SUSTAINABILITY

CHAPTER TWENTY-FIVE

25 Sustainability

This chapter describes the overall approach to sustainability on the project and how specific objectives and initiatives are being incorporated into its design, construction and operation. An assessment of the potential impact of climate change on the project, the resource associated with the project and the greenhouse gas emissions that would be generated during construction and operation of the project is also provided.

25.1 Secretary environmental assessment requirements

The Secretary's environmental assessment requirements relating to sustainability, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 25-1.

Table 25-1 Secretary's environmental assessment requirements – sustainability

Ref.	Secretary's environmental assessment requirements	Where addressed
12. Sustainability		
12	The Proponent must assess the project against the current guidelines including targets and strategies to improve Government efficiency in use of water, energy and transport.	Sustainability is addressed in this chapter.

25.2 Sustainability overview

There are many definitions for sustainability or sustainable development. One of the original descriptions of sustainable development, contained in *Our Common Future* (commonly referred to as the Brundtland Report), is: 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987).

In 1992, the Commonwealth Government defined ecologically sustainable development (ESD) as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future can be increased' (Commonwealth of Australia, 1992). The four principles to assist achievement of ESD are defined in the *Environmental Planning and Assessment Regulation 2000* and the *Protection of the Environment Administration Act 1999* as:

- The precautionary principle – where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for not implementing mitigation measures or strategies to avoid potential impacts
- Inter-generational equity – the present generation should ensure that the health, diversity and productivity of the environment are equal to or better for the future generations
- Conservation of biological diversity and ecological integrity – ecosystems, species and genetic diversity within species should be maintained
- Improved valuation and pricing of environmental resources – economic values for services provided by the natural environment should be determined, such as the atmosphere's ability to receive gaseous emissions; cultural values; and visual amenity.

Chapter 29 (Justification and conclusions) details how the project addresses these four principles.

25.2.1 Sustainability governance and policy

An increasing number of legislative and policy mechanisms include considerations and requirements relating to sustainability, particularly in relation to energy efficiency and resource use. The following provides a summary of these legislative and policy mechanisms:

- The Transport for NSW Corporate Plan 2012-2017 (Transport for NSW, 2012d) promotes the need to ensure that the transport system '...meets present social and economic needs without compromising the quality of life for future generations. An important part of this is minimising the impact of transport on our natural environment now and into the future.' The Plan also places a strong emphasis on energy management and the need to respond to climate change
- The NSW Government's Government Resource Efficiency Policy aims to reduce the NSW Government's operating costs and lead by example in increasing the efficiency of the resources it uses. The policy ensures NSW Government agencies meet the challenge of rising costs for energy, water, clean air and waste management and use purchasing power to drive down the cost of resource-efficient technologies and services
- The *National Greenhouse and Energy Reporting Act 2007* (NGER) is the national framework for reporting and disseminating information on greenhouse gas emissions, energy use and energy production associated with the activities of Australian corporations
- The Commonwealth Renewable Energy Target (RET) currently commits Australia to generating 33,000 GWh per year of electricity from 'low emission' sources by 2020 in order to achieve the goal of a 23.5% share of renewable energy in Australia's electricity supply by 2020. This demonstrates a substantial increase in Commonwealth Government support for renewable energy initiatives.

Regulatory and policy drivers for the inclusion of workforce development initiatives as part of the social sustainability program for the project include:

- NSW State Priorities include creating jobs and apprenticeships for the construction sector through infrastructure investment, and increasing the proportion of people completing apprenticeships and traineeships to 65 per cent
- The *Australian Jobs Act 2013* requires public and private major projects in Australia with a capital expenditure of $500 million or more to prepare and implement an Australian Industry Participation (AIP) plan. The objective is to support the development of a more diverse workforce and future growth opportunities for Australian enterprises
- The NSW Aboriginal Participation in Construction Policy aims to deliver more employment and business opportunities for Aboriginal people on selected government construction projects. The category of project defines the percentage of the project spend directed to Aboriginal related employment and education activities, procurement of goods or services from recognised Aboriginal businesses or other programs.

For Sydney Metro City & Southwest, sustainability means building public transport for current and future generations that optimises environmental, social and sustainability outcomes, transit service quality and cost effectiveness.

An environment and sustainability policy has been developed for Sydney Metro City & Southwest based on the Sydney Metro Northwest sustainability policy, and Transport for NSW sustainability commitments. The policy acknowledges that the project has the potential to maximise the potential sustainability benefits while minimising negative impacts.

Environment & Sustainability Policy

This Policy reflects a commitment in our delivery of the Sydney Metro program to:

- Align with, and support, Transport for NSW (TfNSW) Environment & Sustainability Policy.
- Optimise sustainability outcomes, transport service quality, and cost effectiveness.
- Develop effective and appropriate responses to the challenges of climate change, carbon management, resource and waste management, land use integration, customer and community expectation, and heritage and biodiversity conservation.
- Be environmentally responsible, by avoiding pollution, enhancing the natural environment and reducing the project ecological footprint, while complying with all applicable environmental laws, regulations and statutory obligations.
- Be socially responsible by delivering a workforce legacy which benefits individuals, communities, the project and industry, and is achieved through collaboration and partnerships.

To deliver on these commitments, the Sydney Metro team will:

Industry leadership

- Implement coordinated and transparent decision making, by engaging with stakeholders and suppliers, encouraging innovation and demonstrating sustainability leadership.
- Explore new benchmarks for the transport infrastructure sector by requiring high standards from our designers, contractors and suppliers, building on experience gained through development of Sydney Metro Northwest.

Community and customer

- Provide accessible, safe, pleasurable, and convenient access and transport service for all customers.
- Establish positive relationships with community and stakeholders to maximise opportunities to add value to local communities.

Land use integration and place making

- Create desirable places, promote liveability, cultural heritage, and optimise both community and economic benefit.
- Balance transit oriented development opportunities with stakeholder expectations.

Embedding environmental and social sustainability

- Establish robust sustainability objectives and targets.
- Maintain an environmental management system that is integrated into all our project activities.
- Ensure thorough and open environmental assessment processes are developed and maintained.
- Develop and maintain an environmental management framework to embed best practice pollution management and sustainable outcomes during construction.
- Apply effective assurance processes to monitor performance against the project environment and sustainability objectives and identify appropriate reward or corrective action, as required.
- Apply environment and sustainability specific processes to the procurement of delivery activities.

Accountability

- Undertake public sustainability reporting.
- Hold employees and contractors accountable for proactively meeting their environmental and social sustainability responsibilities.
- Provide appropriate training and resources necessary to meet our responsibilities.

This policy provides an overarching framework for the development of more specific sustainability objectives, developed as part of a sustainability strategy, to guide the integration of sustainability into project governance, design, construction and operation.

The delivery of the project offers the potential to increase workforce capability and capacity, mitigate skills shortages and gaps that would reduce cost, improve productivity and provide local sustainable employment. Sydney Metro's skills legacy would improve the competitiveness of industry, provide individual career pathways and provide major socio-economic benefits to individuals and communities. A workforce development program would be implemented for Sydney Metro City & Southwest, building on current activity from Sydney Metro Northwest and an assessment of future needs.

25.2.2 Sydney Metro City & Southwest sustainability strategy

An initial Sydney Metro City & Southwest sustainability strategy has been developed which incorporates the environment and sustainability policy, provides a response to relevant government regulations and policies, and sets out specific objectives and initiatives to be integrated into the project planning and design, procurement, construction and operational stages of the project.

Figure 25-1 illustrates how the Sydney Metro City & Southwest sustainability strategy integrates sustainability across the project.

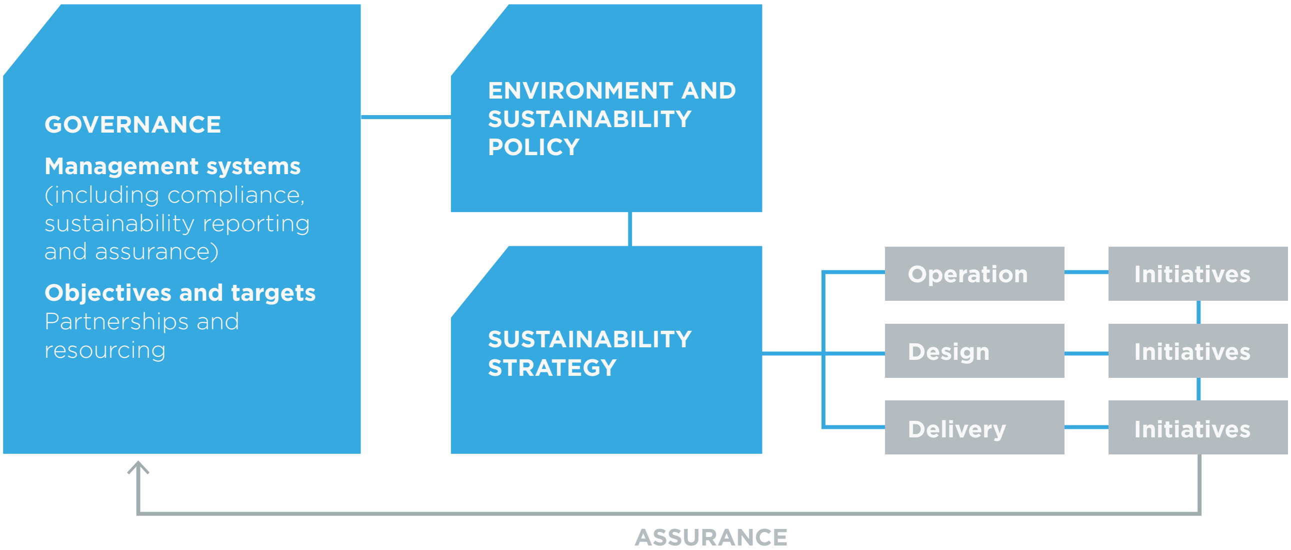

Figure 25-1 Sustainability governance structure

25.3 Sustainability objectives and initiatives

Sustainability objectives and supporting targets and initiatives which have been identified for the project are included in Table 25-3. The proposed initiatives and targets align with those outlined in the Transport for NSW Sustainable Design Guidelines for Rail (version 3) (Transport for NSW, 2013b) and other government resource efficiency policies. These initiatives and targets would be further refined as part of the design process, committed to in the Sustainability Strategy and included in the contract documents for all detailed design, construction and operations contracts. Project contractors would be required to clearly identify how they would ensure that specific sustainability objectives, initiatives and targets are met. This approach would encourage industry to develop innovative value-for-money sustainability solutions.

Table 25-3 Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Governance	Demonstrate leadership by embedding these objectives into decision making	• Ensure the project decision making framework includes sustainability criteria (environment and community).
	Demonstrate a high level of performance against objectives and appropriate benchmarks	• Develop performance targets across all sustainability themes, based on best practice benchmarking and responding to policy and regulatory context • Achieve a best practice level of performance using market leading sustainability rating tools (for example ISCA, Green Star, or equivalent) during design, construction and operation.
	Be accountable and report publicly on performance	• Use an assurance framework and reporting system to assist Sydney Metro and contractors in reliably reporting against sustainability targets • Monitor sustainability performance, and provide public sustainability reports.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Carbon and energy management	Improve the shift toward lower carbon transport	• Optimise integration of the project with the most sustainable access modes including walking, cycling and bus.
	Reduce energy use and carbon emissions during construction	• Estimate carbon emissions, track performance, and reduce emissions through design refinements and construction practices • Establish energy efficiency targets for the project • Incorporate energy efficient construction equipment, methods, and practices • Local sourcing of materials where feasible. • Use biodiesel and ethanol fuel • Implement green travel plans • Offset 25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction.
	Reduce energy use and carbon emissions during operations	• Establish energy efficiency and renewable energy targets for the project • Estimate and track operational carbon emissions and reduce emissions though refinements to design and operational practices • Target energy consumption at least 10 per cent lower than minimum compliance with the National Construction Code • Maximise passive design features including daylight, natural ventilation, and passive cooling • Efficient lighting and lighting control systems • Maximise reuse of energy recovered from the train braking system • Energy efficient ventilation, air conditioning, pumps, escalators, lifts and appliances • Offset 100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation.
	Support innovative and cost-effective approaches to energy efficiency, low-carbon / renewable energy sources and energy procurement	• Utilise wayside energy storage, renewable energy, and district cooling systems where feasible • Offset the greenhouse gas emissions associated with electricity used during operations.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Pollution control	Reduce sources of pollution and optimise control at source to avoid environmental harm	• Ensure Environmental Management Plans and Environmental Management Systems are in place prior to commencement of construction • Integrate water sensitive urban design solutions for storm water treatment • Investigate opportunities to reduce emissions from mobile non-road diesel plant and equipment at source • Include noise and air quality mitigation measures where appropriate • Design stations and temporary facilities to minimise light spill in accordance with standards • Target zero major pollution incidents.
Climate change resilience	Design infrastructure and operations to be resilient to the impacts of climate change	• Carry out a climate change risk assessment • Identify and implement adaptation measures to mitigate extreme and high level climate change risks, and address medium level climate change risks on the project • Review and update the climate change risk assessment and adaptation response through the project life cycle.
Resources water efficiency	Minimise use of potable water	• Estimate and monitor potable water usage, and implement design and construction initiatives to minimise water use • Include water-efficient features, equipment and appliances in the design of stations • Avoid use of potable water for non-potable purposes if non-potable water is available.
	Maximise opportunities for reuse of rainwater, stormwater, wastewater and groundwater	• Establish performance targets for the use of recycled water • Pending the outcome of feasibility analysis, connect to district recycled water networks where available and use non-potable water in concrete • Harvest and reuse rainwater at permanent and temporary facilities where feasible • Incorporate water sensitive urban design solutions for storm water management and reuse.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Resources waste and materials	Minimise waste through the project lifecycle	- Maximise recycling of construction and demolition waste by adopting waste recycling targets (95 per cent) - Enabling recycling of waste materials from office facilities and customers - Planning for final disposal of operational assets, such as train carriages - Use modular, refabricated and precast structural and finishing materials to minimise waste during construction and maintenance.
	Reduce materials consumption	- Design optimisation to minimise volumes of excavation, concrete and steel - Dematerialisation of components and finishes - Maximise reuse of existing materials, buildings, facades, and structures.
	Consider embodied impacts in materials selection	- Minimise the embodied impacts of materials including high impact materials such as steel and concrete used in the project, through selection of low carbon alternatives, and considering durability and local sourcing - Establish targets for reducing embodied energy of high impact materials. Specify healthy surface coatings (eg low-VOC) and other materials.
	Maximise beneficial reuse of spoil	- Beneficial reuse of 100 per cent of usable spoil from excavated tunnels and station caverns, in accordance with a spoil management hierarchy.
Biodiversity conservation	Protect and create biodiversity through appropriate planning and management	- Establish and achieve targets for biodiversity conservation and enhancement - Provide biodiversity offsets as required.
Heritage conservation	Protect and promote local heritage through appropriate design, planning, and management controls	- Identify opportunities to enhance heritage values and show evidence of implementation - Develop partnerships with relevant stakeholders to utilise heritage places to promote local heritage values.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Liveability	Promote improved public transport patronage by leveraging connectivity and interchange capabilities	• Ensure efficient interchange of customers accessing Sydney Metro from bus, rail and other public transport modes • Establish and achieve targets for the creation of cycle ways • Contribute to active transport link connectivity through creating improved pedestrian links • Provide secure and weather protected cycle parking spaces in station precincts.
	Provide comfortable accessible, safe and attractive stations and precincts	• Design in accordance with best practice urban design principles • Incorporate Crime Prevention Through Environmental Design principles in design to deter crime • Design to minimise urban heat island • Provide thermal comfort including consideration of local control for occupants.
Community benefit	Make a positive contribution to community health and well-being	• Establish and achieve targets for identifying and completing projects which benefit local communities and make a positive contribution to community health and well-being • Integrate station entries into public spaces and facilitate uses which benefit local communities.
	Engage and involve the community and local stakeholders in the development of the project	• Seek input from the community and stakeholders throughout the planning, design and delivery stages of the project.
	Contribute to the delivery of legacy projects to benefit local communities	• Investigate and implement feasible opportunities to use residual land to benefit local communities • Establish and achieve targets for the amount of new public open space which will be created as part of the project.
	Create opportunities for local business involvement during construction and operation	• Include involvement of local businesses in the sustainable procurement strategy for the project.
Supply chain	Influence contractors, subcontractors and materials suppliers to adopt these objectives in their works and procurement	• Develop and implement a sustainable procurement strategy, based on best practice policy and frameworks including British Standard *BS8903 Sustainable Procurement Best Practice Guidance and Code*, to apply to Principal Contractors, their subcontractors and their suppliers.

Sustainability theme	Sustainability objective	Potential sustainability initiatives / targets
Workforce development	Priority areas include: Industry participation; workforce skills development; inspiring future talent and developing capacity in the sector; and increasing workforce diversity and inclusion	• Provide employment opportunities for local people • Increase opportunities for local business, and small and medium enterprises, to access Sydney Metro supply chain • Support industry to compete in home and global markets • Resolve skills shortages locally and nationally through targeted and transferable skills development • Respond to changing job roles and increased skill requirements within industry • Embed Sydney Metro health and safety culture within all induction and training activities, promoting continuous improvement • Engage young people through education and work experience • Collaborate with higher education institutions to provide programs responding to rapid transit and other infrastructure requirements • Support vocational career development through apprenticeships and traineeships • Increase participation of indigenous workers and businesses • Increase female representation in non-traditional trades • Target long term unemployed • Develop and implement a Workforce Development and Industry Participation Strategy, establishing targets to be met during the delivery of the project.
Economic	Consider adopting a 'whole of life' costing model to maximise sustainability benefits.	• Include consideration of whole of life costs and benefits in optioneering and decision making.
	Optimise development opportunities for residual land.	• Optimise over station development.
	Capture sustainability benefits in the business case for the project.	• Ensure social and environmental benefits of improved access to transport and employment are documented in the business case • Ensure cost savings to future residents living in higher density developments as a result of the project is considered in as part of the business case for the project.

25.4 Climate change adaptation

Climate change has been recognised internationally as a significant issue with the potential to have a major impact on natural and human systems. Apart from actions to reduce greenhouse gas emissions, there is increased awareness of the need to identify potential effects of climate change and to improve planning to manage or mitigate these effects.

The Intergovernmental Panel on Climate Change, in its *Fifth Assessment Report* (2013) concluded that there is unequivocal evidence of warming of the global climate system. This conclusion is based on observed warming of the atmosphere and ocean, reductions in snow and ice cover, rising sea levels and increased concentrations of greenhouse gases in the atmosphere.

The *NSW Long Term Transport Master Plan* (Transport for NSW, 2012b) acknowledges that meeting community expectations in environmental sustainability is a statewide challenge. Initiatives to manage and minimise the environmental impacts of our transport system include:

- A co-ordinated approach to addressing environmental issues at all levels of transport planning
- Sustainable design guidelines for transport projects
- Better ways to assess the environmental benefits of projects.

Specific actions in the Master Plan to deliver environmental sustainability outcomes include 'boosting our resilience to climate change and natural disasters' and assessing 'transport climate resilience'.

The *Environment and Sustainability Policy Framework* (Transport for NSW, 2013d) is a collective and coordinated approach to deliver the NSW Government's environmental and sustainability agenda across the transport 'cluster' (Transport for NSW, Sydney Trains, NSW Trains, Roads and Maritime Services (Roads and Maritime) and State Transit Authority of NSW (STA)). The framework has been developed to implement the *Transport Environment and Sustainability Policy Statement* (Transport for NSW, 2013e).

The framework's climate change resilience theme acknowledges that some level of climate change is inevitable, and is concerned with the Transport for NSW effort to adapt and build resilience into its planning, projects and operations thereby minimising the impacts and costs of climate change on Transport for NSW customers and contributing to greater climate change resilience for NSW.

The Sustainability Strategy for the project includes an objective that the project infrastructure and operations are resilient to the impacts of climate change.

25.4.1 Climate change risk assessment methodology

The methodology for conducting the climate change risk assessment is based on the Australian Standard AS 5334-2013 *Climate change adaptation for settlements and infrastructure – A risk based approach*. The standard follows the International Standard ISO 31000:2009, *Risk management – Principles and guidelines* (adopted in Australian and New Zealand as AS/NZ ISO 31000:2009), which provides a set of internationally endorsed principles and guidance on how organisations can integrate decisions about risks and responses into their existing management and decision-making processes.

The following key steps were undertaken to complete the risk assessment:

- Determine the climate change context – carried out in accordance with AS 5334 – 2013:
  - Define the greenhouse gas emissions scenarios
  - Define future time slices
  - Define the climate variables
  - Selection of climate data
  - Determine other associated impact studies required (including flood modelling)
  - Obtain past meteorological record
- Identify the climate risks and assess the likelihood and consequence of each risk
- Identify adaptation responses.

Two risk workshops were held with multidisciplinary members of the project team throughout the design phase. The preliminary risks identified at the risk workshops were then formalised in the risk register, and thorough risk descriptions, including cause, impact / consequence and current treatment were identified.

Climate projections

Climate change issues associated with the operational phase of the project are much greater than during the construction phase, as there is much more time for those effects to be realised. Due to the expected design life of assets such as tunnels, bridges and drainage infrastructure (60 to 100 years), the time periods which were selected for the assessment were 2030, 2060 and 2090. The climate models used to project future climate conditions are not an effective tool to determine near term changes such as within the next 10 years (during the expected construction period). Construction phase climate change has therefore not been assessed.

Scientists have modelled the climate system and projected climatic changes likely to occur under various future greenhouse gas emissions scenarios. Greenhouse gas emission scenarios represent estimations of future quantities of greenhouse gas that may be released into the atmosphere. They are based on assumptions about future demographics and the implementation and efficiency of energy policies.

The Intergovernmental Panel on Climate Change produces Assessment Reports (AR) which review and synthesise the current state of scientific knowledge (at the time of them being published) on climate change.

Modelling for the Intergovernmental Panel on Climate Change's Fifth Assessment Report (AR5) used Representative Concentration Pathways (RCPs) to define different projections. The RCPs are labelled according to the radiative forcing values (relative to pre-industrial levels) which could be experienced in 2100 based on different atmospheric concentrations of greenhouse gases (with the exception of RCP2.6 which peaks at 2.6 W/m^2 and then declines by end of century). Radiative forcing refers to the difference between incoming solar energy hitting the earth's surface and that being radiated back to space, which in this context results in additional energy in the climate system resulting from elevated atmospheric greenhouse gases. A positive value results in a net earth energy gain.

There are four modelled RCPs as outlined in Table 25-4.

Table 25-4 Representative concentration pathways

RCP	Increase in radiative forcing on preindustrial levels of approximately
RCP2.6	2.6 W/m^2
RCP4.5	4.5 W/m^2
RCP6.0	6.0 W/m^2
RCP8.5	8.5 W/m^2

Projections used in this study were derived from a number of sources. However, the scenarios selected from these sources largely correlate – and represent both the worst case (and the current trajectory) for emissions and warming scenarios. These include:

- NarClim (NSW Government et al, 2015): NarClim uses a single, representative emissions scenario: the IPCC high emissions scenario similar to RCP8.5. NARCliM uses the Weather Research and Forecasting (WRF) model to develop high resolution models of meteorological variables
- NSW Climate Impact Profile: *The Impacts of Climate Change on the Biophysical Environment of New South Wales* (Department of Environment, Climate Change and Water, 2010d) has based climate change projections findings of a single, high emissions scenario. In addition, work was undertaken by the University of NSW to determine which of the models best simulated Australian climate, and only these models were used in the projections
- Climate Change in Australia (CSIRO et al, 2015): Climate Change in Australia presents the full range of RCPs as per AR5. We have presented most of the RCPs in the data used in this report, and have based the assessment on RCP8.5 representing the highest radiative forcing, and the current emissions trajectory.

The climatic variables identified as potentially generating risks for the project are annual average rainfall, extreme rainfall, extreme temperature, extreme wind, storms (cyclones, hail, dust and lightning), sea level rise and fire danger index for the Sydney region.

25.4.2 Future climate

The Australian climate is likely to experience a greater frequency and severity of extreme weather events due to climate change. As a result, it is especially important to understand the 'most likely' and 'worst case' implications of climate change on high-value infrastructure in major Australian cities such as Sydney. According to CSIRO research, the Sydney area is likely to become warmer, with more hot days and fewer cold nights. Detailed projections are presented below, and can be summarised as follows:

- **By 2030** – about 1.1 degrees Celsius increase in temperature, with increasing frequency of hot days over 35 ºC. Average rainfall may range from a 10 per cent decrease in spring to a 0.7 per cent increase in summer, with increased likelihood and intensity of extreme rainfall
- **By 2060** – up to 2.4 degrees Celsius increase in temperature, with average rainfall ranging from an 11.3 per cent decrease in winter to 0.4 per cent decrease in summer
- **By 2090** – up to 3.9 degrees Celsius increase in temperature, with increasing frequency of hot days over 35 degrees Celsius. Winter and spring rainfall patterns to vary widely, with increased likelihood and intensity of extreme rainfall.

A summary of the projections used for this assessment is presented in Table 25-5. A baseline of 1986–2005 has been presented for some variables as this relates to the period from which the changes are projected. Climate modelling does not typically model extreme storm projections directly – instead these events are inferred from other results.

Table 25-5 Summary of climate change projections – Sydney region

	Baseline (1986-2005)	2030 (RCP8.5)	2060 (RCP8.5)	2090 (RCP8.5)
Temperature				
Mean maximum temperatures (°C) – Annual	22.3	+1.2	+2.4	+3.9
Mean minimum temperatures (°C) – Annual	14.4	+1.1	+2.4	+3.9
Days over 35°C – Annual	3.5	N/A	N/A	+11
Rainfall				
Mean precipitation change (%) – Annual	1335 mm	-6.1	-6.6	-7.9
Mean precipitation change (%) – Spring	258 mm	-9.7	-10.7	-18.5
Mean precipitation change (%) – Summer	389 mm	0.0	-0.4	3.6
Mean precipitation change (%) – Autumn	387 mm	-6.8	-7.1	-7.4
Mean precipitation change (%) – Winter	301 mm	-9.9	-11.3	-15.1
Extreme rainfall				
Extreme rainfall events – Maximum 1 day rainfall	Projected to increase 2–22%			
Extreme rainfall events – 20 year return level of maximum 1 day rainfall	Projected to increase 5–42%			
Fire regimes				
Change in number of severe fire danger days per year	0.9	1.3	N/A	2.1
Severe wind				
Maximum daily wind speed	N/A	N/A	N/A	-6% to 2.5%
Sea conditions				
Sea level rise (m)	0	0.14	N/A	0.66
Sea surface temperature (°C)	N/A	1.0	N/A	3.1

25.4.3 Climate change risks

Climate change is anticipated to have direct and indirect impacts on the project. The types of impacts are relatively well understood, but their severity and extent is uncertain. As such, there is a need to identify these risks and develop strategies to treat them.

The risks identified were rated as either low, medium, high and extreme. The appropriate risk rating level was determined by:

- Determining the consequences of each risk occurring
- Determining the likelihood of each risk occurring
- Considering the existing controls expected to be applied through design and construction
- Determining the risk rating (residual risk).

In summary, the climate risk assessment process identified:

- No extreme ('unacceptable' risk) or high ('undesirable' risk) risks
- Six medium risk ratings ('tolerable' risk)
- 37 low risks ('acceptable' risk). For these risks, no risk treatment is proposed at this stage – although some of the risks would be followed up during detailed design.

The combined effect of the direct and indirect impacts of climate change falls into one of three categories:

- Accelerated infrastructure deterioration and increased maintenance requirement
- Increased frequency of rail closures / cancellations
- Infrastructure loss (total or partial loss as a result of a severe weather event).

Table 25-6 outlines the six 'medium' risks for the project. These risks are considered tolerable and the risk treatments which would be implemented may further reduce these risks to the project.

Table 25-6 Climate change risks identified as 'Medium'

Risk	Pre-mitigation risk rating	Risk treatment
Increased rainfall and extreme events affecting station access and interchange, which causes disruption to scheduled services.	Medium, tolerable	Ensure that adequate flood modelling is carried out and integrated with design.
Increased future temperatures mean that specified air-conditioning is unable to cope in the future and requires replacement and upgrade but insufficient space is available causing passenger discomfort and low levels of service satisfaction.	Medium, tolerable	Test the sensitivity of air-conditioning systems to increased temperatures, and identify potential additional capacity of air-conditioning systems that may be required within the life of the project, with a view to safeguarding space if required.
Increased frequency and severity of extreme rainfall events leading to increased flooding of creeks and waterways and potential inundation of infrastructure.	Medium, tolerable	Ensure that adequate flood modelling is undertaken and integrated with design.
Increased flooding and extreme weather events, which affect tunnel and station drainage, causing temporary closure.	Medium, tolerable	Ensure that adequate flood modelling is carried out and integrated with design.
Increased rainfall frequency and intensity results in changes to groundwater levels, and flooding in tunnels and tunnel portals.	Medium, tolerable	Ensure that adequate flood modelling is carried out and integrated with design.
Increased daily and annual temperatures, which may require larger sized tunnel ventilation equipment to maintain tunnel temperatures below design criteria than those initially specified.	Medium, tolerable	Test the sensitivity of ventilation systems to increased temperatures and provide adequate capacity.

To effectively manage climate change risks, each stage in the project should consider the most up to date climate change projections and design guidelines. The climate risks require ongoing review and response by designers and constructors. Refer to Section 25.7 for mitigation measures to manage climate change risks throughout the life of the project.

25.5 Construction resource use

Construction of the project would require the use of a wide range of resources and materials. An indicative list of construction resources and materials is provided in Table 25-7 along with the estimated quantities required. Details provided in Table 25-7 are indicative only and would be refined during the detailed design and procurement phases of the project.

As shown in Table 25-7, the largest quantities of construction resources are anticipated to comprise concrete, steel, electricity, fuel and water; with tunnel construction and spoil handling activities creating the largest demand for these resources.

Table 25-7 Indicative quantities of resources required to construct the project

Resource	Estimated quantity required	Most resource intensive activities
Electricity	45,413 MWh	Tunnel boring machines, construction site offices,
Fuel	46,172,044 L	Construction plant and equipment
Concrete	407,124 m^3	Civils and station construction works
Tunnel lining segments (pre-cast concrete)	371,886 m^3	Tunnel construction
Structural steel	23,750 tonnes	Construction of tunnels and stations
Reinforcing steel	40,033 tonnes	For use with ready mix concrete
Water	550,000 m^3	Tunnel boring machines, dust suppression

Given the scope and nature of the project, it would not be possible to avoid the need for substantial quantities of materials and resources for construction. Increased demand for construction resources may temporarily exceed existing local supplies of such materials, preventing their use by other projects and / or the community, either directly through a supply shortage of a particular resource or indirectly through an increase in the price to procure such resources (due to increased demand). However, it is considered unlikely that the project alone would result in any resource becoming scarce or in short supply.

Table 25-3 outlines the Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets for reducing resource use for the project.

25.6 Greenhouse gas and energy

Greenhouse gas is a collective term for a range of gases that absorb outgoing infra-red radiation reflected from the earth which in turn generate heat. This heat warms the atmosphere. This is known as the greenhouse effect and is linked to climate change.

Human activities, including the combustion of carbon-based fuels increase the concentration of greenhouse gases in the atmosphere. This leads to greater absorption of infra-red radiation and an increase in atmospheric temperature. This is known as the enhanced greenhouse effect. The following six greenhouse gases are covered under international climate change agreements and are considered in this assessment:

- Carbon dioxide (CO_2) – this is by far the most abundant gas, and is primarily released during fuel combustion
- Methane (CH_4) – this is generated by the anaerobic decomposition of carbon-based material (including enteric fermentation and waste disposal in landfills)
- Nitrous oxide (N_2O) – this is generated by industrial activity, fertiliser use and production
- Hydrofluorocarbons (HFCs) – these are commonly used as refrigerant gases in cooling systems
- Perfluorocarbons (PFCs) – these are used in a range of applications including solvents, medical treatments and insulators
- Sulphur hexafluoride (SF_6) – these are used as a cover gas in magnesium smelting and as an insulator in heavy duty switch gear.

Each greenhouse gas behaves differently in the atmosphere with respect to its ability to trap outgoing radiation and its residence time in the atmosphere. To achieve a common unit of measurement each greenhouse gas has been compared to the warming potential of carbon dioxide over a 100 year period. This provides a global warming potential for each greenhouse gas that can be applied to the estimated emissions of the project. The resulting aggregated emissions are referred to in terms of carbon dioxide-equivalent emissions (or CO_2-e).

Identifying the likely greenhouse gas emissions associated with a project has the benefit of determining the scale of the emissions and providing a baseline from which to develop and deliver greenhouse gas reduction measures.

25.6.1 Greenhouse gas assessment methodology

Greenhouse gas emissions are reported as tonnes of carbon dioxide equivalent (tCO_2-e) and categorised into three different scopes (either scope 1, 2 or 3) in accordance with the Greenhouse Gas Protocol (WRI & WBCSD, 2004), IPCC and Australian Government greenhouse gas accounting / classification systems.

Emissions are categorised into three different scopes to help delineate between direct emissions from sources that are owned or controlled by a project and upstream indirect emissions that are a consequence of project activities but occur at sources owned or controlled by another entity. The three greenhouse gas scopes include:

- Scope 1 emissions, also called 'direct emissions' – emissions are generated directly by a project, eg emissions generated by the use of diesel fuel by construction plant / equipment
- Scope 2 emissions, also referred to as "indirect emissions" – emissions are generated outside of a project's boundaries to provide energy to the project, eg the use of purchased electricity from the grid
- Scope 3 emissions – all indirect emissions (not included in scope 2) due to upstream or downstream activities. For example indirect upstream emissions associated with the extraction, production and transport of purchased construction materials.

The objectives of the greenhouse gas assessment were to:

- Identify the sources of greenhouse gas emissions associated with construction and operation of the project
- Quantify the greenhouse gas emissions associated with each greenhouse gas source
- Present the Scope 1, 2 and 3 greenhouse gas emissions
- Identify opportunities (mitigation measures) which may be implemented to reduce the greenhouse gas emissions associated with construction and operation of the project.

To support the creation of standardised carbon footprints for construction projects, Transport for NSW has released the *Carbon Estimate and Reporting Tool* (Transport for NSW, 2015a). This tool, which is based on the Greenhouse Gas Protocol, has been developed to ensure a consistent methodology is used to complete greenhouse gas inventories for the construction stage of all projects for the Transport for NSW Infrastructure and Services projects.

Scopes 1, 2 and 3 greenhouse gas sources for construction and operation of the project are outlined in Table 25-8.

Table 25-8 Greenhouse gas sources by scope for the project

Scope	Description	Greenhouse gas sources – construction	Greenhouse gas sources – operation
Scope 1	Direct greenhouse gas emissions associated with emissions generated on site.	Removal of vegetation (loss of carbon sink) – vegetation absorbs carbon dioxide from the atmosphere (by photosynthesis). Where vegetation is removed, the ability for the vegetation to act as a carbon sink would be lost.	Maintenance equipment – most maintenance equipment would be operated by the burning of fossil fuels, typically diesel, which would create greenhouse gas emissions.
		Construction equipment – most construction equipment would be operated by the burning of fossil fuels, typically diesel, which would create greenhouse gas emissions.	
		Generator use – some small equipment and lighting for out-of-hours work would require the use of an on-site generator, typically powered by diesel, which creates greenhouse gas emissions.	

Scope	Description	Greenhouse gas sources – construction	Greenhouse gas sources – operation
Scope 2	Indirect greenhouse gas emissions associated with electricity used on-site for lighting construction sites, where actual emissions are generated elsewhere (generally at the source of the electricity generation).	Electricity – tunnel boring machines would be major users of electricity. Electricity would also be used by site offices for lighting and security.	Electricity – metro trains, station facilities, signalling and communications, tunnel ventilation and water treatment plants would be the major users of electricity.
Scope 3	Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities and waste disposal.	Construction materials – different construction materials contain varying levels of embodied emissions. For example, high-strength concrete contains a greater proportion of cement (which has a high level of embodied emissions), compared to concrete for lower-strength applications that contain fly-ash (which has a lower level of embodied emissions).	Materials used for maintenance – different materials contain varying levels of embodied emissions.
		Construction waste – decomposition of cleared vegetation, disposal of contaminated soil and wood material from the demolition of acquired properties would create greenhouse gases, as the breakdown of organic matter as waste material directly releases stored carbon dioxide to the atmosphere.	Operational waste – decomposition of waste from stations would create greenhouse gases, as the breakdown of organic matter as waste material directly releases stored carbon dioxide to the atmosphere.
		Construction transport – all construction-related transport would create greenhouse gas emissions from the consumption and burning of fossil fuels.	Maintenance transport – all maintenance-related transport would create greenhouse gas emissions from the consumption and burning of fossil fuels.

This greenhouse gas assessment is based on current design information and construction staging and should be considered a preliminary estimate. The greenhouse gas emissions assessment for the project would be revised and updated as more accurate information becomes available.

25.6.2 Estimated greenhouse gas emissions construction

Greenhouse gas emissions would be generated during the construction of the project, with substantial energy-consuming activities anticipated to occur over the construction period. Greenhouse gas emissions would predominantly be generated as a result of:

- Combustion of fuel in construction plant, equipment and vehicles – these would be Scope 1 emissions (direct emissions occurring on-site)
- Electricity consumption for the tunnel boring machines – these would be Scope 2 emissions (occurring off-site at power stations)
- Electricity used at construction sites – these would be Scope 2 emissions (occurring off-site at power stations)
- Embodied emissions in key construction materials, including cement and steel – these would be Scope 3 emissions (energy and resources of construction materials consumed to produce a particular construction material).

As this project is based in an urban location, and with a large proportion of it involving tunnelling, no vegetation clearance or construction waste calculations have been included on the basis that the emissions would be low to negligible.

Greenhouse gas emissions were estimated with the level of current design detail for a range of emission sources that make up the overall construction of the project. The estimated Scope 1, 2 and 3 emissions are presented in Table 25-9.

Table 25-9 Estimated construction phase greenhouse gas emissions by scope

Scope	Source	Greenhouse gas emissions (cCO_2e) [1,2]
Scope 1	Construction plant and equipment (liquid fuel)	130,324
Scope 2	Electricity generated off-site	39,055
Scope 3	Embodied emissions of construction materials	367,347
	Construction waste transport	12,409
	Upstream fuel extraction for construction plant and equipment	9,956
	Delivery of materials to site	14,286
	Upstream fuel extraction, transmission and distribution	5,903
TOTAL		579,280

1 *tCO_2e = tonnes of CO_2 equivalent*

2 *Preliminary estimates which would be further refined during detailed design*

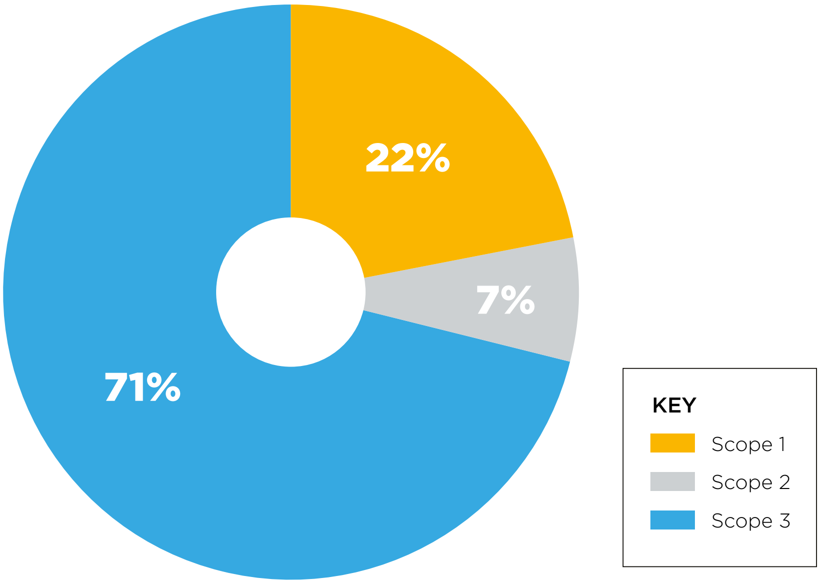

Figure 25-2 Estimated greenhouse gas emissions by scope for construction

NSW's annual greenhouse gas emissions are about 141.8 million tCO_2-e (Office of Environment and Heritage, 2015). The construction of the project is about equal to 0.4 per cent of NSW's current annual greenhouse gas emissions. Annual operation of the proposal would represent 0.05 per cent of state emissions.

Table 25-3 outlines the Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets for reducing materials and energy (and therefore greenhouse gas emissions) for the project.

25.6.3 Estimated greenhouse gas emissions operation

Operational greenhouse gas emissions would predominantly be associated with electrical consumption to power the following:

- Metro trains
- Station facilities
- Signalling and communications
- Tunnel ventilation
- Water treatment plants.

An estimate of the annual electricity consumption for the operational stage of the project is 66,500 megawatt-hours per year at year of opening.

Other operational related greenhouse gas emissions related to maintenance equipment use, maintenance transport, waste generation and materials used for maintenance are considered to be low to negligible in scale when compared with electrical consumption and therefore not included in the operational greenhouse gas assessment.

The subsequent estimate of the volume of greenhouse gas emissions during the operation of the project is provided in Table 25-10. Greenhouse gas emissions are preliminary estimates and may change as the detailed design of the project progresses.

Table 25-10 Estimated greenhouse gas emissions by scope during operation of the project- annually

Scope	Source	Greenhouse gas emissions (tCO_2e)[1]
Scope 2	Electricity generated off-site	57,190
Scope 3	Upstream fuel extraction, transmission and distribution	8,645
TOTAL		65,835

1 *tCO_2e = tonnes of CO2 equivalent*

Operation and maintenance of the project would result in increased direct emissions of greenhouse gas through increased electricity use. However, the project has the potential to reduce greenhouse gas emissions overall by providing a low greenhouse gas alternative to private car travel. Notwithstanding the emissions reductions there remains a significant operational footprint.

Table 25-3 outlines the Sydney Metro City & Southwest sustainability objectives and potential initiatives / targets for reducing energy and carbon (greenhouse gas) emissions for the project.

25.7 Environmental and sustainability management

The contractors for Sydney Metro would be required to develop an environmental and sustainability management system which would link to the Sydney Metro's system.

The relationship between key documents within the Sydney Metro Environment and Sustainability Management System and the contractor's Environment and Sustainability Management System is shown in Figure 25-3. Notably:

- The Construction Environment Management Plan (CEMP) and its sub plans would capture the construction environmental management requirements emerging from the Environmental Impact Statement, subsequent planning approvals and the Sydney Metro City & Southwest Sustainability Strategy
- The Sustainability Plan and its sub plans would capture governance and design requirements as well as social sustainability initiatives required by the Sydney Metro City & Southwest Sustainability Strategy
- These plans would vary in scope across different delivery packages.

Sub-contractors engaged by the contractor would be required to work under the contractor's environmental and sustainability management system.

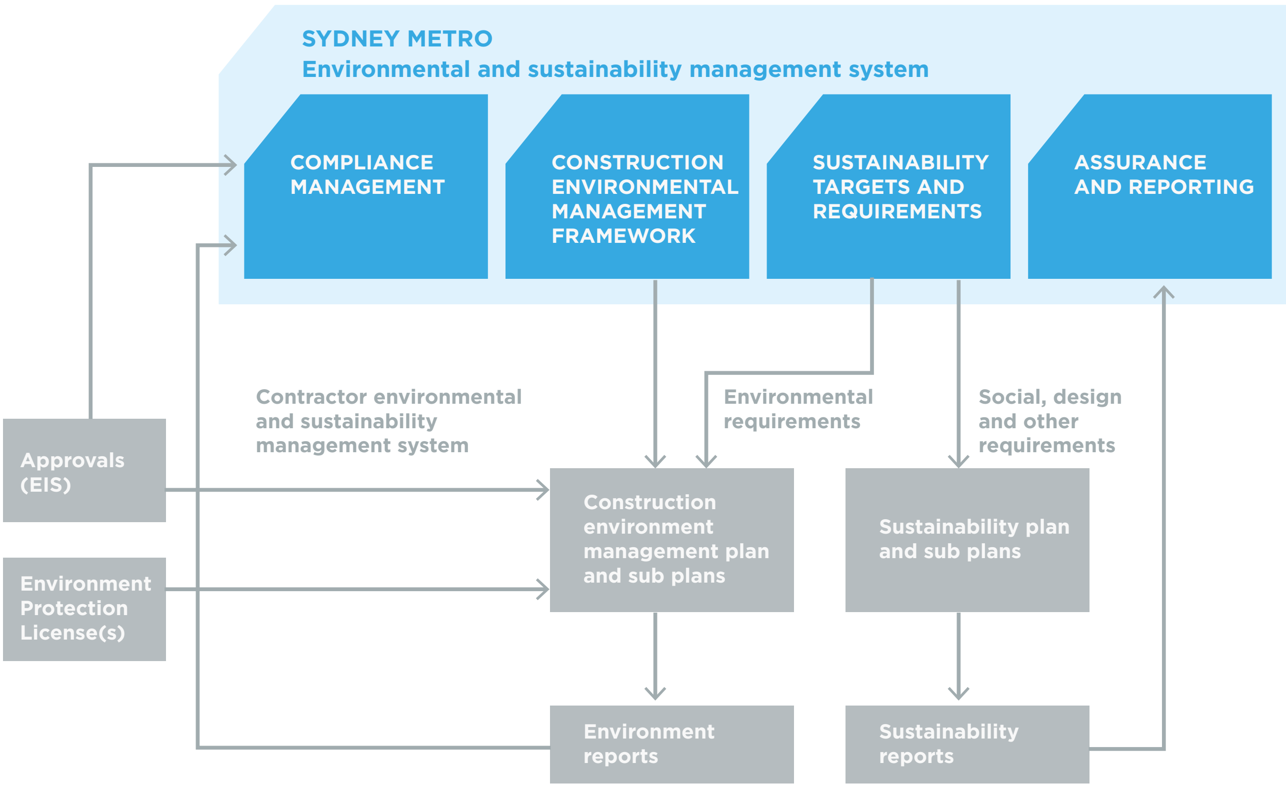

Figure 25-3 Environmental and sustainability management system

25.8 Mitigation measures

The mitigation measures that would be implemented to address project sustainability are listed in Table 25-11 and Table 25-12.

Table 25-11 Mitigation measures – sustainability – construction

Ref	Mitigation measure	Applicable location(s)[1]
SUS1	Sustainability initiatives would be incorporated into the detailed design and construction of the project to support the achievement of the project sustainability objectives.	All
SUS2	A best practice level of performance would be achieved using market leading sustainability rating tools during design and construction.	All
SUS3	A workforce development and industry participation strategy would be developed and implemented during construction.	All
SUS4	Climate change risk treatments would be incorporated into the detailed design of the project including: • Ensuring that adequate flood modelling is carried out and integrated with design • Testing the sensitivity of air-conditioning systems to increased temperatures, and identify potential additional capacity of air-conditioning systems that may be required within the life of the project, with a view to safeguarding space if required. • Testing the sensitivity of ventilation systems to increased temperatures and provide adequate capacity.	All
SUS5	An iterative process of greenhouse gas assessments and design refinements would be carried out during detailed design and construction to identify opportunities to minimise greenhouse gas emissions. Performance would be measured in terms of a percentage reduction in greenhouse gas emissions from a defined reference footprint.	All
SUS6	Opportunities to offset 25 per cent of the greenhouse gas emissions associated with consumption of electricity during construction would be offset.	All

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*

Table 25-12 Mitigation measures – sustainability operation

Ref	Mitigation measure	Applicable location(s)[1]
SUS7	Sustainability initiatives would be incorporated into the operation of the project to support the achievement of the project sustainability objectives.	All
SUS8	Periodic review of climate change risks would be carried out to ensure ongoing resilience to the impacts of climate change.	All
SUS9	A workforce development and industry participation strategy would be developed and implemented during the operation.	All
SUS10	100 per cent of the greenhouse gas emissions associated with consumption of electricity during operation would be offset.	All

1 *STW: Surface track work; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement work; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; facility; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.*