Chapter 23
Sustainability, climate change and greenhouse gas

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This chapter summarises the sustainability, climate change and greenhouse gas (GHG) assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full sustainability, climate change and GHG assessment is provided in Appendix Q (Technical report – Climate change and sustainability).

23.1 Sustainability

23.1.1 Sustainability guidelines

The sustainability of the project is guided by the Blackheath to Little Hartley Sustainability Strategy (AECOM & Aurecon Joint Venture, 2022) and relevant Australian and NSW government strategy documents and policies including:

- Future Transport Strategy: Our vision for transport in NSW (Transport for NSW, 2022g)
- Transport Sustainability Plan (Transport for NSW, 2021e)
- NSW Net Zero Plan Stage 1: 2020-2030 (Department of Planning, Industry and Environment, 2020b)
- NSW Climate Change Adaptation Strategy (NSW Government, 2022)
- NSW Sustainable Design Guidelines Version 4.0 (Transport for NSW, 2017)
- NSW Government Resource Efficiency Policy (Office of Environment and Heritage, 2019)
- NSW Climate Change Policy Framework (Office of Environment and Heritage, 2016)
- NSW Waste and Sustainable Materials Strategy 2041 (Department of Planning, Industry and Environment, 2021b)
- A Metropolis of Three Cities – the Greater Sydney Region Plan (Greater Sydney Commission, 2018)
- Beyond the Pavement (Transport for NSW, 2020g).

23.1.2 Infrastructure Sustainability Rating Tool

The Infrastructure Sustainability Council (ISC) Rating Tool provides a comprehensive rating system for evaluating sustainability across the design, construction and operation of infrastructure projects. Sustainability would be assessed in accordance with the ISC Rating Tool (version 1.2) with a target 'Design' and 'As-Built' rating of 'Excellent' being sought for the project.

In August 2021, ISC released version 2.1 of the ISC Rating Tool. This update provides a number of improved and additional categories and credits to further enhance the sustainability performance of major infrastructure projects. The scheduled retirement of version 1.2 of the ISC Rating Tool is at the end of 2023. Transport is updating its internal procedures to enable a gradual and successful transition of future projects to version 2.1. Although ISC version 1.2 is being applied to this project, Transport is managing this transition by continuing to investigate and implement ISC version 2.1 credits where possible to enhance sustainable project outcomes.

23.1.3 Ecologically sustainable development

Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends is referred to as ecologically sustainable development (ESD). These principles are:

- the precautionary principle: lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- intergenerational equity: the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- conservation of biological diversity and ecological integrity: conservation of biodiversity and ecosystem health should be primary considerations in development
- improved valuation of environmental assets and services: environmental factors should be included in the valuation of assets and services.

The principles of ESD have been considered throughout the development of the project. Chapter 25 (Justification and conclusion) outlines how the project addresses these principles.

23.1.4 Sustainability targets and initiatives

Sustainability initiatives for the project were identified in sustainability workshops with planning and design teams during the design development process and are outlined in Table 23-1. These initiatives would be implemented during further design development and in accordance with the sustainability guidelines outlined in Section 23.1.1. Sustainability initiatives would be reviewed and updated during the design development and construction stages of the project.

Table 23-1 Potential sustainability initiatives to be implemented for the project

Sustainability objective	Potential sustainability initiatives
Energy use	Initiatives for achieving efficiencies in energy use through design of tunnel ventilation, construction programming, construction utilities provision, transport options, offsets and renewable energy generation.
Water use	Initiatives for achieving efficiencies in water use through design of stormwater drainage and utilities, and for reducing potable water use by exploring opportunities to use non-potable water sources instead.
Materials	Initiatives for achieving efficiencies in material lifecycle impacts through the selection of sustainable materials, sourcing near the project to minimise transport, and innovating with recycled materials.
Waste	Including waste minimisation to realise a range of efficiencies (e.g. reduction in transport requirements), the development of a deconstruction plan for mid-tunnel access shaft infrastructure so that it can be dismantled for reuse post-construction, as well as the management and reuse of spoil during construction.
Urban design	Including provision of connectivity with local bushwalking trails and developing an active transport link along the corridor. Transport is investigating potential opportunities for placemaking and active transport initiatives to improve at-surface active transport infrastructure between Blackheath and Little Hartley in consultation with local councils. This would be subject to separate assessment and approval and may be delivered by others.
Environment	Including initiatives to minimise the construction footprint, where possible, and protect ecologically sensitive areas including hollow-bearing trees.
Ecology	Consideration for landscaping to support native species, minimise groundwater drawdown and minimise habitat impacts.
Climate change	Including initiatives to improve the resilience of the project to future extreme climate events.

Sustainability objective	Potential sustainability initiatives
Heritage	Including initiatives for the preservation and enhancement of heritage values.
Health	Consideration of active transport in the project design, and air and noise quality improvement initiatives.
Land use	Initiatives that conserve topsoil and subsoil and minimise impacts to previously undisturbed land.
Stakeholder engagement	Consideration of engagement methods that are tailored for each stakeholder group, particularly vulnerable stakeholders.
Innovation	Initiatives that encourage or rely on solar power such as electric vehicle charging stations and battery storage, optimised tunnel design to utilise space efficiently, and consider alternative materials including recycled materials in the structural design.

The sustainability initiatives for the project would be implemented through:

- targeting an 'Excellent' ISC Rating (see Section 23.1.2)
- climate change risk assessment and adaptation measures developed for the project (see Section 23.2)
- the environmental mitigation measures developed for the design, construction and operational phases of the project (see Appendix R (Compilation of environmental mitigation measures))
- an Infrastructure Sustainability Management Plan which would be developed in future design development.

23.2 Climate change

The peak body for climate change research, the Intergovernmental Panel on Climate Change (IPCC) has confirmed that Australia is experiencing impacts from climate change. Observed trends include changes in the frequency of mean and extreme air temperatures, changes in mean and extreme rainfall, changes in the frequency and intensity of storm events, increases in extreme fire weather events, ocean warming, ocean acidification and sea level rise (IPCC, 2021). The risk of climate change impacts on the project needs to be considered as part of the design process, as it needs to be resilient to these potential impacts.

Infrastructure assets, including road tunnels, are vulnerable to climate change because of their long design lives, during which the potential impacts of climate change would become more significant. Therefore, infrastructure design and planning needs to incorporate mitigation measures, based on the identified climate change risks to an asset.

23.2.1 Assessment approach

A climate change risk assessment was carried out which considered risks and mitigation measures that apply to the project. The climate change risk assessment has been conducted in line with the Transport for NSW Climate Risk Assessment Guidelines (Transport for NSW, 2021g). Risks identified would be reviewed and updated during further design development, during construction, and during operation of the project.

The study area for this assessment has been defined based on data published by the Commonwealth Scientific and Industrial Research Organisation Climate Science Centre. This dataset divides Australia into clusters and sub-clusters based on regional climate trends and natural resources produced in each region. The East Coast South Sub-Cluster was identified as the sub-cluster encompassing the project. This sub-cluster extends from the east coast of NSW to the Central West region of NSW, and from greater Sydney to the Queensland border.

Figure 23-1 provides an overview of the climate change risk assessment approach applied to the project.

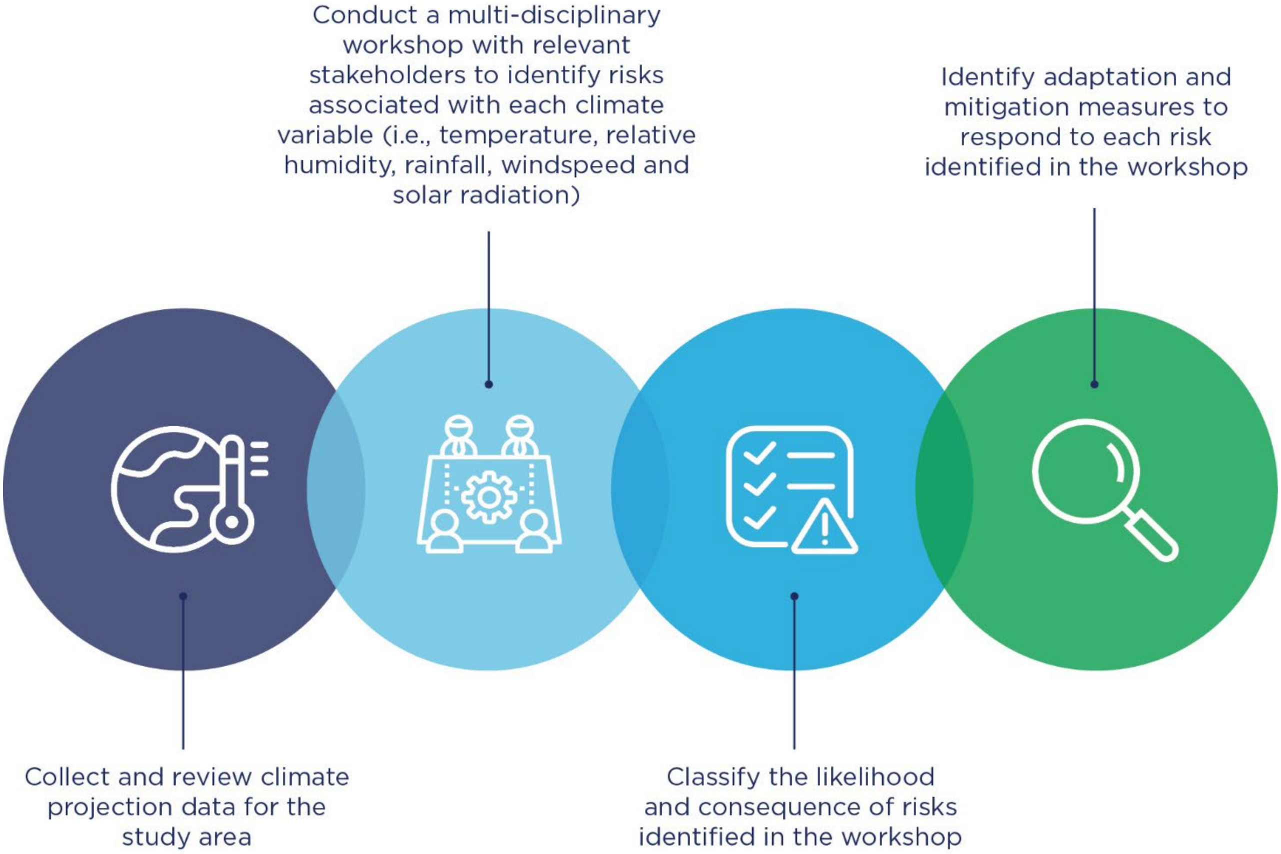

Figure 23-1 Climate change risk assessment approach

23.2.2 Climate change projections

Given the expected design life of the project, its anticipated construction timeframe and available climate data, the following time periods were selected for assessment:

- 2030 – to assess the short-term impacts of climate change
- 2090 – to assess the longer-term impacts of climate change during operation and maintenance of the project.

Historical climate data obtained from the Katoomba Weather Station (Station number: 063039) from 1991-2020 was used to provide context to the potential severity of climate change projections for 2030 and 2090.

Projections extending beyond 2090 can vary and this variation increases exponentially with time. Additionally, there are few publicly available sources for projection data relating to all climate hazards. Therefore 2090 is referred to in this report as a reliable long-term prediction of the likely climate change impacts of each scenario.

Projections are presented for the worst-case emissions scenario, referred to as representative concentration pathway (RCP) 8.5. A summary of climate change projections near the project for the RCP8.5 scenario is provided in Table 23-2.

Table 23-2 Climate change projections in the study area for RCP8.5

Climate variable	1991-2020 climate	2030 climate	2090 climate
Rainfall (mm)			
Mean (yearly)	1,309.2	1,298	1,267
Wettest day	226	235	261
Increase in severe rainfall intensity (%)	-	3.9	15.3
Temperature (°C)			
Hottest day	39.8	41.2	43.9
Coldest night	-3.6	-2.8	-0.2
Extreme heat days (number of days per year)			
Days ≥ 30°C	11.9	15.5	37.3
Days ≥ 35°C	1.1	1.5	7.2
Days ≥ 40°C	0.0	0.0	0.4
Cold days (number of days per year)			
Days ≤ 2°C	35.8	31.2	5.0
Days ≤ 0°C	10.9	7.3	0.4

23.2.3 Climate change risk assessment

A total of 54 pre-mitigation climate change risks for the project were identified in the climate change risk assessment, as detailed in Section 2.3 of Appendix Q (Technical report – Climate change and sustainability). Prior to the assignment of mitigation measures, two risks were rated as medium or high during project construction.

Three climate change risks were rated as high during operation of the project for the 2030 climate scenario, and 19 climate change risks were rated as high during project operation for the 2090 climate scenario.

Mitigation and adaptation measures were then applied to these risks, which were re-assessed for both the 2030 and 2090 climate scenario. Table 23-3 details the medium and high risks identified for construction of the project, and the high risks identified during operation of the project for 2030 (near future) and 2090 (far future) scenarios, both with and without the application of mitigation and adaptation measures.

Post-mitigation, no risks were rated as high or extreme with several rated as low. Out of the 19 risks shown in Table 23-3, post-mitigation there would be:

- two medium risks during construction of the project for the 2030 climate scenario
- eight medium risks during operation of the project for the 2030 climate scenario
- 17 medium risks during operation of the project for the 2090 climate scenario.

Examples of mitigation and adaptation measures applied include:

- incorporating First Nations burning practices into operational maintenance plans to minimise the risk of extreme bushfires
- selecting drought- and heat-tolerant vegetation, especially native species, for project landscaping to reduce temperature and drought impacts
- limiting work hours during extreme weather conditions to minimise health and safety risks to construction workers.

A full list of potential mitigation and adaptation actions is provided in Annexure C of Appendix Q (Technical report – Climate change and sustainability).

Table 23-3 Medium to high climate change risks during construction and operation of the project

Risk #[1]	Climate risk	Timing	Pre-mitigation		Post-mitigation	
			2030 rating	2090 rating	2030 rating	2090 rating
11	Temperature – increased extreme heat days leads to an increased risk of heat stress for construction and maintenance workers	Construction	High	Extreme	Medium	Medium
33	Storm intensity – increased storm intensity leading to safety risk to construction and maintenance workers	Construction	Medium	High	Medium	Medium
3	Temperature – increased exposure to higher temperatures affects the resilience of soil and vegetation and results in a loss of biodiversity and impacts to project landscaping	Operation	Medium	High	Low	Medium
5	Temperature – high temperatures lead to a preference for private vehicles compared to other transport modes which will increase traffic through the tunnel increasing wear of road surface leading to increased maintenance (e.g., resurfacing)	Operation	Medium	High	Medium	Medium
8	Temperature – extreme heat days lead to potential failure of mechanical and electrical systems	Operation	Medium	High	Medium	Medium
13	Drought – increased frequency and severity of drought conditions leads to increased dust build up in mechanical ventilation systems requiring additional maintenance	Operation	High	High	Low	Medium
18	Drought – increased frequency and severity of extreme rainfall events leads to water quality impacts to downstream receivers (groundwater dependent ecosystems, drinking water catchments etc.) leading to biodiversity and reputational impacts	Operation	Medium	High	Low	Medium

Risk #[1]	Climate risk	Timing	Pre-mitigation		Post-mitigation	
			2030 rating	2090 rating	2030 rating	2090 rating
20	Flooding – increased frequency and severity of extreme rainfall events leads to overloading of upstream detention basins and flooding impacts to the project site	Operation	Medium	High	Low	Medium
21	Flooding – increased frequency and severity of extreme rainfall events leads to corrosion of steel structures and decreased durability of other structural materials requiring additional maintenance or replacement	Operation	Medium	High	Low	Medium
23	Flooding – increased frequency and severity of extreme rainfall events leads to increased risk of landslides to new and existing embankments and damage to structures	Operation	Medium	High	Low	Medium
28	Flooding – increased storm intensity leading to damage of structures	Operation	Medium	High	Low	Medium
39	Storm intensity – increased storm intensity leading to increased hail speed and size causing impact on vehicles and commuters at tunnel exits and entries	Operation	Medium	High	Medium	Medium
42	Bushfire – increased frequency and intensity of bushfires leading to entry and exit of the tunnel becoming blocked and travellers becoming trapped inside the tunnel	Operation	Medium	High	Medium	Medium
43	Bushfire – increased frequency and intensity of bushfires leading to a loss of biodiversity and impacts to project landscaping	Operation	High	High	Medium	Medium

Risk #[1]	Climate risk	Timing	Pre-mitigation		Post-mitigation	
			2030 rating	2090 rating	2030 rating	2090 rating
44	Bushfire – increased frequency and intensity of bushfires leading to damage to infrastructure (e.g., noise walls, pavement) resulting in increased maintenance and decrease in operational safety	Operation	Medium	High	Medium	Medium
48	Bushfire – increased frequency and intensity of bushfires leading to damage to power infrastructure impacting tunnel operations	Operation	High	High	Low	Medium
51	Bushfire – increased solar radiation leading to increased strike risk for fauna seeking shade	Operation	Medium	High	Medium	Medium
52	Solar radiation – increased solar radiation leading to increased harmful UV effects to operations personnel	Operation	Medium	High	Medium	Medium
54	Solar radiation – increased frequency and severity of drought conditions leads to increased water scarcity impacting fire prevention systems and increased damage to infrastructure within the tunnel and a health risk for workers and motorists	Operation	Medium	High	Low	Medium

Table notes:

1. Risk numbers correspond to the comprehensive list of climate change risks shown in Section 2.3 of Appendix Q (Technical report – Climate change and sustainability)

23.3 Greenhouse gas

GHGs are gases in the atmosphere that absorb and re-radiate heat from the sun, thereby trapping heat in the lower atmosphere and influencing global temperatures. Emissions of GHGs into the atmosphere are caused by both natural processes (e.g. bushfires) and human activities (e.g. burning of fossil fuels).

Since the industrial revolution there has been an increase in the amount of GHGs emitted from human activities, which has increased the global concentration of GHGs in the atmosphere. This has led to an increase in the Earth's average surface temperature (IPCC, 2021). Adapting to these changes is necessary to minimise the impacts of climate change on the natural and built environments and the NSW communities and economy (NSW Government, 2022).

23.3.1 Assessment approach

The Carbon Estimate Reporting Tool (CERT) developed by Transport for NSW to measure and report GHG emissions has been used to estimate GHG emissions associated with the project. As the GHG assessment has been carried out during an early phase of the design process, high-level and conservative estimates have been applied where exact material types, construction methodologies, and/ or resource requirements are unknown.

GHG emissions from the project have been categorised into direct and indirect emission sources as defined by the Greenhouse Gas Protocol (World Resources Institute and World Business Council for Sustainable Development, n.d.). Emissions sources identified for the GHG assessment for both construction and operation of the project are outlined in Figure 23-2.

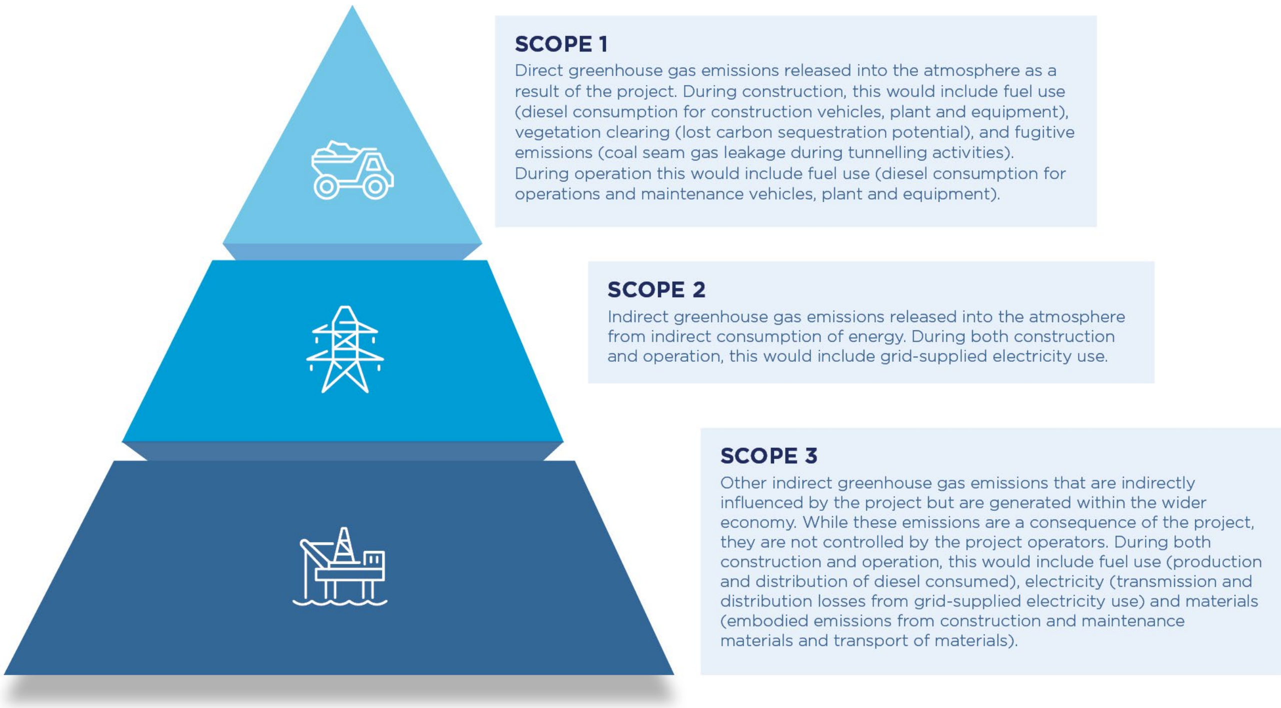

Figure 23-2 Scope 1, 2, and 3 GHG emissions as defined by the Greenhouse Gas Protocol

The GHG assessment provides preliminary estimates based on current indicative design and construction information.

The approach for the GHG assessment for the project included:

- defining the assessment boundary and identifying potential sources of GHG emissions associated with the project
- determining the quantity of each emission source

- quantifying the potential GHG emissions associated with each source
- calculating the potential GHG emissions associated with the project in tonnes of carbon dioxide equivalent (tCO_2-e)
- developing GHG minimisation measures to be considered during design development.

23.3.2 Estimated GHG emissions during construction

Resource use estimates

Key emissions sources and indicative emissions volumes during project construction are presented in Table 23-4 and shown in Figure 23-3. Indicative emission volumes are based on the current project design and subject to change during design development and detailed construction planning.

These results show that the majority of GHG emissions produced during construction are associated with electricity use (scope 2), and embodied emissions from the manufacture of construction materials (scope 3). This is largely due to the electricity and construction materials required for the tunnel boring machines. The difference between construction GHG emissions for both ventilation scenarios (i.e., ventilation outlet and portal emissions) would be negligible.

In addition to the quantitative GHG assessment summarised in Table 23-4, the following activities associated with construction of the new water supply pipeline between Little Hartley and Lithgow would increase plant and equipment energy requirements and materials use and lead to an increase in GHG emissions:

- trench excavation and pipeline installation including backfill and rehabilitation
- concrete foundation and/or encasements works and thrust blocks
- connection to Lithgow water supply.

Table 23-4 Indicative construction GHG emissions by scope and emissions source

Emission source	Emissions (tCO^2-e)[1]			
	Scope 1	Scope 2	Scope 3	Total
Diesel combustion (site vehicles, precast segment delivery and spoil haulage)	72,210	0	3,700	75,910
Diesel combustion (plant and equipment)	50,680	0	2,600	53,260
Vegetation removal	4,740	0	0	4,740
Electricity consumption	0	525,200	47,130	572,330
Embodied emissions from construction materials (including delivery to construction sites)	0	0	689,610	689,610
Fugitive emissions (methane gas from coal seams) during tunnelling	11,290	0	0	11,290
Total	**138,900**	**525,200**	**743,040**	**1,407,140**

Table notes:

1. Indicative emission volumes have been rounded to the nearest 10 t CO2e

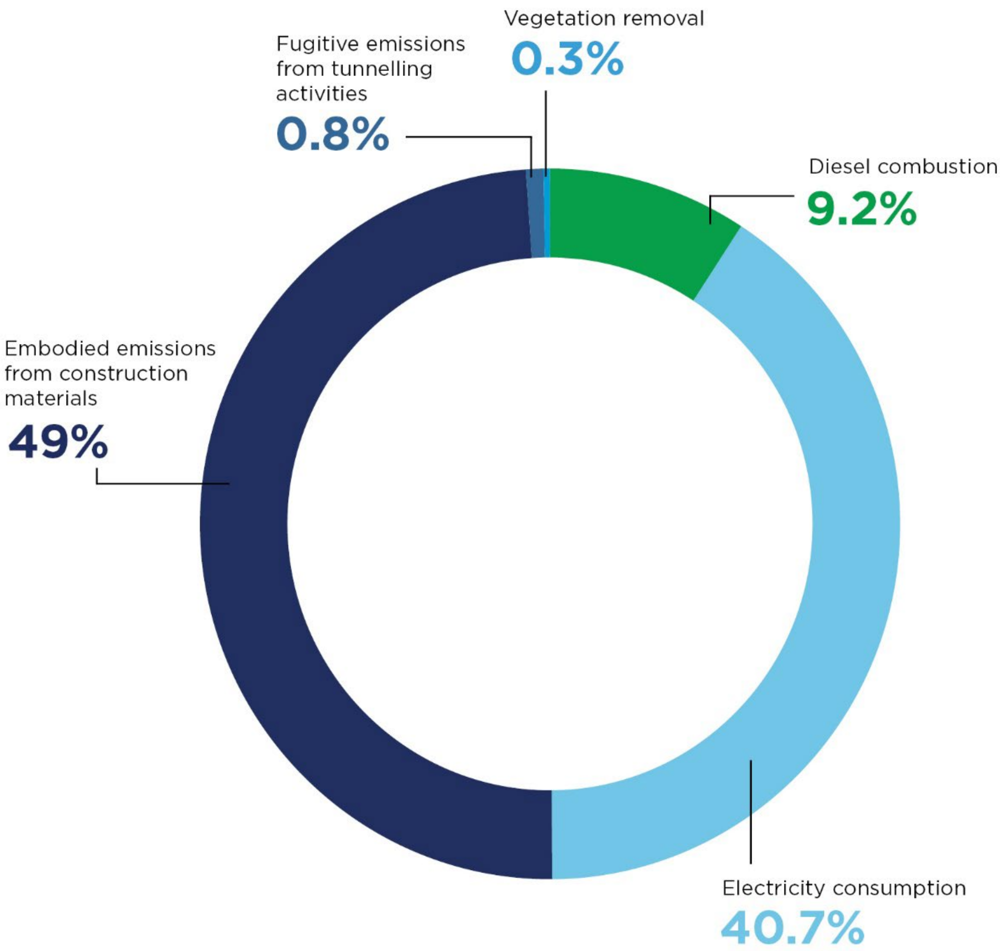

Figure 23-3 Construction GHG emissions by source

Potential coal seam gases

As discussed in Chapter 5 (Construction) and Chapter 13 (Groundwater and geology), the project would require tunnelling through coal seams between the Little Hartley portal and the mid-tunnel access shaft. Coal seams contain methane gas which is a GHG and could be emitted during tunnelling activities. The GHG assessment has incorporated this risk by including estimates of fugitive emissions produced during tunnelling activities. The management of potential coal seam gas is discussed in Chapter 15 (Soils and contamination).

23.3.3 Estimated GHG emissions during operation

Key emissions sources and indicative emission volumes during project operation for both ventilation options are shown in Table 23-5. Indicative emission volumes are based on the current project design and subject to change during design development.

Under both ventilation options, the greatest source of GHG emissions during operation would likely be from electricity consumption from ventilation and lighting systems for the design life of the project. Under both ventilation options, the amount of scope 1 GHG emissions would be the same.

Under the portal emissions option, the project would generate around 2,087,800 tonnes less of scope 2 GHG emissions and around 187,370 tonnes less of scope 3 GHG emissions compared to the ventilation outlet option. The portal emissions option would have a total saving of around 2,275,170 tonnes of GHG emissions which is a saving of around 65 per cent. This is expected to occur (at least in the short-term) due to an easing of congestion, increased travel speed, and reduced travel time as a result of the project, resulting in lower emissions per vehicle per kilometre.

Operation of the water supply pipeline would result in negligible impacts to the project's GHG emissions. Operation of the pipeline may impact emissions in areas outside the assessment boundary, such as pumping energy requirements by relevant water supply operators.

Table 23-5 Operational GHG emissions by scope and emissions source over the design life of the project (100 years)

Emission source	Ventilation option	Emissions (tCO_2-e)[1]			
		Scope 1	Scope 2	Scope 3	Total
Operation emissions (electricity consumption and fuel combustion from operations vehicles)	Ventilation outlet	8,370	3,484,780	313,170	3,806,320
	Portal emissions	8,370	1,396,980	125,800	1,531,150
Maintenance emissions (maintenance plant, equipment and materials)	Ventilation outlet / portal emissions	5,040	0	37,560	42,600
Road users (net change in vehicle tailpipe emissions)	Ventilation outlet / portal emissions	0	0	-298,930	-298,930
Total	**Ventilation outlet**	**13,410**	**3,484,780**	**51,800**	**3,549,990**
	Portal emissions	**13,410**	**1,396,980**	**-135,570**	**1,274,820**

Table notes:

1. Indicative emission volumes have been rounded to the nearest 10 t CO_2e

23.4 Environmental mitigation measures

23.4.1 Performance outcomes

Performance outcomes for the project in relation to sustainability, climate change and GHG are listed in Table 23-6 and identify measurable performance-based standards for environmental management.

Table 23-6 Sustainability and climate change performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
The project is designed, constructed and operated to be resilient to the future impacts of climate change.	Design and implement the project taking into account current climate change projections and potential future climate change impacts.	Design, construction and operation

SEARs desired performance outcome	Project performance outcome	Timing
The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	Design and implement the project to minimise capital and operational costs, consistent with NSW Treasury requirements. Design and implement the project to achieve a minimum Infrastructure Sustainability 'Design' and 'As-Built' rating of 'Excellent' under version 1.2 of the ISC rating tool.	Design, construction and operation

23.4.2 Mitigation measures

Mitigation measures to avoid, minimise or manage potential sustainability, climate change and GHG impacts as a result of the project are detailed in Table 23-7. A full list of mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 23-7 Environmental mitigation measures – sustainability, climate change and GHG

ID	Mitigation measure	Timing
CC1	A climate change risk assessment will be carried as part of further design development. Adaptation actions will be identified and implemented to address extreme and high climate change risks, and will be considered for medium climate change risks where reasonable and feasible.	Design
SU1	An Infrastructure Sustainability Management Plan will be prepared and implemented as part of further design development to guide the implementation of sustainability initiatives. The Plan will detail how the project will achieve an Infrastructure Sustainability rating of 'Excellent'.	Design
SU2	As part of further design development, construction and operation of the project, the initiatives identified in the Great Western Highway Upgrade Program's Sustainability Strategy will be considered.	Design and operation
GG1	Opportunities to minimise greenhouse gas emissions from the project, including as a result of interactions with coal seams, will be identified as part of further design development, and will be implemented during construction and operation where reasonable and feasible. Consideration of opportunities to minimise greenhouse gas emissions will include: • reducing the electricity requirements of the project and/ or sourcing electricity from a renewable energy source • selecting construction materials with reduced embodied greenhouse gas emissions, through reduced materials use, lower emissions construction materials, and/ or local sourcing of materials • selecting plant and equipment with lower fuel/ electricity consumption and/ or greater energy efficiency.	Design, construction and operation

ID	Mitigation measure	Timing
GG2	The project will be designed and implemented with the aim of achieving the following: • at least a 10 per cent reduction in carbon emissions during construction • offset at least 25 per cent of the carbon emissions associated with consumption of fuel and electricity through the purchase of approved offsets and/ or renewable energy during construction • at least a 10 per cent reduction in scope 1 greenhouse gas emissions using Climate Active Standard eligible offsets during construction • at least a 15 per cent reduction in carbon emissions during operation. • A baseline against which the target reductions above will be evaluated will be established during detailed design, with reference to typical construction materials and methodologies, and operational processes and procedures, applied to other road tunnels in NSW.	Design, construction and operation