10 Environmental risk analysis

A detailed environmental risk analysis was conducted as part of this environmental impact statement. This chapter outlines the environmental risk analysis process and identifies the key environmental issues.

Table 10-1 sets out the Director-General's Requirements as they relate to risk analysis and where these have been addressed in the environmental impact statement.

Table 10-1 Director-General's Requirements – environmental risk analysis

Director-General's Requirement	Where addressed
Notwithstanding the key issues identified for consideration, the EIS must include an environmental risk analysis to identify the potential environmental impacts associated with the infrastructure.	This chapter

10.1 Environmental risk analysis process

An environmental risk analysis has been carried out to identify and confirm the key environmental issues for the project. Key issues are those that may have major or moderate impacts (actual or perceived) and require detailed assessment to determine the level or severity of potential effects and to identify appropriate mitigation and management measures.

The environmental risk analysis process carried out for the project included:

- Preliminary environmental assessment carried out as part of the State significant infrastructure application report (AECOM, 2013g) and subsequent State significant infrastructure supplementary report (AECOM, 2014c) to help identify the key environmental issues and to inform the State significant infrastructure application.
- An assessment of the key issues identified in the Director-General's Requirements for the project (**Appendix A**).
- An environmental risk review to confirm the key environmental issues based on the results of the detailed investigations presented in this environmental impact statement.

These steps are described further in **Section 10.2** to **Section 10.4** below.

10.2 Preliminary environmental assessment

A preliminary environmental assessment was undertaken prior to the preparation of this environmental impact statement to inform the State significant infrastructure application for the project. The outcomes of this preliminary assessment identified the following key environmental issues for the project:

- Traffic and transport.
- Noise and vibration.
- Air quality.
- Biodiversity.
- Urban design, landscape character and visual amenity.
- Social and economic.
- Hydrogeology and soils.
- Surface water.

The outcomes of the preliminary environmental assessment were documented in the State Significant Infrastructure Application Report, which was submitted to the Director-General of the then NSW Department of Planning and Infrastructure. The purpose of the application report was to assist the Director-General in identifying the environmental impact assessment requirements for the project, including the key issues to be addressed in the environmental impact statement.

10.3 Assessment of the key issues identified in the Director-General's Requirements

The key issues identified in the Director-General's Requirements are consistent with but add to the key issues identified in the State significant infrastructure application report. The Director-General's Requirements identified the following as the key issues to be addressed in the environmental impact statement for the project:

- Traffic and transport.
- Noise and vibration.
- Air quality.
- Health.
- Urban design, landscape character and visual amenity.
- Biodiversity.
- Social and economic.
- Hydrogeology and soils.
- Surface water.
- Non-Aboriginal heritage.
- Aboriginal heritage.
- Community liaison.

The issues listed above have been assessed in detail as part of the preparation of this environmental impact statement. The results of this assessment are presented in **Chapter 7**, with stakeholder and community engagement detailed in **Chapter 6**.

10.4 Risk analysis framework

The environmental risk analysis has been undertaken in accordance with the principles of the *Australian and New Zealand standard AS/NZS ISO 31000: 2009 Risk Management – Principles and Guidelines*. The risk analysis involved:

- Ranking the risk of each identified potential impact by identifying the consequences of the impact and the likelihood of each impact occurring.
- Considering the probable effectiveness of the proposed mitigation measures to determine the likely residual risk of each impact.

The first step involved the identification of the consequence, should an impact occur. Definitions of the consequences used as a guide are provided in **Table 10-2**.

Table 10-2 Risk analysis consequence definitions

Consequence level	Definition
Catastrophic	Long term (greater than three months) and irreversible impacts. Resulting in a major prosecution under relevant environmental legislation.
Major	Medium term (between one month and three months) and potentially irreversible impacts. Resulting in a fine or equivalent penalty notice under relevant environmental legislation.
Moderate	Moderate and reversible impacts, or medium term (between one and three months).
Minor	Minor and reversible, or short term impacts (less than one month)/
Insignificant	Minor, negligible impacts.

The next step in the risk analysis involved an assessment of the likelihood of the consequence, considering the frequency of activities that are to occur. The definitions of likelihood used as a guide are provided in **Table 10-3**.

Table 10-3 Risk analysis likelihood definitions

Likelihood	Definition	Probability
Almost certain	The event is almost certain to occur in the course of normal or abnormal construction / operational circumstances.	>90%
Likely	The event is more likely than not to occur in the course of normal construction / operational circumstances.	51% - 90%
Possible	The event may occur in the course of normal construction / operational circumstances.	26% - 50%
Unlikely	The event is unlikely to occur in the course of normal construction / operational circumstances.	5% - 25%
Very unlikely	The event may occur in exceptional construction / operational circumstances only.	<5%

The risk rating was then determined by combining the consequence and likelihood according to the matrix in **Table 10-4**.

Table 10-4 Risk Matrix

Consequences	Likelihood				
	Very unlikely	Unlikely	Possible	Likely	Almost certain
Catastrophic	15	19	22	24	25
Major	10	14	18	21	23
Moderate	6	9	13	17	20
Minor	3	5	8	12	16
Insignificant	1	2	4	7	11

Table 10-5 Risk rating categories

Risk rating score	Risk category	Comments
23 - 25	Extreme	Assessment and planning is necessary to avoid these potential impacts to the greatest extent possible.
19 – 22	Very high	Detailed assessment and planning is necessary to develop appropriate measures to mitigate the potential impacts wherever possible.
13 – 18	High	Detailed assessment and planning is necessary to develop appropriate measures to mitigate the potential impacts.
8 – 12	Moderate	Potential impacts can be mitigated through the application of relatively standard environmental mitigation measures.
1 - 7	Low	Potential impacts either require no specific mitigation measures or are adequately mitigated through other working controls (such as detailed design requirements, normal working practice, quality and safety controls)

10.5 Environmental risk analysis

Using the risk framework in **Section 10.4**, an environmental risk analysis has been undertaken for the project including a consideration of the key issues. The analysis is structured towards risk minimisation outcomes. The residual risk rating has been arrived at after the application of mitigation measures developed and recommended by this environmental impact statement (**Chapters 7** to **9**). The results of the risk analysis are presented in **Table 10-5**.

Table 10-5 Environmental risk analysis

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Key issues								
Traffic and transport	**Construction**							
	Reduced safety for road users, cyclists and pedestrians during construction.	Major	Likely	21 Very high	Traffic Management Plans would be developed to identify measures to manage road safety. Further details on management and mitigation measures are provided in **Section 7.1**.	Minor	Unlikely	5 Low
	Reduction in traffic efficiency for local and regional traffic due to construction activities.	Moderate	Almost certain	20 Very high	Traffic Management Plans would identify measures to manage road network disruptions. Works would be undertaken offline wherever feasible and reasonable. Works on live roads would be staged in minimise disruptions. Further details on management and mitigation measures are provided in **Section 7.1**.	Minor	Almost certain	16 High
	Traffic impacts and delays due to temporary road and / or lane closures.	Moderate	Likely	17 High	Traffic Management Plans would identify measures to manage road network disruptions.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Works on live roads would be staged in minimise disruptions. Further details on management and mitigation measures are provided in **Section 7.1**.			
	Impacts to emergency services	Major	Likely	21 Very high	Traffic Management Plans would be developed in consultation with emergency services. Communication systems would be in place with traffic controllers to provide appropriate access and routes for emergency vehicles to bypass queued traffic. Further details on management and mitigation measures are provided in **Section 7.1**.	Moderate	Unlikely	9 Moderate
	Operation							
	Impacts on cyclists	Insignificant	Unlikely	2 Low	Existing access for cyclists would be reinstated following construction. Further details on management and mitigation measures are provided in **Section 7.1**.	Insignificant	Unlikely	2 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Reduction in intersection performance around the southern and northern interchanges	Moderate	Almost Certain	20 Very high	The project has been designed with the aim of minimising deterioration in the performance of existing intersections. However there would be some minor deterioration of intersection performance due to the introduction of the tunnel and new turning movements. Further details on management and mitigation measures are provided in **Section 7.1**.	Moderate	Possible	13 High
	Reduction in road safety.	Minor	Very Unlikely	3 Low	A road safety audit would be undertaken by qualified auditors as part of the detailed design phase of the project, and again immediately prior to project opening, to examine the project design from a road safety perspective and to identify potential safety issues. Further details on management and mitigation measures are provided in **Section 7.1**.	Minor	Very Unlikely	3 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Noise and vibration	**Construction**							
	Noise impacts to surrounding receivers from construction activities, including out of hours works	Moderate	Almost Certain	20 Very high	Construction noise impacts would be managed through a construction noise and vibration management plan. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Likely	17 High
	Noise impacts from construction traffic	Moderate	Almost Certain	20 Very high	Heavy vehicle movements outside of standard daytime construction hours would be minimised as far as feasible and reasonable. Heavy vehicle movements outside of standard construction hours associated with tunnel support works would only occur via access and egress directly to and from Pennant Hills Road or the M1 Pacific Motorway. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Likely	17 High

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Vibration impacts during construction	Moderate	Possible	13 High	Safe working distances for plant and equipment would be complied with where feasible and reasonable. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Unlikely	9 Moderate
	Operation							
	Increase road traffic noise	Major	Almost certain	23 Extreme	Low noise road surface has been incorporated into the design of the project for at surface motorway areas. The operational road traffic noise assessment has identified the requirement for and locations of noise barriers and at property acoustic treatment. A number of these properties are already experiencing acute noise levels in the absence of the project. Further details on management and mitigation measures are provided in **Section 7.2**.	Moderate	Possible	13 High

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Air quality	**Construction**							
	Dust impact to surrounding receivers.	Moderate	Likely	17 High	Potential dust emissions from construction would be managed through standard mitigation measures. Underground tunnels would be ventilated during construction in order to provide safe working environment for the construction workforce. Further details on management and mitigation measures are provided in **Section 7.3**.	Minor	Possible	8 Moderate
	Exhaust emissions during construction.	Minor	Likely	12 Moderate	Plant and equipment used during construction would comply with the *Protection of the Environment Operations (Clean Air) Regulation 2010*. Further details on management and mitigation measures are provided in **Section 7.3**	Minor	Possible	8 Moderate
	Odours from groundwater treatment plants.	Minor	Unlikely	5 Low	If odours arise, appropriate management measures would be developed as part of the Air Quality Management Plan.	Minor	Very unlikely	3 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.3**			
	Operation							
	Air quality impact in the vicinity of ventilation outlets.	Insignificant	Unlikely	2 Low	Air quality in the vicinity of the project would be monitored for a specified time period following project opening. If pollutant concentrations are above predicted levels, additional feasible and reasonable mitigation measures would be considered to meet applicable predicted limits. Further details on management and mitigation measures are provided in **Section 7.3**.	Insignificant	Unlikely	2 Low
	In-tunnel air quality.	Minor	Possible	8 Moderate	An operational air quality management plan would be developed to manage air quality within the tunnels. Further details on management and mitigation measures are provided in **Section 7.3**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Human health	**Construction**							
	Adverse health outcomes from construction noise	Moderate	Likely	17 High	Impacts to health from construction noise would be managed through a construction noise and vibration management plan developed prior to construction. Further details on management and mitigation measures of construction noise are provided in **Section 7.2**.	Minor	Possible	8 Moderate
	Operation							
	Adverse health outcomes from air pollutants	Insignificant	Unlikely	2 Low	Mitigation measures relevant to potential adverse health impacts from air pollutants are provided in **Section 7.3**.	Insignificant	Unlikely	2 Low
	Adverse health outcomes for in-tunnel air quality exposure	Insignificant	Unlikely	2 Low	Mitigation measures relevant to potential adverse health impacts from air pollutants are provided in **Section 7.3**	Insignificant	Unlikely	2 Low
	Adverse health outcomes from operational noise	Moderate	Likely	17 High	Mitigation measures relevant to potential adverse health impacts from noise and vibration are provided in **Section 7.3**	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Urban design, landscape character and visual amenity	**Construction**							
	Visual impacts from the introduction of construction activities and construction ancillary facilities.	Moderate	Likely	17 High	Opportunities to minimise the visual impact of construction activities and facilities would be considered, where possible, including landscaping and rehabilitation following construction. Further details on management and mitigation measures are provided in **Section 7.5**.	Minor	Likely	12 Moderate
	Visual impact of construction night lighting.	Moderate	Likely	17 High	Mitigation measures would be adopted to reduce potential construction lighting impacts including the use of directional lights and cut off fittings. Further details on management and mitigation measures are provided in **Section 7.5**.	Minor	Possible	8 Moderate
	Operation							
	Visual impacts from the introduction of operational surface infrastructure	Moderate	Likely	17 High	During detailed design, opportunities to minimise the visual impact of the project would be considered.	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.5**.			
	Visual impact of operational lighting.	Moderate	Likely	17 High	Further details on management and mitigation measures are provided in **Section 7.5**.	Minor	Possible	8 Moderate
Biodiversity	**Construction and operation**							
	Loss of or disturbance to endangered ecological communities (EECs).	Major	Almost certain	23 Extreme	Opportunities to minimise the loss of EECs would be investigated during detailed design. The permanent loss of EEC vegetation would be offset. The details of vegetation offsets would be provided in a Biodiversity Offset Strategy. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
	Disturbance to terrestrial habitats, including increased fragmentation, edge effects, reduced connectivity and disturbance to wildlife corridors.	Moderate	Likely	17 High	A Flora and Fauna Management Plan(s) would be prepared to detail measures to manage potential impacts on habitat for threatened flora and fauna.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.6**.			
	Impacts to or removal of threatened or migratory species (aquatic and terrestrial).	Major	Almost certain	23 Extreme	Further field surveys would be carried out prior to the commencement of construction, to confirm the actual extent of clearing of *Epacris purpurascens* var. *purpurascens*. Opportunities to avoid or minimise impacts to individual would be investigated during the detailed design phase. Direct impact to *Epacris purpurascens* var. *purpurascens* would be offset as part of the Biodiversity Offset Strategy. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
	Disturbance to aquatic habitats and reductions in water quality.	Moderate	Likely	17 High	During construction discharge would be treated to meet the requirements of an environment protection	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					licence issued for the project. Operational discharge water quality level would be agreed with NSW EPA. Further details on management and mitigation measures are provided in **Section 7.6**.			
	Invasion of environmental weed species.	Moderate	Possible	13 High	Weed management strategies would be implemented during the construction and operation of the project. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
	Increased mortality or injuring of fauna during construction and operation.	Moderate	Possible	13 High	Management of fauna during construction and operation would be in accordance with the Biodiversity Guidelines (Roads and Maritime, 2011b). Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Alterations to surface water flow regimes and interruptions to fish passage.	Moderate	Possible	13 High	Creek crossings would be constructed in accordance with relevant guidelines. Further details on management and mitigation measures are provided in **Section 7.6**.	Minor	Possible	8 Moderate
Social and economic	**Construction**							
	Amenity impacts from construction activities, such as noise, dust and visual impacts.	Moderate	Possible	13 High	Construction amenity impacts would be managed as per the traffic and transport; noise and vibration; air quality; and urban design, landscape character and visual amenity sections above. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Unlikely	5 Low
	Construction traffic impacts, including, temporary disruptions and delays to local and regional traffic and temporary changes to access arrangements to local properties.	Moderate	Possible	13 High	Alterations to traffic flow and access would be managed through the implementation of Traffic Management Plans. Further details on management and mitigation measures are provided in **Section 7.7.**	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Operation							
	Reductions in amenity, particularly around the northern and southern interchanges, and the tunnel support facilities.	Moderate	Likely	17 High	Visual amenity impacts associated with new structures would be managed through design as described in **Section 7.5**. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Possible	8 Moderate
	Severance of communities, including property acquisition, severance of properties and reduced access to community and recreational facilities.	Minor	Unlikely	5 Low	*All property acquisition would be undertaken in accordance with the Land Acquisition (Just Terms Compensation) Act 1991.* Alterations to local roads have been designed to not change the existing movements available from properties to the arterial road network. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Impacts on local businesses, including decreased turnover for businesses along Pennant Hills Road as a result of decreases in passing trade.	Moderate	Likely	17 High	Management and mitigation measures are provided in **Section 7.7**. There is also the potential for an increase in turnover from local customers due to increased amenity and accessibility.	Minor	Likely	12 Moderate
	Impacts to community facilities.	Minor	Possible	8 Moderate	Amenity and traffic related mitigation measures would be implemented to manage impacts to community facilities. Further details on management and mitigation measures are provided in **Section 7.7**.	Minor	Unlikely	5 Low
Hydrogeology and soils	**Construction**							
	Exposing, disturbing or spreading acid sulfate soils.	Minor	Very unlikely	3 Low	In the event that acid sulphate soils (ASS) are encountered, they would be effectively managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998). Further details on management and mitigation measures are provided in **Section 7.8**.	Minor	Very unlikely	3 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Impacts on groundwater quality and quantity, including drawdown.	Moderate	Likely	17 High	During detailed design, additional geotechnical investigations would be completed to inform design opportunities to minimise impacts on groundwater quality and drawdown. If groundwater drawdown impacts are identified, consultation would occur with the groundwater users to develop appropriate mitigation. Further details on management and mitigation measures are provided in **Section 7.8**.	Minor	Possible	8 Moderate
	Exposure and release of contamination at Pioneer Avenue compound (C8)	Major	Possible	18 High	Potentially contaminated areas directly affected by the project would be investigated and managed in accordance with the requirements of the *Contaminated Land Management Act 1997* and Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites (EPA, 1997).	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.8**.			
	Operation							
	Groundwater inflow into the tunnel resulting in localised groundwater drawdown.	Moderate	Likely	17 High	During detailed design, additional geotechnical investigations would be completed to inform design opportunities to minimise impacts on groundwater quality and drawdown. If groundwater drawdown impacts are identified, consultation would occur with the groundwater users to develop appropriate mitigation. Further details on management and mitigation measures are provided in **Section 7.8**.	Minor	Possible	8 Moderate
Surface water	**Construction**							
	Downstream water quality impacts from water discharge.	Moderate	Likely	17 High	The discharge of water would occur in accordance with the provision of an environment protection licence issued for the project.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.9**.			
	Changes to surface water flow regimes	Moderate	Likely	17 High	The location of the discharge points would be investigated in order to prevent erosion and sedimentation impacts. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Possible	8 Moderate
	Erosion and sedimentation during and following construction.	Major	Likely	21 Very high	Erosion and sedimentation would be managed in accordance with the Blue Book 2 (Department of Environment and Climate Change (DECC), 2008) and follow the Roads and Maritime Erosion and Sediment Management Procedure (Roads and Further details on management and mitigation measures are provided in **Section 7.9**.	Moderate	Possible	13 High
	Spills from construction vehicles, equipment and plant.	Major	Possible	18 High	Construction equipment would be maintained to reduce the potential for spills and leaks.	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Spill response procedures would be implemented on-site to respond to spills and to limit the potential for off-site impacts. Further details on management and mitigation measures are provided in **Section 7.9**.			
	Operation							
	Modifications to existing drainage infrastructure resulting in water quality impacts.	Moderate	Possible	13 High	Works in the vicinity of existing waterways would be managed to protect bed and bank stability. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Unlikely	5 Low
	Impact to surface water quality and receiving environments from spillages due to vehicle and truck accidents.	Major	Possible	18 High	The operational drainage infrastructure includes provision for capture of hydrocarbons in the event of a spillage. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Unlikely	5 Low
	Downstream water quality impacts from water discharge.	Moderate	Likely	17 High	The discharge water quality level would be determined in consultation	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					with the NSW Environment Protection Authority during the detailed design phase taking into consideration the current water quality of the receiving watercourses. Further details on management and mitigation measures are provided in **Section 7.9**.			
	Changes to surface water flow regimes.	Moderate	Likely	17 High	Further investigation would be undertaken in relation to the specific discharge point and waterway stabilisation works if required in order to manage downstream erosion and sedimentation. Further details on management and mitigation measures are provided in **Section 7.9**.	Minor	Possible	8 Moderate
	Impact to surface water quality and receiving environments due to runoff from road surfaces.	Moderate	Likely	17 High	Water captured within the tunnels would be treated at the water treatment plant prior to discharge. Where changes would occur to surface roads,	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					existing operational drainage system and detention basins would be augmented, as required, to manage the additional drainage catchment area. Further details on management and mitigation measures are provided in **Section 7.9**.			
Non-Aboriginal heritage	**Construction and operation**							
	Potentially direct impact to a heritage item.	Moderate	Possible	13 High	Where feasible and reasonable, plant and equipment would be selected to maintain safe working distances to minimise the potential for vibration related impacts. Further assessments would be undertaken during detailed design to determine the level of potential impact on structures and to identify appropriate mitigation and management measures to minimise these impacts. Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Indirect impacts (visual context and surrounds) to heritage items.	Moderate	Possible	13 High	Further investigations would be undertaken during the detailed design phase to minimise these potential impacts where reasonable and feasible. Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Unlikely	5 Low
	Direct impact to the heritage listed Thornleigh Maltworks (ID No A66 under the Hornsby LEP).	Moderate	Almost certain	20 Very high	An archival recording would be undertaken to record the connection of the original structures with the modern structures. An archaeological test excavation would also be undertaken. Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Likely	12 Moderate
	Direct impact to a heritage listed garden at the northern interchange (ID No I762 under the Hornsby LEP), including two heritage listed trees.	Minor	Almost certain	16 High	Options to avoid direct impacts or to identify an appropriate area on the site for relocation would be investigated during the detailed design phase. Further details on management and	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					mitigation measures are provided in **Section 7.10**.			
	Partial and direct impacts to the Beecroft – Cheltenham heritage conservation area (ID No C2 under the Hornsby LEP), the Wahroonga North heritage conservation area (ID No C8 under the Hornsby LEP) and Street trees (ID No I769).	Minor	Likely	12 Moderate	Further details on management and mitigation measures are provided in **Section 7.10**.	Minor	Possible	8 Moderate
	Partial and direct impacts to Street Trees (ID No I769).	Minor	Almost certain	16 High	Measures to avoid direct impacts to the specific listed vegetation "*Blue Gum High Forest*" would be investigated during the detailed design phase. If avoidance is not feasible or reasonable the impact would be mitigated through sympathetic plantings of similar species as part of landscaping / revegetation.	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 7.10**.			
Aboriginal cultural heritage	**Construction and operation**							
	Impact to recorded archaeological sites and potentially archaeologically sensitive areas (ASAs).	Minor	Possible	8 Moderate	Sensitive Aboriginal archaeological and cultural heritage areas and sites would be delineated prior to the commencement of construction works in the vicinity of these items / areas. Monitoring would be carried out to ensure that indirect impacts, such as vibration, would not pose the potential for adverse impacts on these areas and sites. Further details on management and mitigation measures are provided in **Section 7.11**.	Minor	Unlikely	5 Low
Other issues								
Land use and property	**Construction**							
	Temporary acquisition.	Moderate	Almost certain	20 Very high	Discussions would be undertaken with affected property owners regarding acquisition of or leasing the required land in the	Minor	Likely	12 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					short term during the construction phase of the project. All acquisitions would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. Further details on management and mitigation measures are provided in **Section 8.1**.			
	Impacts on community facilities – walking track under Darling Mills Creek viaduct.	Minor	Likely	12 Moderate	Options would be investigated for opening of the walking track at Darling Mills Creek Viaduct on the weekend or at other times when works are not actively occurring in the area. Further details on management and mitigation measures are provided in **Section 8.1**.	Minor	Possible	8 Moderate
	Changes to property access.	Minor	Almost certain	16 High	Where impacts are unavoidable consultation would be undertaken with the property owner and / or tenant to develop appropriate alternative access arrangements.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 8.1**.			
	Impacts on surrounding development.	Minor	Possible	8 Moderate	Mitigation measures relevant to impacts such as noise, traffic and air quality are provided in **Sections 7.1, 7.2** and **7.3.**	Minor	Unlikely	5 Low
	Operation							
	Permanent acquisition of private property.	Major	Almost certain	23 Extreme	All acquisitions would be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. Further details on management and mitigation measures are provided in **Section 8.1**.	Moderate	Likely	17 High
	Property access.	Minor	Almost certain	16 High	Arrangements for altered property accesses would be subject to consultation with the affected property owner. Further details on management and mitigation measures are provided in **Section 8.1**.	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
Hazard and risk	**Construction**							
	Impacts from handling, storage and transport of dangerous goods and hazardous substances.	Major	Possible	18 High	The transport, storage, handling and use of hazardous construction materials would be undertaken in accordance with Occupational Health and Safety (OH&S) legislation and codes. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
	Occupational health and safety hazards, such as dangers to construction workers and road users.	Major	Likely	21 Very high	Appropriate processes would be implemented including a permit to tunnel to ensure the ongoing structural integrity of the tunnel. Site specific hazard and risk management plans would be prepared and implemented as part of the CEMP. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
	Rupture of underground services	Moderate	Likely	17 High	Utility checks and consultation with the relevant service	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					infrastructure providers would occur prior to construction. Utilities would be relocated or protected as required. Further details on management and mitigation measures are provided in **Section 8.2**.			
	Bushfires	Major	Possible	18 High	Measures to mitigate and manage bushfire risks would be developed and included in site-specific hazard and risk management measures within the Construction Environmental Management Plan(s). Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
	Operation							
	Impact from handling, storage and transport of dangerous goods and hazardous substances for the operational water treatment plant.	Major	Possible	18 High	The transport, storage, handling and use of hazardous materials would be undertaken in accordance with Occupational Health and Safety (OH&S) legislation and codes.	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					Further details on management and mitigation measures are provided in **Section 8.2**.			
	Vehicle collisions	Major	Likely	21 Very high	The project design has incorporated feasible and reasonable design measures including in relation to geometry, pavement, lighting and signage, consistent with current Australian Standards, road design guidelines and industry best practice. To minimise the likelihood of an incident associated with over height vehicles within the tunnel, an over height detection system has been included in the design of the project. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Possible	13 High
	Accidental spills of dangerous goods as a result of vehicle collisions	Major	Likely	21 Very high	Dangerous goods vehicles would be restricted from entering the tunnels. Drainage infrastructure	Moderate	Unlikely	9 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					would provide capacity to capture spillages and capacity to treat the first flush from the pavement surface as a minimum. Further details on management and mitigation measures are provided in **Section 8.2**.			
	Bushfires	Major	Possible	18 High	Infrastructure critical to the ongoing safe operation of the project, including the motorway operations complex, would be located outside of bushfire prone areas. Further details on management and mitigation measures are provided in **Section 8.2**.	Moderate	Unlikely	9 Moderate
Resource and waste	**Construction**							
	Inappropriate management of waste generated during construction of the project.	Moderate	Likely	17 High	Wastes would be managed and disposed of in accordance with relevant State legislation and government policies. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Incorrect management and disposal of spoil management	Moderate	Likely	17 High	A Spoil Management Strategy would be developed and documented for the project prior to the commencement of soil disturbing works. Options for the beneficial re-use of spoil within the project or within other developments would be considered during the detailed design phase. Spoil disposal offsite would be to a location that has an appropriate licence or approval to accept the material. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low
	Incorrect management of demolition waste containing hazardous materials.	Moderate	Likely	17 High	Management and disposal of asbestos containing materials would be undertaken in accordance with relevant legislation and guidelines. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
	Operation							
	Inappropriate management of waste generated during the operation and maintenance of the project.	Moderate	Likely	17 High	Standard work practices and Roads and Maritime waste policies and specifications would be implemented during routine maintenance and repair activities. Further details on management and mitigation measures are provided in **Section 8.3**.	Minor	Unlikely	5 Low
Greenhouse gas and climate change	**Construction and operation**							
	Release of greenhouse gas emissions during construction.	Moderate	Likely	17 High	Standard procedures would be implemented to reduce greenhouse gas emissions associated with the use of carbon based fuels and energy sources, the removal of vegetation, and emissions resulting from the use of materials to construct the project. Further details on management and mitigation measures are provided in **Section 8.4**.	Minor	Possible	8 Moderate
	Release of greenhouse gases during operation (including maintenance).	Moderate	Likely	17 High	During detailed design, measures to reduce greenhouse gas emissions over the life of the project would be	Minor	Possible	8 Moderate

Issue	Potential adverse impacts	Consequence	Likelihood	Risk rating	Proposed mitigation measures	Residual consequence	Residual likelihood	Residual risk rating
					considered, where feasible and feasible. Further details on management and mitigation measures are provided in **Section 8.4**.			
	Climate change impacts on the project.	Moderate	Likely	17 High	Future climate change predictions would be considered in maintenance procedures, such as monitoring, review and maintenance of road surfaces and drainage structures. Further details on management and mitigation measures are provided in **Section 8.4**.	Minor	Possible	8 Moderate

10.6 Confirmation of key environmental issues

Based on the results of the environmental risk analysis, the following issues have been confirmed as the key environmental issues for the project based on the information presented in this environmental impact statement:

- Traffic and transport.
- Noise and vibration.
- Air quality.
- Human health.
- Urban design, landscape character and visual amenity.
- Biodiversity.
- Social and economic.
- Hydrogeology and soils.
- Surface water.
- Non-Aboriginal heritage.
- Aboriginal heritage.
- Community liaison.

The majority of environmental issues have a residual risk rating of low or moderate and a few issues with a residual risk of high. No environmental issues have a residual risk rating of very high or extreme and, as such, it is considered that no environmental issues would have a significant risk to the environment. As such, no contingency plans are required.

All key issues have been addressed in **Chapter 7**, with community liaison addressed in **Chapter 6**.