Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 23

Hazards and risks

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23 Hazards and risks

This chapter assesses potential hazards arising from possible incidents during project construction and operation that could pose a risk to public safety, the surrounding community or the environment, and summarises the approaches taken to manage these risks. Other potential environmental hazards resulting from construction and operation of the project, and measures to avoid, mitigate and manage these risks are addressed in Chapter 8 (Construction traffic and transport) to Chapter 27 (Cumulative impacts) of this environmental impact statement. The impacts associated with human health risks are detailed in Chapter 13 (Human health).

The Secretary's environmental assessment requirements as they relate to hazard and risk impacts, and where in the environmental impact statement these have been addressed, are detailed in Table 23-1.

Avoiding or minimising impacts has been a key consideration throughout the design and development process for the Beaches Link and Gore Hill Freeway Connection project. A conservative approach has generally been used in the assessments, with potential impacts presented before implementation of environmental management measures. The environmental management measures proposed to minimise the potential impacts in relation to hazards and risks are included in Section 23.4.

Table 23-1 Secretary's environmental assessment requirements – hazards and risks

Secretary's requirement	Where addressed in EIS
Transport and traffic	
1. The Proponent must assess construction transport and traffic (vehicle, marine, pedestrian and cyclists) impacts, including, but not necessarily limited to: a. a considered approach to route identification and scheduling of marine and land transport movements, particularly outside standard construction hours j. impacts to water-based traffic on Middle Harbour.	Within **Chapter 6** (Construction work), **Section 6.7** and **Section 6.8** show the land and maritime construction traffic/vessel movements for each temporary construction support site, as well as the operating hours of each site. Construction traffic routes are discussed in **Chapter 8** (Construction traffic and transport). **Section 8.4** discusses the proposed marine and land transport movements. **Section 23.2.4** outlines interactions between maritime traffic and tunnel infrastructure during construction.
Health and safety	

Secretary's requirement	Where addressed in EIS
2. The assessment must: f. assess the likely risks of the project to public safety, paying particular attention to pedestrian safety, subsidence risks, bushfire risks and the handling and use of dangerous goods.	An assessment of bushfire risks relating to construction and operation is presented in **Section 23.2.6** and **Section 23.3.5** respectively. The handling, transport and use of dangerous goods is described in **Section 23.2** and **Section 23.3**. An assessment of potential ground movement associated with the project is provided in **Chapter 16** (Geology, soils and groundwater). Ground movement due to construction activities is also discussed in **Section 23.2.3.** Pedestrian safety is discussed in **Chapter 8** (Construction traffic and transport). **Section 23.3.3** provides an assessment of the impacts of potential traffic incidents during operation.
Socio-economic, land use and property	
4. The Proponent must assess potential impacts on utilities (including communications, electricity, gas, fuel and water and sewerage) and the relocation of these utilities.	**Chapter 6** (Construction work) details utilities impacted during construction. **Chapter 5** (Project description) outlines utilities and services management for the project. **Appendix D** (Utilities management strategy) provides a detailed description of utilities likely to be impacted and a framework for utility adjustment, relocation and protection. The framework is outlined in **Section 23.2.5**.
Hazards	
1. The Proponent must describe the process for assessing the risk of emissions from ventilation facilities on aircraft operations taking into consideration the requirements of the *Airports Act 1996* (Commonwealth) and the Airports Regulations 1997.	The process for the assessment of risk of emissions from ventilation facilities on aircraft operation is described in **Chapter 2** (Assessment process). The findings of the assessment are summarised in **Section 23.3.6.**

23.1 Assessment methodology

An assessment was carried out to identify environmental hazards and risks that could arise during construction and operation of the project, as well as appropriate risk management measures.

The assessment focused on those hazards with the potential to adversely affect the surrounding environment, and general public. It took into account the following guidelines:

- *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011)
- *Australian Code for the Transport of Dangerous Goods by Road and Rail* (7th edition) (National Transport Commission, 2007)
- *Storage and Handling of Dangerous Goods Code of Practice* (WorkCover, 2005)
- *Planning for Bushfire Protection* (Rural Fire Service (RFS), 2019)

- *Bush Fire Risk Management Planning Guidelines for Bush Fire Management Committees* (RFS, 2008)
- *Garigal National Park Fire Management Strategy* (Department of Environment and Conservation (DEC), 2006b)
- *Manly Warringah War Memorial Park Fire Regime Management Plan* (Eco Logical Australia, 2006)
- Bushfire prone land mapping developed and published by the relevant local councils
- Relevant Bush Fire Risk Management Plans including:
  - *Mosman North Sydney Willoughby Bush Fire Risk Management Plan 2017–2022* (Mosman North Sydney Willoughby Bush Fire Management Committee, 2017)
  - *Warringah Pittwater Bush Fire Risk Management Plan 2010–2015* (Warringah Pittwater Bush Fire Management Committee, 2010).

23.2 Assessment of potential construction impacts

During construction, potential hazards and risks to public safety, the surrounding community or the environment may be associated with:

- Storage and handling of dangerous goods and hazardous substances (Section 23.2.1)
- Transport of dangerous goods and hazardous substances (Section 23.2.2)
- Ground movement (settlement) or geotechnical uncertainty (Section 23.2.3)
- Interactions between maritime traffic and tunnel infrastructure (Section 23.2.4)
- Damage to, or disruption of, both underground and above ground utilities (Section 23.2.5)
- Bushfires (Section 23.2.6).

Other potential environmental hazards resulting from the construction of the project are considered and addressed in the relevant chapters of this environmental impact assessment.

23.2.1 Storage and handling of dangerous goods and hazardous substances

The anticipated types and quantities of dangerous goods and hazardous substances that would be stored and used at the temporary construction support sites are listed in Table 23-2. The types and quantities of dangerous goods and hazardous substances are indicative and would be confirmed during further design development and detailed construction planning, and if necessary, further screening of potential risks would be carried out at that time. The screening would be used to confirm that the project would not pose a substantial off-site risk.

State Environmental Planning Policy No 33 – Hazardous and Offensive Development (SEPP 33) presents a systematic approach to the assessment of development proposals for potentially hazardous and offensive industry or storage. SEPP 33 ensures that proposals can be built and operated with an adequate level of safety and pollution control. *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Applying SEPP 33) (Department of Planning, 2011) includes a screening method, based on the quantities of dangerous goods on a site, to assist in determining if a proposed development is considered potentially hazardous and offensive under SEPP 33.

A screening comparison of the indicative quantities of dangerous goods to be stored at the temporary construction support sites against the threshold quantities listed in Applying SEPP 33 has been carried out. These thresholds represent the level at which dangerous goods may present a credible off-site risk requiring further, more detailed assessment. The comparison against the screening thresholds in Applying SEPP 33 is included in Table 23-2. Other potentially dangerous goods and hazardous substances to be used during construction of the project and not listed in Applying SEPP 33 have also been included in Table 23-2 for completeness.

Table 23-2 demonstrates that the Applying SEPP 33 inventory thresholds would not be exceeded for any material at any temporary construction support site. The storage and use of dangerous goods and hazardous materials at the temporary construction support sites would therefore not pose an unacceptable risk of harm beyond the temporary construction support site boundary.

Environmental hazards and risks associated with the on-site storage and use of chemicals, fuels and materials would be managed through standard mitigation measures (refer to Section 23.4). Storage of dangerous goods and hazardous substances would be in accordance with the supplier's instructions, and would comply with applicable legislation, guidelines and Australian Standards.

Table 23-2 Indicative dangerous goods and hazardous substances stored at temporary construction support sites

Material	Australian Dangerous Goods Code class	Storage method	Assessment against Applying SEPP 33 inventory thresholds	Temporary construction support site
Explosives	1.1	No on site storage – delivery would be timed to avoid the need for on-site storage	Explosives would not be stored on site and would therefore not be subject to the Applying SEPP 33 thresholds.	N/A
Diesel	C1[1], 3 PG III[2]	Self-bunded fuel tank (up to 2.5 kilolitres) and 20 litre drums	Diesel would be less than five tonnes and would not be stored with Class 3 (flammable liquids) materials. It would therefore not be subject to the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Petrol	C1[1], 3 PG III[2]	Self-bunded fuel tank (up to 2.5 kilolitres) and 20 litre drums	Petrol would be less than five tonnes and would not be stored with Class 3 materials. It would therefore not be subject to the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Lubricating and hydraulic oils and grease	C2	20 litre drums	Lubricating and hydraulic oils and grease would not be stored with Class 3 materials and would therefore not be subject to the Applying SEPP 33 thresholds.	All temporary construction support sites.
Industrial grade acetylene	2.1	3.2 m^3 cylinders (13 kilograms)	Individual cylinders containing acetylene would not trigger the Applying SEPP 33 thresholds (100 kilograms). Maximum stored inventories (250 kilograms) would be located more than 25 metres away from the temporary construction support site boundary and would therefore also not trigger the Applying SEPP 33 thresholds if considered in aggregate.	All temporary construction support sites.

Material	Australian Dangerous Goods Code class	Storage method	Assessment against Applying SEPP 33 inventory thresholds	Temporary construction support site
Industrial grade oxygen	2.2	8.9 m^3 cylinders	Industrial grade oxygen is a class 2.2 dangerous good and is therefore not subject to the Applying SEPP 33 thresholds.	All temporary construction support sites.
Accelerator for shotcrete	3.2	1000 litre intermediate bulk containers (IBC)	Individual IBCs containing accelerator fluid would not trigger the Applying SEPP 33 thresholds (five tonnes). Maximum stored inventories (20,000 litres) would be located more than eight metres away from the temporary construction support site boundary and would therefore also not trigger the Applying SEPP 33 thresholds if considered in aggregate.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13) • Wakehurst Parkway north (BL14).
Retardants for concrete	3 PGIII	205 litre drums	Retardants would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.	All land based temporary construction support sites.
Epoxies	3 PGIII	20 litre drums	Epoxies would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.	All temporary construction support sites.
Acids	8 PGIII	1000 litre IBC (and smaller containers)	Acids would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.	All temporary construction support sites.
Bases	8 PGIII	1000 litre IBC	Bases would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.	All temporary construction support sites.
Disinfectants	8 PGIII	500 litre IBC	Disinfectants would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.	All land based temporary construction support sites.

Material	Australian Dangerous Goods Code class	Storage method	Assessment against Applying SEPP 33 inventory thresholds	Temporary construction support site
General purpose Portland cement	N/A	20 kilogram bags	Cement is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Road and joint sealants	N/A	12 litre boxes	Road and joint sealants are not a dangerous good and therefore do not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites (except Spit West Reserve (BL9)).
Concrete curing compounds	N/A	1000 litre IBC	Concrete curing compounds are not a dangerous good and therefore do not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Pavement layers curing compound	N/A	1000 litre IBC	Pavement layers and curing compounds are not a dangerous good and therefore do not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Paint for tunnel roof	N/A	1000 litre IBCs	Paint is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).
Paints	N/A	50 litre drums	Paints are not a dangerous good and therefore do not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Coagulants	N/A	1000 litre IBCs	Coagulants are not a dangerous good and therefore do not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).

Material	Australian Dangerous Goods Code class	Storage method	Assessment against Applying SEPP 33 inventory thresholds	Temporary construction support site
Anti-scalent	N/A	100 litre drums	Anti-scalent is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).

Note 1: Classified as C1 if not stored with other Class 3 flammable liquids
Note 2: Classified as 3 PG III if stored with other Class 3 flammable liquids

23.2.2 Transport of dangerous goods and hazardous substances

Dangerous goods and hazardous materials that would be transported to each temporary construction support site are outlined in Table 23-3. Potential transportation hazards and risks have been considered through comparison of the likely type, quantity and frequency of dangerous goods and hazardous materials transportation with the thresholds presented in Applying SEPP 33. In all cases, the transportation of dangerous goods and hazardous materials to temporary construction support sites would be below the Applying SEPP 33 thresholds. This indicates that risks associated with transport of dangerous goods and hazardous materials would not be significant.

The proposed haulage routes outlined in Chapter 6 (Construction work) have been identified to avoid local roads where possible and would therefore minimise the risks associated with the transport of dangerous goods and hazardous materials.

Table 23-3 Indicative dangerous goods and hazardous substances transported to temporary construction support sites

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity	Assessment against Applying SEPP 33 transport thresholds	Temporary construction support site destination
Explosives	1.1	As required, if blasting is carried out.	As required	Not subject to the Applying SEPP 33 thresholds if not transported with Class 3 dangerous goods.	• Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).
Diesel[1]	C1[2], 3 PG III[3]	Daily	1500 litres	Not subject to the Applying SEPP 33 thresholds if not transported with Class 3 dangerous goods. Refuelling at cofferdams would be carried out by fit for purpose refuelling barges.	All temporary construction support sites.
Petrol[1]	C1[2], 3 PG III[3]	Weekly	50 litres	Not subject to the Applying SEPP 33 thresholds if not transported with Class 3 dangerous goods. Refuelling at cofferdams would be carried out by fit for purpose refuelling barges.	All temporary construction support sites.
Lubricating and hydraulic oils and grease	C2	Weekly	40 litres	Not subject to the Applying SEPP 33 thresholds if not transported with Class 3 dangerous goods.	All temporary construction support sites.
Industrial grade acetylene	2.1	Monthly	410 litres[4]	Transport quantities would not trigger the Applying SEPP 33 thresholds.	All temporary construction support sites.
Industrial grade oxygen	2.2	Monthly	410 litres[4]	Not subject to Applying SEPP 33 transport thresholds	All temporary construction support sites.

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity	Assessment against Applying SEPP 33 transport thresholds	Temporary construction support site destination
Accelerator for shotcrete	3PGII	Weekly	100 litres[4]	Transport quantities would not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13) • Wakehurst Parkway north (BL14).
Retardants for concrete	3PGIII	Monthly	205 litre drum	Transport quantities would not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Epoxies	3PGIII	Monthly	20 litres[4]	Transport quantities would not trigger the Applying SEPP 33 thresholds.	All temporary construction support sites.
Acids	8 PGIII	Monthly	20 litres[4]	Not subject to Applying SEPP 33 transport thresholds.	All temporary construction support sites.
Bases	8 PGIII	Monthly	20 litres[4]	Not subject to Applying SEPP 33 transport thresholds.	All temporary construction support sites.
Disinfectants	8 PGIII	Monthly	20 litres[4]	Not subject to Applying SEPP 33 transport thresholds.	All land based temporary construction support sites.
General purpose Portland cement	N/A	Monthly	72 bags[4]	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Road and joint sealants	N/A	Monthly	Four 12 litre boxes	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites (except Spit West Reserve (BL9)).

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity	Assessment against Applying SEPP 33 transport thresholds	Temporary construction support site destination
Concrete curing compounds	N/A	Monthly	50 litres	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Pavement layers curing compound	N/A	Monthly	100 litres	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Paint for tunnel roof	N/A	Five to six deliveries	50 litre drums	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).

Material	Australian Dangerous Goods Code class	Transport frequency	Transport quantity	Assessment against Applying SEPP 33 transport thresholds	Temporary construction support site destination
Paints	N/A	Monthly (during the second half of construction program)	250 litres	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	All land based temporary construction support sites.
Coagulants	N/A	Monthly	150 kilograms	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).
Anti-scalent	N/A	Monthly	1000 litres	This is not a dangerous good and therefore does not trigger the Applying SEPP 33 thresholds.	• Cammeray Golf Course (BL1) • Flat Rock Drive (BL2) • Punch Street (BL3) • Balgowlah Golf Course (BL10) • Wakehurst Parkway east (BL13).

Note 1: For some temporary construction support sites, the quantity of diesel and unleaded petrol delivered to site would be greater than the quantity stored within the facility at any time, because the delivery volume takes into the account fuel which is brought to the facility by mini-tanker and used to directly refuel plant. As this fuel is 'in use' in the plant it is not classified as 'stored'.
Note 2: Classified as C1 if not stored with other Class 3 flammable liquids.
Note 3: Classified as 3 PG III if stored with other Class 3 flammable liquids.
Note 4: Per temporary construction support site.

23.2.3 Ground movement and geological uncertainty

Ground movement (or settlement) refers to a localised lowering of the ground level due to construction activities involving excavation or disturbance below ground. If unmanaged, ground movement can present a risk to the stability of nearby buildings and other structures, including building basements and ground support structures.

Ground movement may occur as a result of:

- Tunnel induced movement caused by the relief of stress from the removal of intact rock during tunnelling
- Settlement induced by groundwater drawdown.

The construction of tunnels, even using the most modern machinery and control methods, results in some volume loss and corresponding ground movement. Geotechnical investigations have confirmed that high quality Hawkesbury Sandstone would be encountered for the majority of the proposed tunnel alignment. Furthermore, the alignment of the proposed tunnels means that they would be very deep for the majority of their length, with a substantial amount of sandstone between the tunnels and surface. Most of the induced settlement along the alignment due to tunnel excavation would therefore likely be as a result of stress redistribution within the rock mass.

An assessment of potential ground movement associated with the project is provided in Chapter 16 (Geology, soils and groundwater). Preliminary ground movement predictions indicate that there may be potential settlement of up to 40 millimetres around the Burnt Bridge Creek Deviation and Wakehurst Parkway portals. This would be considered 'slight' severity under relevant guidelines. Potential settlement at Flat Rock Creek Reserve could reach 85 millimetres, however no buildings are present at this location. This prediction assumes that groundwater inflows into the tunnel beneath Flat Rock Reserve are unconstrained. Additional modelling and settlement predictions at this location indicated that when reduced inflows and groundwater drawdown were taken into account, the maximum predicted total settlement reduced to 35 millimetres.

For most of the tunnelling works, the anticipated drawdown in the groundwater table would occur within the bedrock stratigraphy above the tunnel and this drawdown is assessed not to cause consolidation settlement in the overlying natural or filled soils, which are currently above the groundwater table. However, tunnelling works could potentially lower the groundwater table within poorly consolidated fill which could result in surface settlements where the tunnel crosses beneath the former Flat Rock Creek. At this location, the tunnelling works could drain the groundwater currently “ponded” within landfill in the former creek. Inflow of groundwater into the tunnels would result in a depressurisation of the groundwater surrounding the tunnels and could lead to ground settlement.

The groundwater and settlement modelling completed for this environmental impact statement is conservative in that it disregards the effects of the permanent concrete and waterproofing linings that will be installed within the tunnels. The tunnel will be designed to limit groundwater inflow into the tunnel, minimising the actual groundwater drawdown and associated settlement predicted to occur during construction.

A number of major design and construction method reviews have been carried out to better understand the Lane Cove Tunnel failure which occurred at Longueville in 2005. The causes of the failure are generally cited as a complex combination of factors, including the changing ground conditions and geological defects and the inadequacy of the tunnel support system.

The risks of a similar incident occurring during a Sydney tunnelling project are considered extremely low. The reasons for this include:

- Vastly improved geotechnical assessment and modelling
- Improved predictive two dimensional and three dimensional modelling of geology, excavation spans, temporary and permanent loads

- Fit for purpose design to develop the appropriate type of ‘support’ to match the ground conditions as the excavation progresses on a day to day basis
- Continuous independent review of the temporary and permanent works design and construction methods
- Continual construction verification that tunnel support is installed and performing as per the design
- Robust change management processes for conditions that are out of the ordinary or unexpected, including probe drilling and ground treatment through suspected poor ground zones
- Continuous assessment of likely excavation and groundwater conditions
- Detailed survey monitoring of surface roads, buildings and structures in the tunnel vicinity.

In addition to the consideration of the above, the project design and tunnel construction methods have been informed by early geotechnical investigations to reduce the construction risks associated with uncertain ground conditions (additional geotechnical investigations would be carried out during further design development to confirm ground conditions, where required). Primary support for the tunnels would be installed as the excavation progresses, as recommended by an appropriately qualified geotechnical or tunnel engineer, to ensure tunnel stability during construction.

23.2.4 Interactions between maritime traffic and tunnel infrastructure

The project would require marine vessel movements during construction of the immersed tube tunnels in Middle Harbour, including:

- Barges for construction activities including delivering construction materials, removing cofferdam spoil and removing dredged material
- Dredging vessels
- Barges with piling equipment and cranes
- Tugboats for manoeuvring barges
- Transport vessels for workers.

The steel shells for the immersed tube tunnel units for the Middle Harbour crossing would be prepared at a location outside of Middle Harbour. Once prepared, the immersed tube tunnel steel shells would be transported by sea either on a barge or directly towed and guided by several tug boats to Middle Harbour, through the Spit Bridge navigation channel and moored at Spit West Reserve construction support site (BL9) to be completed.

There is a shallow sand bar located near the entrance to Middle Harbour which would need to be navigated by the barge or tug boat and immersed tunnel unit steel shells. While the waterway at the Middle Harbour entrance is relatively wide, the water depths through the deepest part of the channel are about 4.5 metres, becoming shallower at low tide. The immersed tube tunnel units have been designed as incomplete steel shells so that they would be lighter during transportation into Middle Harbour. The steel shell design would enable the barge or floating immersed tube tunnel unit steel shells to float higher in the water, enabling their safe and efficient transport over the shallow sand bar and into Middle Harbour. This would minimise the potential for the vessel (barge or tug boat) transporting the immersed tube tunnel unit steel shells, or the floating steel shells, grounding on the shallow sand bar. Casting of the steel shells with reinforced concrete and fitout of the completed immersed tube tunnels would be carried out at Spit West Reserve construction support site (BL9) prior to immersion.

During immersion of the tube tunnel units, there is a risk that maritime traffic could collide with the units if they pass the location of the Middle Harbour crossing before the tube tunnel units are in their final position on the bed of the harbour. The timeframe for immersion would be very short

(less than two days per unit), and measures would be put in place to manage potential risks, including restrictions such as partial or full closures to marine vessel movements through the crossing location during immersion of the tube tunnels. As outlined in Chapter 8 (Construction traffic and transport), simulation modelling has demonstrated that the transportation of both steel shell and completed immersed tube tunnel units can be carried out safely.

23.2.5 Damage or disruption to underground and above ground utilities

The project has been designed, where possible, to avoid utilities, taking into account the results of utility investigations and consultation with utility providers carried out during the design process (refer to Chapter 7 (Stakeholder and community engagement)). Where the project is unable to avoid utilities, if possible, they would be adjusted, relocated or protected prior to the commencement of construction to avoid impacts. Alternatively, adjustment, relocation or protection would occur during construction.

Consultation with utility providers would continue during the further design development and construction planning phases of the project to mitigate the risk of unplanned and unexpected disturbance of utilities. In rare circumstances, the relocation of utilities may result in planned short term outages of some utilities to surrounding areas. Utilities which would be directly impacted and require adjustment, protection or relocation have been considered in Appendix D (Utilities management strategy).

23.2.6 Bushfires

A bushfire risk assessment was carried out to assess potential bushfire implications of the project. In accordance with *Planning for Bushfire Protection* (RFS, 2019) the predominant vegetation class (bushfire prone land) has been assessed to a distance of 140 metres from the project in all directions. Table 23-4 provides the assessed bushfire risk level for temporary construction support sites located on, or close to, bushfire prone land. The level of bushfire risk is determined using a combination of likelihood and consequence, with the likelihood of bushfire risk for all assets being defined as the chance of a bushfire igniting and spreading and the consequence being the outcome or impact of a bushfire event (RFS, 2008).

Table 23-4 Bushfire risk level for temporary construction support sites

Temporary construction support site(s)	Bushfire risk level	Proximity to bushfire prone land
Cammeray Golf Course (BL1)	Low	No bushfire prone land within 140 metres.
Flat Rock Drive (BL2)	Low	The northern, eastern and southern areas of the temporary construction support site would be within 10 metres of bushfire prone land.
Punch Street (BL3) Dickson Avenue (BL4) Barton Road (BL5) Gore Hill Freeway median (BL6)	Low	The northern portion of the Punch Street construction support site (BL3) would be located more than 70 metres from bushfire prone land (and separated by Gore Hill Freeway). Other temporary construction support sites would be located greater than 100 metres from bushfire prone land.
Middle Harbour south cofferdam (BL7) and Middle Harbour north cofferdam (BL8)	N/A	Not applicable as the temporary construction support sites would be located within Middle Harbour.

Temporary construction support site(s)	Bushfire risk level	Proximity to bushfire prone land
Spit West Reserve (BL9)	Low	No land based structures are proposed within the temporary construction support site, with site access only proposed.
Balgowlah Golf Course (BL10) Kitchener Street (BL11)	Low	The northern portion of the Balgowlah Golf Couse construction support site (BL10) would be located within 60 metres of bushfire prone land.
Wakehurst Parkway south (BL12) Wakehurst Parkway east (BL13)	Medium	These two temporary construction support sites would be located in an area classified as bushfire prone land.
Wakehurst Parkway north (BL14)	High	This temporary construction support site would be located in an area classified as bushfire prone land.

The bushfire risk assessment identified that during construction, all areas of the project, with the exception of areas along the Wakehurst Parkway, would have a bushfire risk level of 'low'. With respect to the Wakehurst Parkway, the risk of bushfires would be considered higher, with the Wakehurst Parkway south (BL12) and Wakehurst Parkway east (BL13) temporary construction support sites assessed as having a bushfire risk level of 'medium' and Wakehurst Parkway north construction support site (BL14) having a rating of 'high'. The difference in these ratings is largely as a result of greater consequences should a bushfire occur.

Several areas associated with the project, including areas within Naremburn, Northbridge and Frenchs Forest are identified in the *Mosman North Sydney Willoughby Bushfire Risk Management Plan 2017-2022* (Mosman North Sydney Willoughby Bush Fire Management Committee, 2008) and the *Warringah Pittwater Bush Fire Risk Management Plan 2010–2015* (Warringah Pittwater Bush Fire Management Committee, 2010) as being subject to bushfire planning measures. Council management of these areas would contribute to the bushfire protection measures for the relevant temporary construction support sites.

Strategies to reduce risk from bushfire, such as site layout, setbacks from bushfire prone vegetation, access and emergency procedures along the Wakehurst Parkway would be developed and implemented during construction (refer to Section 23.4).

23.3 Assessment of potential operational impacts

During operation, potential hazards and risks to public safety, the surrounding community or the environment may be associated with:

- Storage and handling of dangerous goods and hazardous substances (Section 23.3.1)
- Transport of dangerous goods and hazardous substances (Section 23.3.2)
- Traffic incidents on surface roads and within tunnels (Section 23.3.3)
- Interactions between maritime traffic and tunnel infrastructure (Section 23.3.4)
- Bushfires (Section 23.3.5)
- Atmospheric turbulence caused by discharges from the ventilation outlets and motorway facilities at the Warringah Freeway, Gore Hill Freeway, Burnt Bridge Creek Deviation and the Wakehurst Parkway and the interface with aviation (Section 23.3.6).

Other potential environmental hazards resulting from the operation of the project are considered and addressed in the relevant chapters of this environmental impact statement.

23.3.1 Storage and handling of dangerous goods and hazardous substances

Dangerous goods and hazardous materials would be stored at the operational facilities to be provided as part of the project and used during operation of the project. The types and quantities of dangerous goods and hazardous materials to be stored on-site during operation are summarised in Table 23-5. Additional small quantities of other materials may be required on-site from time to time to support maintenance activities. Managed in accordance with the measures in Section 23.4, these materials would not pose a substantial risk to the general public during operation of the project.

Comparison of the types and quantities of dangerous goods and hazardous materials to be stored on-site with the thresholds outlined in Applying SEPP 33, demonstrates that operational inventories would not pose a substantial risk of harm beyond the boundary of the operational facilities.

Table 23-5 Indicative dangerous goods and hazardous substances stored on site during operation

Material and Australian Dangerous Goods Code class	Storage method (amount stored at any one time)	Inventory thresholds in Applying SEPP 33	Assessment against Applying SEPP 33 inventory thresholds
Diesel C1[1], 3 PG III[2]	Bunded tanks on site.	N/A	Diesel would be less than five tonnes and would not be stored with Class 3 materials. It would therefore not be subject to the Applying SEPP 33 thresholds.
Grease C2	400-gram cartridge, 20 litre containers stored undercover on site.	N/A	Grease would not be stored with Class 3 materials and would therefore not be subject to the Applying SEPP 33 thresholds.
Adhesives C2, PGIII	375-gram cartridge, 20 litre containers stored on site.	Five tonnes	Adhesives would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.
Acetylene C2.1	Size G cylinders on site.	100 kilograms	Individual cylinders containing acetylene would not trigger the Applying SEPP 33 thresholds. Maximum stored inventories would not trigger the Applying SEPP 33 thresholds if considered in aggregate.
Linemarking aerosol C2.1	375 millimetre aerosol container stored undercover on site.	100 kilograms	Linemarking aerosol would not trigger the Applying SEPP 33 thresholds.
Oxygen C2.2	Size G cylinders on site.	N/A	Industrial grade oxygen is a Class 2.2 dangerous good and is not subject to the Applying SEPP 33 thresholds.
Kerosene C3, PGIII	20 litre containers stored in an undercover bunded area on site.	Five tonnes	Kerosene would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.
Oxygen (subsidiary risk) C5.1	Size G cylinders on site.	Five tonnes	Oxygen has a subsidiary risk Class of 5.1. It would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.

Material and Australian Dangerous Goods Code class	Storage method (amount stored at any one time)	Inventory thresholds in Applying SEPP 33	Assessment against Applying SEPP 33 inventory thresholds
Sodium hydroxide C8, PGII	10,000 litre feed tank in an undercover bunded area on site.	25 tonnes	Sodium hydroxide would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.
Bitumen C9	12,000 litre tanker (brought onto site as required).	N/A	Bitumen is a Class 9 dangerous good and is not subject to the Applying SEPP 33 thresholds.
Coagulant N/A	12,000 litre feed tank in an undercover bunded area on site.	N/A	Coagulant is not classified as a dangerous good and does not trigger the Applying SEPP 33 thresholds.
Polymers N/A	20 kilogram bags stored in a container and undercover on site.	N/A	Polymers are not classified as a dangerous good and would not trigger the Applying SEPP 33 thresholds.
Non-shrink grout N/A	20 kilogram bags stored undercover on site.	N/A	Non-shrink grout is not classified as a dangerous good and does not trigger the Applying SEPP 33 thresholds.
Release agent (lanolin-based) N/A	20 litre drums stored undercover on site.	N/A	Release agent (lanolin-based) is not classified as a dangerous good and does not trigger the Applying SEPP 33 thresholds.

Note 1: Classified as C1 if not stored with other Class 3 flammable liquids
Note 2: Classified as 3 PG III if stored with other Class 3 flammable liquids

23.3.2 Transport of dangerous goods and hazardous substances

Dangerous goods and hazardous materials that would be transported to the project during operation are outlined in Table 23-6. The risks associated with transport of dangerous goods and hazardous materials would not be high.

Prior to opening to traffic, the mainline tunnels would be listed as prohibited areas under Road Rules 2014 – Rule 300-2: NSW rule: carriage of dangerous goods in prohibited areas (Regulation 300-2). The transport of dangerous goods in prohibited areas, including the mainline tunnels, would be prohibited. Signage would be provided near tunnel entry points advising of applicable restrictions to ensure compliance with Rule 300-2.

Table 23-6 Indicative dangerous goods and hazardous substances transported during operation

Material and Australian Dangerous Goods Code class	Transport frequency	Transport quantity	Transport thresholds in Applying SEPP 33	Assessment against Applying SEPP 33 transport thresholds
Diesel C1[1], 3 PG III[2]	As required	As required	N/A	Diesel would not be transported with Class 3 materials and would therefore not be subject to the Applying SEPP 33 thresholds.
Grease C2	Weekly	50 cartridges (20 kilograms)	N/A	Grease would not be transported with Class 3 materials and would therefore not be subject to Applying SEPP 33 thresholds.
Adhesives C2, PGIII	Weekly	50 cartridges (19 kilograms)	Minimum transport load or transport frequency of 10 tonnes, more than 60 times per week	Adhesives would not trigger the Applying SEPP 33 thresholds.
Acetylene C2.1	Weekly	50 cylinders	Minimum transport load or transport frequency of two tonnes, more than 30 times per week	Industrial grade acetylene would not trigger the Applying SEPP 33 thresholds for minimum transport load or transport frequency of two tonnes, more than 30 times per week.
Line-marking aerosol C2.1	Quarterly	50 cans	Minimum transport load or transport frequency of two tonnes, more than 30 times per week	Line-marking aerosol would not trigger the Applying SEPP 33 thresholds.
Oxygen C2.2	Weekly	50 cylinders	N/A	Industrial grade oxygen is a Class 2.2 dangerous good and is not subject to the Applying SEPP 33 thresholds.
Kerosene C3, PGIII	Monthly	80 litres	Minimum transport load or transport frequency of 10 tonnes, more than 60 times per week	Kerosene would not trigger the Applying SEPP 33 thresholds.
Oxygen (subsidiary risk) C5.1	Weekly	50 cylinders	Minimum transport load or transport frequency of two tonnes, more than 30 times per week	Oxygen has a subsidiary risk Class of 5.1. It would not trigger the Applying SEPP 33 thresholds.

Material and Australian Dangerous Goods Code class	Transport frequency	Transport quantity	Transport thresholds in Applying SEPP 33	Assessment against Applying SEPP 33 transport thresholds
Sodium hydroxide C8, PGII	Six monthly	10,000 litres	Minimum transport load of 25 tonnes	Sodium hydroxide would not trigger the Applying SEPP 33 thresholds if considered as individual containers or in aggregate.
Bitumen C9	Quarterly	12,000 litres	Minimum transport frequency of more than 60 times per week	Bitumen would not trigger the Applying SEPP 33 thresholds.
Coagulant N/A	Quarterly	10,000 litres	N/A	Coagulant is not classified as a dangerous good and does not trigger the Applying SEPP 33 thresholds.
Polymers N/A	Quarterly	1000 kilograms	N/A	Polymers are not classified as a dangerous good and would not trigger the Applying SEPP 33 thresholds.
Non-shrink grout N/A	Monthly	1900 kilograms	N/A	Non-shrink grout is not classified as a dangerous good and does not trigger the Applying SEPP 33 thresholds.
Release agent (lanolin-based) N/A	Twice monthly	180 litres	N/A	Release agent (lanolin-based) is not classified as a dangerous good and does not trigger the Applying SEPP 33 thresholds.

Note 1: Classified as C1 if not stored with other Class 3 flammable liquids
Note 2: Classified as 3 PG III if stored with other Class 3 flammable liquids

23.3.3 Traffic incidents

The project has been designed to provide efficient, free flowing traffic conditions with capacity to safely accommodate forecast traffic volumes. The project design incorporates all feasible and reasonable traffic safety measures including those related to geometry, pavement, lighting, signage and shared user infrastructure consistent with current Australian Standards, road design guidelines and industry best practice. In doing so, the design of the project inherently minimises the likelihood of incidents and accidents.

Each project tunnel would be one-directional, reducing the risk of crashes through head on collisions and simplifying smoke management and egress requirements. The transport of dangerous goods and hazardous substances would be prohibited through the mainline and ramp tunnels and on and off ramps, reducing the risk of very large fires or the release of toxic materials in the tunnels.

Notwithstanding, human factors in particular cannot be entirely removed during operation of the project and there would remain a residual risk of incidents and accidents. In the event of incidents and accidents, the project has been designed to meet appropriate fire and life safety requirements. The key fire and life safety aspects of the project are described in Chapter 5 (Project description), and would include maintenance and emergency breakdown bays, fire and incident detection equipment, communications systems, fire suppression systems, emergency lighting, smoke management and power systems, cross passages or longitudinal egress passages, and tunnel closure systems. The fire and life safety systems would be installed in accordance with Australian Standard *AS 4825:2011 Tunnel Fire Safety*, applicable Austroads and Transport for NSW guidelines, and the outcomes of consultation with emergency services.

In the event of an incident, approaching traffic would be prevented from entering the mainline and ramp tunnels. Vehicle occupants upstream of the fire or incident would be instructed to stop their vehicles, and exit in the opposite direction through the section of carriageway that would be protected by the smoke management system, or through an exit door to a pressurised and fire rated cross-passage leading to the other non-incident tunnel.

Occupants downstream of the fire or incident would be encouraged to continue driving out of the tunnel. If this is not possible and they are forced to evacuate on foot, egress would be provided via exit doors to pressurised and fire rated cross-passages leading to the non-incident tunnel. Emergency services would be able to reach the fire or incident via the non-incident tunnel, or from the upstream direction in the affected tunnel. Emergency vehicle cross passages have also been included in the design at key locations.

During emergency conditions the ventilation system would extract smoke from the affected tunnels. Depending on the location of the incident, smoke would be emitted from one or more of the ventilation outlets and from the ramp tunnel portals at the ramp tunnel surface connections.

23.3.4 Interactions between maritime traffic and tunnel infrastructure

The crossing of Middle Harbour would comprise two immersed tube tunnels between Northbridge and Seaforth. The immersed tube tunnels would be located within a tunnel trench on the bed of Middle Harbour. The immersed tube units would be placed to provide sufficient clearance for all maritime traffic in Middle Harbour.

With respect to maritime traffic, the immersed tube tunnel units would be appropriately designed including with an additional layer of concrete to protect against:

- Falling and dragging anchors
- Sinking vessels
- High currents
- Propeller wash and vessel wake.

As such, it is not expected that there would be any risk to the tunnels during operation of the project as a result of maritime traffic.

23.3.5 Bushfires

Most of the project's operational facilities would not be vulnerable to bushfire attack due to its incombustible nature (road surface materials, retaining walls, road barriers), fire safety ratings and/or location underground.

However, some operational facilities would be located on or close to bushfire prone land. These facilities and their associated bushfire risk are listed in Table 23-7.

Table 23-7 Bushfire risk level for operational sites

Operational facilities	Bushfire risk level	Proximity to bushfire prone land
Ventilation outlet and motorway facilities at Warringah Freeway	Low	The ventilation outlet and motorway facilities would not be located within 140 metres of bushfire prone land.
Motorway control centre at the Gore Hill Freeway at Artarmon	Low	The motorway control centre would not be located within 140 metres of bushfire prone land.
Ventilation outlet and motorway facilities at the Gore Hill Freeway	Low	The ventilation outlet and motorway facilities would not be within 140 metres of bushfire prone land (separated by the Gore Hill Freeway).
Tunnel support facilities at the Gore Hill Freeway	Low	The tunnel support facilities would not be located within 140 metres of bushfire prone land.
Ventilation outlet and motorway facilities at the Burnt Bridge Creek Deviation	Low	The ventilation outlet and motorway facilities would not be located within 140 metres of bushfire prone land.
Ventilation outlet and motorway facilities at the Wakehurst Parkway	Medium	The ventilation outlet and motorway facilities would be located in an area classified as bushfire prone land.
Tunnel support facilities at the Wakehurst Parkway	High	The tunnel support facilities would be located in an area classified as bushfire prone land.

Operational facilities along the Wakehurst Parkway were assessed as having a medium or high bushfire risk level. The difference in bushfire risk ratings is largely as a result of greater consequences should there be the occurrence of bushfires. Bushfire risks associated with operational infrastructure along the Wakehurst Parkway would be minimised through continued application of bushfire management practises on the adjoining National Parks land, in accordance with the *Garigal National Park Fire Management Strategy* (DEC, 2006b) administered by the National Parks and Wildlife Service, Crown Land in accordance with the *Manly Warringah War Memorial Park Fire Regime Management Plan* (Eco Logical Australia, 2006) administered by Northern Beaches Council, and routine maintenance within the road reserve.

Strategies to reduce risk from bushfire during operation of the project are included in Section 23.4.

23.3.6 Aviation risks

The operational design of the project has considered airspace protection and associated risks and hazards. As discussed in Chapter 2 (Assessment process), under the *Airports Act 1996*, a 'controlled activity' in relation to a prescribed airspace must not be carried out or caused to be

carried out without the approval of the Secretary of the Department of Infrastructure, Transport, Regional Development and Communications or otherwise exempt under the Airspace Regulations 2007.

Regulations define the 'prescribed airspace' for Sydney Airport as the airspace above any part of either an obstacle limitation surface (OLS) or procedures for air navigation systems operations (PANS-OPS) surface for Sydney Airport.

The OLS is an invisible level that defines the limits to which objects may project into the airspace around an aerodrome so that aircraft operations may be conducted safely. The OLS defines the airspace to be protected for aircraft operating during the initial and final stages of flight, or manoeuvring near Sydney Airport. This has been established in accordance with International Civil Aviation Organisation specifications, as adopted by the Civil Aviation Safety Authority.

PANS-OPS surfaces are conceptual surfaces in space that establish the airspace that is to remain free of any potential disturbance (including physical objects and other disturbances such as emissions from ventilation outlets) so that aircraft operations may be conducted safely. Where structures may (under certain circumstances) be permitted to penetrate the OLS, they would not normally be permitted to penetrate any PANS-OPS surface.

Operational buildings and structures that form part of the project, including the ventilation outlets and motorway facilities at the Warringah Freeway, Gore Hill Freeway, Burnt Bridge Creek Deviation and Wakehurst Parkway are designed to be below the prescribed airspace heights.

The Civil Aviation Safety Authority stipulates requirements for the construction and operation of new infrastructure that has the potential to influence aviation safety. The Civil Aviation Safety Authority may determine that exhaust from a ventilation outlet is a hazardous object if the vertical velocity of the emissions exceeds 4.3 metres per second within the OLS and/or PANS-OPS surfaces.

A plume rise assessment was carried out in accordance with the *Civil Aviation Safety Authority Advisory Circular Plume Rise Assessments AC 139-5(1) November 2012* to determine whether plume rise resulting from the operation of the ventilation outlet and motorway facilities at the Warringah Freeway, Gore Hill Freeway, Burnt Bridge Creek Deviation and Wakehurst Parkway would be a controlled activity as defined in section 183 of the *Airports Act 1996*. The modelling considered an expected case, based on predicted typical operational conditions of the project, and a capacity case, based on the maximum theoretical airflow that can be discharged from each ventilation outlet. The capacity case scenario is conservative and represents the upper bound of potential plume rise extents from the ventilation outlets. It is noted that the ventilation outlets are not expected to operate at design capacity on a regular basis. In addition, the cumulative case was modelled, which considered the merged ventilation outlets at the Warringah Freeway for the Western Harbour Tunnel and Beaches Link program of works.

The plume rise assessment found that air exhausted from the majority of the ventilation outlets and motorway facilities would not exceed a vertical velocity of 4.3 metres per second, nor penetrate the OLS and PANS-OPS surfaces under the expected and capacity case scenarios. At the Warringah Freeway, under the capacity case when the ventilation outlet is considered in conjunction with the ventilation outlet for the Western Harbour Tunnel at the Warringah Freeway, the combined exhausted air from the ventilation outlets is predicted to penetrate the OLS at a vertical velocity of greater than 4.3 metres per second about 0.5 per cent of the time. There would be no penetration of the PANS-OPS surface or exceedance of the critical vertical velocity of 4.3 metres per second at the PANS-OPS surface under this scenario.

The design of the ventilation outlets and motorway facilities would be finalised during further design development and designed to satisfy requirements set by the Department of Infrastructure, Transport, Regional Development and Communications in relation to erected structures (such as ventilation outlets), equipment manoeuvring and lighting. A plume rise application would be prepared for approval under the *Airports Act 1996* for the Warringah Freeway ventilation outlet and motorway facilities where they may constitute a controlled activity.

23.4 Environmental management measures

The implementation of environmental management measures for the project would avoid, to the greatest extent possible, risks to public safety and achieve the desired performance outcomes in relation to the hazards identified in this chapter. Environmental management measures relating to hazards and risks identified in this chapter are outlined in Table 23-8. Management measures relating to other potential environmental hazards resulting from the construction or operation of the project are outlined in Chapter 8 (Construction traffic and transport) to Chapter 27 (Cumulative impacts) of this environmental impact statement.

Table 23-8 Environmental management measures – hazards and risks

Ref	Phase	Impact	Environmental management measure	Location
HR1	Construction and operation	Storage of dangerous goods and hazardous substances	Dangerous goods and hazardous materials will be stored in accordance with supplier's instructions and relevant legislation, Australian Standards, and applicable guidelines and may include bulk storage tanks, chemical storage cabinets/containers or impervious bunds.	BL/GHF
HR2	Construction	Transportation of dangerous goods and hazardous substances	Dangerous goods and hazardous substances will be transported in accordance with relevant legislation and codes, including the *Dangerous Goods (Road and Rail Transport) Act 2008*, Road and Rail Transport (Dangerous Goods) (Road) Regulation 1998 and the *Australian Code for the Transport of Dangerous Goods by Road and Rail* (National Transport Commission, 2007).	BL/GHF
HR3	Construction	Bushfire	Adequate access and egress for fire fighting vehicles and staff will be provided at the Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites. Access roads will have a minimum width of four metres to allow passage of fire fighting vehicles.	Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites.
HR4	Construction	Bushfire	Adequate setbacks from bushfire prone vegetation to allow for fire fighting vehicle access will be provided for the Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites.	Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites.

Ref	Phase	Impact	Environmental management measure	Location
HR5	Construction	Bushfire	An emergency response plan will be prepared for the construction of the project at the Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites, including a bushfire risk matrix.	Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites.
HR6	Construction	Bushfire	First response capabilities, including fire extinguishers, water carts and hoses will be assessed and provided at the Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites, where needed.	Wakehurst Parkway south (BL12), Wakehurst Parkway east (BL13) and Wakehurst Parkway north (BL14) construction support sites.
HR7	Operation	Bushfire	Adequate access and egress for fire fighting vehicles and operation vehicles will be provided at the Beaches Link tunnel support facilities at the Wakehurst Parkway at Frenchs Forest.	Beaches Link tunnel support facilities at Wakehurst Parkway at Frenchs Forest.
HR8	Operation	Bushfire	Adequate setbacks from bushfire prone vegetation will be provided for the Beaches Link tunnel support facilities at the Wakehurst Parkway at Frenchs Forest and ventilation outlet at the Wakehurst Parkway at Killarney Heights.	Beaches Link tunnel support facilities at the Wakehurst Parkway at Frenchs Forest and ventilation outlet at the Wakehurst Parkway at Killarney Heights.

Ref	Phase	Impact	Environmental management measure	Location
HR9	Operation	Fire and life safety	The fire and safety systems and measures adopted for the project will be equivalent to or exceed the fire safety measures recommended by NFPA502 (American) (National Fire Protection Association (NFPA), 2020), Permanent International Association of Road Congresses (PIARC) (European), AS4825-2011 (Standards Australia, 2011) and AS3959-2018 (Standards Australia, 2018), and Transport for NSW standards.	BL/GHF
HR10	Operation	Transportation of dangerous goods and hazardous substances	The transport of dangerous goods and hazardous substances will be prohibited through the mainline and ramp tunnels.	BL/GHF
HR11	Operation	Incident response	The response to incidents within the motorway 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.	BL/GHF
HR12	Operation	Aviation risks	The ventilation outlet and motorway facilities at the Warringah Freeway will be operated in accordance with any conditions of approval from the Secretary of Department of Infrastructure, Transport, Regional Development and Communications to manage penetration of the OLS layers.	BL

Note: BL = Beaches Link, GHF = Gore Hill Freeway Connection