and 137 kilometres per hour in August and December.

21.4 Assessment of potential impacts

21.4.1 Climate change projections

Carbon dioxide (CO_2) is a vital gas for photosynthesis and global climate regulation. CO_2 and other greenhouse gases trap long wave radiation, as such, changes in their concentrations in the atmosphere influence the Earth's radiation balance and contribute to the warming of both the atmosphere and the Earth's surface. This phenomenon is known as the greenhouse effect.

Climate change projections are derived using general circulation models (often referred to as global climate models or GCMs), which simulate the ocean, atmospheric and land surface processes which influence climate. The IPCC's Fifth Assessment Report (AR5) (IPCC 2014) provides a synthesis of climate change modelling carried out by leading international climate research organisations. The RCP8.5 representative concentration pathway (RCP) identified under AR5, is used throughout this report as it reflects the highest of the emissions scenarios considered in AR5.

The reliability of climate change projections varies between climate variables. In general, global projections are more certain than regional projections which were used for this assessment, and temperature projections are more certain than those for rainfall. Changes in average conditions are also more certain than changes in extremes.

Rainfall

The average rainfall is projected to decrease in 2030 and the climate is projected to become drier in 2050 and 2090. Maximum annual rainfall is projected to increase very slightly from the 1976 to 2015 baseline to 2090, while minimum annual rainfall is projected to decline by 2090.

Seasonal patterns in rainfall are not projected to change much to 2030, 2050 or 2090, although winter rainfall is projected to be slightly less.

Extreme daily rainfall values are generally projected to increase in summer by 2090. Design of the project has considered very low frequency rainfall events, with average recurrence intervals (ARI) in excess of 500 years. Atmospheric warming may increase the frequency of the current 1000-year ARI event, as well as increase the rainfall total during the projected 500-year daily rainfall event with the 2050 or 2090 climate.

Temperature

Average and extreme maximum and minimum temperatures are projected to increase 3.8 degrees Celsius and 3.9 degrees Celsius, respectively, under the RCP8.5 scenario. The highest projected temperature for 2030 onwards exceeds the highest recorded temperature for the RAAF Williamtown BOM meteorological station.

The historical trend for reduced incidence of extreme cold conditions is projected to continue (albeit with more recent slight increase in the number of these days). The number of days with freezing minimum temperatures is projected to reduce, with temperatures being less severe.

Climate change is projected to increase average and extreme temperatures for the Lower Hunter throughout the year. Temperatures through the cooler months of winter are projected to increase to a lesser extent than those during other times of year. The range in average temperatures for winter is projected to increase from 11.9 degrees Celsius to 23.4 degrees Celsius during the climate change reference period to 15.8 degrees Celsius to 27.2 degrees Celsius in 2090.

Periods throughout the year with maximum temperatures above 40 degrees Celsius are projected to change from between November to February and extend to between September to April.

Days in which maximum temperatures reach high temperature benchmarks (35/40/45 degrees Celsius) in the Lower Hunter are projected to increase in frequency. The frequency of days with temperatures exceeding 35 degrees Celsius is projected to more than triple relative to the climate change projection reference period by 2090. Days with temperatures exceeding 40 degrees Celsius are projected to experience a fivefold increase in frequency. Historically, temperatures exceeding 45 degrees Celsius have only been experienced in the last few years. Such days are projected to be experienced almost once every 2 years by 2090.

Days with extreme minimum temperatures are projected to decline in frequency over the course of this century under the RCP8.5 scenario. Freezing days occur at a rate of approximately 0.5 days per year over the reference period and are projected to decline to zero by 2090. Days of frost are also projected to decline from 3.6 days per year to zero days per year by 2090.

The frequency of days with excess heat is projected to increase more than fourfold between the climate change reference period and 2090, with the frequency of such days increasing from 24.75 occurrences per year to 117 occurrences per year. Severe heatwave days are projected to increase in frequency by a similar order.

Wind

Climate change is anticipated to have only marginal impact on average and extreme wind events. Average wind speed is projected to decline by up to five per cent in all seasons, except winter in 2050 and summer in 2090 under the RCP8.5 scenario, when small increases in wind speed are projected.

The severity of the 1 in 20-year wind gust is projected to decline slightly in summer and autumn throughout the projection period and in winter in 2030 and spring in 2090, under the RCP8.5 scenario.

21.4.2 Construction impacts

Climate change

While construction of the project would generate GHGs as described in the section below, the resulting climate change impacts are not anticipated to occur during construction due to the short-term nature of construction. As a result, the risks associated with climate change are considered to be operational, and have been assessed in **Section 21.4.3**.

GHG emissions estimations

The estimated Scope 1, 2 and 3 emissions for the construction of the project are summarised below and in **Table 21-3**. Construction emissions associated with the project would result from the following:

- Construction fuel combustion
- Construction material embedded emissions
- Vegetation clearing.

Electricity generation resulting from fuel combustion for the project was assumed to be from diesel generators.

Construction fuel combustion

Construction fuel combustion is estimated to produce 31,669 tonnes of CO_2e throughout the duration of construction. Diesel used for site offices and site vehicles, construction works, demolition and earthworks and vegetation removal would produce scope 1 emissions of 30,124 tonnes of CO_2e and would produce scope 3 emissions of 1,545 tonnes of CO_2e.

Construction material embedded emissions

Emissions factors for activities associated with the production of construction materials were derived from the Infrastructure Sustainability Council of Australia (ISCA) Materials Calculator. These represent the emissions 'embedded' in the production of 1 metric tonne of each material and are largely derived from the Australian Life Cycle Inventory (AusLCI) project. The emission factors for construction materials are as follows:

- Aggregate (0.006t CO_2e/t)
- Asphalt and bitumen (0.390t CO_2e/t)
- Cement and concrete (0.200t CO_2e/t)
- Steel (2.324t CO_2e/t).

In total, 1,288,076 tonnes of material would be used during construction and 151,210 tonnes of CO_2e would be produced as scope 3 emissions.

Vegetation clearance

Clearing of vegetation is estimated to produce 60,384 tonnes of CO_2e. About 171 hectares of vegetation would be cleared and all emissions would be scope 1 emissions.

In summary, construction fuel combustion is estimated to produce 31,669 tonnes of CO_2e throughout the construction phase. Further, 151,210 tonnes of CO_2e are estimated to be embedded in the materials used for the construction of the project and clearing of vegetation is estimated to produce 60,384 tonnes of CO_2e.

Table 21-3 Construction GHG emissions

Emission source	Scope 1 Emissions (t CO_2e)	Scope 2 Emissions (t CO_2e)	Scope 3 Emissions (t CO_2e)	Total Emissions (t CO_2e)
Fuel combustion				
Site offices and site vehicles	634	-	33	667
Construction works	15,607	-	801	16,407
Demolition and earthworks	12,618	-	647	13,265
Vegetation removal	1,266	-	65	1,330

Emission source	Scope 1 Emissions ($t\ CO_2e$)	Scope 2 Emissions ($t\ CO_2e$)	Scope 3 Emissions ($t\ CO_2e$)	Total Emissions ($t\ CO_2e$)
Total fuel combustion	**30,124**	**-**	**1,545**	**31,669**
Construction materials				
Aggregate	-	-	5,128	5,128
Asphalt and bitumen	-	-	973	973
Cement and concrete	-	-	80,651	80,651
Steel	-	-	64,458	64,458
Total construction materials	**-**	**-**	**151,210**	**151,210**
Vegetation clearance				
Class A (Rainforest and Vine Thicket)	0	-	-	0
Class B (Eucalypt Tall Open Forest)	4,754	-	-	4,754
Class C (Open Forest)	47,551	-	-	47,551
Class I (Grasslands)	8,079	-	-	8,079
Total vegetation clearance	**60,384**	**-**	**-**	**60,384**
Total construction emissions				**243,263**

21.4.3 Operational impacts

Climate change

Climate change is anticipated to have direct and indirect impacts on the proposal. The types of impacts are relatively well understood however their severity and extent are uncertain. The combined direct and indirect impacts of climate change may contribute to one or more of the following:

- Accelerated infrastructure deterioration and increased maintenance requirements
- Safety incidents
- Increased frequency and/or duration of road closure/cancellations
- Infrastructure loss (total or partial loss because of a severe weather event).

Risk analysis and evaluation was carried out through desktop assessment and liaison with other technical specialists. Prior to the implementation of environmental management, four risks were identified as ‘high’, four risks were identified as ‘medium’ and eight risks were identified as ‘low’. Medium and high risks are presented in **Table 21-4**.

Following the implementation of design controls or proposed risk treatments, three risks were identified as ‘high’, two risks were identified as ‘medium’ and eleven risks were identified as ‘low’. The full results of the risk assessment are presented in Appendix C of the Climate Change Risk Working Paper (**Appendix U**).

Table 21-4 Climate change risks with a residual risk of 'medium' or higher

ID	Cause, trigger or issue	Risk, hazard or opportunity	Potential consequences	Inherent (original) risk rating	Proposed risk treatment	Residual risk
9	Increase in the frequency and intensity of severe rainfall events coupled with Sea Level Rise.	Increased flooding (extent and depth) covers and damages areas previously modelled/designed to be immune from flooding (to the 5% AEP design standard).	Flooding damage to road and road infrastructure which could temporarily close the road which will severely delay traffic. Impact will require clean up and repair depending on level of damage. Impact could extend to neighbouring properties due to inability of flood waters to dissipate.	High	Much of the current alignment achieves immunity to the 1% AEP event and as such provides a level of immunity above the design parameter 5% AEP event. With 5% AEP immunity, the road is expected to flood at times, and is therefore designed to provide a level of resilience to this. Additional flood modelling will be carried out if any design changes are made during detailed design. Additional flood modelling would consider climate change related flood risks to the project and the flood impacts from the project.	High
10		Increased flooding (extent and depth) overwhelms areas previously modelled/designed to be immune from flooding (to the 5% AEP design standard).	Flooding/standing water causes accidents for motor vehicles and cyclists resulting in safety incidents for road users	High	Much of the current alignment achieves immunity to the 1% AEP event and as such provides a level of immunity above the design parameter 5% AEP event. Access to the motorway would be limited during a flood event as local roads would be inundated (the motorway would be one of the more flood proof areas). Number of road users would therefore be greatly reduced and limited to those already travelling north or south along the M1 Pacific Motorway. Variable messaging signs would inform road users of hazards. Additional flood modelling will be carried out if any design changes are made during detailed design. Additional flood modelling would consider climate change related flood risks to the project and the flood impacts from the project	High

ID	Cause, trigger or issue	Risk, hazard or opportunity	Potential consequences	Inherent (original) risk rating	Proposed risk treatment	Residual risk
11	Increase in the frequency and intensity of severe rainfall events.	Drainage channels and culverts are too small as 5% AEP storms (the design standard) are more severe as a result of climate change. Exits of culverts suffer increased scour.	Culverts and drainage channels are overwhelmed causing increased flooding on the up-flow side of the culverts, and increased scour at the outflows. This results in increased road closures, and increased maintenance/rectification costs. Diverted water may lead to increased flooding at existing properties.	High	Additional drainage and flood assessment will be carried out if any design changes are made during detailed design. This is presented as management measure FH02 (**Chapter 10** (hydrology and flooding))	High
13	More severe fire weather and elevated fire weather conditions.	Increased local bushfires cause decreased visibility due to smoke.	Road users suffer reduced visibility due to smoke resulting in accidents.	Medium	The project includes Variable Message Signs to warn road users of potential hazards.	Medium
14		Increased local bushfires cause damage to structures such as retaining walls and bridges.	Bushfires in proximity to the project may cause direct damage to structures, utilities and fauna connectivity measures, resulting in road closures while repairs / damage assessment is carried out.	High	Concept design has considered potential impacts to structures, utilities and fauna connectivity structures in bushfire prone areas. Access to fire trails will be maintained.	Medium

GHG emissions

Activities that would generate GHG emissions during operation include:

- Grid electricity consumption (e.g. for powering street lights and traffic signals)
- Pavement maintenance
- Use of the road by vehicles.

Annual use of electricity would result in scope 2 and scope 3 GHG emissions. The predicted total GHG emissions associated with the use of electricity during operation of the project is estimated to be 217t CO_2e per annum.

Ongoing annual maintenance of the project would result in the use of pavement materials including full depth asphalt, deep strength asphalt and plain concrete. The use of materials to carry out annual maintenance activities was estimated to generate about 279t CO_2e of scope 1 emissions and 82t CO_2e of scope 3 emissions. The total GHG emissions associated with annual road maintenance would be 361t CO_2e.

Fuel combustion by future road users would likely generate the greatest amount of GHG during project operation. A comparison was made of GHG emissions that would be produced by the project against a 'no project' scenario where vehicles use the existing road network. The results are presented in **Table 21-5**.

As shown in **Table 21-5**, the net 2028 emission contribution of traffic is 13,905t CO_2e per annum and the 2038 emission contribution is 23,726t CO_2e per annum. Given the contribution traffic makes to the overall annual predicted emissions for the project, it should be noted that due to potential future changes in technology in regard to road vehicles in Australia, emissions projected from traffic may significantly decrease in the future. The modelling method used assumes improved fuel efficiency in new models of cars when predicting future emissions, however it does not yet account for the growing adoption of lower emission electric vehicles. It is likely that the increased production and adoption of electric vehicles would mean that by 2028 and 2038 there would be a much greater number of electric vehicles using the project roads, hence resulting in lower traffic emissions than estimated.

Table 21-5 CO_2e contribution of traffic to the project emissions

Emissions source	Scope 3 emissions as a result of traffic (t CO_2e/yr)					
	With project 2028	Without project 2028	Project contribution 2028	With project 2038	Without project 2038	Project contribution 2038
Project roads	35,036	0	35,036	40,014	0	40,014
Pre-existing roads	177,707	198,838	-21,131	201,709	217,997	-16,288
Total	212,743	198,838	13,905	241,724	217,997	23,726

Table 21-6 presents the annual vehicle kilometres travelled (VKT) for scenarios with and without the project. The VKT are higher for scenarios that include the project ('With project') compared to scenarios without the project ('Without project'), indicating that more vehicles can use the roads in the 'With project' scenarios, leading to higher emissions for these scenarios. Emissions per kilometre are lower for 'With project' scenarios, indicating that the 'With Project' scenario is about 2.4 per cent more carbon efficient than the 'Without project' scenario. As a result, operation of the project would result in 2.4 per cent fewer emissions produced per kilometre travelled when compared with the existing road network in the same year.

Table 21-6 Comparison of vehicle kilometres travelled between model scenarios

Scenario	Scope 3 emissions ($t\ CO_2e/year$)	Vehicle kilometres travelled (VKT)	$t\ CO_2e/VKT$
‘Without project’ 2028	198,838	921,662,910	0.000216
‘With project’ 2028	212,743	1,009,609,085	0.000211
‘Without project’ 2038	217,997	1,033,154,080	0.000211
‘With project’ 2038	241,724	1,174,701,268	0.000206

Overall, the project is estimated to result in the generation of 23 kilotonnes of carbon dioxide equivalent annually during the operation of the project over the design life of the project (100 years).

21.5 Environmental management measures

The environmental management measures that will be implemented to minimise the climate change risk and GHG impacts of the project, along with the responsibility and timing for those measures, are presented in **Table 21-7**.

Table 21-7 Environmental management measures (climate change risk)

Impact	Reference	Management measure	Responsibility	Timing
Flood Risk	CC01	Hydrological and hydraulic assessments would be carried out for any design changes during detailed design and would consider the climate change related flood risks to the project and flood impacts from the project.	Contractor	Detailed design
Other relevant management measures				
Project sustainability outcomes	SU1	A Sustainability Management Plan (or similar framework) for the project will be developed and implemented during detailed design and construction, detailing measures to meet the project's sustainability objectives and targets. The Sustainability Management Plan will: • Demonstrate leadership and commitments to sustainability • Adopt relevant sustainability performance targets in accordance with the Transport's Sustainability Strategy • Identify sustainable procurement requirements • Document the process for the identification, assessment and implementation of sustainability initiatives and opportunities • Document the process to be used to monitor and review of sustainability performance against achieving the project's sustainability targets • Outline the documentation and reporting requirements for sustainability on the project.	Transport/ Contractor	Prior to construction/ construction