Appendix N

Climate Change and Greenhouse Gas Impact Asessment

Prepared for
Transport for NSW
ABN: 18 804 239 602

AECOM

Climate Change and Greenhouse Gas Impact Assessment

Technical Report

17-Jul-2022
Westlink M7 Widening

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Delivering a better world

Climate Change and Greenhouse Gas Impact Assessment

Client: Transport for NSW

ABN: 18 804 239 602

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Glossary and abbreviations

Key terms	Description
Approved project	The Westlink M7 (previously referred to as Western Sydney Orbital) is an existing 39-kilometre-long toll road connecting the M5 Motorway at Prestons, the Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek.
Climate adaptation	Actions undertaken to manage or reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities. Adaptation actions may include physical changes to an asset to achieve or facilitate adaptation including changes/upgrades to technology and equipment or design standards for particular project elements (e.g. flood protection designed to the Probable Maximum Flood (PMF)). Adaptation actions may also include changes to contracts, setting specific targets or objectives, scheduling regular reviews or inspections, development of an emergency management plan, development of design guidelines, etc.
Climate change	A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC).
Climate mitigation	Refers to efforts to reduce or prevent emission of greenhouse gases.
Climate resilience	Climate resilience is the capacity of organisations to survive, adapt, and grow no matter what kinds of climate-related chronic stresses and acute shocks they experience.
Climate change mitigation	Climate change mitigation includes actions we take globally, nationally and individually to limit changes caused in the global climate by human activities. Mitigation activities are designed to reduce greenhouse emissions and/or increase the amounts of greenhouse gases removed from the atmosphere by greenhouse sinks.
Conditions of Approval (CoA)	These are the current conditions that apply to the approved project. Found here: https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-663-MOD-5%2120190718T013836.398%20GMT
Construction footprint	The area required for construction of the proposed modification.
Critical infrastructure	The assets, systems and networks required to maintain security, health and safety, operations of the Westlink M7.
Greenhouse gas (GHG)	Any various gaseous compounds (such as carbon dioxide or methane) that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse effect.
GreenPower	GreenPower is a government accredited renewable energy product offered by most electricity retailers to households and businesses in Australia.
Modification	Proposed changes to be made to the conditions of approval for the approved project.
Operational footprint	The area required for operation of the proposed modification
Physical risks	Risks driven by physical changes in climate such as heatwaves, flooding, and sea level rise. These can be event driven (acute) or longer-term shifts (chronic) in climate patterns.

Key terms	Description
Proposed modification	The addition of a trafficable lane in both directions within the existing median of the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to the Westlink M7 Bridge at Richmond Road in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7 Light Horse Interchange.
Scope 1	Direct emissions: greenhouse gas emissions generated by sources owned or controlled by the project, for example emissions generated by the use of diesel fuel in project-owned construction plant, equipment or vehicles.
Scope 2	Indirect emissions: greenhouse gas emissions from the consumption of purchased electricity in project-owned or controlled equipment or operations. These greenhouse gas emissions are generated outside the project's boundaries, for example the use of electricity purchased from the grid.
Scope 3	Indirect upstream/downstream emissions: greenhouse gas emissions generated in the wider economy due to third party supply chains and road users as a consequence of activity within the boundary of the project, for example greenhouse gas emissions associated with the mining, production and transport of materials used in construction (referred to as the embodied energy of a material).
Shocks	Acute shocks are sudden, short-term events that disrupt individuals, communities, institutions, business and systems. Examples include: major storms, foods, bushfires, heatwaves, disease outbreaks, terrorism and cyber-attacks.
Stresses	Chronic stresses weaken a systems and communities on a day-to-day or cyclical basis. Examples include: homelessness and housing affordability, lack of access to public transportation systems, family violence, climate change, structural inequity, and chronic food or water shortages.
Westlink M7	M7 Motorway or formerly known as Western Sydney Orbital.
Transport for NSW (Transport)	The proponent seeking approval for the modification.

Acronym	Definition
CCRA	Climate change risk assessment
CEMP	Construction Environmental Management Plan - A site specific plan developed for the construction phase to ensure that all contractors and sub-contractors comply with the environmental conditions of approval and that the environmental risks are properly managed.
CERT	Carbon Estimate & Reporting Tool
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent emissions
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPE	NSW Department of Planning and Environment
EIS	Environmental Impact Statement
EMS	Environmental management system
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW). Provides the legislative framework for land use planning and development assessment in NSW

Acronym	Definition
EP&A Regulation	*Environmental Planning and Assessment Regulation 2021* (NSW)
EPA	NSW Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Act 1999* (Commonwealth)
EPL	Environment protection licence
ISC	Infrastructure Sustainability Council
ITS	Intelligent transport systems
km	Kilometres
LEP	Local Environmental Plan
LGA	Local Government Area
m	Metres
RMS	Roads and Maritime Services
SEARs	Secretary's Environmental Assessment Requirements
t	Tonnes
tCO2e	Tonnes of carbon dioxide equivalent emissions
Transport	Transport for NSW
TRAQ	Tool for Roadside Air Quality
VMS	Variable message signs
WSO Co	WSO Co Pty Limited

Executive Summary

The Westlink M7 is an existing 39-kilometre-long toll road connecting the M5 Motorway at Prestons, The Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek. Transport for NSW (Transport) is seeking a modification to the approved project to widen part of the Westlink M7 into the existing median. This is proposed in response to recent and forecast traffic growth, to improve motorway efficiency, travel time performance and safety. If approved, it is expected to open in 2026.

This technical report provides a climate change and greenhouse gas (GHG) assessment of the proposed modification and has been prepared to inform the modification report. The aim of this report is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) issued for the proposed modification.

Climate change risk assessment

The climate change risk assessment was completed in line with the Australian Government's *Climate Change Impacts and Risk Management – A Guide for Business and Government* (Department of the Environment and Heritage Australian Greenhouse Office, 2006) and the *Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime Services - RMS, in draft).

The assessment identified the climate effects relevant to the construction and operational phases of the proposed modification for two time periods - the short-term time period of 2030, and a longer-term time period of 2070. It recommends appropriate risk management and adaptation measures to be incorporated into the design, construction, and operational phases of the proposed modification.

Climate change risks were identified for key climate hazards (extreme heat, bushfire, drought, extreme rainfall and flooding, and extreme storms).

- For the construction phase a total of six risks were identified, one of which was rated a medium risk which was the highest risk identified
- For the operational phase, 18 risks were identified, as well as two opportunities. For the 2030 time period, four risks were rated as medium. For the 2090 time period, 11 risks were rated medium. There were no high or extreme risks identified in this assessment.

Table 1-1: Climate change risks identified as 'medium' or higher in the 2030 time period during construction and operation of the proposed modification

	Risk Statement	2030 Risk Rating
Construction	Extreme rainfall and wind events leading to construction interruption resulting in project delays for day to day works	Medium
Operation	Extreme heat events leading to health and safety concerns for motorway staff, contractors and road users (e.g. heat stress, dehydration)	Medium
	Extreme temperatures leading to increased stress of carriageway to bridge connections resulting in structural failure of motorway	Medium
	Increased rainfall intensity leading to scour of embankments and cuttings resulting in landslips causing damage to infrastructure	Medium
	Extreme storms and winds leading to increased instances of debris on the motorway resulting in health and safety concerns for road users	Medium

Greenhouse gas assessment

A greenhouse gas (GHG) impact assessment has also been undertaken to determine the impacts of the proposed modification and to identify management and mitigation options to reduce the GHG emissions associated with the proposed modification. The Carbon Estimate and Reporting Tool (CERT) provided by Transport was used to calculate the GHG emissions produced from construction and operation of the proposed modification.

Construction impacts from the proposed modification represent the majority of scope 1, 2 and 3 GHG emissions associated with the project lifecycle. Construction is estimated to produce approximately 130,701 tonnes of carbon dioxide equivalent emissions (tCO_2e) emissions. Operation and maintenance of the proposed modification is estimated to produce approximately 10,162 tCO_2e emissions over a nominal 100-year operational period, excluding tailpipe emissions from road traffic. The proposed modification would impact the number of vehicles on the Westlink M7, the amount of time those vehicles spend on the road and their associated GHG emissions, though these have not been quantified in this study.

While the forecast traffic volumes along the Westlink M7 would increase as a result of the proposed modification, the overall network performance would improve, congestion would improve, vehicle speeds would generally increase, average travel times would decrease, and vehicle speeds may decrease at northern and southern extents outside the proposed widening areas (refer to **Appendix D** (Traffic and Transport Technical Assessment). Higher tailpipe greenhouse emissions can generally be expected with higher traffic volumes. Lower congestion may contribute to lower emissions per car per kilometre travelled, though this should be considered with potential increases in congestion outside the proposed modification extents.

Mitigation measures have been recommended to reduce GHG emissions associated with the proposed modification, including purchasing GreenPower during construction, sustainable material selection and solar construction lighting (among others), where feasible.

1.0 Introduction

The Westlink M7 is an existing 39-kilometre-long toll road connecting the M5 Motorway at Prestons, The Hills M2 Motorway at Baulkham Hills and the M4 Motorway at Eastern Creek ('the approved project'). Transport for NSW (Transport) is seeking a modification to the approved project to widen part of the Westlink M7 in response to current and forecast traffic growth, and to improve motorway efficiency, travel time performance and safety.

1.1 Overview of proposed modification

Transport, as the proponent for the proposed modification, is requesting that the Minister for Planning and Homes modify the planning approval for the Western Sydney Orbital (now referred to as Westlink M7) under section 5.25 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The original approval (DPE reference number SSI-663) was for the construction and operation of the existing four-traffic lane motorway. The proposed modification would provide an additional trafficable lane in both directions within the existing median of the Westlink M7. The motorway would be widened from about 140 metres south of the Kurrajong Road bridge at Prestons (southern end) to the intersection with Richmond Road in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7 Motorway (Light Horse) interchange (refer to Figure 2-1).

1.2 Purpose of this technical report

This technical report provides a climate change and greenhouse gas (GHG) assessment of the proposed modification, and has been prepared to inform the modification report. The aim of this report is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) for the modification, provided by DPE (reference number SSI-663).

1.2.1 Secretary's Environmental Assessment Requirements

The relevant climate change and GHG assessment SEARs are presented in Table 1-1.

Table 1-1: SEARs – Climate Change and GHG Emissions assessments

Desired Performance Outcome	SEAR	Where addressed within this report
Other Issues	An assessment of the following must be undertaken in accordance with the commitments in Attachment 2 of the M7 Motorway (SSI 663) – Project Modification letter submitted 09 May 2022 (via Major Projects Portal): • Climate Change Risk	
	Extract from Attachment 2 of the M7 Motorway (SSI 663): • *Assess the risk and vulnerability of the proposed modification to climate change in accordance with the current guidelines.*	**Sections 5.1** and **5.2** for the climate change risk assessment (CCRA). **Sections 6.1** and **6.2** for the GHG assessment.
	• *Quantify specific climate change risks with reference to the NSW Government's climate projections at 10 kilometre resolution (or lesser resolution if 10 kilometre projections are not available) and incorporate specific adaptation actions in the design.*	**Section 5.3** for the climate adaptation actions and **Section 6.3** for the GHG mitigation actions.

Desired Performance Outcome	SEAR	Where addressed within this report
Flooding The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	A flood impact and risk assessment (FIRA) must be undertaken by a qualified flooding engineer. As a minimum the FIRA should consider: d) impacts of climate change on both existing and post development flood behaviour due to increase in rainfall intensities; and e) proposed temporary management actions to mitigate impacts of flooding during construction on the community, personnel, machinery, and construction sites.	**Sections 5.1** and **5.2** for the climate change risk assessment, including flooding. **Section 5.3** for the climate adaptation actions, including flood mitigation issues.

1.3 Structure of this technical report

This technical report is structured as follows:

- **Section 1.0 – Introduction**: This section introduces features of the proposed modification.
- **Section 2.0 – Proposed modification**: This section provides a description of the proposed modification including construction and operational activities.
- **Section 3.0 – Method of Assessment**: This section outlines the methods used to assess the proposed modification as it relates to climate change and GHG.
- **Section 4.0 – Existing environment**: This section describes the existing environment as it relates to climate change and GHG.
- **Section 5.1 and 6.1 – Construction impact assessment**: This section assesses the impacts of the proposed modification during construction as it relates to climate change and GHG, respectively.
- **Section 5.2 and 6.2 – Operational impact assessment**: This section assesses the impacts of the proposed modification during operation as it relates to climate change and GHG, respectively.
- **Section 5.3 and 6.3 – Mitigation and management measures**: This section documents mitigation and management measures that are proposed to mitigate the identified impacts of the proposed modification (taking into account the existing Conditions of Approval for the approved project). The mitigation and management measures are outlined for climate change and GHG respectively.
- **Section 7.0 – Conclusion**: This section summarises the construction and operational impacts of the proposed modification as it relates to climate change and GHG and briefly describes the recommended mitigation and management measures.

2.0 Proposed modification

The proposed modification would permit the addition of a trafficable lane in both directions within the existing median of the Westlink M7. A full description of the construction activities and operational features are provided in detail in **Chapter 4** (Proposed modification) of the Modification Report. An overview of the proposed modification is shown on Figure 2-1.

The proposed modification to the approval for the Westlink M7 would include the following key operational components:

- Widening of the motorway into the existing median for a length of about 26 kilometres along the Westlink M7, from about 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to Richmond Road interchange in Oakhurst/Glendenning (northern end), excluding at the M4 Motorway/Westlink M7(Light Horse) Interchange
- Widening the exit from the Westlink M7 northbound onto the M4 Motorway westbound from one lane to two lanes
- Widening of 43 existing northbound and southbound bridges on the Westlink M7 at 23 locations within the centre median, and widening on outside of the bridges on the approach to the M4 Motorway from Old Wallgrove Road
- Upgrades, additions and modifications to noise walls
- Utility works and upgrades to drainage
- Intelligent Transport System (ITS) installations, adjustments and relocations to cover the new lane configurations.

Existing operational features impacted by the proposed modification would include:

- Main road alignment, including median and bridge areas
- Interchanges, tie-ins and entry/exit ramps
- Fill embankments and cuttings
- Culverts and drainage structures
- Water quality control measures, including basins
- Landscaping
- Existing public art and landscaping at the M4 (Light Horse) Interchange
- Maintenance access
- Security fencing
- Noise barriers
- Shared path
- Other associated elements required during operation (for example, intelligent transport systems (ITS), utilities and variable message signs (VMS)).

The following activities would be required to facilitate construction of the proposed modification:

- Establishment of several construction ancillary facilities within and adjacent to the Westlink M7 and the M12 Motorway construction area. These would be used for stockpiling, construction support at bridge and median widening locations, project offices and compounds. The precise number and location of construction ancillary facilities would be determined by the construction contractor in accordance with the environmental approval
- Vegetation clearing within the median/widening areas and construction ancillary facilities (including for construction accesses)
- Demolition of existing structures and infrastructure within the widening areas

- Provision of temporary water management infrastructure including the maintenance of stormwater drainage and establishment of waterway crossings and diversions
- Utility works within Westlink M7 and adjoining roads, particularly around existing motorway bridge substructures
- Earthworks for bridge and road widening within the existing median, and placement and compaction of fill material
- Bridge widening works including establishment of substructures such as piles, abutments, piers and headstocks and superstructures including beams, girders, decks and barriers
- Pavement widening works within the road median
- Finishing works including asphalting the carriageway surface, line marking, signage, permanent barriers and median infill, adjustments to noise walls, installation of communications infrastructure and landscaping treatments.

Temporary motorway network changes would be required including a reduction in speed limits of the Westlink M7 within the project limits, temporary traffic diversions and lane closures. Two lanes in each direction on the Westlink M7 would be maintained during peak traffic periods. Temporary lane and full local road closures, as well as temporary off-motorway detour routes, would be required to predominantly support the construction of widened bridges. Construction access and haulage routes would primarily utilise the Westlink M7, however would also include roads adjacent to the Westlink M7. The existing Westlink M7 shared path would also be closed in places during construction, however appropriate detours would be provided to maintain full north-south connectivity.

Construction would likely commence in 2023 and continue through to the end of 2025. The construction program for the M12 Motorway, and how this interfaces with the Westlink M7, has been considered in the development of this program. It is proposed to construct the proposed modification at this interchange at the same time as the M12 Motorway project works to minimise disruption and achieve efficiencies during construction.

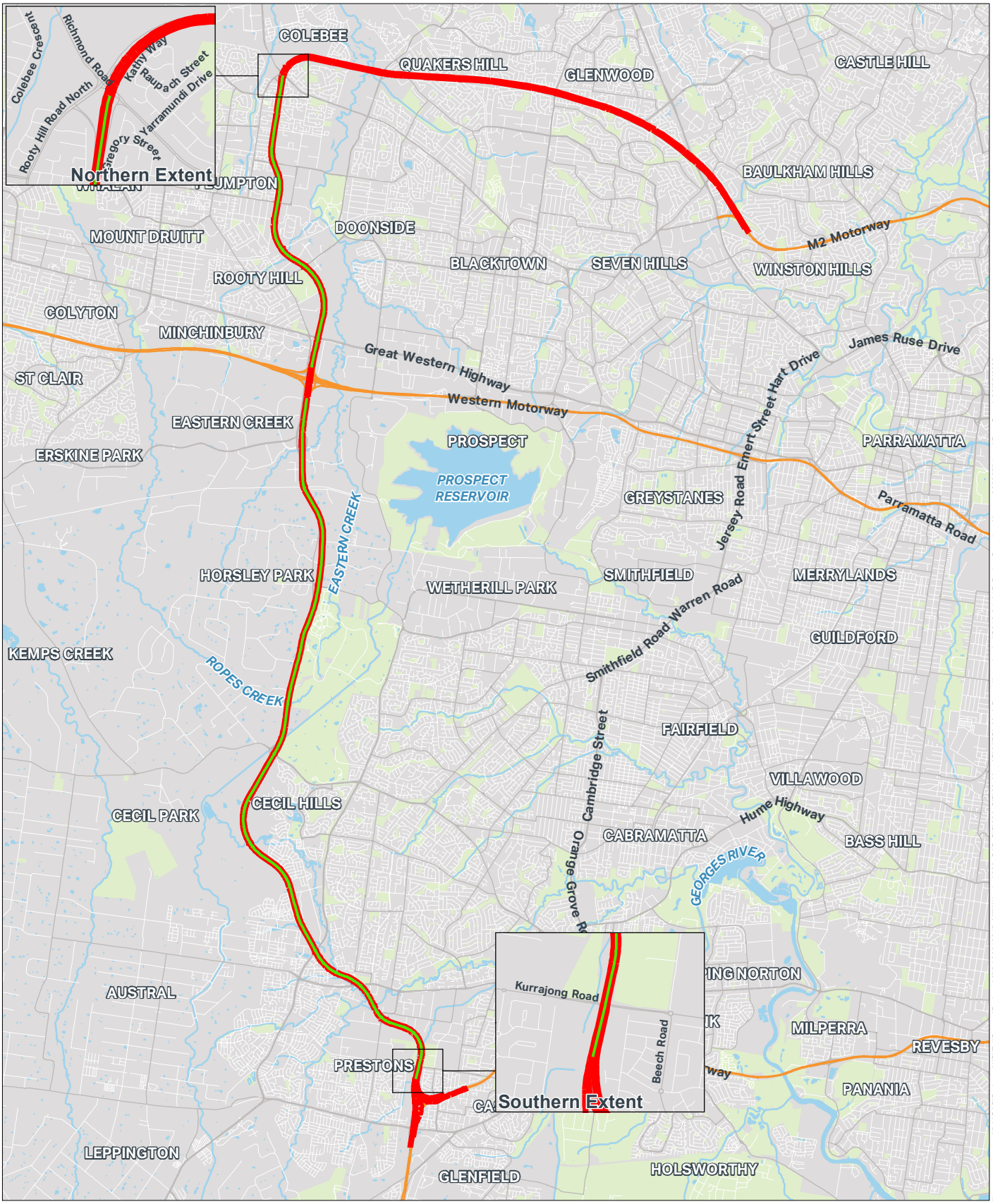

FIGURE 2-1: EXTENT OF THE APPROVED PROJECT AND THE PROPOSED MODIFICATION

N

0 2 4 km

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Legend

- Proposed modification
- Approved project
- Motorway
- Primary road

Source:

3.0 Method of assessment

This section describes the method of assessment used in this technical assessment report, and also outlines the legislation, guidelines and policy that are relevant to the assessment.

3.1 Study area

The study area for the climate change and GHG assessments is the physical boundary of the Westlink M7, and the construction footprint and operational footprint for the proposed modification (refer **Chapter 4** (Proposed modification) of the Modification Report). The assessment boundary for the CCRA also includes the surrounding traffic network and local areas as these can directly impact the level of exposure of the Westlink M7 to climate-related risks.

3.2 Relevant legislation, guidelines and policy

Risk assessment describes the overall process of risk identification, analysis and evaluation, informed by findings of the previous stage. Risk management for physical risks has been guided by the following and assessed in accordance with the Transport *Climate Risk Assessment Guidelines* (Transport, 2021):

- The risk assessment approach set out in the *TfNSW Enterprise Risk Management Standard,* TfNSW Enterprise Risk Management Team (2020)
- *ISO 14091 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment, ISO standard* (2021)
- *Climate Risk Ready NSW Guide*, Adapt NSW (2021)
- ISv1.2 Technical Manual, Infrastructure Sustainability Council (2018)
- *AS 5334-2013 Climate change adaptation for settlements and infrastructure* – A risk-based approach, Australian Standard (2013)
- Australian Government, *Climate Change Impacts & Risk Management – A Guide for Business and Government*, Australian Government (2006).

The following summarises relevant GHG related legislation, policy and guidelines applicable to the assessment of the proposed modification:

- International:
  - Paris Agreement: Driver for setting Commonwealth and State GHG legislation, policy, and targets (United Nations Framework Convention on Climate Change, 2015)
  - *GHG Protocol: A Corporate Accounting and Reporting Standard* (World Business Council for Sustainable Development and the World Resources Institute, 2015)
  - *AS/ISO 14064.1:2006 GHG Part 1: Specification with guidance at the organisational level for quantification and reporting of GHG emissions and removals* (International Organization for Standardization, 2006).
- Commonwealth:
  - *National Greenhouse and Energy Reporting Act 2007* (NGER Act)
  - *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
  - The current *Australian National Greenhouse Accounts: National Greenhouse Accounts Factors* (NGA Factors) (Department of Industry, Science, Energy and Resources, 2021).
- State:
  - *NSW Climate Change Policy Framework* (State of NSW and Office of Environment and Heritage, 2016)
  - *Transport Environment and Sustainability Policy* (Transport for NSW, 2020).
  - *Transport Carbon Estimate and Reporting Tool (CERT).*

3.3 Climate change risk assessment

3.3.1 Method of assessment

The following steps were undertaken to complete the CCRA:

1. Identification of key climate variables (e.g. those related to temperature, rainfall and extreme events) across the study area
2. Identification of potential climate change scenarios, based on the latest climate science, which describes how each variable may change over the design life of the proposed modification
3. Identification of project-specific climate-based risks that may impact on the proposed modification
4. Completion of the CCRA, with risk ratings evaluated using the Transport's *Climate Risk Assessment Guidelines*. These guidelines include likelihood and consequence criteria. Consequence ratings have been selected based on the highest rating for the risk categories
5. Identification of potential measures to mitigate and adapt to the identified climate change risks.

The overarching CCRA approach is shown in Figure 3-1.

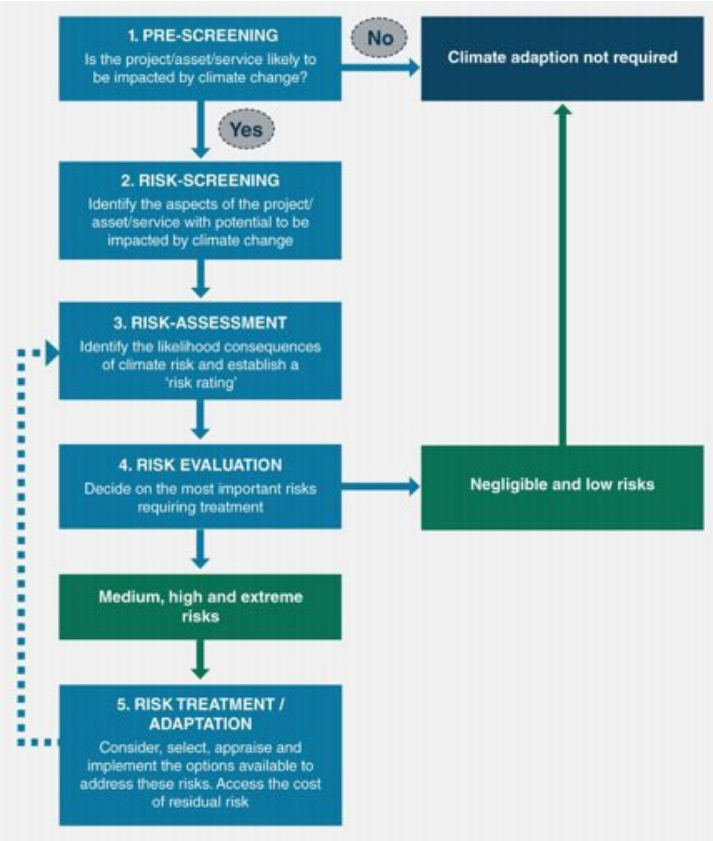

Figure 3-1: CCRA approach (adapted from *Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime Services, in draft).

The risk assessment was undertaken by first consolidating risks identified in a CCRA prepared by WSO Co in 2017. A multidisciplinary workshop was held on 1 October 2021 with key members of the project design and environment team to identify and validate climate change risks specific to the assessment of the proposed modification. The risks identified as a priority in the workshop were then used to inform the discussion of adaptation actions. The outcomes of the workshop were summarised and reviewed by the key stakeholders.

Assessment criteria

The CCRA was undertaken in accordance with the criteria outlined in Transport's *Climate Risk Assessment Guidelines*. Refer to **Appendix A** for the risk matrix, consequence and likelihood criteria.

3.3.2 Data sources

An assessment of the risk of climate change requires an understanding of the current climate using historical data for comparison with future climate scenarios. In order to assess the risk to the proposed modification posed by climate change, the current climate science and model projections have been investigated using information published by Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM) and the NSW and ACT Regional Climate Modelling (NARCLiM).

CSIRO and BoM have published climate change projections for Australia based on published datasets and emissions scenarios specific to relevant locations, defined as 'clusters', across the country. The entirety of the assessment scope falls within boundaries of the East Coast cluster region (Southern sub-cluster) (the CSIRO and the Bureau of Meteorology). Projections for a full range of variables are only provided for the 2030 to 2090-time horizons for the cluster reports. The 2090-time horizon serves as a comparison to understand how the climate may change for some of the longer design life elements.

NARCliM projections were delivered by NSW Government in 2014 and provided high resolution climate change projections across NSW (Adapt NSW) which outline projections for future periods of 2030 and 2070. Projections for 2070 have been used to inform the 'long term' scenario of 2090.

Emissions scenarios

Projections are presented for two emission scenarios or possible pathways, referred to as 'representative concentration pathways' (RCPs), each reflecting a different concentration of global GHG emissions. The two RCPs reported here are moderate emissions (RCP 4.5) and high emissions (RCP 8.5).

While RCP 8.5 represents the most conservative emission scenario, it is considered appropriate for reference as the past decade of observed emissions have been tracking closest to this emission scenario. In addition, over the next 15 years, in the absence of global action to curb emissions, this trajectory is unlikely to change significantly, suggesting that the most extreme emissions scenario is most likely to occur (as a minimum) through to 2030.

Further detail regarding the selection of climate change projections and emission scenarios used as part of the assessment for the proposed modification is provided in **Appendix B**.

Future timescales

Given the expected design life of the infrastructure, the proposed construction timeframe and the available climate data, the time periods selected for the assessment were 2030 (representative of the 2026 opening year) and 2090 (representative of the far future). Climate change projections for 2030 were identified as appropriate for assessment of short-term impacts of climate change and construction, while projections for 2090 are relevant to the longer-term operation and maintenance stages of the proposed modification.

3.4 GHG assessment

3.4.1 Method of assessment

The CERT has been used to estimate GHG emissions associated with the proposed modification. The CERT is developed by Transport and assists with the measurement and report of GHG emissions. Once the emissions were quantified using the CERT, emissions were classified in accordance with the relevant reporting guidelines outlined in section 3.2.

CERT provides generic calculations to convert quantities of materials, fuel use, vegetation removal, etc. into mass of GHG emissions produced. Whilst the CERT sources emissions factors from the NGA 2016, the only relevant emissions factors that change significantly year-to-year are emissions from the electricity grid. For emissions from electricity use, an adjustment factor was applied to account for this change such that the GHG emissions reflect the most recent (2021) emissions factor for NSW grid electricity. CERT was used instead of two alternate tools:

1. Infrastructure Sustainability Council (ISC) Materials Calculator: The ISC materials calculator only covers embodied emissions from materials, so if the ISC materials calculator was used, it would need to be supplemented by CERT or a bespoke calculation to cover the remaining GHG

emissions sources, such as diesel use and vegetation clearing. CERT provides inputs for all the materials that were included in the data received for the Westlink M7 assessment, as only major materials such as concrete and asphalt are covered in the scope of this assessment.

2. Tool for Roadside Air Quality (TRAQ): TRAQ is used for quantifying GHG emissions from vehicles using a new or existing roadway. Assessment of Scope 3 emissions for a project is non-mandatory, and tailpipe emissions from traffic are more commonly undertaken at a network level, or for new (greenfield) road infrastructure and other traffic generating developments. Due to the nature of the proposed modification, being the addition of a lane northbound and southbound to reduce existing traffic congestion and improve existing traffic speeds on an existing motorway, the GHG scope for this assessment excludes scope 3 emissions from traffic during continued operation of the Westlink M7, and instead incorporates a qualitative discussion of emissions from traffic. Further, as the proposed improvement in congestion on the Westlink M7 would draw some traffic off parallel routes on the surrounding road network, calculation of the modification's discrete contribution to scope 3 tailpipe emissions within the context of the regional network is complex.

To calculate the potential GHG emissions associated with the proposed modification, the following steps were followed:

1. Define the assessment boundary and identify potential sources of GHG emissions associated with the proposed modification
2. Determine the quantity of each emission source (fuel and electricity consumed, vegetation cleared, construction materials used, and waste produced)
3. Quantify the potential GHG emissions associated with each GHG source, using equations and emission factors specified in the Transport CERT
4. Present the potential GHG emissions associated with the proposed modification.

Only emissions associated with the additional lanes of the proposed modification have been quantified. All emissions associated with existing Westlink M7 operations are not included in the scope of the assessment. As such, the primary source of emissions for the purposes of this assessment are associated with the construction phase, with only maintenance of the additional lanes included in the scope of the GHG assessment of the operational phase of the asset.

GHG emissions are reported in this assessment as tonnes of carbon dioxide equivalent (tCO2e).

3.4.2 Data sources

Data inputs provided by WSO Co include:

- Construction compound vehicle movements
- Power consumption details (site facility power consumption)
- Quantities for haulage and elements (materials and waste)
- Fuel use for construction plant and equipment
- Vegetation clearing areas
- Asphalt resurfacing requirements during asset life.

Data sources used by the Transport CERT include:

- AusLCI: *National Life Cycle Inventory database* set up by the Australian Life Cycle Assessment Society (Australian Life Cycle Assessment Society, 2011)
- NGA 2016: *Australian National Greenhouse Accounts* published by the Australian Government Department of Industry, Science, Energy and Resources (Department of Industry, Science, Energy and Resources, 2016)
- TAGG 2013: *Transport Authorities Greenhouse Group Australia and New Zealand* (TAGG), GHG Assessment Workbook for Road Projects (TAGG, 2013)
- EPDs: *Environmental Product Declarations*, published within the Australasian EPD Programme (2018).

3.5 Cumulative impact assessment

A cumulative impact assessment of climate change risks has been undertaken for both construction and operation, to assess the potential cumulative impacts of the proposed modification with those of the existing Westlink M7 and other relevant projects in the area. This was undertaken based on a screening of other nearby projects to determine those that have the potential to cause cumulative impacts, and discussion of climate-related risks within a multidisciplinary workshop to understand the additional impact of the proposed modification compared to the existing Westlink M7. In accordance with the SEARs, the screening considered projects that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed. The screening process is described further in **Section 7.18** (Cumulative impacts) of the Modification Report. The cumulative impact assessment was based on the residual impacts of the proposed modification (i.e. those that are expected to exist after application of management and mitigation measures described in this modification report).

3.6 Assumptions and limitations

3.6.1 GHG Modelling Assumptions and Limitations

The proposed modification remains subject to detailed design, and therefore high level assumptions have been made where detail on the exact material types, construction methodology and resource requirements are unknown. Data and assumptions used for inputs into the CERT are detailed in **Appendix D**.

Table 3-1: Summary of assumptions

Emissions source	Assumptions
Construction fuel use	• Majority of plant and equipment fuel use is diesel. Petrol use from plant and equipment use would be negligible. • Light vehicle assumptions based on construction traffic modelling. Details in **Appendix D**. Light vehicles are diesel. • Site sheds are primarily powered by diesel generators, with a smaller proportion connected to mains electricity. Detailed breakdown of generator vs mains-connected site sheds detailed in **Appendix D**.
Construction electricity	• Mains-connected site sheds purchase standard NSW grid electricity. Note, the CERT calculates emissions based on 2016 grid emissions factors. As such, an 'adjustment factor' has been applied so that the equivalent emissions from current NSW grid electricity is reported.
Construction materials	• A basic bill of quantities covering primary construction materials (fill/spoil, asphalt, bitumen, concrete, and steel) has been input into the CERT. Default domestic CERT transport distances were assumed. Concrete assumed to be Portland cement based, 40MPa strength grade; and asphalt assumed to be 'hot mix' and contain 0 per cent reclaimed asphalt pavement (RAP).
Construction waste	• Material export quantities assumed to be waste. Quantities broadly classified into inert waste, timber and vegetation, and mixed waste. • Default CERT transport distances assumed.
Operational light vehicles and electricity	• Any change to the asset operator's current light vehicle and electricity use assumed to be negligible.
Maintenance	• Road resurfacing required every 15 years for a nominal asset life of 100 years.
Public road traffic	• Public road traffic and staff commuting are scope 3 emissions and reporting of these are optional under the GHG Protocol (World Business Council for Sustainable Development and World Resources Institute, 2015). As such, these have not been quantified as part of the GHG assessment.

4.0 Existing environment

This section provides a description of the existing environment as it relates to current climate and GHG emitting activities.

4.1 Current climate

Greater Sydney currently has a significant variation in climate, ranging from the coastal fringes of Metropolitan Sydney to the Blue Mountains. Table 4-1 provides a brief overview of Greater Sydney's current climate. Refer to **Appendix B** for further detail.

Table 4-1: Greater Sydney's baseline [1961-1990] climate (AdaptNSW, 2014)

Climate component	Summary
Temperature	• Summer average temperatures range from 16-24 degrees Celsius (°C) • On average, Greater Sydney experiences less than 10 days over 35°C per year • Winter average temperatures range from 4-14°C • On average, Greater Sydney experiences less than 10 nights below 2°C per year • An increase in temperature has been observed across the region since the 1960s.
Rainfall	• Annual average rainfall is in the range of 800–1200 millimetres for Greater Sydney • There is typically more rainfall in summer and autumn than in winter and spring.
Fire weather	• Greater Sydney experiences on average one to two days per year of fire weather conditions considered 'severe' or greater.

4.2 Climate change

Australia's climate has warmed by 1.44°C since 1910. The eight years from 2013 to 2020 are among the warmest years on record, with 2019 being the hottest year ever recorded (CSIRO). 2020 was Australia's fourth-warmest year on record (Australian Bureau of Meteorology).

In addition to an increase in annual mean temperature, oceans around Australia are warming and acidifying while sea levels are rising. Longer droughts are predicted in southern Australia, in addition to increased flooding in the north. A long-term increase in extreme fire weather and length of fire season will be progressively experienced. The effects of climate change will not only be felt within Australia, but across the globe. These extreme weather events pose significant threat to the environment, society and the economy, and building self-resilience throughout Australian communities is critical.

The possible impacts of climate change are identified through an analysis of available climate models and projections of how the climate will respond to changes of GHG concentrations. The models are based on historical climate data and future trends of GHG concentrations. As future GHG concentrations are not known, many different models have been developed to provide a range of possible future climate scenarios.

The key climate hazards identified for this assessment include:

- **Extreme heat** – which may drive health and safety concerns for road users and workers on the motorway
- **Bushfire** – which smoke could impact on reduced visibility for road users and result in poor air quality
- **Drought** – which could reduce the availability of water for landscaping and increased cracking of soils
- **Extreme rainfall and flooding** – which could result in scour of embankments and cuttings resulting in landslips causing damage to infrastructure
- **Extreme storms** – which can result in damage and disruption to electrical equipment (monitoring cameras and toll collection systems).

4.3 Current GHG activities

Transport in Australia accounts for 17 per cent of total emissions (96 Metric tons of carbon dioxide equivalent ($MtCO_2e$) per year) (Australian Government Department of the Environment and Energy, 2017), making it the nation's third largest source of GHG emissions. Cars are responsible for approximately half of all transport emissions (43 $MtCO_2e$) (Australian Government Department of the Environment and Energy, 2017). In NSW, transport was responsible for 20.8 per cent of GHG emissions in 2015/16 (NSW Environment Protection Authority, 2018). GHG emissions in NSW across all sectors contributed to 136.58 $MtCO_2e$ in 2019 representing approximately 26 per cent of Australia's total emissions (Australian Government Department of Industry, Science, Energy and Resources, 2019).

Activities that generate GHG emissions during usual operation on the Westlink M7 include:

- Vehicle emissions
- Operational energy
    - E.g. lighting signalling, communications, fire, hydraulics, miscellaneous power, variable messaging signs
- Maintenance materials
    - E.g. protective coatings and paints, rubberised bitumen for road maintenance
- Maintenance plant and equipment
    - E.g. rollers for resurfacing.

5.0 Climate change risk assessment

This section describes the performance outcomes related to the CCRA, provides an assessment of both construction and operational climate change impacts, and mitigation measures to ameliorate those impacts.

5.1 Construction impact assessment

This section provides an assessment of construction impacts from the proposed modification in terms of climate change. Climate change projections for the near future (2030) are considered relevant to the construction timeframes for the proposed modification, as the construction is due to be completed by 2025. A total of six risks were identified for the construction period one of which was a medium risk with remaining risks rated as low. Table 5-1 outlines the risk identified as medium, prior to the implementation of mitigation measures. All construction related risks can be found in **Appendix C**.

Table 5-1: Construction risks to proposed modification identified as medium or higher

Risk ID	Risk Statement	Risk Rating
Extreme rainfall and flooding		
C-P2	Extreme rainfall and wind events leading to construction interruption resulting in construction delays for day to day works	Medium

5.1.1 Cumulative impact assessment

There are not expected to be any material additive climate change impacts during the construction phase of the proposed modification. Cumulative climate change risks would be associated with an increase in extreme climate events and delays to respective construction programs, resulting in a cumulative increase in the duration of construction periods.

There may be impacts from the construction of other nearby infrastructure projects, notably the M12 Motorway. Construction for this project is due to start in 2022 and continue for several years, meaning that it will be constructed at the same time as the proposed modification. This means that any extreme climate event that has material impacts on the M12 Motorway, could potentially impact the construction phase of the proposed modification. However, as the M12 Motorway is a similar project to the proposed modification, it is expected that it would have a similar construction risk profile and the impacts are likely to occur during the same time periods. This would reduce the likelihood of any flow on impacts to the proposed modification.

5.2 Operational impact assessment

This section provides an assessment of the potential impacts from climate change on the operation of the proposed modification. The CCRA identified a total of 18 direct and indirect risks and two opportunities to the proposed modification at the 2030 time period. Of these risks, four medium risks and 14 low risks were identified at the 2030 timescale. At 2090, 11 risks were rated medium prior to application of mitigation measures. Table 5-2 outlines risks identified as medium for the 2030 and/or 2090 time period prior to the consideration of climate adaptation controls. All operational risks are described in **Appendix C.**

Table 5-2: Operational risks to proposed modification identified as medium or higher within any time period (prior to implementation of mitigation measures)

Risk ID	Risk Statement	2030			2090
		Likelihood	Consequence	Risk Rating	Risk Rating
Increasing temperatures and number of hot days					
T1	Extreme heat events leading to health and safety concerns for motorway staff, contractors and road users (e.g. heat stress, dehydration)	Likely	Moderate	Medium	Medium
T2	Extreme temperatures leading to increased stress of carriageway to bridge connections resulting in structural failure of motorway	Very unlikely	Severe	Medium	Medium
T3	Extreme heat/extreme weather leading to higher rates of vehicle breakdown resulting in demand on incident response crews	Unlikely	Minor	Low	Medium
T5	Increase in paved surfaces exacerbating urban heat island effects resulting in cumulative increase in extreme temperatures	Unlikely	Minor	Low	Medium
T6	Heat-related failure of intelligent transport systems (ITS) and critical roadside technology, leading to service interruption	Very unlikely	Moderate	Low	Medium
T7	Prolonged duration of heatwave leading to increased energy demands and peak usage period consumption, resulting in unplanned cost increases	Unlikely	Minor	Low	Medium
Extreme rainfall and flooding					
P1	Increased rainfall intensity leading to a higher frequency of floods resulting in flooding and reduction or loss of infrastructure service	Very unlikely	Moderate	Low	Medium
P2	Increased rainfall intensity leading to scour of embankments and cuttings resulting in landslips causing damage to infrastructure	Likely	Moderate	Medium	Medium

Risk ID	Risk Statement	2030			2090
		Likelihood	Consequence	Risk Rating	Risk Rating
Bushfire					
B2	Increasing bushfire frequency and intensity resulting in damage to the motorway corridor and/or ancillary assets and infrastructure	Very unlikely	Moderate	Low	Medium
Storms					
S1	Extreme weather events leading to damage and disruption to electrical equipment (lighting, toll collection systems, monitoring cameras)	Likely	Insignificant	Low	Medium
S2	Extreme storms and winds leading to increased instances of debris on the motorway resulting in health and safety concerns for road users	Unlikely	Minor	Low	Medium

5.2.1 Cumulative impact assessment

Cumulative impacts associated with climate change risk would primarily occur as a result of interdependencies between the proposed modification and the local environment. These impacts may occur where the introduction of the proposed modification exacerbates climate change risks for receiving environments. Examples of interdependencies for the proposed modification, which may be susceptible to climate change risks, include:

- Infrastructure for the proposed modification would interact with existing drainage systems. The flooding assessment undertaken for the proposed modification (refer **Appendix G** (Surface water and flooding assessment) of the Modification Report) found that the rate and volume of runoff from the widened motorway would be increased, which has the potential to impact on flooding patterns along the drainage lines that cross the Westlink M7 corridor. However this impact would be minor, with inundation likely to increase slightly within Government Road Basin and along the southern side of the Main Western Railway to the west (upstream) of the Westlink M7 corridor at transverse drainage infrastructure. The existing drainage infrastructure for the Westlink M7 was designed to accommodate runoff from a future widening of the motorway into the median (i.e. the proposed modification). Drainage infrastructure for the proposed modification would be designed with regard to this and to meet or improve current drainage flows.
- Introduction of additional infrastructure as part of the proposed modification, contributing to the “urban heat island effect” and an increase in local average temperatures. This would have implications for the urban heat island profile of the study area and surrounding suburbs and new residential growth corridors.
- The proposed modification would interact with surrounding motorways and the local traffic network. Climate-related impacts, such as flooding on those roads may impede accessibility to the Westlink M7 and could also lead to restrictions in traffic flow for the proposed modification. Key roads within the local road network including the M12 Motorway, Elizabeth Drive, the M4, and the Great Western Highway may independently be disrupted by climate-related hazards which could lead to impacts on traffic flows for the widened Westlink M7.

The population of Greater Sydney is expected to grow to about 6.6 million people by 2036 (NSW Department of Planning, Industry and Environment, 2020), while the population of Greater Western

Sydney (extending from Windsor in the north to Campbelltown in the south, and from Parramatta in the east to Penrith and the Blue Mountains in the west) is expected to grow to three million people in the same timeframe (Infrastructure Australia, 2020). It is expected that by 2031, more than half of all new jobs in Sydney will be created in Western Sydney (Department of Planning and Environment, 2014). This residential growth is likely to increase traffic flows and in the event of an extreme weather event may heighten the safety risks for road users. Adaptation measures identified in **Section 5.3** would improve the resilience of the proposed modification to climate change and reduce potential interdependencies and cumulative climate change risks. The implementation of adaptation measures for the proposed modification to address climate change risks provides opportunities to improve the resilience of the road network within the Sydney region as a whole.

5.3 Mitigation and management measures

This section describes mitigation and management measures to manage potential climate change risks and impacts from the proposed modification.

5.3.1 Performance outcomes

The performance outcomes for the CCRA for the proposed modification are as follows:

- Understanding of the proposed modification's exposure to climate related risks during the construction and operational phases
- Identification of current controls which mitigate climate related risks
- Identification of adaptation actions to be considered for implementation during the construction and operational phases of the proposed modification.

The proposed modification would be designed, constructed, and operated with the aim of achieving these performance outcomes.

The current Conditions of Approval (CoA) for the approved Westlink M7 required climate adaptation and management measures to be implemented during construction and operation (either directly in the conditions or through reference to environmental management plans required).

The mitigation and management measures for priority risks associated with the construction and operational phase of the proposed modification are described in Table 5-3 and Table 5-4 respectively. These have been identified to address the impacts assessed in this report. and provides an indication of when the measures would need to be considered in the design, construction and operational phase of the proposed modification.

Measures that address priority risks, would be incorporated into existing environmental management plans where they have not been accounted for already. Mitigation for the priority operational risks would be implemented prior to the operational phase of the proposed modification.

Table 5-3: Mitigation measures for priority construction risks

Risk ID	Risk statement	Mitigation and management measure	Phase
C-P2	Extreme rainfall and wind events leading to construction interruption resulting in construction delays for day to day works	• Delivery schedule to allow contingency for potential delays associated with extreme rainfall. • Clear communication of contractual expectations that there is an increased likelihood of these extreme rainfall and wind events occurring during construction.	Construction

Table 5-4: Mitigation measures for priority operational risks

Risk ID	Risk statement	Mitigation and management measure	Phase
T1	Extreme heat events leading to health and safety concerns for motorway staff, contractors and road users (e.g. heat stress, dehydration) Extreme temperatures leading to increased stress of carriageway to bridge connections resulting in structural failure of motorway	• Continue to apply existing operational procedure whereby work health and safety settings are adjusted accordingly during extreme temperatures, including reducing/adjusting work hours and requiring personal protective equipment.	Operation
		• Investigate opportunities to provide additional shading for road users who may be exposed to high temperatures for prolonged periods (e.g. breakdown bays).	Detailed design
T2	Extreme heat/extreme weather leading to higher rates of vehicle breakdown resulting in demand on incident response crews	• Routine maintenance and inspections are undertaken of key structural components. Maintenance programs are to be augmented to account for extreme weather events. • Undertake risk assessments for key scheduled works to include extreme heat impacts and mitigation measures identified as a result implemented.	Operation
T3	Increase in paved surfaces exacerbating urban heat island effects resulting in cumulative increase in extreme temperatures	• Review operational controls (e.g. monitor and increase resourcing/ capacity of incident response crews) ahead of expected extreme heat events.	Operation
T5	Heat-related failure of intelligent transport systems (ITS) and critical roadside technology, leading to service interruption	• Appropriate landscape design to consider future climate impacts relating to drought (i.e. tolerant species) to ensure ongoing shading where possible	Detailed design
T6	Prolonged duration of heatwave leading to increased energy demands and peak usage period consumption, resulting in unplanned cost increases	• Explore options for implementing redundancy (e.g. batteries) into the ITS.	Detailed design
T7	Extreme heat events leading to health and safety concerns for motorway staff, contractors and road users (e.g. heat stress, dehydration)	• Energy efficient LED lighting will be installed. • Explore low power mode options for electrical equipment to reduce energy demand.	Detailed design
P1	Increased rainfall intensity leading to a higher frequency of floods resulting in flooding and reduction or loss of infrastructure service	• Flood modelling included a sensitivity test to account for increased rainfall intensities associated with climate change in both 2030 and 2090 timeframes.	Detailed design

Risk ID	Risk statement	Mitigation and management measure	Phase
		• Drainage package to be designed considering the projected flooding impacts from the 2030 and 2090 climate change projections modelled within flood studies.	
P2	Increased rainfall intensity leading to scour of embankments and cuttings resulting in landslips causing damage to infrastructure	• Explore options for stabilising and/or reducing the slope of embankments for the proposed modification.	Detailed design
S1	Extreme weather events leading to damage and disruption to electrical equipment (lighting, toll collection systems, monitoring cameras)	• Ensure electrical equipment will be able to connect generators to roadside cabinets in the event of wider power outages. • Lightning protection systems/earth proofing to be installed on major electrical equipment.	Detailed design

6.0 GHG assessment

GHG emission sources are categorised into the following three 'scopes':

- Scope 1 – direct emissions: GHG emissions generated by sources owned or controlled by the proposed modification, for example emissions generated by the use of diesel fuel in project-owned construction plant, equipment, or vehicles
- Scope 2 – indirect emissions: GHG emissions from the consumption of purchased electricity in owned or controlled equipment or operations for the proposed modification. These GHG emissions are generated outside the construction and operational footprint of the proposed modification, for example the use of electricity purchased from the grid
- Scope 3 – indirect upstream/downstream emissions: GHG emissions generated in the wider economy due to third party supply chains and road users as a consequence of activity within the boundary of the proposed modification, for example GHG emissions associated with the mining and production of materials used in construction (referred to as the embodied emissions of a material) and transport of materials and waste to and from site.

This section provides an assessment of GHG emissions for the construction and operational maintenance of the proposed modification, performance outcomes, and mitigation and management measures to manage potential GHG emission impacts from the proposed modification.

Assessment of Scope 3 emissions for a project is non-mandatory, and tailpipe emissions from traffic are more commonly undertaken at a network level, or for new (greenfield) road infrastructure and other traffic generating developments. Traffic and air quality modelling for the proposed modification has been centred on the area proposed for widening and as such data from those models would need to be considered in the broader context of nearby parallel routes and the local road network for the purpose of useful scope 3 operational traffic GHG emissions calculations.

6.1 Construction impact assessment

It is estimated that the proposed modification would generate approximately 130,701 tCO2e during construction. The breakdown of emissions by scope is shown in Table 6-1 and summarised as:

- 28,101 tCO2e of Scope 1 (direct) GHG emissions
- 5,146 tCO2e of Scope 2 (indirect) GHG emissions
- 97,454 tCO2e of Scope 3 (indirect) GHG emissions.

Key emissions sources during construction of the proposed modification are shown in Table 6-1.

Table 6-1: Construction GHG emissions

Emissions source	GHG emissions (tCO2e)				
	Scope 1	Scope 2	Scope 3	Total	% of total
Fuel use					
Diesel consumption for site vehicles	1,847	0	95	1,941	1%
Diesel consumption for stationary plant and equipment	3,197	0	164	3,361	3%
Diesel consumption for mobile plant and equipment	20,792	0	1,066	21,858	17%
Electricity					
Electricity consumption	0	5,146	462	5,608	4%
Construction materials					
Concrete	0	0	45,953	45,953	35%
Steel	0	0	15,592	15,592	12%
Asphalt and bitumen	0	0	2,356	2,356	2%
Other	0	0	0.1	0.1	0%
Transport of materials	0	0	3,200	3,200	2%
Waste					
Construction and demolition waste to landfill: inert waste (concrete, masonry, glass, metals)*	0	0	0	0	0%
Construction and demolition waste to landfill: timber, vegetation waste	0	0	27,323	27,323	21%
Construction and demolition waste to landfill: mixed waste	0	0	0	0	0%
Transport of waste materials	0	0	1,242	1,242	1%
Land clearing					
Land clearing	2,266	0	0	2,266	2%
Total	**28,101**	**5,146**	**97,454**	**130,701**	

**Note: inert waste has a 0 tCO2e/tonne emissions factor associated with the breaking down of material in landfill. Transport of these waste quantities is covered in "Transport of waste materials."*

As shown in Table 6-1, the majority of GHG emissions produced during construction are associated with construction materials, followed by fuel use and waste. This is mainly due to the large quantities of concrete required for the proposed modification. For the purposes of the assessment, it was assumed that a standard cement content of approximately 400 kilograms of cement per cubic metre of concrete would be used for the project. The emissions associated with concrete use may be reduced by using concrete mix designs with higher proportions of supplementary cementitious materials.

The high emissions associated with timber and vegetation waste is due to the estimated 8,880 cubic metres of material removed from clearing and grubbing estimated for the proposed modification. A conservative estimate was taken that all exported material from clearing and grubbing would be classified as timber and vegetation. In reality, a portion of this waste material would be inert, leading to lower emissions. Further, if material from clearing and grubbing can be processed for reuse by an appropriate facility rather than being taken to landfill, this can further reduce the GHG emissions associated with this source.

Diesel consumption is also a major component of the estimated GHG emissions for construction. Reducing GHG emissions from fuel use is an ongoing challenge across the broader construction industry. Minor reductions in emissions from fuel use can be made through the use of biodiesel and bioethanol and more efficient plant and equipment such as hybrid excavators.

Refer to **Section 6.3** for a full list of recommended mitigation measures to reduce GHG emissions associated with the construction of the proposed modification.

The estimated total emissions from the construction component of the proposed modification of the Westlink M7 are equivalent to 0.1 per cent of total NSW annual emissions in 2019. These emissions are anticipated to occur over the three-year construction period which is expected to run from 2023 to 2025.

6.1.1 Cumulative impact assessment

The M12 Environmental Impact Statement (EIS) predicts a total of 271,607 tCO2e emissions resulting from construction. The cumulative impact from construction of both the M12 project and the proposed modification is 402,308 tCO2e. This is equivalent to 0.29 per cent of total NSW annual emissions in 2019.

6.2 Operational impact assessment

It is estimated that the proposed modification would generate approximately 10,162 tCO2e during the nominal 100-year operational life. The breakdown of emissions by scope is shown in Table 6-2 and summarised as:

- 657 tCO2e of Scope 1 (direct) GHG emissions
- 0 tCO2e of Scope 2 (indirect) GHG emissions
- 9,505 tCO2e of Scope 3 (indirect) GHG emissions.

Key emissions sources during construction of the proposed modification are shown in Table 6-2.

Table 6-2: Operation and maintenance GHG emissions

Emission source	GHG Emissions (tCO2e)			
	Scope 1	Scope 2	Scope 3	Total
Annual operation emissions (tCO2e per year)				
Electricity consumption	Negligible – proposed widening is not expected to increase electricity consumption from existing levels.			
Operation and maintenance light vehicles	Negligible – proposed widening is not expected to increase operation and maintenance light vehicle use from existing levels.			
Total maintenance emissions (100-year major maintenance) (tCO2e)				
Fuel use– mobile plant and equipment	657		34	691
Maintenance materials			9,471	9,471
Total maintenance emissions	**657**	**0**	**9,505**	**10,162**

As the scope of this report is to assess the GHG impacts of the proposed widening of the Westlink M7, only activities that occur in *addition* to regular operations are assessed. No major changes are anticipated to electricity consumption or operational vehicles as a result of the proposed modification. As such, any change to operational electricity or fuel use for light vehicles is anticipated to be negligible.

Emission estimates for the use of fuel and materials for the maintenance of the proposed modification are based on one major re-sheeting of the motorway between the M5 Motorway and Richmond Road, 30 millimetres deep, every 15 years. The materials included in the assessment of maintenance requirements included asphalt and bitumen for re-sheeting, as these are anticipated to be the major materials required for maintenance of the widened portions of the Westlink M7.

The proposed modification of the Westlink M7 would impact the number of vehicles on the road, the amount of time those vehicles spend on the road and the traffic flow dynamic. The change in emissions from vehicles during operation compared to the scenario without the road widening are not included in the GHG assessment in this report, as assessment of this scope 3 GHG impact should be assessed at a broader planning level rather than a project-by-project basis. While the forecast traffic volumes along the Westlink M7 would increase as a result of the proposed modification, the overall network performance would improve, congestion would improve, vehicle speeds would generally increase, average travel times would decrease and the segment densities would also decrease (refer to

Operational Traffic and Transport Assessment Technical Report). Higher tailpipe greenhouse emissions can generally be expected with higher traffic volumes, however lower congestion may contribute to lower emissions per car per kilometre travelled.

It is noted that emissions are anticipated to be produced as a result of maintenance activities throughout the asset life. If this continues beyond 2050, it would be incongruous with the NSW Government's objective to achieve net zero GHG emissions by 2050 (NSW EPA) unless net zero emissions alternatives were found by this time for construction plant and equipment and materials sourcing. This should be considered at a broader organisation level by the asset operator.

The estimated emissions from the maintenance of the proposed modification of the Westlink M7 would be equivalent to 0.007 per cent of total NSW annual emissions in 2019. These emissions are anticipated to occur during scheduled maintenance, aligning with maintenance of the wider Westlink M7, which has been assumed to occur every 15 years over a nominal 100-year asset life.

6.2.1 Cumulative impact assessment

The M12 Environmental Impact Statement (EIS) (NSW Roads and Maritime Services, 2019) predicts a total of 114,006 tCO2e emissions per annum for the year of opening (2026) resulting from operation. Excluding tailpipe emissions from road traffic, the average annual estimated emissions during operation of the M12 project is 20,919 tCO2e emissions per annum (20,399 tCO2e per annum from electricity, plus 25,996 tCO2e over 50 years for maintenance). The cumulative impact from operation of both the M12 project and the proposed modification, excluding tailpipe emissions, is 21,021 tCO2e per annum on average. This is equivalent to 0.02 per cent of total NSW annual emissions in 2019.

6.3 Mitigation and management measures

6.3.1 Performance outcomes

The performance outcomes for the GHG assessment for the proposed modification are as follows:

- Understanding of the sources of GHG emissions during the construction and operational phases
- Identification of mitigation measures which can reduce GHG emissions during the construction and operational phases of the proposed modification.

The proposed modification would be designed, constructed, and operated with the aim of achieving these performance outcomes.

6.3.2 Mitigation and management measures

The current CoA that apply to the approved project (Westlink M7) require mitigation and management measures to be implemented (either directly in the conditions or through reference to environmental management plans required).

The mitigation and management measures described in Table 6-3 have been identified to address the impacts identified by the GHG assessment undertaken in this report. These measures would be incorporated into existing environmental management plans where they have not been accounted for already. Proposed amendments to the CoA for the proposed modification are described in **Chapter 8** (Conditions of Approval) of the modification report.

Table 6-3: Mitigation and management measures relating to GHG emissions impacts

New ID	Mitigation and management measure	Phase
GG1	Reduce GHG emissions through the use of GreenPower and/or other renewable energy sources as part of the proposed modification's electricity procurement. Target 100% renewable energy-sourced electricity for operations, and minimum 20% during construction.	Construction Operation
GG2	Opportunities to use low emission construction materials, such as recycled aggregates in road pavement and surfacing, and cement replacement materials will be investigated and incorporated where feasible and cost-effective.	Detailed design

New ID	Mitigation and management measure	Phase
GG3	Construction plant and equipment will be well maintained to allow for optimal fuel efficiency.	Construction
GG4	Raw materials will be managed to reduce energy requirements for their processing. For example, stockpiled materials will be covered or provided undercover storage where possible to reduce moisture content of materials, and therefore the process and handling requirements.	Construction
GG5	Locally produced goods and services will be procured where feasible and cost effective, to reduce transport fuel emissions.	Construction
GG6	Solar construction lighting and variable message signs (VMS) will be utilised during construction where feasible.	Construction
GG7	E10 bioethanol and B5 biodiesel will be utilised where feasible.	Construction
GG8	Purchasing certificates to offset Scope 1 and 2 emissions for construction and maintenance activities will be considered.	Construction, Operation

7.0 Conclusion

The assessment has been prepared to support the modification report and to address the relevant SEARs issued for the proposed widening. These are outlined in **Section 1.2**. Specifically, this report has been prepared to assess the potential impacts of construction and operation of the proposed modification on climate change and GHG and to identify appropriate mitigation and management measures to address the impacts identified. For detail, please refer to **Sections 5.0** and **6.0** for the respective assessments.

Climate change assessment

The proposed modification has eight priority climate-related risks. These risks relate to each of the climate variables (extreme heat, bushfire, drought, extreme rainfall, and flooding and extreme storms) selected. A total of 24 risks were identified in this assessment, however no high or extreme risks were identified. A total of six risks were identified for the construction phase, one of which was a medium risk, and one risk was identified as a priority for the proposed modification. A total of 18 operational risks and two opportunities were identified. Of these risks, four medium risks were identified, and six were identified as a priority. At 2090, 11 risks were rated medium.

Mitigation and management measures were identified for the priority risk statements (as well as other non-priority risks). A number of the measures proposed can be applied to mitigate more than one of the risk statements identified.

It is recognised that while there is uncertainty regarding the extent to which the climate will change into the future, the adaptation actions identified within this report would reduce the impacts of the risks across a range of future scenarios (both emissions pathways and future time frames) and serve to build the resilience of the proposed modification to climate change.

GHG assessment

A GHG impact assessment was undertaken to determine the impacts of the proposed modification and to identify management and mitigation measures to reduce the GHG emissions associated with the proposed modification.

Construction impacts from the proposed modification represent the majority of GHG emissions associated the project lifecycle, as quantified within the scope of this assessment. Construction is estimated to produce 130,701 tCO2e emissions. Operation and maintenance of the proposed modification is estimated to produce 10,162 tCO2e emissions. This is equivalent to 0.1 per cent and 0.007 per cent respectively of total annual GHG emissions in NSW in 2019. The proposed modification would impact the number of vehicles on the road, the amount of time those vehicles spend on the road and their associated GHG emissions, though these have not been quantified in this study.

Opportunities to reduce and mitigate emissions have been recommended in **Section 6.3**.

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Appendix A

Risk Assessment Framework

Appendix A Risk Assessment Framework

Table 7-1: Transport risk likelihood table

Risk Likelihood Table						
Rating	**L6**	**L5**	**L4**	**L3**	**L2**	**L1**
Descriptor / Definition	**Almost Unprecedented**	**Very Unlikely**	**Unlikely**	**Likely**	**Very Likely**	**Almost Certain**
Qualitative Expectation	Not expected to ever occur during time of activity or project	Not expected to occur during the time of activity or project	More likely not to occur than occur during time of activity or project	More likely to occur than not occur during time of activity or project	Expected to occur occasionally during time of activity or project	Expected to occur frequently during time of activity or project
Quantitative Frequency	Less than once every 100 years	Once every 10 to 100 years	Once every 1 to 10 years	Once each year	1-10 times every year	10 times or more every year

Table 7-2: Transport combined consequence table

Combined consequence table						
Rating	**C6**	**C5**	**C4**	**C3**	**C2**	**C1**
Descriptor/ Impact Area	**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**	**Catastrophic**
Health and Safety (Injury and Disease)	Illness, first aid or injury not requiring medical treatment.	Illness or minor injuries requiring medical treatment.	Single recoverable lost time injury or illness, alternate/restricted duties injury, or short-term occupational illness.	1-10 major injuries requiring hospitalisation and numerous days lost, or medium-term occupational illness.	Single fatality and/or 10-20 major injuries/permanent disabilities/chronic diseases.	Multiple fatalities and/or >20 major injuries/permanent disabilities/chronic diseases.
Environment	No appreciable changes to environment and/or highly localised event.	Change from normal conditions within environmental regulatory limits and environmental effects are within site boundaries.	Short-term and/or well-contained environmental effects. Minor remedial actions probably required.	Impacts external ecosystem and considerable remediation is required.	Long-term environmental impairment in neighbouring or valued ecosystems. Extensive remediation required.	Irreversible large-scale environmental impact with loss of valued ecosystems.
Customer Experience/ Operational Reliability	Short duration disruptions affecting part of one transport mode.	Minor disruptions affecting several parts of one transport mode.	Serious disruptions affecting operation of one complete transport mode.	Major disruptions affecting operations of one transport mode with network-wide effects on one or more other modes of transport.	Short duration shutdowns or substantial disruptions affecting multiple transport modes with sector-wide cascading effects.	Extensive shutdowns or extended disruptions with economy-wide effects.
Government/ Stakeholder / Public Trust/ Confidence	Negative article in local media. No discernible reaction/apprehension. Goodwill, confidence and trust retained.	Unease – Series of negative articles in local/state media. Confidence remains with some minor loss of goodwill or trust. Recoverable with little effort or cost. Some continuing scrutiny/attention.	Disappointment – Extended negative local/state media coverage. Confidence and trust dented but are quickly recoverable at modest cost within existing budget and resources.	Concern – Short-term negative state/national media coverage. Confidence and trust are diminished but are recoverable with time, staff effort and additional funding.	Displeasure – Extended negative state/national media coverage. Confidence and trust are damaged but recoverable at considerable cost, time and staff effort.	Outrage – Material change in the public perception of the organisation. Confidence and trust are severely damaged, possibly irreparably, and full recovery both questionable and costly.
Regulatory or Legal Breach	Low-level non-compliance with legal and/or regulatory requirement or duty by individuals or TfNSW.	Minor non-compliance with legal and/or regulatory requirement or duty. Investigation and/or report to authority.	Moderate non-compliance. Subject to comment and monitoring from applicable regulator. Small fine and no disruption to services.	Major breach resulting in enforcement action and/or prohibition notices. Substantial fine and no disruption to services.	Substantial breach resulting in prosecution, fines and/or litigation. Licence or accreditation restricted or conditional affecting ability to operate.	Prosecution leading to imprisonment of TfNSW executive. Loss of operating licence.
Management Effort/ Organisational Fatigue	An event, the impact of which can be absorbed as part of normal activity.	An event, the impact of which can be absorbed but some additional management effort is required.	An event, the impact of which can be absorbed but much broader management effort is required.	Major event which can be absorbed, but substantial management effort is required.	Severe event which requires extensive management effort but can be survived.	Catastrophic event with the clear potential to lead to the collapse of the organisation.
Benefit Realisation of Initiative, Program or Project	No time delay with initiative or project but it will incur a slight decrease in the benefits realised.	Minor delay with the initiative and/or a minor decrease in the benefits realised; or minor delay on the project or another project, with no public implications.	Several delays with the initiative and/or moderate decrease in benefits realised; or completion date missed for non-critical path project.	Major delays with the initiative and/or major decrease in benefits realised; or publicly announced portion/milestone missed or final completion date missed with demonstrable mitigating external circumstances.	Severe delays with initiative, which impacts across divisions and/or significant decrease in benefits realised; or publicly announced portion/milestone missed or final completion date missed on critical path project.	Failure to realise benefits of the initiative which adversely affects the enterprise-wide operations of TfNSW; or publicly announced portion/ milestone significantly missed or final completion date significantly missed on critical path project.
Budget, Costs or Revenue	<$100k	$100k - $1m	$1m - $10m	$10m - $50m	$50m - $100m	>$100m

Table 7-3: Transport Risk matrix

Risk Matrix Evaluation Table								
Risk Ratings A – Very High B – High C – Medium D – Low			Consequence					
			Insignificant	Minor	Moderate	Major	Severe	Catastrophic
			C6	C5	C4	C3	C2	C1
Likelihood	Almost Certain	L1	C	B	B	A	A	A
	Very Likely	L2	C	C	B	B	A	A
	Likely	L3	D	C	C	B	B	A
	Unlikely	L4	D	D	C	C	B	B
	Very Unlikely	L5	D	D	D	C	C	B
	Almost Unprecedented	L6	D	D	D	D	C	C

Appendix B

Climate change context

Appendix B Climate change context

Observed Local Climate Exposure

The proposed modification is located within Greater Sydney. The Metropolitan Sydney Climate change snapshot (AdaptNSW), published in 2014 has a comprehensive summary of Greater Sydney's observed climate as described in Table 7-4.

Table 7-4: Greater Sydney's climate summary

Climate component	Summary
Temperature	• Greater Sydney experiences large temperature variations between Western Sydney, the Blue Mountains and coastal Sydney. • In summer, average temperatures range from 16–18 degrees Celsius (°C) in the Blue Mountains to 22–24°C in Western Sydney. Average summer maximum temperatures range from 28–30°C in Western Sydney to 22–24°C in the Blue Mountains. • In winter, average temperatures range from 12–14°C along the coast to 4–6°C in the upper Blue Mountains. In winter, average minimum temperatures range from 8–10°C along the coast to 0–2°C in the upper Blue Mountains. • An increase in temperature has been observed across the region since the 1960s.
Hot days (maximum temperature above 35°C)	• On average there are fewer than 10 hot days per year across most of Greater Sydney. • Western Sydney experiences an average of 10–20 hot days per year.
Cold nights (minimum temperatures below 2°C)	• Most of Greater Sydney experiences fewer than 10 cold nights per year. • Western Sydney has an average between 10 to 20 cold nights per year. • The upper Blue Mountains typically has over 70 cold nights per year.
Rainfall	• Annual average rainfall is in the range of 800–1200 mm for much of the region. Rainfall is higher in coastal Sydney and the Blue Mountains with a range of 1200–1600 mm per year. • There is typically more rainfall in summer and autumn than in winter and spring. Coastal Sydney and the Blue Mountains experience the greatest seasonal variation in the region. Western Sydney has the most uniform rainfall patterns in the region.
Fire weather	• Severe fire weather conditions are estimated to occur on average one day per year at Sydney Airport and 1.8 days per year at Richmond. These days are more likely to be in summer and spring months.

Climate Modelling

The climate of the broader Sydney metropolitan region, as with global climate trends, is naturally variable. Climate change, however, will lead to shifts beyond this natural variability. Risk assessment based on climate change requires an understanding of the current climate, using historical data for comparison with future climate scenarios. Future climate scenarios are generated and prepared using data from Global Climate Models (GCM). GCMs are tools used for understanding how the climate will respond to changes in GHG emission levels.

Representative Concentration Pathways

The Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental organisation of the United Nations, whose primary objective is to conduct research and assessments in relation to climate change science in order to inform adaptation and mitigation measures. The IPCC has defined four GHG concentration trajectories (outlined in Figure 7-1) known as Representation Concentration Pathways (RCPs) for use in climate modelling and research.

Projections are presented for an emissions scenario or possible pathway, referred to as 'representation concentration pathway' (RCP), each of which reflects a different concentration of global GHG emissions. RCPs have been modelled for low emissions (RCP 2.5), medium emissions (RCP 4.5) and high emissions (RCP 8.5). The RCP 8.5 pathway, which arises from little effort to reduce emissions and represents a failure to prevent warming by 2100, is also closest to the current emissions trajectory. The CAP for the proposed modification has therefore considered RCP 8.5 for the emissions scenario for appropriate time periods of 2030 and 2090. Conversely, the RCP 2.6 pathway is generally considered the most appropriate climate scenario for considering transition risks as it assumes drastic action in terms of climate policy, emissions regulation/reduction and technological growth and development.

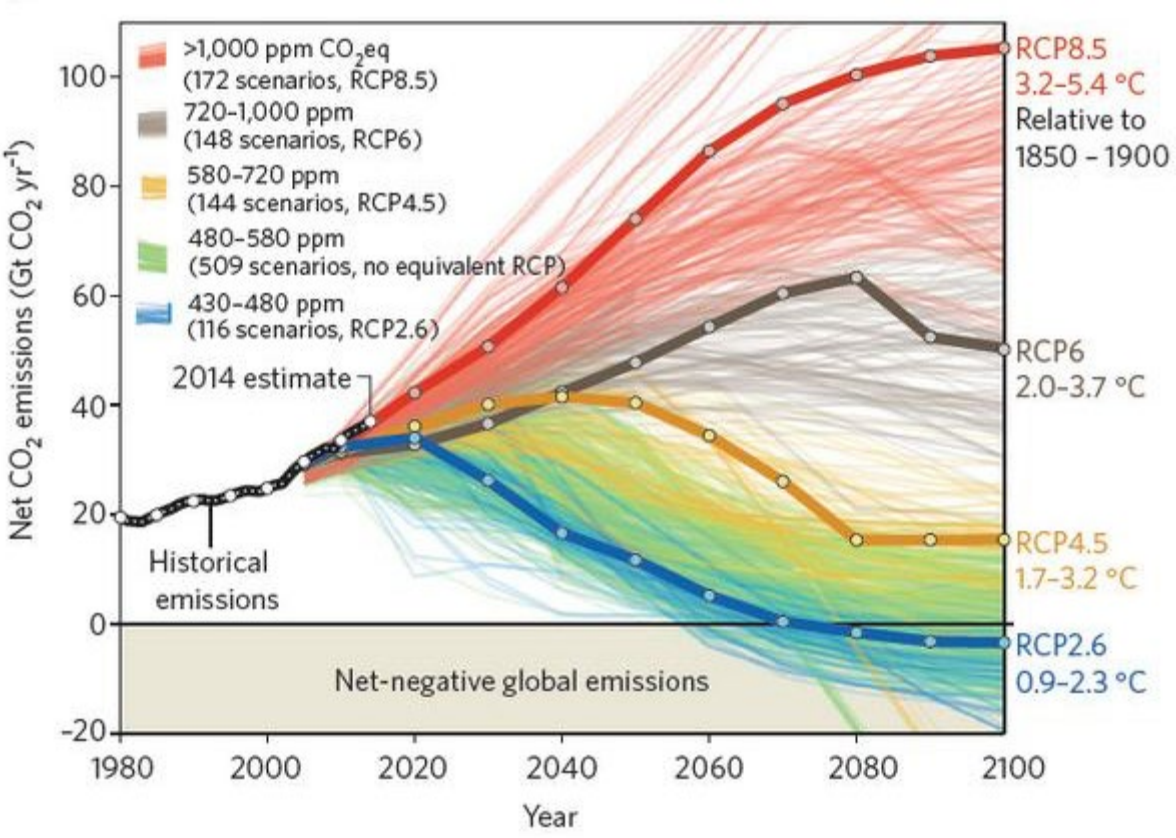

Figure 7-1: Carbon dioxide (CO_2) Concentrations from Global Observations[1]

Climate Change Projections

The following table presents the associated climate change projections based on high emissions scenarios, Representative Concentration Pathway (RCP) 8.5 and the *Special Report on Emissions Scenarios* (SRES) A2. Furthermore, provided data is presented as the median (50th percentile) and has included the 10th to 90th confidence percentiles to provide the likely range for climate data.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM) have published climate change projections for Australia based on published datasets and

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o Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world – Technical Report
org/index.htm

emissions scenarios specific to relevant locations defined as 'clusters' across the country. The entirety of the assessment scope falls within boundaries of the East Coast cluster region (Southern sub-cluster) (the CSIRO and the Bureau of Meteorology). Projections for a full range of variables are only provided for the 2030 to 2090-time horizons for the cluster reports. The 2090-time horizon serves as a comparison to understand how the climate may change for some of the longer life design elements.

NARCliM (NSW and ACT Regional Climate Modelling) projections were delivered in 2014 and provided high resolution climate change projections across NSW (Adapt NSW). The projections are for the 2030 and 2070 time-horizons and are similar to RCP 8.5 scenario projections. Projections for 2070 have been used to inform the 'long term' scenario of 2090.

While RCP 8.5 represents the most conservative emission scenarios, it is considered appropriate for reference as the past decade of observed emissions have been tracking closest to these emission scenarios. In addition, over the next 15 years, in the absence of global action to curb emissions, this trajectory is unlikely to change significantly, suggesting that the most extreme emissions scenario is most likely to occur (as a minimum) through to 2030.

The longer-term projections at the 2090 and 2090 timescales provide an indication of the direction of the projected 2050 trends from the 2030 projections.

Table 7-5: Climate change projections for Sydney

Climate variable	Baseline (period 1986 2005)	CSIRO & BoM Summary of regional projections (2030 & 2090)[2]	NARCliM Summary of regional projections (2030 & 2070)[3,4]
Mean temperature change	Summer 22-24°C Winter 12-14°C	2030: Increase by 1.0°C (range of 0.7°C to 1.3°C), with Max and Min temperatures increasing by up to 1.1°C and 1.0°C respectively 2090: Increase by 3.7°C (range of 2.9°C to 4.6°C), with Max and Min temperatures increasing by up to 3.8°C and 3.8°C respectively	2030: increase by 0.7°C (range of 0.5°C to 0.8°C) with Max and Min temperatures both increasing by up to 0.7°C. 2070: increase by 2°C (range of 1.5°C to 2.4°C) with Max and Min temperatures both increasing by up to 2.0°C.
Extreme heat	3.1 days above 35°C (CSIRO & BOM cluster) 10-20 days above 35°C (NARCliM)	Extreme heat days and heat waves are anticipated to increase in intensity and frequency. Average number of days above 35°C for coastal Sydney (nearest available location with data) are projected to increase from 3.1 to 7.4 days (range of 7.1 to 8.1 days) in 2030 under RCP4.5; and 14.1 days (range of 11.3 to 18.1 days) in 2090 under RCP8.5	Average number of days above 35°C forecast to increase by 4 days in 2030 and continue to rise to an additional 11 days by 2070.
Solar radiation	N/A	2030: 0.8% change (range of -0.7% to 2.7%) 2090: 1.3% change (range of -1.2% to 3.4%)	N/A
Mean rainfall change	High variability from year to year, however annual	2030: -1% change (range of -11% to 6%) across the region	2030: +1.7% change (range of -13% to 18%)

[2] Projections are based on an RCP8.5 emissions scenario.
[3] Projections are based on SRES A2 emissions scenario, which is broadly in line with the RCP8.5 scenario. Projections for 2070 have been used to inform the 'long term' scenario of 2090.
[4] CSIRO and NARCliM, as different organisations have each selected two different time horizons. Two different future time horizons were selected to show broad trends across the future scenarios.

Climate variable	Baseline (period 1986 2005)	CSIRO & BoM Summary of regional projections (2030 & 2090)[2]	NARCliM Summary of regional projections (2030 & 2070)[3,4]
	rainfall between 800-1600mm across Sydney. .	2090: -3% change (range of -20% to 16%) across the region	2070: +8.9% change (range of -8.7% to 24.2%)
Extreme rainfall – flooding	N/A	Extreme rainfall to increase in intensity	
Sea level rise (SLR) – coastal flooding	N/A	2030 increase by 0.14m (range of 0.10 to 0.19m) 2090 increase by 0.66m (range of 0.45 to 0.88m)	N/A
Drought	N/A	Time spent in drought conditions to increase	
Wind and hail	Strong annual cycle of thunderstorms with accompanying winds and tornados, with maximum occurrence during warmer months.	2030: Minimal change in wind speed of -0.5% (range of –2.3% to 1.9%) 2090: Substantial Increase in wind speed of -1.1% (range of -6.9% to 4.2%)	N/A
Extreme storms (east coast lows)	Around 4 per year for the cluster.	East coast lows expected to decrease in frequency but increase in intensity and travel further south down the NSW coastline	
Bushfires	Average annual FFDI 5.5 (Sydney Airport) and 7.1 at Richmond. Number annual severe (FFDI>50) fire weather days 1.0 (Sydney Airport) and 1.8 for Richmond.	The sum of daily Forest Fire Danger Index (FFDI) per annum is expected to increase by around 6% (coastal Sydney) in 2030 and 17% (coastal Sydney) in 2090. 2030: severe fire weather days +1.5 days (range of +1.5 to +1.6 days) 2090: severe fire weather days +2.3 days (range +1.4 to +3.0 days)	2030: severe fire weather days are not expected to change (range of -0.8 to 1.2 days) 2070: severe fire weather days +0.6 days (range -0.7 to 2 days)
Relative humidity	N/A	2030: Minimal change in humidity of -0.6% (range of -1.4% to 0.9%) 2090: Minimal change in humidity of -1.5% (range of -3.8% to 1.3%)	N/A

Appendix C

Climate change risk register

Appendix C Climate change risk register

Table 7-6: Construction risk register and mitigation measures

Risk ID	Risk Statement	Likelihood	Consequence	Risk Rating	Mitigation measures
C-T1	Extreme heat events leading to health and safety concerns for construction staff (e.g. heat stress, dehydration) resulting in stop work orders and project delays.	Unlikely	Minor	Low	Delivery schedule to factor potential delays associated with this risk into delivery schedule. Extreme heat days which stop work are currently an average of four days/year, so the impacts to the project program is limited. Operational procedures exist to manage this risk such as: timing of work – scheduling to maximise use of night shifts during summer months to reduce; adjusting working hours or construction activities if extreme heat forecast.
C-P1	Extreme rainfall events overwhelm construction control measures resulting in environmental impact.	Unlikely	Minor	Low	Construction control measures to consider regulatory requirements and incorporate monitoring inspections to ensure performance meets compliance requirements.
C-P2	Extreme rainfall and wind events leading to construction interruption resulting in project delays for day to day works.	Likely	Minor	Medium	Delivery schedule to allow contingency for potential delays associated with extreme rainfall. Clear communication of contractual expectations that there is an increased likelihood of these extreme rainfall and wind events occurring during construction.
C-B1	Increasing bushfire frequency and intensity resulting causing poor air quality and reduced visibility on construction sites leading to safety concerns and project delays.	Unlikely	Minor	Low	Contractor to consider this risk and factor into work planning. Safety procedures outline safe work conditions.
C-B2	Increasing bushfire frequency and intensity resulting in damage to construction sites, ancillary assets and infrastructure, or supply chains.	Unlikely	Minor	Low	Contractor to consider this risk and factor into work planning.

Risk ID	Risk Statement	Likelihood	Consequence	Risk Rating	Mitigation measures
C-D1	Period of drought leading to water restrictions resulting in reduced water availability for construction period.	Unlikely	Minor	Low	Contractor to consider this risk and factor into work planning.

Table 7-7: Operational risk register and mitigation measures

Risk ID	Risk Statement	2030 Likelihood	2030 Consequence	2030 Risk Rating	2090 Risk Rating	Mitigation measure
T1	Extreme heat events leading to health and safety concerns for motorway staff, contractors and road users (e.g. heat stress, dehydration).	Likely	Moderate	Medium	Medium	• Continue to apply existing operational procedure whereby work health and safety settings are adjusted accordingly during extreme temperatures, including reducing/adjusting work hours and requiring personal protective equipment. • Investigate opportunities to provide additional shading for road users who may be exposed to high temperatures for prolonged periods (e.g. breakdown bays)
T2	Extreme temperatures leading to increased stress of carriageway to bridge connections resulting in structural failure of motorway.	Very unlikely	Severe	Medium	Medium	• Routine maintenance and inspections are undertaken of key structural components. Maintenance programs are to be augmented to account for extreme weather events. • Risk assessments undertaken for key scheduled works to include extreme heat impacts and mitigation measures identified as a result implemented.
T3	Extreme heat/extreme weather leading to higher rates of vehicle breakdown resulting in demand on incident response crews.	Unlikely	Minor	Low	Medium	• Easing congestion from the proposed modification will reduce traffic incidents and reduce demand on incident response crews. • Review operational controls (e.g. monitor and increase resourcing/ capacity of response crews) ahead of expected extreme heat events

Risk ID	Risk Statement	2030 Likelihood	2030 Consequence	2030 Risk Rating	2090 Risk Rating	Mitigation measure
T4	Extreme weather events leading to unexpected delays in planned maintenance and/or minor construction.	Unlikely	Minor	Low	Low	• Maintenance programs augmented to account for extreme weather events.
T5	Increase in paved surfaces exacerbating urban heat island effects resulting in cumulative increase in extreme temperatures.	Unlikely	Minor	Low	Medium	• Appropriate landscape design to consider future climate impacts relating to drought (i.e. tolerant species) to ensure ongoing shading where possible • Consultation with Transport to explore options to reduce the heat island effect for the proposed modification
T6	Heat-related failure of intelligent transport systems (ITS) and critical roadside technology, leading to service interruption.	Very unlikely	Moderate	Low	Medium	• Temperature is considered and managed as an operational risk and work settings adjusted accordingly. • Routine maintenance and inspections undertaken of key structural components. • Explore options for implementing redundancy (e.g. batteries) into the ITS.
T7	Prolonged duration of heatwave leading to increased energy demands and peak usage period consumption, resulting in unplanned cost increases.	Unlikely	Minor	Low	Medium	• Variable messaging systems can be turned off and use of default road signage can occur. • Energy efficient LED lighting installed. • Explore low power mode options for electrical equipment to reduce energy demand.
P1	Increased rainfall intensity leading to a higher frequency of floods resulting in flooding and reduction or loss of infrastructure service.	Very unlikely	Moderate	Low	Medium	• Flood modelling incudes sensitivity test to account for increased rainfall intensities associated with climate change. • Drainage package to be designed considering the projected flooding impacts from the climate change projections. • Revise flood modelling to account for 2090 climate change projections.

Risk ID	Risk Statement	2030 Likelihood	2030 Consequence	2030 Risk Rating	2090 Risk Rating	Mitigation measure
P2	Increased rainfall intensity leading to scour of embankments and cuttings resulting in landslips causing damage to infrastructure.	Likely	Moderate	Medium	Medium	• Routine maintenance and inspections undertaken of key structural components, and this is enhanced following extreme events. • Explore options for stabilising and/or reducing the slope of embankments within the design of the proposed modification.
P3	Increased rainfall intensity leading to higher velocity runoff flows through creeks resulting in scour and damage to the asset.	Very unlikely	Moderate	Low	Low	• Pollution control basins subject to regular maintenance regime to ensure detention and performance requirements.
P4	Increased periods and volumes of extreme rainfall leading decreased effectiveness of pollution control basins resulting in environmental impact.	Very unlikely	Moderate	Low	Low	• Pollution control basins subject to regular maintenance regime to ensure detention and performance requirements.
P5	Road agencies and local council do not respond to climate impacts, creating network wide disruptions and restricting access to motorway.	Unlikely	Minor	Low	Low	• Transport capital works program includes projects to mitigate flood risk across Sydney.
B1	Bushfires leading to reduced air quality and visibility resulting in safety concerns for road users, staff and contractors.	Unlikely	Minor	Low	Low	• Maintenance programs augmented to account for extreme weather events. • Variable signage installed on the which can manage vehicle speeds. • Control room has evacuation procedures in the event of smoke infiltration.

Risk ID	Risk Statement	2030 Likelihood	2030 Consequence	2030 Risk Rating	2090 Risk Rating	Mitigation measure
B2	Increasing bushfire frequency and intensity resulting in damage to the motorway corridor and/or ancillary assets and infrastructure.	Very unlikely	Moderate	Low	Medium	• Business continuity plan is in place and is utilised in the event an evacuation of offices is required. • Operational procedures currently include ongoing bushfire hazard assessment and mitigation. • Proposed modification would provide greater access for emergency services in the Region and improve journey times by increasing the lane capacity.
D1	Period of drought leading to water restrictions resulting in reduced water availability for maintenance activities and landscaping.	Likely	Insignificant	Low	Low	• Drought tolerant species selection for landscaping. • 150,000 litre (L) rainwater tanks available for irrigation use. • All watering is completed using a water cart.
D2	Reduced soil moisture and more frequent wet/dry cycles leading to cracking (e.g. movement of culverts, foundations, road base) resulting in damage to infrastructure.	Very Unlikely	Moderate	Low	Low	• Maintenance programs augmented to account for extreme weather events. • Existing tolerances would enable safe operation of bridge joints in extreme heat circumstances. • Infrastructure designed to meet performance specifications that incorporate climate change factors. • Continuous reinforced concrete pavement more resilient.
S1	Extreme weather events leading to damage and disruption to electrical equipment (lighting, toll collection systems, monitoring cameras).	Likely	Insignificant	Low	Medium	• Existing signage reverts variable speed signage to default speeds following interruption to variable messaging systems. • Installed electrical equipment can connect generators to roadside cabinets in the event of wider power outages. • Lightning protection systems/earth proofing installed on major electrical equipment.

Risk ID	Risk Statement	2030 Likelihood	2030 Consequence	2030 Risk Rating	2090 Risk Rating	Mitigation measure
S2	Extreme storms and winds leading to increased instances of debris on the motorway resulting in health and safety concerns for road users.	Unlikely	Minor	Low	Medium	• Emergency response teams have procedures for clearing debris from the roadway. • Vegetation maintenance in corridor removing dead/dying trees with potential to impact roadway.

Appendix D

GHG Calculations (CERT Printout)

Carbon Estimate & Reporting Tool

About Infrastructure and Services

Within Transport for NSW (TfNSW) the Infrastructure and Services Division (I&S) is responsible for delivering cost-effective and sustainable transport solutions to support the growth of NSW, enhancing its natural and urban environments to provide tangible benefits to customers.
I&S delivers a diverse portfolio of projects ranging in type and size. This includes:
• Infrastructure projects – rail, light rail, commuter car parks, station upgrades etc.
• Fleet procurement – rollingstock, ferries etc.
• Power supply upgrades
In addition to project delivery, I&S delivers environmental, urban design, heritage, sustainability, property, quality management, safety management and commercial support services.

About this tool

This Carbon Estimate and Reporting Tool (CERT) has been developed to provide consistency in GHG assessment and reporting across all I&S projects and streamline and simplify the GHG assessment process for both I&S and its supply chain.
The tool has been structured to enable the user to input data across a range of stages, from SDR (or equivalent design stage) and CDR (or equivalent design stage) through to construction (at 6-month intervals) and operation (operational energy and maintenance). Use of the CERT will be required on new projects with a value ≥$15 million.
The tool has two main objectives:
1) To estimate a project's construction phase GHG emissions profile at detailed design through to construction and operation.
2) To encourage the investigation and implementation of GHG reduction (mitigation) measures.
The tool has been structured across 6 core tabs:
a) Introduction (this – light orange - tab) – provides an overview of the tool.
b) Navigation (yellow tab) – enables the user to select their relevant input reporting stage (SDR, CDR etc).
c) Project detail (grey tab) – requires the user to input relevant project information, including any project-specific reduction targets, and includes a section for data to be validated and approved prior to submission.
d) Data inputs (orange tabs) – comprises the core data entry and calculation component of the tool and includes calculators associated with usage and mitigation for: Materials; Energy Use; Waste; Land Use/Vegetation. Two tabs are included to deal specifically with operational energy and maintenance aspects of the project.

Why we built this tool

The NSW Long Term Transport Master Plan sets a clear strategic direction for transport in NSW for the next 20 years and sets actions for implementation across the transport sector. Reducing greenhouse gas (GHG) emissions and managing energy use is identified as a key transport challenge in the Plan.
TfNSW's Transport Environment and Sustainability Policy Framework includes Energy Management as a key theme, with an action to "identify GHG emission sources at project planning stage and measures taken, where cost effective, to reduce these emissions through design and construction processes."
I&S is also committed to sustainability and the practical implementation of sustainability initiatives across its projects.
Historically, the Greenhouse Gas Inventory Guide for Construction Projects has required projects to establish GHG assessment boundaries as per the GHG Protocol Corporate Accounting and Reporting Standard. I&S has undertaken a materiality exercise based on previous I&S project GHG assessments to determine the typical material GHG emitting activities. This has informed a prescriptive approach to determining the GHG emitting activities to be included in I&S project assessments.
I&S is also introducing the concept of 'forecast', 'base case' and 'actual' to the GHG assessment and reporting process. This will allow reduction from mitigation measures to be demonstrated, and will meet ISCA's IS Rating Tool 'Reference Design' or 'Base Case'

Useful links and references

A comprehensive user guide has been developed to assist users in completing the tool. If you do not have a copy of the guide please contact sustainability@transport.nsw.gov.au to request a copy.

CERT makes reference to the TAGG Greenhouse Gas Assessment Workbook for Road Projects which can be accessed here.

TfNSW Transport Environment and Sustainability Policy Framework

TfNSW Transport Projects Sustainability Framework – Key performance indicators and targets

NSW Long Term Transport Master Plan

A list of common conversion factors is included in the formulas and background worksheet.

e) Detailed results (red tab) – there are 2 red tabs, both of which provide report summary information including useful tables and graphs. The detailed results tab also provides a breakdown of scope 1 and scope 2 emissions for use towards the ISCA Ene-1 credit.
f) Dashboard (red tab) – The dashboard provides a performance summary of the relevant project stages in comparison to a base case (an auto-generated business as usual scenario) and analyses performance against project reduction targets.

* In addition to the above, there are six empty worksheets at the back of this CERT

Version control
CERT2.1.00 for publication by TfNSW, 30 June 2017

Key updates to CERT v2 include:
- State based electricity emission factors added
- Updated National Greenhouse Account Factors
- Updated materials emission factors using Australian EPD's where available
- Inclusion of additional materials such as timber products and synthetic reinforcement fibres
- Changes to aggregates, asphalt products and steel products
- Inclusion of GHG emissions from street tree removal
- Inclusion of revegetation and street tree planting carbon sequestration
- Changes to the mitigation sections
- Inclusion of an Operational energy reporting tab
- Inclusion of a Maintenance reporting tab

Developed by:

energetics

Carbon Estimate & Reporting Tool

Data input: Colour Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Select reporting period: SDR (or equivalent) design

Quick guide to using this tool:

A First, fill in the project details tab.
B Then come back to this tab and select the relevant reporting period in the blue field above.
C Click the button <Go to Data input> to get taken to the correct data entry tab.
D Send completed reports to TfNSW
E Repeat data entry for each relevant period
F View (intermediate) results on the "Detailed results" and "Dashboard" tabs

Carbon Estimate & Reporting Tool

Project details

Project name	M7 Widening	
Project value		
Primary project type	Civil infrastructure	
Secondary project type	select a project type	
State/Territory where the project is constructed	New South Wales	
Project geographical scale, primary	27	other, please specify
		km
Project geographical scale, secondary	*[enter value]*	select a unit
Expected construction start date	1 January 2022	
Expected construction date of completion	31 December 2024	

Note: The CERT tool can deal with a maximum construction period of five years

User comments

Note: This informs the electricity emission factor

Project description

Widening within the existing median of the Westlink M7 from approximately 140 metres south of the Kurrajong Road overhead bridge at Prestons (southern end) to the Westlink M7 bridge at Richmond Road in Oakhurst/Glendenning (northern end)
Widening of 24 existing Westlink M7 bridges within the median alignment (centre of bridges)
21 bridges widened both northbound and southbound. 3 bridges widening in one direction only
Widening would not occur through the Light Horse Interchange
Relocation or upgrade of existing drainage infrastructure and establishment of new drainage infrastructure
Use of construction ancillary facilities along the corridor

User comments

Define your GHG assessment and mitigation requirements

Select all that apply	*Enter reduction target(s) below for selected items*
☐ SDG v3.0	
☐ I&S Corporate target	
☐ TSR	
☐ ISCA	
☐ Other Contract Requirement	
☐ Other (please specify in user comments)	

Maximum GHG reduction target you are required to achieve: 0.0%

If you have set an internal (informal) GHG reduction target, you can enter this here to keep track of progress towards this target.
Internal GHG % reduction requirement:

User comments

Please note: ISCA Ene-1 credit covers construction and operational emissions and requires a % reduction against an ISCA verified base case. Therefore the reduction targets and data in both tools may not be directly comparable.

Contact information

	Primary contact	*Secondary contact (if applicable)*
Person(s) that entered the data	*[Name]*	*[Name]*
Position	*[Position]*	*[Position]*
Organisation	*[Name of your organisation]*	*[Name of your organisation]*
Contact details		
Address	*[Address line 1]*	*[Address line 1]*
	[Address line 2]	*[Address line 2]*
City	*[City or suburb]*	*[City or suburb]*
State	*[State]*	*[State]*
Postcode	*[Postcode]*	*[Postcode]*
Telephone or mobile contact number	*[telephone number]*	*[telephone number]*
E-mail	*[e-mail]*	*[e-mail]*
	Site address	*Project location*
Address	*[Address line 1]*	*[Address line 1]*
	[Address line 2]	*[Address line 2]*
City	*[City or suburb]*	*[City or suburb]*
State	*[State]*	*[State]*
Postcode	*[Postcode]*	*[Postcode]*

User comments

Data validation

Optional: describe type of validation

Data validated by	*[Name]* *[Position]* *[Organisation]*	
Signature		Date signed
Sign-off by	*[Name]* *[Position]* *[Organisation]*	
Signature		Date signed

User comments

For internal use by I&S only!

Report validated and accepted by: *[Name]*, *[Position]*

TINSW comments

GOVERNMENT NSW

Date accepted

Carbon Estimate & Reporting Tool

Project	M7 Widening
Reporting period	**SDR (or equivalent) design**
Date of data entry	**18 October 2021**

Legend
Concrete Click text to go to calculator
250.0 Calculated result
Cell for user input
Cell for user commentary

Materials

Concrete & reinforcement	**Quantity**	**Unit**	**Transport scenario**	**Evidence / data source / comments**
Ready mixed concrete	106157.1	m^3	Default domestic	Assumption: strength grade 40MPa. See "Sheet for notes (Materials)"
Reinforcement steel bars - Australian products	7.093	tonnes	Default domestic	See "Sheet for notes (Materials)"
Reinforcement steel mesh - Australian products		tonnes		
Reo steel; low relaxation strand and wire - Australian products		tonnes		
Precast concrete	22451.7	tonnes	Default domestic	Assumption: strength grade 40MPa. See "Sheet for notes (Materials)"

Steel	**Quantity**	**Unit**	**Transport scenario**	**Evidence / data source / comments**
Structural steel, beams and columns - Australian products	729	tonnes	Default domestic	See "Sheet for notes (Materials)"
Structural steel, hot rolled coil - Australian products		tonnes		
Structural steel, merchant bar - Australian products		tonnes		
Structural steel, plate - Australian products		tonnes		
Galvanised steel - Australian products		tonnes		
Total steel rails (heavy & light)	-	track m		

Asphalt & Aggregates	**Quantity**	**Unit**	**Transport scenario**	**Evidence / data source / comments**
Asphalt	84,655	tonnes	Default domestic	Assumption: Hot mix asphalt, 0% RAP. See "Sheet for notes (Materials)"
Coarse aggregates				
Recycled (coarse) aggregates				
Ballast				
Sand				
Manufactured sand				
Recycled crushed glass				

Piping	**Quantity**	**Unit**	**Transport scenario**	**Evidence / data source / comments**
Reinforced concrete pipes	0	m		
Steel pipe and tube	0	m		
HDPE pipes	0	m		
PVC pipes	0	m		
Other pipes	If other materials are used for piping, then define these under 'Additional materials' below			

Timber	**Quantity**	**Unit**	**Transport scenario**	**Evidence / data source / comments**
Timber, Structural (softwood)				*If type of wood is unknown, select softwood*
Timber, Structural (hardwood)				
Timber, MDF / Particleboard				
Timber, Plywood				
Timber, Cross-Laminated Timber (CLT)				

Other materials	**Quantity**	**Unit**	**Transport scenario**	**Evidence / data source / comments**
Aluminium		tonnes		
Glass	0.0	m^2		
Ceramics (e.g. tiles)		tonnes		
Electrical cables	0.0	m		

Additional materials	**Quantity**	**Unit**	**Material Emission factor (kg CO_2e/unit)**	**Evidence / data source / comments**
Sprayed bitumen	345.5	m3	0.4	Emissions factor sourced from IS Materials Calculator - Aus
Select Material and Topsoil import	147040.7	m3	0.0	Emissions factor sourced from IS Materials Calculator - Aus

Transport mode(s) for Additional materials	**Quantity (tonnes)**	**Avg. Distance (km)**	**Transport task**	**Unit**	**Evidence / data source / comments**
Rigid truck	345.5	50	17,274	tkm	Transport for bitumen assumed to be same as default transport distance asphalt. Assumed rigid truck transport mode.
Articulated truck	169,832.0	100	16,983,204	tkm	Transport for bitumen assumed to be same as default transport distance and mode for ballast. Assumed same density as inert waste.
Shipping			0	tkm	
Train			0	tkm	

Materials - Mitigation calculator

Materials related mitigation measures	**Quantity**	**Unit**	**Emission factor (kg CO_2e/unit)**	**Net mitigation (t CO_2e)**	**Evidence / data source / comments**
				0.0	
				0.0	
				0.0	
				0.0	
				0.0	
				0.0	

Value engineering is not available at SDR stage

Energy use

Energy use	**Quantity**	**Unit**	**Emission factor (kg CO_2e/unit)**	**Evidence / data source / comments**
Electricity use, on-site total	5841.4	MWh	960	See "Sheet for notes (Energy)"
Diesel consumption for site vehicles	681.5	kL	2849	See "Sheet for notes (Energy)"
Diesel consumption for stationary plant and equipment	1179.7	kL	2849	See "Sheet for notes (Energy)"
Diesel consumption for mobile plant and equipment	7673.1	kL	2849	See "Sheet for notes (Energy)"
Total of other fuels consumed on-site in site vehicles, stationary and mobile plant	0.0	kL		

Energy use - Mitigation calculator

Energy use related mitigation measures	**Quantity**	**Unit**	**Emission factor (kg CO_2e/unit)**	**Net mitigation (t CO_2e)**	**Evidence / data source / comments**
On-site renewable energy generation			0.0	0.0	*On-site generation can only be claimed if the generated electricity is consumed within the project and you are not selling any renewable energy certificates*
Change in electricity use			0.0	0.0	
Change in diesel consumption for site vehicles			0.0	0.0	
Change in diesel consumption for stationary plant			0.0	0.0	
Change in diesel consumption for mobile plant			0.0	0.0	
Change in other fuels			0.0	0.0	

Transport scenario
1 Default domestic — Reinforcement steel bars - Australian products
2 Default imported — Reinforcement steel bars - imported products
3 User defined — Reinforcement steel mesh - Australian products
Reinforcement steel mesh - imported products
If not imported
1 Default domestic — Reo steel; low relaxation strand and wire - Australian products
Reo steel; low relaxation strand and wire - imported products
2 User defined

If always imported
1 Default imported
2 User defined

Units		Result
Structural steel, beams	track meters 1	1
Structural steel, bear	tonnes 2	1
Structural steel, hot rolled coil - Australian products		
Structural steel, hot rolled coil - imported products		
Structural steel, merchant bar - Australian products		
Structural steel, merchant bar - imported products		
Structural steel, plate - Australian products		
Structural steel, plate - imported products		
Galvanised steel - Australian products		
Galvanised steel - imported products		

Units		Result
	m^3 1	0
	tonnes 2	0
		0
		0
		0
		0

Transport Reinforced concrete pipes
Result 1
Transport Galvanised steel
Result 2
Transport Steel rails 1
Result 2

Units		Result	Density cr	Total mass (tonnes)
	m^3 1	0	0	0
	tonnes 2	0	0	0
		0	0	0
		0	0	0
		0	0	0

Units	Result
1 kg	1
2 tonnes	2
3 m	3
4 m^2	4
5 m^3	5
6 tkm	

Units	Result
1 kWh	1
2 MWh	2
6 kL	

Units		EF (kg CO2e/unit)									
1	kWh elec	0.96	kWh elec	0.96	GJ diesel	73.8	GJ diesel	73.8	GJ diesel	73.8	
2	MWh elec	960	MWh elec	960	kL diesel	2849	kL diesel	2849	kL diesel	2849	
3	GJ diesel	73.8	% of total	56077.2	% diesel	19414.3	site vehicl	% diesel	33606.05946	stationary	% diesel	218582	mobile
4	kL diesel	2849									
5	GJ petrol	71.4									
6	kL petrol	2442									

Change in use of biodiesel			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			0.0	0.0	
			0.0	0.0	

Total net mitigation 0.0 t CO_2e / year

Construction energy use related offset measures	Quantity	Unit	Offset Emission factor (kg CO_2e/unit)	Offsets mitigation (t CO_2e)	Evidence / data source / comments
Green Power / renewable electricity purchased			0.0	0.0	
Green energy certificates			0.0	0.0	
Carbon offsets		t CO_2e	1000.0	0.0	

Total offsets mitigation 0.0 t CO_2e / year

Waste generated

Waste related emissions	Quantity	Unit		Evidence / data source / comments
Transport of waste to landfill	192590.4	tonnes	assumes 50 km to landfill site	
Construction and demolition waste to landfill: inert waste (concrete, masonry, glass, metals)	165245.7	m3		See 'Sheet for notes (Materials)' . Assume all exported material goes to landfill.
Construction and demolition waste to landfill: timber, vegetation waste	8880.0	m3		See 'Sheet for notes (Materials)' . Assume all exported material goes to landfill.
Construction and demolition waste to landfill: mixed waste	0.0	m3		Mixed waste, e.g. office waste, considered negligible.

Waste - Mitigation calculator

Waste related mitigation measures	Quantity	Unit	Emission reduction factor (kg CO_2e/unit)	Net mitigation (t CO_2e)	Evidence / data source / comments
Transport of waste to recycling centre	0.0	tonnes	assumes 22 km to recycling centre		
Waste to off-site recycling centre					
"Waste" re-used on-site					
				0.0	
				0.0	
				0.0	
				0.0	
				0.0	

Land use / Vegetation clearing

Land use / Vegetation clearing related emissions	Quantity	Unit	Evidence / data source / comments
Total area of vegetation cleared	7.48	ha	HOLD POINT. Biodiversity specialists to provide data after draft GHG assessment submission.

7	GJ LPG	64.2
8	kL LPG	1650
9	GJ ethanc	64.3
10	kL ethano	2129
11	GJ biodies	0.3
12	kL biodies	9

kWh elect	0.96		kWh elect	0.96
MWh elec	960		MWh elec	960
t CO2e	1000		% of total	56077.16246

Units		Density conversion	Total mass (tonnes)	EF (kg CO2e/t)	t CO2e
tonnes	1		192590	6.45	1242.2
m3	2		0	2.838	0.0
		1	190859	0	0
		0.195	1732	600	1038.96
		1.195	0	200	0
		landfill	192590 tonnes		2281 t CO2e

	1	0	0
		0	0

Units		Result
kg	1	4
tonnes	2	1
m^3	3	2
tkm	4	3
		4
recycling		0 tonnes

Total emissions due to carbon sequestration loss			2,232	t CO_2e
Extra emissions from fuels used for clearing and grubbing (Australian methodology)			34	t CO_2e
Total street trees cleared	-	trees		
Total emissions due to carbon sequestration loss			-	t CO_2e

Revegetation - Land use Mitigation calculator

Carbon sequestration related mitigation measures
Sequestration from reveoetation of the proiect site is not included in line with the Australian method outlined in the TAGG 2013 Workbook. Link to TAGG 2013 Workbook

Reveoetation related sequestration	Quantitv	Unit		Evidence / data source / comments
Total area of revegetation	-	ha		
Net sequestration due to revegetation			- t CO_2e	
Total street trees planted	-	trees		
Net sequestration from additional street tree planting			- t CO_2e	

End of Main data entry

Go back to the top

Operational energy

Carbon Estimate & Reporting Tool

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Project	M7 Widening
Reporting period	Energy use modeled over asset lifetime
Date of data entry	18 October 2021

Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Operational energy totals - BASE CASE

Asset service life 100 years

	Quantity	Unit		Quantity	Unit
Annual operational energy use	0.0	GJ/year	Total operational energy use over asset life	0	GJ
Annual operational greenhouse gas emissions; scope 1	0.0	t CO_2e/year	Total operational greenhouse gas emissions over asset life; scope 1	0	t CO_2e
Annual operational greenhouse gas emissions; scope 2	0.0	t CO_2e/year	Total operational greenhouse gas emissions over asset life; scope 2	0	t CO_2e
Annual operational greenhouse gas emissions; scope 3	0.0	t CO_2e/year	Total operational greenhouse gas emissions over asset life; scope 3	0	t CO_2e
Annual operational greenhouse gas emissions; total	0.0	t CO_2e/year	Total operational greenhouse gas emissions over asset life; total	0	t CO_2e

Copy Base Case data to Forecast Optimised

Base Case - Estimated BAU energy use

Project	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
TOTAL project						
Annual electricity consumption			Electricity		0	GJ/year
Annual diesel consumption			Diesel		0	GJ/year
Annual natural gas consumption			Natural gas		0	GJ/year
Annual LPG consumption			LPG		0	GJ/year
Annual petrol consumption			Petrol / ULP		0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10'		0	GJ/year
					0.0	GJ/year

WARNING!!! EITHER fill in the project totals above OR fill in the breakdown per project element below. When values are entered for the total project (above) the breakdown (below) is disregarded!

Breakdown into project elements	Quantity	Unit	Energy source	Evidence / data source / comments		
[Enter project element I]						
[please specify]				e.g. traction power, rolling stock	0	GJ/year
[please specify]				e.g. lighting, HVAC, vertical transport	0	GJ/year
[please specify]				e.g. signalling, communications, fire, hydraulics	0	GJ/year
[please specify]				e.g. tunnel power, ventilation	0	GJ/year
[please specify]				e.g. retail, front-of-house, back-of-house	0	GJ/year
[please specify]				e.g. miscellaneous power	0	GJ/year
[please specify]				e.g. diesel for emergency back-up generators	0	GJ/year
[please specify]				e.g. diesel for vessels	0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year

Subtotals [Enter project element I]				
Electricity	0.0	GJ/year	0.0	t CO_2e/year
Diesel	0.0	GJ/year	0.0	t CO_2e/year
Natural gas	0.0	GJ/year	0.0	t CO_2e/year
LPG	0.0	GJ/year	0.0	t CO_2e/year
Petrol / ULP	0.0	GJ/year	0.0	t CO_2e/year
Petrol / Ethanol (10%) blend	0.0	GJ/year	0.0	t CO_2e/year

0.0 GJ/year

Add another project element | Hide any following project elements

Base Case - Estimated BAU use of synthetic gases

Synthetic gases - refrigerants and other gases with high global warming potentials (GWPs)

E.g. refrigerants used in HVAC; gases used in switch gear and circuit breakers. Define the refrigerant gas and determine its GWP

Location (e.g. building, rolling stock, switch gear, etc.)	*Quantity*	*Unit*	*Synthetic gas*	*GWP**	*Evidence / data source / comments*
		kg/year			
		kg/year			
		kg/year			
		kg/year			
		kg/year			

Default leakage rates for synthetic gases	Source: NGA 2016	
Equipment type	*HFCs*	*SF_6*
Commercial air conditioning - chillers	0.09	
Commercial refrigeration - supermarket systems	0.23	
Industrial refrigeration including food processing and cold storage	0.16	
Gas insulated switchgear and circuit breaker applications		0.0089

* A list of GWP factors for common greenhouse gases is provided on the "Formulas and background" worksheet.

If your refrigerant is not on this list, it is likely that it consists of a mix of different gases. The GWP of the mix can be calculated based on the GWPs of the individual constituents.

Click here to go to the GWP list

Base Case - Optional reporting

Optional - other scope 3 emissions

	Quantity	Unit	Energy source		
Employee business travel					0
Employees commuting to/from work					0

User defined scope 3 emissions	Quantity	Unit	Energy density (GJ/unit)	Emission factor (kg CO_2e/unit)		
						0
						0
						0

0.0 GJ/year

0.0 t CO_2e/year

Optional - secondary effects of asset delivery or operation

	Quantity	Unit	Energy source		
				e.g. induced traffic growth	0

Operational energy

Carbon Estimate & Reporting Tool

NSW GOVERNMENT | Transport for NSW

Legend

Concrete	Click text to go to calculator
250.0	Calculated result
	Cell for user input
	Cell for user commentary

Operational energy totals: Forecast – Optimised

100 year asset service life

	Quantity	Unit			Quantity	Unit
Annual operational energy use	0.0	GJ/year		Total operational energy use over asset life	0	GJ
Annual operational greenhouse gas emissions; scope 1	0.0	t CO_2e/year	*includes mitigation*	Total operational greenhouse gas emissions over asset life; scope 1	0	t CO_2e
Annual operational greenhouse gas emissions; scope 2	0.0	t CO_2e/year	*includes mitigation*	Total operational greenhouse gas emissions over asset life; scope 2	0	t CO_2e
Annual operational greenhouse gas emissions; scope 3	0.0	t CO_2e/year	*includes mitigation*	Total operational greenhouse gas emissions over asset life; scope 3	0	t CO_2e
Annual green power, offsets and certificates purchased	0.0	t CO_2e/year		Total green power, offsets and certificates purchased	0	t CO_2e
Annual operational greenhouse gas emissions; total	0.0	t CO_2e/year		Total operational greenhouse gas emissions over asset life; total	0	t CO_2e

Forecast – Optimised: Estimated optimised energy use

Project	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion	
TOTAL project						
Annual electricity consumption			Electricity		0	GJ/year
Annual diesel consumption			Diesel		0	GJ/year
Annual natural gas consumption			Natural gas		0	GJ/year
Annual LPG consumption			LPG		0	GJ/year
Annual petrol consumption			Petrol / ULP		0	GJ/year
Annual E10 consumption			Petrol / Ethanol (10'		0	GJ/year
					0.0	GJ/year

Breakdown into project elements	Quantity	Unit	Energy source	Evidence / data source / comments		
[Enter project element I]						
[please specify]				e.g. traction power, rolling stock	0	GJ/year
[please specify]				e.g. lighting, HVAC, vertical transport	0	GJ/year
[please specify]				e.g. signalling, communications, fire, hydraulics	0	GJ/year
[please specify]				e.g. tunnel power, ventilation	0	GJ/year
[please specify]				e.g. retail, front-of-house, back-of-house	0	GJ/year
[please specify]				e.g. miscellaneous power	0	GJ/year
[please specify]				e.g. diesel for emergency back-up generators	0	GJ/year
[please specify]				e.g. diesel for vessels	0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year
[please specify]					0	GJ/year

Subtotals [Enter project element I]				
Electricity	0.0	GJ/year	0.0	t CO_2e/year
Diesel	0.0	GJ/year	0.0	t CO_2e/year
Natural gas	0.0	GJ/year	0.0	t CO_2e/year
LPG	0.0	GJ/year	0.0	t CO_2e/year
Petrol / ULP	0.0	GJ/year	0.0	t CO_2e/year
Petrol / Ethanol (10%) blend	0.0	GJ/year	0.0	t CO_2e/year

0.0 GJ/year

Forecast – Optimised: Estimated optimised use of synthetic gases

Synthetic gases - refrigerants and other gases with high global warming potentials (GWPs)

E.g. refrigerants used in HVAC; gases used in switch gear and circuit breakers. Define the refrigerant gas and determine its GWP

Location (e.g. building, rolling stock, switch gear, etc.)	*Quantity*	*Unit*	*Synthetic gas*	*GWP**	*Evidence / data source / comments*
		kg/year			
		kg/year			
		kg/year			
		kg/year			
		kg/year			

Default leakage rates for synthetic gases	Source: NGA 2016	
Equipment type	*HFCs*	*SF_6*
Commercial air conditioning - chillers	0.09	
Commercial refrigeration - supermarket systems	0.23	
Industrial refrigeration including food processing and cold storage	0.16	
Gas insulated switchgear and circuit breaker applications		0.0089

* A list of GWP factors for common greenhouse gases is provided on the "Formulas and background" worksheet.

If your refrigerant is not on this list, it is likely that it consists of a mix of different gases. The GWP of the mix can be calculated based on the GWPs of the individual constituents.

Click here to go to the GWP list

Forecast – Optimised: Optional reporting

Optional - other scope 3 emissions

	Quantity	Unit	Energy source		
Employee business travel					0
Employees commuting to/from work					0

User defined scope 3 emissions	Quantity	Unit	Energy density (GJ/unit)	Emission factor (kg CO_2e/unit)		
						0
						0
						0

0.0 GJ/year

0.0 t CO_2e/year

Optional - secondary effects of asset delivery or operation

	Quantity	Unit	Energy source		
				e.g. induced traffic growth	0

				e.g. exports of fossil fuels associated with port construction

0	
0	
0	
0	
0.0	GJ/year
0.0	t CO_2e/year

Base Case - Mitigation

Mitigation is not captured under the Base Case.

End of data entry

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				e.g. exports of fossil fuels associated with port construction

0	
0	
0	
0	
0.0	GJ/year
0.0	t CO_2e/year

Forecast – Optimised: Operational energy Mitigation calculator

Operational energy use related mitigation measures	Quantity	Unit	Emission factor (kg CO_2e/unit)	Mitigation achieved (t CO_2e)	Evidence / data source / comments	
On-site renewable energy generation			0.0	0.0	*On-site generation can only be claimed if the generated electricity is consumed within the project and you are not selling any renewable energy certificates*	0 GJ/year
Change in electricity use			0.0	0.0		0 GJ/year
Change in diesel consumption for site vehicles			0.0	0.0		0 GJ/year
Change in diesel consumption for stationary plant			0.0	0.0		0 GJ/year
Change in diesel consumption for mobile plant			0.0	0.0		0 GJ/year
Change in other fuels			0.0	0.0		0 GJ/year
Use of biodiesel			0.0	0.0		0 GJ/year
			0.0	0.0		0 GJ/year
			0.0	0.0		0 GJ/year
			0.0	0.0		0 GJ/year
			0.0	0.0		0 GJ/year
			0.0	0.0		0 GJ/year
Total mitigation achieved				0.0	**t CO_2e / year**	0.0 GJ/year

Operational energy use related offset measures	Quantity	Unit	Offset Emission factor (kg CO_2e/unit)	Offsets purchased (t CO_2e)	Evidence / data source / comments	
Green Power / renewable electricity purchased			0.0	0.0		0.0 GJ/year
Green energy certificates			0.0	0.0		0.0 GJ/year
Carbon offsets		t CO_2e/year	1000.0	0.0		
Total offsets purchased				0.0	**t CO_2e / year**	

End of data entry

Go back to the top

Carbon Estimate & Reporting Tool

Transport for NSW

Project	M7 Widening
Reporting period	Maintenance modeled over asset lifetime
Date of data entry	18 October 2021

Legend
- Concrete — Click text to go to calculator
- 250.0 — Calculated result
- Cell for user input
- Cell for user commentary

Maintenance totals - BASE CASE

Asset service life: 100 years

	Quantity	Unit		Quantity	Unit
Annual Routine Maintenance energy use	0.0	GJ/year	Total Routine Maintenance energy use over asset life	0	GJ
Annual Routine Maintenance GHG emissions; scope 1	0.0	t CO_2e/year	Total Routine Maintenance GHG emissions over asset life; scope 1	0	t CO_2e
Annual Routine Maintenance GHG emissions; scope 2	0.0	t CO_2e/year	Total Routine Maintenance GHG emissions over asset life; scope 2	0	t CO_2e
Annual Routine Maintenance GHG emissions; scope 3	0.0	t CO_2e/year *(includes materials)*	Total Routine Maintenance GHG emissions over asset life; scope 3	0	t CO_2e
Annual Routine Maintenance GHG emissions; total	0.0	t CO_2e/year	Total Routine Maintenance GHG emissions over asset life; total	0	t CO_2e

Copy Base Case data to Expected Actual

Base Case - Estimated BAU ROUTINE MAINTENANCE (RM) material & energy use

Average annual energy use for Routine Maintenance (RM)

Energy for RM	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion
Annual electricity consumption			Electricity		0.0 GJ/year
Annual diesel consumption			Diesel		0.0 GJ/year
Annual natural gas consumption			Natural gas		0.0 GJ/year
Annual LPG consumption			LPG		0.0 GJ/year
Annual petrol consumption			Petrol / ULP		0.0 GJ/year
Annual E10 consumption			Petrol / Ethanol (10%		0.0 GJ/year
					0.0 GJ/year

Average annual materials use for Routine Maintenance (RM)

Additional materials required for Routine Maintenance	Quantity	Unit	Emission factor (kg CO_2e/unit)	Evidence / data source / comments
Protective coatings, paints			0.0	
Rubberised bitumen for road maintenance			0.0	

Base Case - Estimated BAU MAJOR PREVENTIVE MAINTENANCE (MPM) material & energy use

Average annual energy use for Major Preventive Maintenance (MPM)

Energy for MPM	Quantity	Unit		Evidence / data source / comments	Energy conversion
Annual electricity consumption			Electricity		0.0 GJ/year
Annual diesel consumption			Diesel		0.0 GJ/year
Annual natural gas consumption			Natural gas		0.0 GJ/year
Annual LPG consumption			LPG		0.0 GJ/year
Annual petrol consumption			Petrol / ULP		0.0 GJ/year
Annual E10 consumption			Petrol / Ethanol (10%		0.0 GJ/year
					0.0 GJ/year

Materials use associated with Major Preventive Maintenance (MPM)

Material/product replacement associated with Major Preventive Maintenance (MPM)	Total quantity of materials used at CDR stage	Product Service life (years)	% material that needs to be replaced at the end of each cycle	# of Replacements over asset life	Evidence / data source / comments	tonnes of material replaced
Coarse aggregates	0 t			0		0
Recycled (coarse) aggregates	0 t			0		0
Ballast	0 t			0		0
Sand	0 t			0		0
Manufactured sand	0 t			0		0
Recycled crushed glass	0 t			0		0
Ready mixed concrete (I)	0 t			0		0
Ready mixed concrete (II)	0 t			0		0
Ready mixed concrete (III)	0 t			0		0
Ready mixed concrete (IV)	0 t			0		0
Ready mixed concrete (V)	0 t			0		0
Ready mixed concrete (VI)	0 t			0		0
Ready mixed concrete (VII)	0 t			0		0
Ready mixed concrete (VIII)	0 t			0		0
Ready mixed concrete (IX)	0 t			0		0
Ready mixed concrete (X)	0 t			0		0
Ready mixed concrete (XI)	0 t			0		0
Ready mixed concrete (XII)	0 t			0		0
Ready mixed concrete (XIII)	0 t			0		0
Ready mixed concrete (XIV)	0 t			0		0
Ready mixed concrete (XV)	0 t			0		0
Precast concrete (I)	0 t			0		0
Precast concrete (II)	0 t			0		0
Precast concrete (III)	0 t			0		0
Precast concrete (IV)	0 t			0		0
Precast concrete (V)	0 t			0		0
Precast concrete (VI)	0 t			0		0
Precast concrete (VII)	0 t			0		0
Precast concrete (VIII)	0 t			0		0
Precast concrete (IX)	0 t			0		0
Precast concrete (X)	0 t			0		0
Precast concrete (XI)	0 t			0		0
Precast concrete (XII)	0 t			0		0

Maintenance

Carbon Estimate & Reporting Tool

Transport for NSW

Project	M7 Widening
Reporting period	Maintenance modeled over asset lifetime
Date of data entry	

Legend
- Concrete — Click text to go to calculator
- 250.0 — Calculated result
- Cell for user input
- Cell for user commentary

Maintenance totals - Forecast

Asset service life: 100 years

	Quantity	Unit		Quantity	Unit
Annual Routine Maintenance energy use	98.5	GJ/year	Total Routine Maintenance energy use over asset life	9,845	GJ
Annual Routine Maintenance GHG emissions; scope 1	6.9	t CO_2e/year	Total Routine Maintenance GHG emissions over asset life; scope 1	691	t CO_2e
Annual Routine Maintenance GHG emissions; scope 2	0.0	t CO_2e/year	Total Routine Maintenance GHG emissions over asset life; scope 2	0	t CO_2e
Annual Routine Maintenance GHG emissions; scope 3	94.7	t CO_2e/year *(includes materials and mitigation)*	Total Routine Maintenance GHG emissions over asset life; scope 3	9,471	t CO_2e
Annual Routine Maintenance GHG emissions; total	101.6	t CO_2e/year	Total Routine Maintenance GHG emissions over asset life; total	10,162	t CO_2e

Forecast – Estimated Optimised ROUTINE MAINTENANCE (RM) material & energy use

Average annual energy use for Routine Maintenance (RM)

Energy for RM	Quantity	Unit	Energy source	Evidence / data source / comments	Energy conversion
Annual electricity consumption			Electricity		0.0 GJ/year
Annual diesel consumption			Diesel		0.0 GJ/year
Annual natural gas consumption			Natural gas		0.0 GJ/year
Annual LPG consumption			LPG		0.0 GJ/year
Annual petrol consumption			Petrol / ULP		0.0 GJ/year
Annual E10 consumption			Petrol / Ethanol (10%		0.0 GJ/year
					0.0 GJ/year

Average annual materials use for Routine Maintenance (RM)

Additional materials required for Routine Maintenance	Quantity	Unit	Emission factor (kg CO_2e/unit)	Evidence / data source / comments
Protective coatings, paints			0.0	
Rubberised bitumen for road maintenance	24098	L/year	0.8	Previous project data scaled based on M7 Widening resurfacing requirements. See 'Notes (Maintenance)' sheet

Forecast – Estimated Optimised MAJOR PREVENTIVE MAINTENANCE (MPM) material & energy use

Average annual energy use for Major Preventive Maintenance (MPM)

Energy for MPM	Quantity	Unit		Evidence / data source / comments	Energy conversion
Annual electricity consumption			Electricity		0.0 GJ/year
Annual diesel consumption	2.55	kL/year	Diesel	Previous project data scaled based on M7 Widening resurfacing requirements. See 'Notes (Maintenance)' sheet	98.5 GJ/year
Annual natural gas consumption			Natural gas		0.0 GJ/year
Annual LPG consumption			LPG		0.0 GJ/year
Annual petrol consumption			Petrol / ULP		0.0 GJ/year
Annual E10 consumption			Petrol / Ethanol (10%		0.0 GJ/year
					98.5 GJ/year

Materials use associated with Major Preventive Maintenance (MPM)

Material/product replacement associated with Major Preventive Maintenance (MPM)	Total quantity of materials used at CDR stage	Product Service life (years)	% material that needs to be replaced at the end of each cycle	# of Replacements over asset life	Evidence / data source / comments	tonnes of material replaced
Coarse aggregates	0 t			0		0
Recycled (coarse) aggregates	0 t			0		0
Ballast	0 t			0		0
Sand	0 t			0		0
Manufactured sand	0 t			0		0
Recycled crushed glass	0 t			0		0
Ready mixed concrete (I)	0 t			0		0
Ready mixed concrete (II)	0 t			0		0
Ready mixed concrete (III)	0 t			0		0
Ready mixed concrete (IV)	0 t			0		0
Ready mixed concrete (V)	0 t			0		0
Ready mixed concrete (VI)	0 t			0		0
Ready mixed concrete (VII)	0 t			0		0
Ready mixed concrete (VIII)	0 t			0		0
Ready mixed concrete (IX)	0 t			0		0
Ready mixed concrete (X)	0 t			0		0
Ready mixed concrete (XI)	0 t			0		0
Ready mixed concrete (XII)	0 t			0		0
Ready mixed concrete (XIII)	0 t			0		0
Ready mixed concrete (XIV)	0 t			0		0
Ready mixed concrete (XV)	0 t			0		0
Precast concrete (I)	0 t			0		0
Precast concrete (II)	0 t			0		0
Precast concrete (III)	0 t			0		0
Precast concrete (IV)	0 t			0		0
Precast concrete (V)	0 t			0		0
Precast concrete (VI)	0 t			0		0
Precast concrete (VII)	0 t			0		0
Precast concrete (VIII)	0 t			0		0
Precast concrete (IX)	0 t			0		0
Precast concrete (X)	0 t			0		0
Precast concrete (XI)	0 t			0		0
Precast concrete (XII)	0 t			0		0

Precast concrete (XIII)	0 t			0	0	0
Precast concrete (XIV)	0 t			0	0	0
Precast concrete (XV)	0 t			0	0	0
Reinforcement steel bars - Australian products	0 t			0	0	0
Reinforcement steel bars - imported products	0 t			0	0	0
Reinforcement steel mesh - Australian products	0 t			0	0	0
Reinforcement steel mesh - imported products	0 t			0	0	0
Reo steel: low relaxation strand and wire - Australian product	0 t			0	0	0
Reo steel: low relaxation strand and wire - imported products	0 t			0	0	0
Structural steel, beams and columns - Australian products	0 t			0	0	0
Structural steel, beams and columns - imported products	0 t			0	0	0
Structural steel, hot rolled coil - Australian products	0 t			0	0	0
Structural steel, hot rolled coil - imported products	0 t			0	0	0
Structural steel, merchant bar - Australian products	0 t			0	0	0
Structural steel, merchant bar - imported products	0 t			0	0	0
Structural steel, plate - Australian products	0 t			0	0	0
Structural steel, plate - imported products	0 t			0	0	0
Galvanised steel - Australian products	0 t			0	0	0
Galvanised steel - imported products	0 t			0	0	0
Steel rails - Australian products	0 t			0	0	0
Steel rails - imported products	0 t			0	0	0
Hot mix asphalt, 0% RAP (5.5% bitumen)	0 t			0	0	0
Hot mix asphalt, 0-20% RAP	0 t			0	0	0
Hot mix asphalt, 20-40% RAP	0 t			0	0	0
Hot mix asphalt, 40-60% RAP	0 t			0	0	0
Hot mix asphalt, >60% RAP	0 t			0	0	0
Warm mix asphalt, 0% RAP (5.5% bitumen)	0 t			0	0	0
Warm mix asphalt, 0-20% RAP	0 t			0	0	0
Warm mix asphalt, 20-40% RAP	0 t			0	0	0
Warm mix asphalt, 40-60% RAP	0 t			0	0	0
Warm mix asphalt, >60% RAP	0 t			0	0	0
Reinforced concrete pipes	0 t			0	0	0
Steel pipe and tube - Australian products	0 t			0	0	0
Steel pipe and tube - imported products	0 t			0	0	0
HDPE pipes	0 t			0	0	0
PVC pipes	0 t			0	0	0
Timber, Structural (softwood)	0 t			0	0	0
Timber, Structural (hardwood)	0 t			0	0	0
Timber, MDF / Particleboard	0 t			0	0	0
Timber, Plywood	0 t			0	0	0
Timber, Cross-Laminated Timber (CLT)	0 t			0	0	0
Aluminium	0 t			0	0	0
Glass	0 t			0	0	0
Ceramics	0 t			0	0	0
Power cables, Copper conductors	0 t			0	0	0
Power cables, Aluminium conductors	0 t			0	0	0
Power cables, Other conductors	0 t			0	0	0

Additional or alternative materials required for Major Preventive Maintenance (MPM)

Quantity	Unit

Evidence / data source / comments

Base Case - Estimated BAU Maintenance Mitigation

Mitigation is not captured under the Base Case.

Precast concrete (XIII)	0 t			0	0	0
Precast concrete (XIV)	0 t			0	0	0
Precast concrete (XV)	0 t			0	0	0
Reinforcement steel bars - Australian products	0 t			0	0	0
Reinforcement steel bars - imported products	0 t			0	0	0
Reinforcement steel mesh - Australian products	0 t			0	0	0
Reinforcement steel mesh - imported products	0 t			0	0	0
Reo steel: low relaxation strand and wire - Australian product	0 t			0	0	0
Reo steel: low relaxation strand and wire - imported products	0 t			0	0	0
Structural steel, beams and columns - Australian products	0 t			0	0	0
Structural steel, beams and columns - imported products	0 t			0	0	0
Structural steel, hot rolled coil - Australian products	0 t			0	0	0
Structural steel, hot rolled coil - imported products	0 t			0	0	0
Structural steel, merchant bar - Australian products	0 t			0	0	0
Structural steel, merchant bar - imported products	0 t			0	0	0
Structural steel, plate - Australian products	0 t			0	0	0
Structural steel, plate - imported products	0 t			0	0	0
Galvanised steel - Australian products	0 t			0	0	0
Galvanised steel - imported products	0 t			0	0	0
Steel rails - Australian products	0 t			0	0	0
Steel rails - imported products	0 t			0	0	0
Hot mix asphalt, 0% RAP (5.5% bitumen)	0 t			0	0	0
Hot mix asphalt, 0-20% RAP	0 t			0	0	0
Hot mix asphalt, 20-40% RAP	0 t			0	0	0
Hot mix asphalt, 40-60% RAP	0 t			0	0	0
Hot mix asphalt, >60% RAP	0 t			0	0	0
Warm mix asphalt, 0% RAP (5.5% bitumen)	0 t			0	0	0
Warm mix asphalt, 0-20% RAP	0 t			0	0	0
Warm mix asphalt, 20-40% RAP	0 t			0	0	0
Warm mix asphalt, 40-60% RAP	0 t			0	0	0
Warm mix asphalt, >60% RAP	0 t			0	0	0
Reinforced concrete pipes	0 t			0	0	0
Steel pipe and tube - Australian products	0 t			0	0	0
Steel pipe and tube - imported products	0 t			0	0	0
HDPE pipes	0 t			0	0	0
PVC pipes	0 t			0	0	0
Timber, Structural (softwood)	0 t			0	0	0
Timber, Structural (hardwood)	0 t			0	0	0
Timber, MDF / Particleboard	0 t			0	0	0
Timber, Plywood	0 t			0	0	0
Timber, Cross-Laminated Timber (CLT)	0 t			0	0	0
Aluminium	0 t			0	0	0
Glass	0 t			0	0	0
Ceramics	0 t			0	0	0
Power cables, Copper conductors	0 t			0	0	0
Power cables, Aluminium conductors	0 t			0	0	0
Power cables, Other conductors	0 t			0	0	0

Additional or alternative materials required for Major Preventive Maintenance (MPM)

Quantity	Unit
Hot mix asphalt, 0% RAP (5.5% bitumen)	1132.5825	tonnes/year

Evidence / data source / comments

See 'Notes (maintenance)' sheet

Forecast – Estimated Optimised Maintenance Mitigation Calculator

Change in materials used for Routine Maintenance & Major Preventive Maintenance (MPM)

Quantity	Unit		
			replaces
			replaces
			replaces
			replaces
			replaces
			replaces

Avoided/Replaced materials that would have been required for Routine Maintenance & Major Preventive Maintenance (MPM)

Quantity	Unit

Change in materials used for Routine Maintenance & Major Preventive Maintenance (MPM)

Quantity	Unit	Emission factor (kg CO_2e/tonne)	
			replaces
			replaces
			replaces
			replaces
			replaces

Avoided/Replaced materials that would have been required for Routine Maintenance & Major Preventive Maintenance (MPM)

Quantity	Unit

Forecast - Avoided annual energy use for Routine Maintenance & Major Preventive Maintenance (MPM)

Change in energy for RM & MPM	Quantity	Unit		Evidence / data source / comments	Energy conversion	
Change in annual electricity consumption			Electricity		0.0	GJ/year
Change in annual diesel consumption			Diesel		0.0	GJ/year
Change in annual natural gas consumption			Natural gas		0.0	GJ/year
Change in annual LPG consumption			LPG		0.0	GJ/year
Change in annual petrol consumption			Petrol / ULP		0.0	GJ/year
Change in annual E10 consumption			Petrol / Ethanol (10%) blend		0.0	GJ/year
					0.0	GJ/year

Table 6-1: Construction GHG emissions

Emissions source	GHG emissions (tCO2e)				
	Scope 1	Scope 2	Scope 3	Total	% of total
Fuel use					
Diesel consumption for site vehicles	1,847	0	95	1,941	1%
Diesel consumption for stationary plant and equipment	3,197	0	164	3,361	3%
Diesel consumption for mobile plant and equipment	20,792	0	1,066	21,858	17%
Electricity					
Electricity consumption	0	5,146	462	5,608	4%
Construction materials					
Concrete	0	0	45,953	45,953	35%
Steel	0	0	15,592	15,592	12%
Asphalt & Bitumen	0	0	2,356	2,356	2%
Other	0	0	0.1	0.1	0%
Transport of materials	0	0	3,200	3,200	2%
Waste					
Construction and demolition waste to landfill: inert waste (concrete, mansonry, glass, metals)	0	0	0	0	0%
Construction and demolition waste to landfill: timber, vegetation waste	0	0	27,323	27,323	21%
Construction and demolition waste to landfill: mixed waste	0	0	0	0	0%
Transport of waste materials	0	0	1,242	1,242	1%
Land Clearing					
Land Clearing	2,266	0	0	2,266	2%
Total	**28,101**	**5,146**	**97,454**	**130,701**	

Table 6-2 Operation and maintenance GHG emissions

Emission source	GHG Emissions (tCO2e)			
	Scope 1	Scope 2	Scope 3	Total
Annual operation emissions (tCO2e per year)				
Electricity consumption	Negligible – proposed widening is not expected to increase electricity consumption from existing levels.			
Operation and maintenance light vehicles	Negligible – proposed widening is not expected to increase operation and maintenance light vehicle use from existing levels.			
Total maintenance emissions (100-year major maintenance) (tCO2e)				
Fuel use– mobile plant and equipment	657		34	691
Maintenance materials			9,471	9,471
Total maintenance emissions	**657**	**0**	**9,505**	**10,162**

Total lifecycle emissions (tCO2e)
140,863

NSW total emissions 2019 (tCO2e)
136,580,000

M7 project proportion of emissions
0.103%

M7 construction emissions proportion of NSW emissions

0.10%

M7 operations emissions proportion of NSW emissions
0.007%

M12 construction emission (tCO2e)
271607

M7 mod + M12 construction emissions (tCO2e)
402,308

M7 mod + M12 construction emissions proportion of NSW emissions
0.29%

M12 operations emissions (tCO2e/yr)
114006

M7 mod annual emissions (tCO2e/yr)
102

M7 mod + M12 construction emissions (tCO2e)
114,108

M7 mod + M12 construction emissions proportion of NSW emissions
0.08%