



Transport for NSW

Western Harbour Tunnel and Warringah Freeway Upgrade

Appendix A -
Environmental risk analysis

A Environmental risk analysis

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A1 Environmental risk analysis

A1.1 Introduction

An environmental risk analysis for the project was carried out as part of the environmental impact statement and has been updated in this submissions report to consider the effectiveness of the proposed revised environmental management measures. The following outlines the environmental risk analysis process and identifies the key environmental issues as determined by the analysis.

A1.2 Assessment methodology

Identification of environmental risk categories

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

- A preliminary environmental assessment (scoping report), that was carried out as part of the *State significant infrastructure application report* (Roads and Maritime Services, 2017) to allow early identification of the key environmental issues and to inform the State significant infrastructure application
- An assessment of the key issues identified in the Secretary’s environmental assessment requirements for the project (refer to the Secretary’s environmental assessment requirements checklist in Appendix A of the environmental impact statement)
- An environmental risk analysis carried out to confirm the impacts based on the results of the detailed investigations carried out for the environmental impact statement (Appendix C of the environmental impact statement)
- An update to the environmental risk analysis to include an assessment of the effectiveness of the proposed revised environmental management measures included in Part D of this submissions report.

Through the environmental risk analysis process, issues that may be associated with the project were identified and categorised as a ‘key issue’ or ‘other’ (see Table A-1). This enabled the identification of any matters that might be considered as additional key issues, and provided a basis for an appropriately detailed assessment of these additional key issues in the environmental impact statement and this submissions report.

Table A-1 Environmental risk categories

Consequence level	Definition
Key issue	Potential for high or moderate impacts (actual or perceived) requiring further investigation to identify specific management and mitigation measures.
Other	Potential for low impacts that can be managed effectively with standard and/or best practice management and mitigation measures.

As required by the Secretary’s environmental assessment requirements, this process of key issue identification and analysis continued during the course of preparing the environmental impact statement. Emphasis was placed on using the detailed information gathered for the project to identify and review potential environmental issues. More specifically, the analysis:

- Identified environmental issues, including key issues in the Secretary’s environmental assessment requirements

- Examined potential impacts and proposed management and mitigation measures in relation to the identified issues
- Identified the impacts likely to remain after management and mitigation measures are applied (ie the residual impacts).

The identified environmental issues are described and assessed in Chapter 8 to Chapter 26 of the environmental impact statement. An assessment of cumulative impacts is also presented in Chapter 27 (Cumulative impacts) of the environmental impact statement. The risk assessment has been refined in response to the submissions received and considered the revised environmental management measures in Table D2-1 of this submissions report.

Likelihood and consequence analysis

To determine the residual impacts for each potential key issue, a risk analysis involving a likelihood and consequence analysis was carried out in accordance with the principles of the Australian and New Zealand standard *AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines*.

This involved:

- Rating 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 management and mitigation measures to determine the likely residual risk of each impact.

The definitions of the likelihood are provided in Table A-2 and the definitions of consequences are provided in Table A-3. The risk rating was then determined by combining the consequence and likelihood to identify the level of risk as shown in Table A-4.

Table A-2 Risk analysis likelihood definitions

Likelihood	Definition
Certain	Expected to happen routinely during the project life.
Likely	Could easily happen and has occurred on a previous similar project.
Unlikely	Possible, but not anticipated.

Table A-3 Risk analysis consequences definitions

Consequence level	Definition
Minor	<ul style="list-style-type: none"> • Minor effects on biological, social, economic or physical environment, both built and natural • Minor short to medium term damage to small area of limited significance, easily rectified.
Moderate	<ul style="list-style-type: none"> • Moderate effects on biological, social, economic or physical environment, both built and natural • Moderate short to medium term widespread impacts. More difficult to rectify.
Major	<ul style="list-style-type: none"> • Serious effects on biological, social, economic or physical environment, both built or natural • Relatively widespread medium to long term impacts. Rectification difficult or impossible.

Table A-4 Risk rating matrix

Likelihood	Consequence		
	Minor	Moderate	Major
Certain	Medium	High	High
Likely	Low	Medium	High
Unlikely	Low	Low	Medium

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Using the framework described above, the environmental risk analysis results for the project are presented in Table A-5. The risk analysis identifies an initial risk rating for each of the environmental issues, consideration of the effectiveness of the proposed revised environmental management measures and the residual risk rating derived after the application of the revised environmental management measures listed in Table D2-1 of this submissions report.

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Table A-5 Environmental risk analysis

Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Traffic and transport								
Construction								
<ul style="list-style-type: none"> Construction traffic impacts on road network performance Local road and parking impacts. 	Major	Likely	High	CTT1, CTT4, CTT5, CTT6, CTT7, CTT8, CTT9, CTT11, CTT12, CTT13, CTT14	Minimising the movement of construction road traffic during peak periods and around construction support sites and the use of truck marshalling areas would reduce the likelihood and consequence of traffic impacts. Additionally, road closures will occur outside of peak periods and/or during night time where feasible and reasonable, minimising impacts.	Moderate	Likely	Medium
<ul style="list-style-type: none"> Temporary disruption to bus services Construction impacts on cyclists and pedestrian routes. 	Major	Likely	High	CTT4, CTT5, CTT8, CTT10, CTT19	Advanced notification of proposed transport network changes and restrictions along with directional signage and linemarking would reduce the consequence of impacts to public and active transport from the project.	Moderate	Likely	Medium
<ul style="list-style-type: none"> Temporary maritime traffic impacts to ferries, recreational users, community groups and clubs, commercial and government operations. 	Major	Likely	High	CTT2, CTT3, CTT4, CTT5, CTT15, CTT16, CTT17, CTT18	Consultation with relevant stakeholders, advance notification of maritime restrictions and the appropriate scheduling of construction marine traffic activities would reduce the risk of maritime traffic impacts.	Moderate	Likely	Medium

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)			
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk	
Operation									
<ul style="list-style-type: none"> Improved travel times and accessibility to and from the Lower North Shore, particularly between North Sydney and Rozelle Road network performance improvements Improved road safety Provision of new and improved public and active transport links Improved connectivity Urban amenity improvements. 	Positive impact								
<ul style="list-style-type: none"> Increased traffic on some parts of the arterial and local road network and changes to some access and parking arrangements. 	Moderate	Likely	Medium	OT1, OT2, OT3, OT4	<p>Measures to reduce the increase of traffic on some parts of the arterial and local road network as a result of the project have been incorporated into the development of the project design (refer to Chapter 5 (Project description) of the environmental impact statement).</p> <p>Transport for NSW will investigate opportunities to reduce or offset the loss of long stay parking spaces along Alfred Street North and to include additional pedestrian connections across Ernest Street.</p>	Moderate	Likely	Low	

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Noise and vibration								
Construction								
<ul style="list-style-type: none"> Ground-borne noise impacts during tunneling. 	Major	Likely	High	CNV1, CNV2, CNV4, CNV7	Measures to reduce ground-borne noise impacts during tunnelling have been incorporated into the construction methodology (refer to Chapter 6 (Construction work) of the environmental impact statement). The consequence of impacts would be reduced through periodic noise monitoring and the implementation of measures where exceedances are recorded or predicted.	Moderate	Likely	Medium
<ul style="list-style-type: none"> Airborne noise impacts from surface works during standard construction hours Construction vibration impacts during standard construction hours. 	Major	Likely	High	CNV1, CNV2, CNV4, CNV6, CNV8	The selection and management of plant and equipment to minimise noise and vibration, detailed programming and respite protocols and the establishment of minimum buffer distances from vibration-generating activities as well as periodic noise monitoring would reduce the consequence of potential impacts.	Moderate	Likely	Medium
<ul style="list-style-type: none"> Noise and vibration impacts outside of standard construction hours surface works. 	Major	Certain	High	CNV1, CNV3, CNV4, CNV6, CNV8	The implementation of out of hours works protocols which specify noise controls such as programming the noisiest activities to occur during less sensitive time periods and the limiting of noise intensive work would reduce the likelihood of impacts.	Major	Likely	Medium

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
<ul style="list-style-type: none"> Construction road traffic noise impacts. 	Moderate	Likely	Medium	CNV1, CNV4, CNV5, CNV8	Minimising truck movements past sensitive receivers and during night-time periods would reduce the consequence of traffic noise impacts	Minor	Likely	Low
Operation								
<ul style="list-style-type: none"> Reduced road traffic noise as a result of traffic moving off surface roads into the tunnels. 	Positive impact							
<ul style="list-style-type: none"> Surface road traffic noise impacts. 	Moderate	Likely	Medium	ONV1, ONV2	Operational noise mitigation measures, including low noise pavement, noise barriers, at-property treatments or a combination of treatments as required have been incorporated into the development of the project design (refer to Chapter 5 (Project description) of the environmental impact statement) reducing the consequence of impacts.	Minor	Likely	Low
<ul style="list-style-type: none"> Noise impacts from motorway facilities (eg ventilation fans, attenuators, substations, fire water tanks, water treatment plants etc). 	Moderate	Unlikely	Low	ONV3	The consequence of the impact of operational fixed facilities will be reduced as facilities will be designed to meet project specific noise criteria derived in accordance with the <i>Noise Policy for Industry</i> (NSW EPA, 2017a).	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Air quality								
Construction								
<ul style="list-style-type: none"> Local air quality impacts due to dust generation. 	Moderate	Likely	Medium	AQ1, AQ2	The adoption of dust suppression management measures, including the use of water carts, dust sweepers, sprinklers, dust screens, site exit controls (eg wheel washing systems and rumble grids), stabilisation of exposed areas and stockpiles, and surface treatments as part of the construction methodology for the project would minimise potential impacts.	Minor	Likely	Low
<ul style="list-style-type: none"> Emissions from construction plant and equipment Emissions during blasting (if required) Odour impacts (if any) from treatment and stockpiling of dredged material (eg at White Bay). 	Moderate	Likely	Medium	AQ1, AQ2	The adoption of standard construction air quality mitigation measures would minimise the potential impacts from construction plant emissions, blasting, and odour (if any) emanating from dredged material.	Minor	Likely	Low
Operation								
<ul style="list-style-type: none"> In tunnel air quality impacts to human health Impacts to ambient air quality due to increased 	Moderate	Likely	Medium	Incorporated in project design (refer to Chapter 5 (Project	The tunnel ventilation system will be designed and operated to maintain in-tunnel air quality and to avoid portal emissions. Tunnel air will be discharged vertically via tunnel ventilation outlets to dilute and	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
traffic and emissions from tunnel ventilation facilities <ul style="list-style-type: none"> Odour impacts from vehicle emissions. 				description and Chapter 12 (Air quality) of the environmental impact statement).	disperse emissions. Additionally, various operational measures are available to manage in-tunnel emissions and ambient air quality such as traffic management, cleaning the tunnel regularly, incident response and the provision of public information and advice. These measures would reduce the likelihood and consequence of impacts.			
Human health								
Construction								
<ul style="list-style-type: none"> Human health impacts associated with air quality. 	Moderate	Likely	Medium	Chapter 13 (Human health).	Revised environmental management measures provided in Table D2-1 of this submissions report would reduce the likelihood of human health impacts associated with air quality.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Human health impacts associated with noise and vibration from tunnelling activities. 	Moderate	Likely	Medium	Chapter 13 (Human health).	Revised environmental management measures for noise and vibration provided in Table D2-1 of this submissions report would reduce the likelihood of human health impacts associated with noise and vibration from tunnelling activities.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Human health impacts associated with noise and vibration from surface works. 	Major	Likely	High	Chapter 13 (Human health).	Revised environmental management measures for noise and vibration provided in Table D2-1 of this submissions report would reduce the consequence of human health impacts associated with noise and vibration from surface works.	Moderate	Likely	Medium

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
<ul style="list-style-type: none"> Human health impacts associated with social impacts. 	Moderate	Likely	Medium	Chapter 13 (Human health).	Revised environmental management measures provided in Table D2-1 of this submissions report would reduce the likelihood and consequence of human health impacts associated social impacts.	Minor	Unlikely	Low
<ul style="list-style-type: none"> Underwater noise impacts (from piling and dredging activities) to human health. 	Major	Unlikely	Medium	HH1, HH2	Monitoring of underwater noise during piling activities will allow for the adaptation of management measures during the construction of the project. In addition, communication of the piling program to water-based recreational users would reduce the consequence of potential impacts.	Moderate	Unlikely	Low
Operation								
<ul style="list-style-type: none"> Human health benefits associated with improved surface road air and noise environments, and social aspects across the broader network. 	Positive impact							
<ul style="list-style-type: none"> Human health impacts associated with ambient air quality. 	Moderate	Unlikely	Low	Incorporated in project design (refer to Chapter 5 (Project description) of the environmental	The tunnel ventilation system will be designed and operated to maintain in-tunnel air quality and to avoid portal emissions. Tunnel air will be discharged vertically via tunnel ventilation outlets to dilute and disperse emissions. Additionally, various operational measures are available to manage in-tunnel emissions and ambient air quality such as traffic	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
				impact statement).	management, cleaning the tunnel regularly, incident response and the provision of public information and advice. These measures would reduce the likelihood of impacts.			
<ul style="list-style-type: none"> Human health impacts associated with noise and vibration. 	Moderate	Likely	Medium	Chapter 11 (Operational noise and vibration) and incorporated in project design (refer to Chapter 5 (Project description) of the environmental impact statement).	Revised environmental management measures for noise and vibration provided in Table D2-1 of this submissions report would reduce the risk of human health impacts associated with noise and vibration from surface works.	Minor	Unlikely	Low
<ul style="list-style-type: none"> Human health impacts associated with social impacts during operation. 	Moderate	Unlikely	Low	Chapter 21 (Socio-economics) of the environmental impact statement.	Revised environmental management measures provided in Table D2-1 of this submissions report would reduce the risk of human health impacts associated with social impacts.	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Non-Aboriginal heritage								
Construction								
<ul style="list-style-type: none"> Direct impacts to terrestrial heritage items, archaeology or heritage conservation areas Direct impacts to marine heritage items. 	Major	Certain	High	NAH3, NAH4, NAH5, NAH6, NAH7, NAH8, NAH9, NAH13, NAH14, NAH15, NAH16, NAH17, NAH18, NAH19	Through the implementation of standard heritage management measures, the preparation of a Maritime Heritage Management Plan and specific measures to manage the impact to individual heritage items, the consequence and likelihood of potential impacts would be reduced.	Moderate	Likely	Medium
<ul style="list-style-type: none"> Potential direct impacts to terrestrial heritage items due to the proximity of construction vehicles and equipment. 	Major	Unlikely	Medium	NAH10, NAH11, NAH12, NAH20, NAH21, NAH24, NAH25	Non-Aboriginal historical heritage awareness training to be provided for contractors prior to commencement of construction works will increase the understanding of potential heritage items that may be impacted during the project and reduce the likelihood of potential impacts.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Indirect impacts to terrestrial heritage items due to temporary visual, aesthetic and social impacts, or permanent settlement and vibration impacts Indirect vibration, visual and settlement impacts to marine heritage items. 	Moderate	Likely	Medium	NAH2, NAH16, NAH22, NAH23 CNV6	Heritage interpretation will be incorporated into the urban design for the project reducing the consequence of potential indirect impacts to terrestrial heritage items. The establishment of minimum buffer distances from vibration generating activities and consideration of the heritage value of listed items will ensure adequate monitoring and management. The preparation of a Maritime Heritage Management Plan and specific measures will manage indirect impact to individual marine heritage items.	Minor	Likely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Aboriginal heritage								
Construction								
<ul style="list-style-type: none"> Direct impacts to terrestrial Aboriginal heritage sites. 	Major	Unlikely	Medium	AH5, AH6	Cultural and historic heritage awareness training will be carried out for personnel engaged in work that may impact heritage items, reducing the risk of impacting heritage items.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Indirect impacts to terrestrial Aboriginal heritage sites due to vibration and settlement. 	Moderate	Unlikely	Low	AH2, AH3, AH4, AH10	The consequence of impacts would be reduced through vibration monitoring to be carried out at AHIMS sites and the implementation of additional measures where exceedances are identified.	Minor	Unlikely	Low
<ul style="list-style-type: none"> Direct and indirect impacts to potential submerged Aboriginal sites. 	Moderate	Likely	Medium	AH8, AH9	Specialist surveys prior to and during construction to determine whether soil units have the potential to contain cultural material and the recovery and documentation of any artefacts or cultural material would reduce the risk of potential impacts.	Minor	Unlikely	Low
Geology, soils and groundwater								
Construction								
<ul style="list-style-type: none"> Soil erosion and offsite sedimentation during construction 	Moderate	Likely	Medium	SG5, SG12	The risk of potential impacts from soil erosion, offsite sedimentation and acid sulfate soils would be reduced through the implementation of erosion and sediment measures at all work sites in accordance with the 'Blue Book' and testing for the presence of	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
<ul style="list-style-type: none"> Exposure of acid sulfate soils or soil salinity during construction. 					acid sulfate soils and subsequent management if required.			
<ul style="list-style-type: none"> Disturbance of contaminated land or groundwater contamination during construction works Marine contamination during dredging activities. 	Moderate	Likely	Medium	SG6, SG7, SG11, SG15	<p>Measures to reduce the disturbance of contaminated land or groundwater during construction including the investigation and management of potentially contaminated areas affected by the project will be incorporated into the construction methodology for the project.</p> <p>The discovery of previously unidentified contaminated material will be managed in accordance with relevant guidelines.</p> <p>Land disposal of marine sediments and any soil/fill material surplus to construction will be carried out in accordance with the <i>Waste Classification Guidelines</i> (NSW EPA, 2014a).</p>	Moderate	Likely	Medium
<ul style="list-style-type: none"> Disturbance of contaminated sediments during marine construction activities. 	Major	Likely	High	SG15, SG16	<p>The appropriateness of offshore disposal will be assessed in accordance with the <i>National Assessment Guidelines for Dredging</i> (Department of the Environment, Water, Heritage and the Arts, 2009). Marine sediments requiring disposal to landfill will be assessed in accordance with the <i>Waste Classification Guidelines</i> (NSW EPA, 2014), reducing the consequence of potential impacts.</p>	Minor	Likely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
<ul style="list-style-type: none"> Groundwater drawdown impacts and tunnel inflows during construction Impacts to groundwater quality due to saltwater intrusion, mobilisation of contaminants or acidification during construction. 	Moderate	Likely	Medium	SG2, SG14, SG17, SG18, SG19, SG20, SG21, SG22	The incorporation of measures to reduce groundwater inflows into tunnels will be applied as part of the construction methodology (refer to Chapter 6 (Construction work) of the environmental impact statement) as appropriate. Additionally, ongoing monitoring during construction will be carried out along with updates to groundwater modelling at different stages of the project allowing for the management of groundwater drawdown and any associated impacts. These measures would reduce the likelihood and consequence of impacts.	Minor	Unlikely	Low
Operation								
<ul style="list-style-type: none"> Ground movement (ie settlement) impacts to nearby buildings and structures. 	Moderate	Unlikely	Low	SG1, SG3, SG4	The development of detailed predictive settlement models guiding tunnel design and construction will minimise settlement and would reduce the consequence of potential impacts.	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
<ul style="list-style-type: none"> Groundwater impacts due to tunnel inflows and drawdown Impacts to groundwater quality due to saltwater intrusion, mobilisation of contaminants or acidification during operation. 	Moderate	Likely	Medium	SG17, SG18, SG19, SG20, SG21, SG22	<p>Measures to reduce tunnel inflows and groundwater drawdown have been incorporated into the development of the project design (refer to Chapter 5 (Project description) of the environmental impact statement).</p> <p>The existing groundwater monitoring program will be continued through the operational phase. As more information becomes available through ongoing groundwater monitoring, groundwater modelling will be updated, reducing the likelihood of impacts.</p>	Minor	Unlikely	Low
Hydrodynamics and water quality								
Construction								
<ul style="list-style-type: none"> Marine water quality impacts from increased turbidity and sedimentation from dredging. 	Major	Likely	High	WQ6	Ongoing monitoring of dredge plumes will be carried out to validate the dredge plume dispersion predictions allowing for the implementation of additional management measures if exceedances occur. This would reduce the risk of potential marine water quality impacts.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Surface water quality impacts due to soil disturbance, runoff and discharge of tunnel water. 	Moderate	Likely	Medium	WQ1, WQ2, WQ3, WQ4, WQ13	The implementation of erosion and sediment measures at all work sites and surface road upgrades in accordance with the principles and requirements in the 'Blue Book', as well as construction wastewater treatment plants designed to treat wastewater	Moderate	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
					generated during construction, would reduce the likelihood of impacts to surfaces water quality.			
<ul style="list-style-type: none"> Impacts on geomorphology, water availability and flows. 	Moderate	Unlikely	Low	WQ5, WQ7, WQ8, WQ13	The construction drainage and discharge outlet infrastructure directing flows downstream to minimise alterations and erosion of watercourse bed and banks, along with the implementation of energy dissipation and erosion scour protection, would reduce the consequence of potential impacts to geomorphology, water availability and flows.	Minor	Unlikely	Low
Operation								
<ul style="list-style-type: none"> Operational hydrodynamic impacts within Sydney Harbour due to the tunnel. 	Minor	Unlikely	Low	Incorporated in project design as described in Chapter 5 (Project description) of the environmental impact statement.	The development of the project design has ensured that the bed of Sydney Harbour would be returned to about the same level as prior to works commencing. Therefore, no hydrodynamic impacts to Sydney Harbour are expected during operation of the project (refer to Chapter 5 (Project description) of the environmental impact statement).	Minor	Unlikely	Low
<ul style="list-style-type: none"> Surface water quality impacts due to runoff and discharge of tunnel water. 	Moderate	Likely	Medium	WQ9, WQ11	Wastewater generated from tunnel groundwater ingress and rainfall runoff in tunnel portals will be treated at a permanent wastewater treatment plant at Rozelle, reducing the likelihood of potential impacts.	Moderate	Unlikely	Low

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	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
<ul style="list-style-type: none"> Impacts on geomorphology, water availability and flows. 	Minor	Likely	Low	WQ10, W12	Consideration of Water Sensitive Urban Design (WSUD) during the development of the design for the stormwater management system and confirmation of the capacity of local stormwater systems to receive operation wastewater and the implementation of measures to control water outflow would reduce the likelihood of impacts on geomorphology, water availability and flows.	Minor	Unlikely	Low
Flooding								
Construction								
<ul style="list-style-type: none"> Impacts on construction activities due to flooding. 	Moderate	Likely	Medium	F3, F4, F5, F6	Construction activities will be protected from impacts due to flooding by locating activities outside of flood prone areas, and/or the provision of local bunding and flood protection barriers as well as the adoption of a flood standard at tunnel entries.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Impacts on flood-prone areas and properties. 	Moderate	Likely	Medium	F8	The incorporation of measures aimed at mitigating the impact of the project on flood behaviour as part of the project design would reduce the likelihood of potential impacts during construction.	Moderate	Unlikely	Low

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	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Operation								
<ul style="list-style-type: none"> Flooding of the tunnels. 	Moderate	Likely	Medium	F7	Implementation of flood emergency management measures as part of relevant environmental and/or safety management documentation during operation of the project would reduce the risk of impacts.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Impacts on flood-prone areas and properties. 	Moderate	Likely	Medium	F1, F2, F9	Consideration of future climate change and partial blockage of the local stormwater drainage system during further design development as well as the implementation of measures aimed at mitigating the impact of the project on flood behaviour would reduce the likelihood of potential impacts.	Moderate	Unlikely	Low
Biodiversity (construction stage only)								
Flora								
<ul style="list-style-type: none"> Impact on native vegetation and threatened ecological communities. 	Moderate	Likely	Medium	B1, B2, B3, B4, B5, B14, B15, B16, B17, B18, B19, B20, B21, B22, B23, B28	The implementation of exclusion zones, pre-clearing surveys, management of invasive species, minimisation of vegetation removal by the project, compensatory planting where appropriate and rehabilitation and restoration of habitats following construction would reduce the likelihood of impacts on vegetation and threatened ecological communities.	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Fauna								
<ul style="list-style-type: none"> Impacts to fauna habitat, including aquatic and marine habitats Impacts on threatened fauna species and endangered populations. 	Moderate	Likely	Medium	B1, B2, B3, B4, B6, B8, B9, B10, B11, B12, B13, B24, B25, B27, B29,	The implementation of pre-clearing surveys, species relocation, monitoring, adaptive management measures, stop work procedures, exclusion zones and the minimisation of vegetation removal by the project, compensatory planting where appropriate and rehabilitation and restoration of habitats following construction would reduce the consequence of impacts on fauna, endangered populations and fauna habitat.	Minor	Likely	Low
<ul style="list-style-type: none"> Underwater noise impacts (from piling and dredging activities) to marine ecology. 	Moderate	Likely	Medium	B26, B27	Pre-clearing surveys and visual monitoring from the harbour surface to identify any underwater noise related impacts on fish and the implementation of additional at source protection measures as required would reduce the risk of impacts.	Minor	Likely	Low
Land use and property								
Construction								
<ul style="list-style-type: none"> Property acquisition Creation of residual and surplus lands. 	Moderate	Certain	High	LP1, LP6	Acquisition of property as part of the project will be carried out in accordance with the NSW Government land acquisition reforms. Where acquisition is to occur the appointment of a Personal Manager – Acquisition will be available to answer questions and queries of property owners. The project has been designed to avoid impacts to private property where feasible.	Minor	Certain	Medium

A1 Environmental risk analysis

A1.3 Environmental risk analysis

Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
					Appropriate land use, taking into consideration the location, land use characteristics, area and adjacent land uses will be identified for any residual land remaining following construction of the project. These measures would reduce the risk of any potential impacts.			
<ul style="list-style-type: none"> Temporary land use changes and changes to access. 	Moderate	Certain	High	LP2, LP3, LP4, LP9	Rehabilitation of land subject to temporary use by the project would reduce the consequence of impacts. Transport for NSW will maintain access to properties and moorings and develop alternative access arrangements in consultation with affected parties.	Minor	Likely	Low
Operation								
<ul style="list-style-type: none"> Creation of subsurface stratum Potential restrictions on future development due to subsurface tunnels and elevated receivers near operational ventilation facilities. 	Minor	Unlikely	Low	LP6, LP8	Consultation with relevant councils regarding land use considerations applicable to future development in the immediate vicinity of ventilation outlets and management of any residual land remaining following construction of the project would reduce the likelihood of any potential impacts.	Minor	Minor	Low

A1 Environmental risk analysis

A1.3 Environmental risk analysis

Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Socio-economics								
Construction								
<ul style="list-style-type: none"> Temporary impacts on social infrastructure and community values during construction Impacts to businesses during construction (passing trade, access, parking etc) Access and connectivity impacts during construction. 	Moderate	Likely	Medium	SE1, SE2, SE3, SE4, BU1, BU2, BU3	<p>Further design development will consider minimising the impact of the project on social infrastructure. Additionally where parks, open space and sport and recreation areas are impacted by construction and not required for permanent infrastructure they will be reinstated and rehabilitated.</p> <p>Consultation will be carried out with businesses potentially impacted during construction. Consultation will aim to identify specific management measures for individual businesses, minimising the consequences of impacts.</p>	Moderate	Likely	Medium
Operation								
<ul style="list-style-type: none"> Improved access and transport and connections Reduced congestion and travel times. 	Positive impact							
<ul style="list-style-type: none"> Impacts to businesses during operation (passing trade, etc). 	Moderate	Likely	Medium	Incorporated in project design as described in Chapter 5 (Project description) of	The development of the project design has ensured that impacts to businesses would be minimised.	Minor	Likely	Low

A1 Environmental risk analysis

A1.3 Environmental risk analysis

Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
				the environmental impact statement				
Urban design and visual amenity								
Construction								
<ul style="list-style-type: none"> Landscape character and visual impacts from construction activities and construction support sites. 	Major	Likely	High	V1, V2, V3, V4, V5, V6, V7, V8, V9, V10, V11	Development of construction support sites to minimise visual impacts for adjacent receivers, location of storage areas away from residential areas and use of neutral colours and designs for site hoardings would reduce the consequence of potential impacts to landscape character due to construction.	Moderate	Likely	Medium
Operation								
<ul style="list-style-type: none"> Landscape character and visual impacts from surface infrastructure (tunnel portals, motorway facilities and ventilation outlets). 	Moderate	Likely	Medium	V8, V9, V10, V11, V12	The preparation of an urban design and landscape plan implemented in line with the strategic urban design framework for the project, retaining and protecting existing trees adjacent to the works, trimming rather than removing trees and early planting works for operation phase screening buffers would reduce the consequence of potential impacts to landscape character due to the project.	Minor	Likely	Low

A1 Environmental risk analysis

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Hazard and risk								
Construction								
<ul style="list-style-type: none"> Transport and storage of hazardous substances and dangerous goods during construction. 	Major	Unlikely	Medium	HR1, HR2	Transportation and storage of dangerous goods and hazardous materials in accordance with the relevant guidelines would reduce the risk of any impacts.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Interactions between maritime traffic and tunnel infrastructure. 	Major	Unlikely	Medium	CTT2, CTT3, CTT4, CTT5, CTT15, CTT16, CTT17, CTT18	Consultation with relevant stakeholders, advance notification of maritime restrictions and the appropriate scheduling of construction marine traffic activities would reduce the risk of maritime traffic impacts.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Potential rupture of, or interference with, underground utilities. 	Major	Unlikely	Medium		The relocation of utilities as part of the project will be managed in accordance with Appendix D (Utility management strategy) of the environmental impact statement.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Risk of bushfires. 	Major	Unlikely	Medium	HR3, HR4, HR5	As part of construction, adequate access and egress for fire fighting vehicles and construction vehicles and staff will be provided and appropriate setbacks from bushfire prone vegetation near to the project will be implemented, reducing the risk of impacts.	Moderate	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Operation								
<ul style="list-style-type: none"> Transport and storage of hazardous substances and dangerous goods during operation. 	Major	Unlikely	Medium	HR1, HR7	The transport and storage of dangerous goods and hazardous substances will be prohibited through the mainline tunnels and on and off-ramp tunnels, reducing the risk of impacts.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Traffic incidents, including incidents within the immersed tube tunnels. 	Major	Unlikely	Medium	HR6, HR8	The tunnel has been designed to include fire and safety systems in accordance with international and Australian standards. Additionally, incidents within the tunnels will be managed in accordance with the memorandum of understanding between Transport for NSW and the NSW Police Service, NSW Rural Fire Service, NSW Fire Brigade and other emergency services.	Moderate	Unlikely	Low
<ul style="list-style-type: none"> Interference with aviation. 	Major	Unlikely	Medium	HR9	Operation of ventilation outlets and motorway facilities will be in accordance with any conditions of approval, reducing the risk of impacts.	Moderate	Unlikely	Low
Resource use and waste management								
Construction								
<ul style="list-style-type: none"> Increased demand on electricity and water supply Increased demand on local and regional resources 	Moderate	Likely	Medium	WM1, WM5	The risk of potential impacts would be reduced by sourcing of construction materials for the project in accordance with the project's Sustainability Framework and with a preference for Australian	Minor	Unlikely	Low

A1 Environmental risk analysis

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
including sand and aggregate <ul style="list-style-type: none"> Increased diesel use during construction. 					materials and prefabricated products with low embodied energy. Opportunities for wastewater reuse will be investigated.			
<ul style="list-style-type: none"> Impacts associated with poor waste management during construction Impacts associated with unexpected waste volume or types. 	Moderate	Likely	Medium	WM2, WM3, WM4, WM5	The implementation of the resource management hierarchy principles by the project, the classification of waste in accordance with relevant guidelines and appropriate transport, storage and handling of waste would reduce the likelihood and consequence of impacts.	Minor	Unlikely	Low
Operation								
<ul style="list-style-type: none"> Increased electricity and water use during operation. 	Moderate	Likely	Medium	WM6, WM8	Guided by the project's Sustainability Framework, the project will optimise resource efficiency and waste management during operation. The risk of potential impacts would also be reduced by the consideration of opportunities to reuse treated groundwater during project operation. Opportunities for wastewater reuse will be investigated.	Minor	Unlikely	Low

A1 Environmental risk analysis

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Sustainability								
<p>An assessment of the sustainability of the project was carried out in Chapter 25 (Sustainability) of the environmental impact statement, which describes how sustainability principles have been applied to the design, construction and operation of the project including:</p> <ul style="list-style-type: none"> • Application of the principles of ecologically sustainable development to the project • Legislation and policies relevant to the project • The sustainability framework that has been developed for the project, including the application of the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability rating scheme to the project. <p>A Sustainability Management Plan for the project will be developed and implemented during detailed design, to give effect to the sustainability framework for the project. The Sustainability Management Plan will detail measures to meet the sustainability objectives and targets and Infrastructure Sustainability rating scheme credit requirements.</p> <p>With the proposed Sustainability Management Plan in place there is a low residual risk of the principles of ecologically sustainable development, relevant legislation and policies or the sustainability framework not being implemented across all elements of the project.</p>								
Climate change risk and adaptation (Operation stage only)								
<ul style="list-style-type: none"> • Impact of climate change on road operations and infrastructure • Impact of climate change on customer and staff comfort. 	Major	Unlikely	Medium	CC1	During further design development flood modelling will continue to use sea level rise projections and rainfall projections, the extent of scour protection will be refined, sensitivity testing for drainage channels will be carried out and any specific property impacts from flooding will be addressed reducing the consequence of impacts.	Minor	Unlikely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Greenhouse gases								
Construction								
<ul style="list-style-type: none"> Emissions of greenhouse gases from embodied energy in construction materials and electricity consumption. 	Moderate	Likely	Medium	GHG1	Implementation of the Sustainability Management Plan will manage and minimise greenhouse gas emissions produced by the project, reducing the consequence of impacts.	Minor	Likely	Low
Operation								
<ul style="list-style-type: none"> Emissions of greenhouse gases from operational energy use and vehicle emissions. 	Moderate	Likely	Medium	GHG2	Further design development will consider the implementation of energy efficient systems as part of the project where reasonable and practicable, reducing the risk of potential impacts.	Minor	Likely	Low

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Potential impact	Initial risk rating (unmitigated)			Proposed revised environmental management measures	Effectiveness of key mitigation measures	Residual risk rating (with mitigation)		
	Unmitigated consequence	Unmitigated likelihood	Unmitigated risk			Residual consequence	Residual likelihood	Residual risk
Cumulative impacts								
Construction								
<ul style="list-style-type: none"> Construction noise and traffic associated with developments in proximity to construction sites including the Beaches Link and Gore Hill Freeway Connection project (if approved), the Chatswood to Sydenham component of Sydney Metro City & Southwest project, the M4-M5 Link project and other developments. 	Moderate	Likely	Medium	CNV10, CI1, CI2	Coordination of work between project construction sites and construction works to avoid cumulative noise impacts and the incorporation of additional mitigation measures as required would be used to manage cumulative noise impacts.	Moderate	Likely	Medium
<ul style="list-style-type: none"> Road based spoil haulage management (traffic and noise impacts). 	Moderate	Likely	Medium	CI1, CI2	Engagement within other nearby construction activities and coordination of haulage routes and road occupancy with other major transport projects via Transport Coordination within Transport for NSW would reduce the risk of potential impacts.	Minor	Likely	Low
Operation								
When completed, the Western Harbour Tunnel and Beaches	Positive impact							

A1 Environmental risk analysis

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Link program of works is expected to deliver beneficial cumulative impacts including significant increases in travel speeds through sections of the surface road network, increased reliability, increased connectivity, and a reduction in average travel times.								

A1.4 Risk analysis outcomes

No potential impacts with a residual risk rating of 'high' were identified for the project.

A number of 'medium' level residual risks were identified. Through the further design development, construction and operation of the project, additional review of the 'medium' residual risk level items would be carried out, and additional measures to ensure these risks are suitably managed would be implemented where necessary. During further design development there would be additional opportunities to:

- Resolve residual impacts through detailed design refinement
- Refine construction methodologies and planning with the contractor to ensure that management and mitigation measures are effectively implemented
- Implement a process of review, correction and audit for the construction environmental management plan and operational management plan as described in Part D of this submissions report. This is a process of continuous improvement that will form part of the construction environmental management plan and operational environmental management plan and allow for management measures to be updated or improved during construction and operational phases where practical.

Other issues which have been identified as having a low residual risk would be adequately managed through further design development and construction, and by the implementation of the revised environmental management measures proposed in Table D2-1 of this submissions report.