Chapter 3
Project alternatives and options

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3 Project alternatives and options

3.1 Background

The upgrade of the Great Western Highway between Blackheath and Little Hartley (the project) has undergone many years of investigation. This has included consideration of various strategic alternatives and route options as part of the upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program).

An initial phase of work started in 2008 and included an NSW Government announcement of an upgrade from Mount Victoria to Lithgow. Four corridors were initially identified (the strategic alternatives described in Section 3.3). The Great Western Highway and Bells Line of Road were identified as the preferred strategic alternatives due to the presence of existing motorway infrastructure.

Investigations were then carried out for the Upgrade Program in 2019. This work included a review of the initial 2008 phase of work and a review of previous and new strategic options. The outcomes of these 2019 investigations are discussed in Section 3.3. Following the selection of the Great Western Highway Upgrade Program as the preferred strategic alternative, four separate projects were identified including:

- the Great Western Highway East – Katoomba to Blackheath Upgrade (Katoomba to Blackheath Upgrade)
- the Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade)
- the Great Western Highway Blackheath to Little Hartley (the project)
- the Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade).

A discussion of how these four projects were identified is provided in Section 3.4.

Further design development for the project continued from 2021 and included investigations into two different tunnel options, the Blackheath and Mount Victoria tunnel bypasses and the Blackheath to Little Hartley tunnel, described further in Sections 3.5.3 and 3.5.4.

Upon identification of the Blackheath to Little Hartley tunnel as the preferred option, further investigations have focussed on construction methods and other design refinements to avoid and minimise potential environmental impacts, as described in Section 3.7.

3.2 Approach

The project alternatives and option development process is shown in Figure 3-1. Strategic alternatives and project options were assessed against the project objectives, which are consistent with the Upgrade Program objectives and detailed in Chapter 2 (Strategic context and project need). Strategic alternatives and project options have also been informed by the outcomes of community and stakeholder engagement, as detailed in Chapter 7 (Community and stakeholder engagement).

Options relating to specific project elements are outlined in Section 3.6 and include tunnel construction methodologies and spoil transport options as well as design elements including options for the proposed ventilation system design.

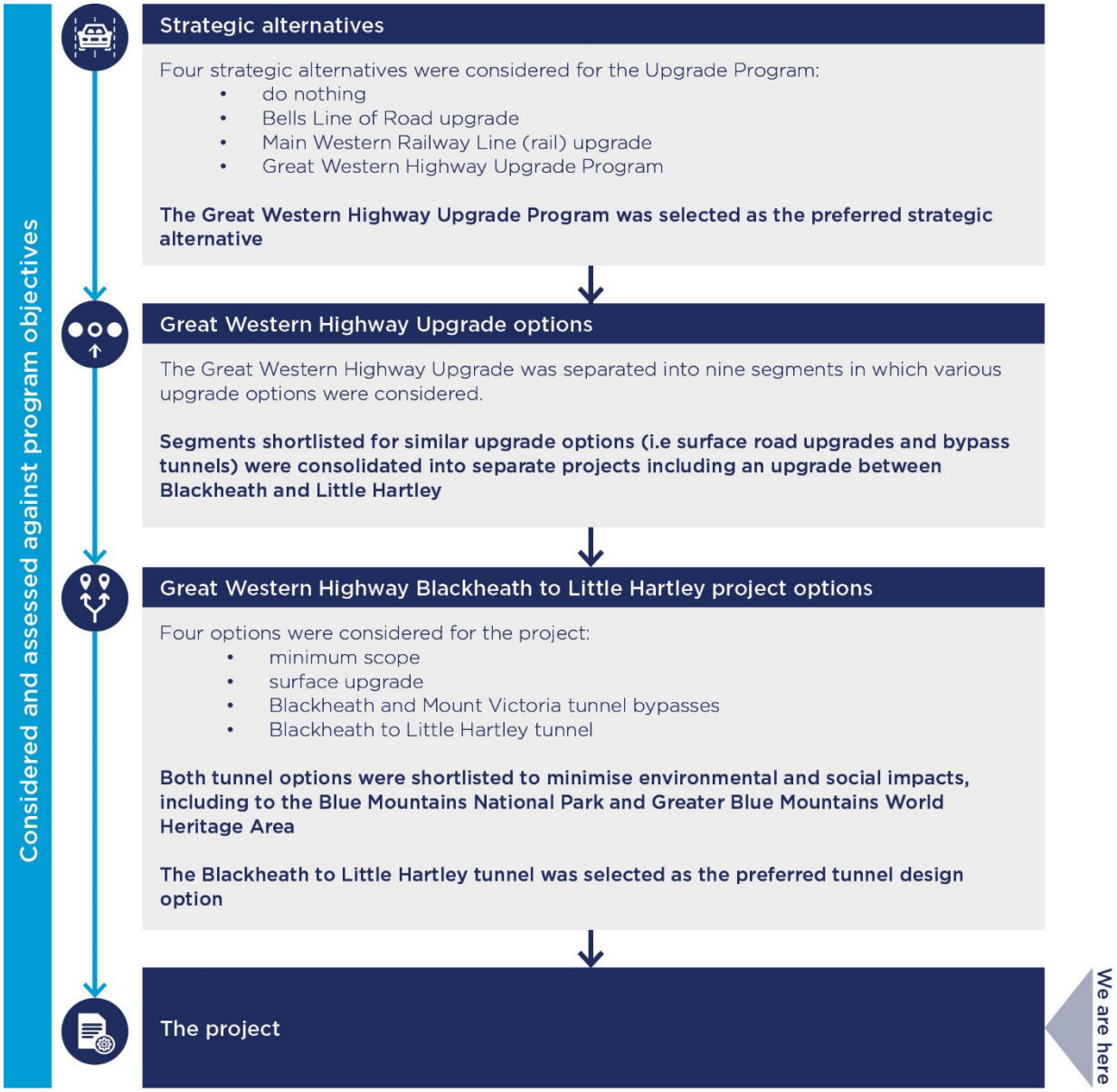


Figure 3-1 Approach to project alternatives and options development

3.3 Strategic alternatives considered

Given the strategic context outlined in Chapter 2 (Strategic context and project need), four strategic alternatives were considered to address the project need and meet the project objectives. These options included:

- do nothing
- Bells Line of Road upgrade
- Main Western Railway Line (rail) upgrade
- Great Western Highway Upgrade Program.

The strategic alternatives were assessed against the project objectives using a traffic light rating system to demonstrate strong alignment (green), some or neutral alignment (yellow) or limited or no alignment (red), as shown in Figure 3-2. A discussion of each of the strategic alternatives considered, and their performance against the project objectives, is provided in the following sections.

Figure 3-2 Assessment of strategic alternatives against the objectives

3.3.1 Do nothing

The do nothing alternative would rely on the continued operation of existing transport networks and other transport projects to meet current and future transport needs. A summary of how the do nothing strategic alternative performed against the project objectives is provided in Table 3-1.

Ultimately the do nothing strategic alternative would not address the project need and is not consistent with the objectives described in Chapter 2 (Strategic context and project need). As such this strategic alternative was not progressed.

Table 3-1 Performance of the do nothing strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would not address limited overtaking opportunities, steep grades and lengthy travel times on the Great Western Highway that currently affect freight movements. Left unaddressed, this would constrain access between Sydney and proposed future freight infrastructure (and associated land use change) in the Central West, including the Parkes National Logistics Hub and the Inland Rail Program • under the do nothing alternative, freight efficiency would further deteriorate to unacceptable levels.	
Resilience	• given the single lane two-way traffic arrangements in many sections of the existing Great Western Highway, the do nothing alternative would not change the current vulnerability of the highway to closure from climate events and traffic incidents.	

Objective	Strategic alternative performance against the project objectives	Rating
Transport network performance	• forecast traffic modelling described in Chapter 8 (Traffic and transport) indicates that under the do nothing alternative, the Great Western Highway would be unable to accommodate efficient road travel through the Blue Mountains in the future, resulting in considerable delays • would not address freight efficiency given provision of a B-double (a truck and two trailers) capable road is currently not provided or would not be provided.	
Safety	• would not address current road safety issues such as steep gradients which exceed safety standards at Victoria Pass (between Mount Victoria and the base of the Blue Mountains escarpment in the west), tight curves around mountains and non-compliant clear zones (a roadside area free of objects where an out-of-control vehicle can traverse safely) • would not address the current incident rate between Katoomba to Lithgow where an incident occurs every four days that forces a road closure for up to 80 minutes (Transport for NSW, 2021d) • would not address current safety issues for active transport users, given there would be no separation of through (freight) traffic from local traffic using the local road network and the Great Western Highway.	
Environment	• no environmental impacts due to construction or land use disturbance • would result in continued increased traffic congestion, idling and concentration of vehicle emissions creating localised noise and air pollution.	
Value for money	• would avoid construction costs however would not provide a value for money outcome because no additional transport capacity or improved freight accessibility would be provided between Sydney and the Central West and Orana regions • would not address the need for the project described in Chapter 2 (Strategic context and project need).	

3.3.2 Bells Line of Road upgrade

In 2000 and 2004, the Australian and NSW governments investigated the feasibility of upgrading the Bells Line of Road corridor which runs between Windsor in northwest Sydney and Bell in the Blue Mountains. The upgrade included widening the existing two lane road corridor to a four lane B-double capable road. This information was reviewed in light of the project need and a summary of how this strategic alternative performed against the project objectives is provided in Table 3-2.

Ultimately the Bells Line of Road strategic alternative was not progressed due to significant costs, engineering challenges, direct impacts to the Greater Blue Mountains World Heritage Area, impacts to land use through Sydney's north-western suburbs, and substantially greater travel distance and likely greater travel times between regional centres (Sydney and the Central West region).

Table 3-2 Performance of the Bells Line of Road strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would not upgrade a key freight and road corridor, given Bells Line of Road is not designated as a Road of National Importance (as part of the Auslink National Network) • would provide a less direct connection to freight hubs between Sydney and the Central West and Orana regions.	
Resilience	• would partially improve resilience of the road network across the Blue Mountains given additional lanes would enable increased capacity and safety opportunities, allowing essential services better access to the area via Bells Line of Road during vehicle incidents or extreme weather events • would not provide an alternative route or separated carriageway in addition to existing road networks across the Blue Mountains.	
Transport network performance	• Bells Line of Road near Bell carries about 3,000 vehicles per day compared to 11,000 vehicles near Mount Victoria along the Great Western Highway (Transport for NSW, 2022a), which indicates that an upgrade of Bells Line of Road would not improve network performance and efficiency for as many road users as an upgrade to the Great Western Highway • would improve transport network performance across the Blue Mountains, however, would also result in a greater travel time between Sydney and the Central West region when compared to an upgrade to the Great Western Highway.	
Safety	• would partially address safety of the Bells Line of Road corridor but would not provide safety improvements on the Great Western Highway, which is the more frequently used corridor for freight and other road users across the Blue Mountains.	
Environment	• would have impacts to the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area given their proximity to Bells Line of Road between Kurrajong in Sydney's northwest to around the town of Dargan • would not improve local amenity of the Blue Mountains townships located off the Great Western Highway.	
Value for money	• would require substantial costs due to the steep terrain and extent of work required to the existing Bells Line of Road, which is currently susceptible to extreme weather events (Transport for NSW, 2021d) • would require further costs for property acquisition and local road and bridge upgrades in Sydney (such as over the Hawkesbury River and at Richmond Road) required to provide an adequate connection to Bells Line of Road.	

3.3.3 Main Western Railway Line (rail) upgrade

An upgrade and strengthening of the resilience of the existing Main Western Railway Line, a railway route which runs between Sydney Central in the east via the Blue Mountains and Lithgow to Dubbo in the west, was considered as a strategic alternative to meet the project objectives. The existing passenger railway line terminates at Lithgow (where passengers must change travel

modes), whereas the freight line extends to Orange, Wellington, Dubbo and Nyngan. A summary of how this strategic alternative performed against the project objectives is provided in Table 3-3.

Ultimately this strategic alternative was not progressed given it would require substantial property acquisition and a significant construction timeframe.

The Australian Government has committed $8 million to fund investigations into faster rail options from Sydney to Parkes (via Bathurst and Orange) in partnership with the NSW Government (Department of Infrastructure, Transport, Regional Development and Communities, 2021). Potential future provision of railway improvements across the Blue Mountains would likely be captured by this initiative.

Table 3-3 Performance of the Main Western Railway Line (rail) upgrade strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would require substantial additional infrastructure to separate freight and passenger services to meet this objective • without significant investment to allow for sufficient separation of freight and passenger services, freight accessibility would be constrained to a predominantly single track arrangement unable to provide capacity for increased freight services through the area and thereby limiting economic development and productivity through the regions • would not fully address freight accessibility improvements, given the majority of freight movements are via the road corridor.	
Resilience	• would partially improve the resilience of the corridor through upgrades including electrical signalling and communication infrastructure, substations, power poles and components of safe working systems, however the railway line would still be vulnerable to closure (such as from bushfires and landslides) • would not address the resilience of the road corridor which is used by the majority of transport users and essential services.	
Transport network performance	• would not address current and future congestion for the majority of travellers. Light vehicle movements are the primary mode of transport across the Blue Mountains (Transport for NSW, 2021d) • would not be efficient given the semi-rural nature of the Blue Mountains. Local residents using a rail service would still likely require another form of transport for part of their journey, which would likely be a private vehicle on the local road network • would help facilitate a shift from road freight to rail freight thereby reducing the number of heavy vehicle movements on the Great Western Highway.	
Safety	• would not provide improved road safety outcomes, with road vehicles comprising the primary mode of transport in the region.	
Environment	• would promote the use of public transport • would not address the existing amenity impacts for towns located adjacent to the existing Great Western Highway associated with trucks and traffic using the highway.	

Objective	Strategic alternative performance against the project objectives	Rating
Value for money	• while promoting public transport as a sustainable travel mode, this strategic alternative would likely have substantial costs, as a result of construction on steep gradients with tight track curvature (Roads and Traffic Authority, 2008) • would require substantial acquisition of residential and commercial land to extend the railway.	

3.3.4 Great Western Highway Upgrade Program

The Great Western Highway Upgrade Program strategic alternative included upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway. At the strategic alternative level, there was no definition around whether the Upgrade Program would comprise a surface upgrade or a tunnel (refer to Section 3.4 for this discussion). A summary of how the strategic alternative performed against the project objectives is provided in Table 3-4.

Table 3-4 Performance of the Great Western Highway Upgrade Program strategic alternative against the project objectives

Objective	Strategic alternative performance against the project objectives	Rating
Economic development	• would upgrade a key freight and road corridor, given the road is designated as a Road of National Importance (as part of the Auslink National Network) • would provide additional transport capacity across the Blue Mountains and would enhance connection between the regions • would improve freight accessibility by providing access for B-doubles and Performance Based Standards (PBS) level 2 vehicles up to 26 metres long where four lanes are provided along the Great Western Highway • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d) • would provide additional transport capacity and improve freight accessibility between Sydney and the Central West and Orana regions. This would result in cost savings associated with freight transportation efficiency and would encourage goods production and agricultural trade between the regions.	
Resilience	• would improve resilience given additional lanes would enable increased capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events.	
Transport network performance	• the Great Western Highway near Mount Victoria carries about 11,000 vehicles per day with forecast growth rates of up to around two per cent expected annually, as compared to Bells Line of Road near Bell which carries about 3,000 vehicles per day (Transport for NSW, 2022a), indicating that the strategic alternative would accommodate a higher number of road transport users than the Bells Line of Road strategic alternative • would provide additional transport capacity which would reduce current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d)	

Objective	Strategic alternative performance against the project objectives	Rating
	• would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction such as through Victoria Pass • would provide the shortest, quickest and preferred route for the majority of motorists across the Blue Mountains which would benefit road users.	
Safety	• would improve safety of the corridor for road transport users, including active transport users, by providing additional traffic lanes, overtaking opportunities, and potential separation of through traffic from local traffic • would alleviate congestion on the Great Western Highway and adjacent local roads by providing additional traffic lanes which may also improve safety • would address existing steep gradients, tight curves around mountains and clear zones (a roadside area free of objects where an out-of-control vehicle can traverse safely) that do not meet current safety standards.	
Environment	• would avoid and/ or minimise impacts to the Blue Mountains National Park and Greater Blue Mountains World Heritage Area • would improve local amenity in the Blue Mountains townships located off the Great Western Highway by easing congestion.	
Value for money	• would provide value for money considering costs and benefits.	

3.3.5 Preferred strategic alternative

The Great Western Highway Upgrade Program strategic alternative best addresses the identified project need and best meets the project objectives. On this basis this strategic alternative was taken forward for further development.

3.4 Great Western Highway Upgrade projects

Following the selection of the Great Western Highway Upgrade Program as the preferred strategic alternative, the corridor between Katoomba to Lithgow was divided into nine segments in which various upgrade options were examined (as outlined in Table 3-5).

These nine segments were identified based on the characteristics of the road (e.g., separating areas comprising townships such as Blackheath and Medlow Bath from open road areas) and are shown in Figure 3-3. As part of the strategic business case for the Great Western Highway Upgrade Program, a viability assessment was carried out for these options. The shortlisted options identified for the nine segments through this viability assessment are summarised in Table 3-5.

Segments shortlisted for similar upgrade options (i.e., surface road upgrades and bypass tunnels) were consolidated into four separate projects including:

- Katoomba to Blackheath Upgrade
- Medlow Bath Upgrade (separated from the Katoomba to Blackheath Upgrade as this was identified as a priority section to progress to construction based on the viability assessment)
- the project
- Little Hartley to Lithgow Upgrade.

Table 3-5 Options considered for the Great Western Highway Upgrade

Section of Great Western Highway	Total number of options considered	Upgrade options considered by type				Shortlisted options
		Surface road upgrade	Road bypass	Tunnel bypass	Rail upgrade	
Katoomba to Medlow Bath	2	2	-	-	-	• surface road upgrade
Medlow Bath	1	1	-	-	-	• surface road upgrade
Medlow Bath to Blackheath	1	1	-	-	-	• surface road upgrade
Blackheath	17	5	4	6	2	• removal of level crossing and provision of rail underpass at Shipley Street • tunnel bypass
Blackheath to Mount Victoria	2	1	-	1	-	• surface road upgrade and tunnel bypass
Mount Victoria to Little Hartley	3	-	-	3	-	• bypass including five bridges and two tunnels
Little Hartley to River Lett	1	-	1	-	-	• surface road bypass
River Lett to Forty Bends	1	-	1	-	-	• surface road bypass
Forty Bends to Lithgow	1	1	-	-	-	• surface road upgrade

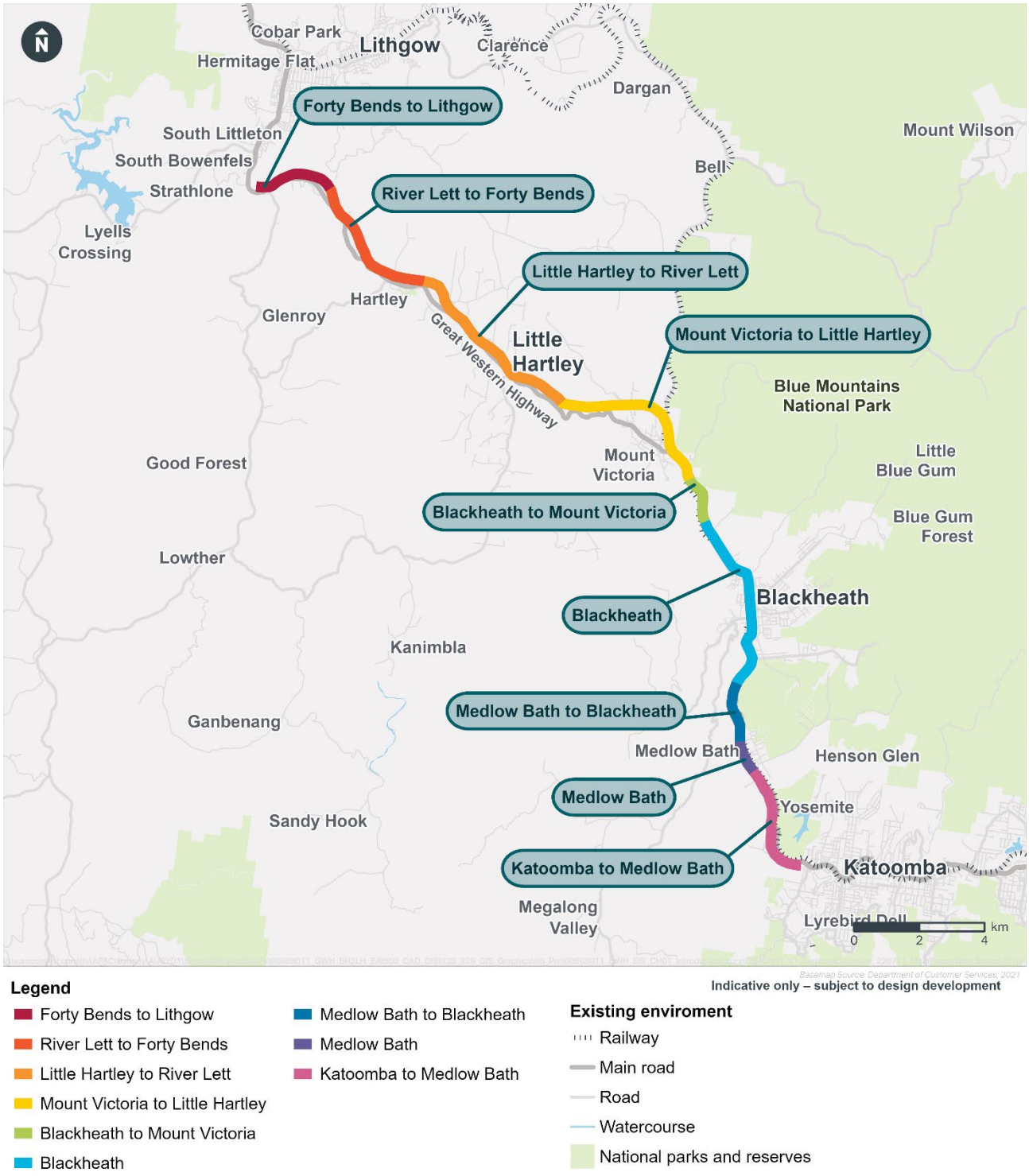


Figure 3-3 Sections considered for the Great Western Highway Upgrade

3.5 Project options considered

Four options were considered to support the preferred strategic alternative to upgrade the Great Western Highway between Blackheath and Little Hartley (the project) including:

- minimum scope (targeted minor road upgrades and intersection work)
- surface road upgrade (surface upgrade and bypass of Mount Victoria to provide two lanes in each direction)

- two tunnels (tunnel bypasses of Blackheath and Mount Victoria and a surface road upgrade between Blackheath and Mount Victoria)
- single tunnel (tunnel from Blackheath to Little Hartley).

The project options were assessed against the project objectives using the same traffic light rating system applied to strategic alternatives (refer to Section 3.3) to demonstrate strong alignment (green), some or neutral alignment (yellow) or limited or no alignment (red), as shown in Figure 3-4. A discussion of each of the project options considered, and their performance against the project objectives, is provided in the following sections.

Project options	Objectives					
	Economic development	Resilience	Transport network performance	Safety	Environment	Value for money
Minimum scope	🔴	🔴	🟡	🟡	🟡	🟡
Surface road upgrade	🟡	🟡	🟡	🟡	🟡	🟡
Blackheath and Mount Victoria tunnel bypasses	🟢	🟡	🟢	🟢	🟡	🟡
Blackheath to Little Hartley tunnel	🟢	🟢	🟢	🟢	🟢	🟢

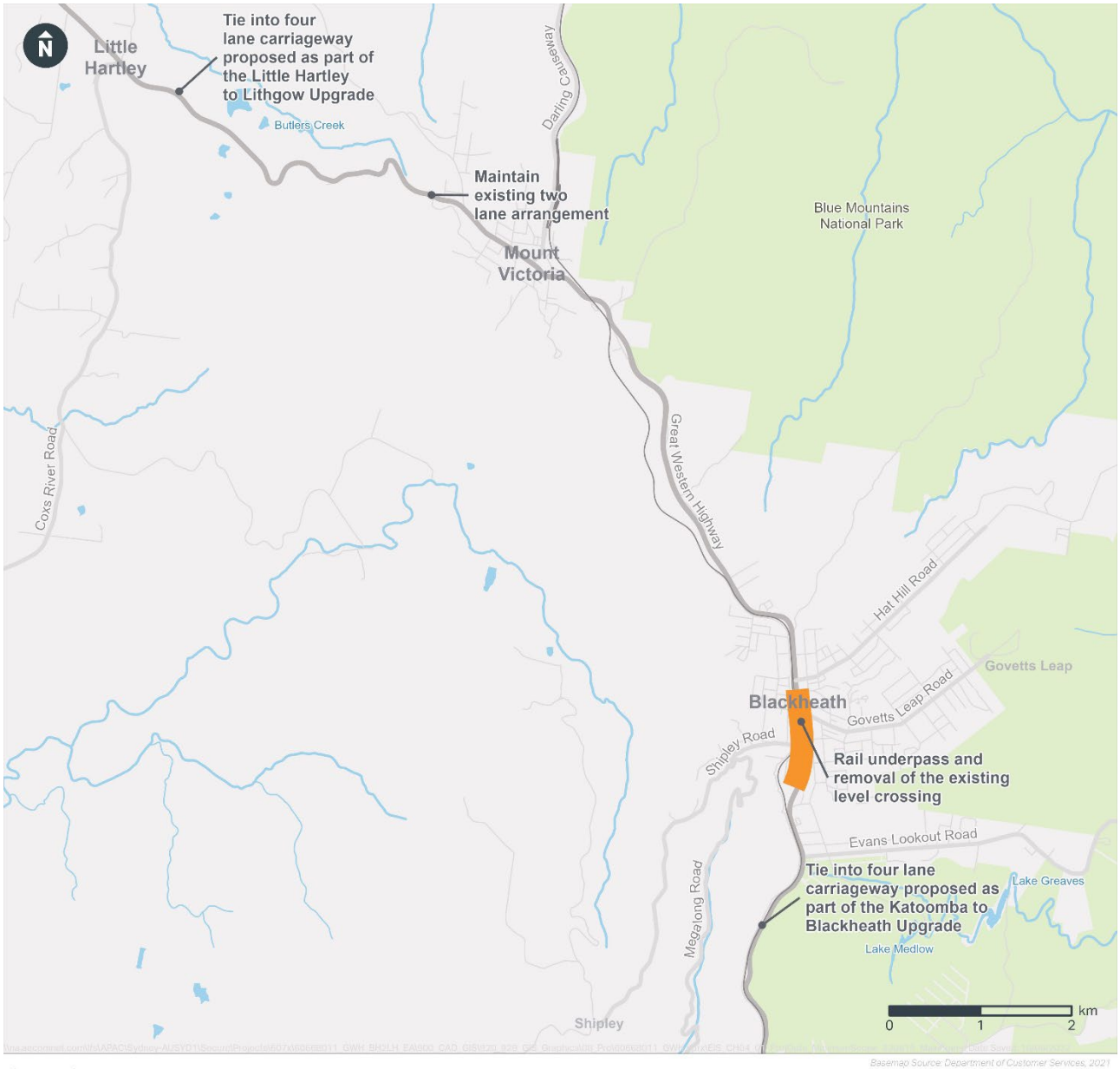
Figure 3-4 Assessment of project options against the objectives

3.5.1 Minimum scope

The minimum scope option would include targeted minor upgrades between Blackheath and Little Hartley. These targeted minor upgrades would integrate with the upgraded sections of the Great Western Highway between Katoomba and Blackheath and Little Hartley and Lithgow, which would be upgraded to a four lane surface carriageway.

Between Blackheath and Little Hartley this option would include a rail underpass and removal of the existing level crossing at Bundarra Street in Blackheath village to reduce substantial queuing that currently occurs at the intersection of Govetts Leap Road and the Great Western Highway. The minimum scope option is shown in Figure 3-5.

As summarised in Table 3-6, this option would not address the identified project need and is largely not consistent with the project objectives described in Chapter 2 (Strategic context and project need). As such this option was not progressed.



Legend

Existing environment

- Railway
- Main road
- Road
- Watercourse
- National Parks and Reserves

Figure 3-5 Minimum scope option overview

Table 3-6 Performance of the minimum scope option (between Blackheath and Little Hartley) against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would not increase freight accessibility on the existing road network between Blackheath and Little Hartley, given that no additional traffic lanes would be provided.	
Resilience	• would not improve resilience given no additional lanes, alternative route or separated carriageways between Blackheath and Little Hartley would be provided to enable overtaking opportunities, increased capacity, or safety opportunities, including in the event of an incident.	
Transport network performance	• would not provide additional traffic lanes between Blackheath and Little Hartley and therefore would not increase road capacity • would improve congestion in a specific location as the rail underpass would help to alleviate significant queuing across the Great Western Highway at Govetts Leap Road • would likely result in a worsening of transport network performance, as the four lane arrangements east of Blackheath and west of Little Hartley would reduce to a two lane arrangement between Blackheath and Little Hartley.	
Safety	• would not improve (and potentially worsen into the future) the safety of the corridor due to congestion and merging traffic east of Blackheath and west of Little Hartley • would not improve the steep grades traversed by the existing Great Western Highway at Mount Victoria • would improve safety in a specific location by alleviating significant queuing across the Great Western Highway at Govetts Leap Road.	
Environment	• would limit the need for property acquisition and native vegetation removal • would only slightly improve liveability for locals by reducing the substantial queuing that currently occurs at the intersection of Govetts Leap Road and the Great Western Highway and providing a walkway for pedestrians to access the railway • would not improve (and potentially worsen) amenity between Blackheath and Little Hartley given there may be increased traffic noise and vehicle emissions from additional vehicles using and merging with the upgraded Great Western Highway east and west of this section • would be inconsistent with stakeholder feedback received indicating a preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	
Value for money	• would minimise construction costs and materials required, however would not provide value for money with no additional transport capacity or improved freight accessibility provided between Sydney and the Central West and Orana regions.	

3.5.2 Surface road upgrade

This option would include at-surface widening of the existing Great Western Highway or infrastructure upgrades to provide two lanes in each direction and would include:

- surface road widening from two to four lanes between Blackheath and Mount Victoria
- a bypass of Mount Victoria village and Victoria Pass via five bridges and twin tunnels (which would be up to around 1.4 kilometres long with two lanes in each direction)
- a rail underpass and removal of the existing level crossing at Bundarra Street in Blackheath village to reduce significant queuing that currently occurs at the intersection of Govetts Leap Road and the Great Western Highway
- a bypass of Mount Victoria township to Darling Causeway via northbound off-ramps and southbound on-ramps.

The surface road upgrade option is shown in Figure 3-6. This option would partially address the identified project need and project objectives described in Chapter 2 (Strategic context and project need). Following consideration of the factors summarised in Table 3-7 this option was not progressed.

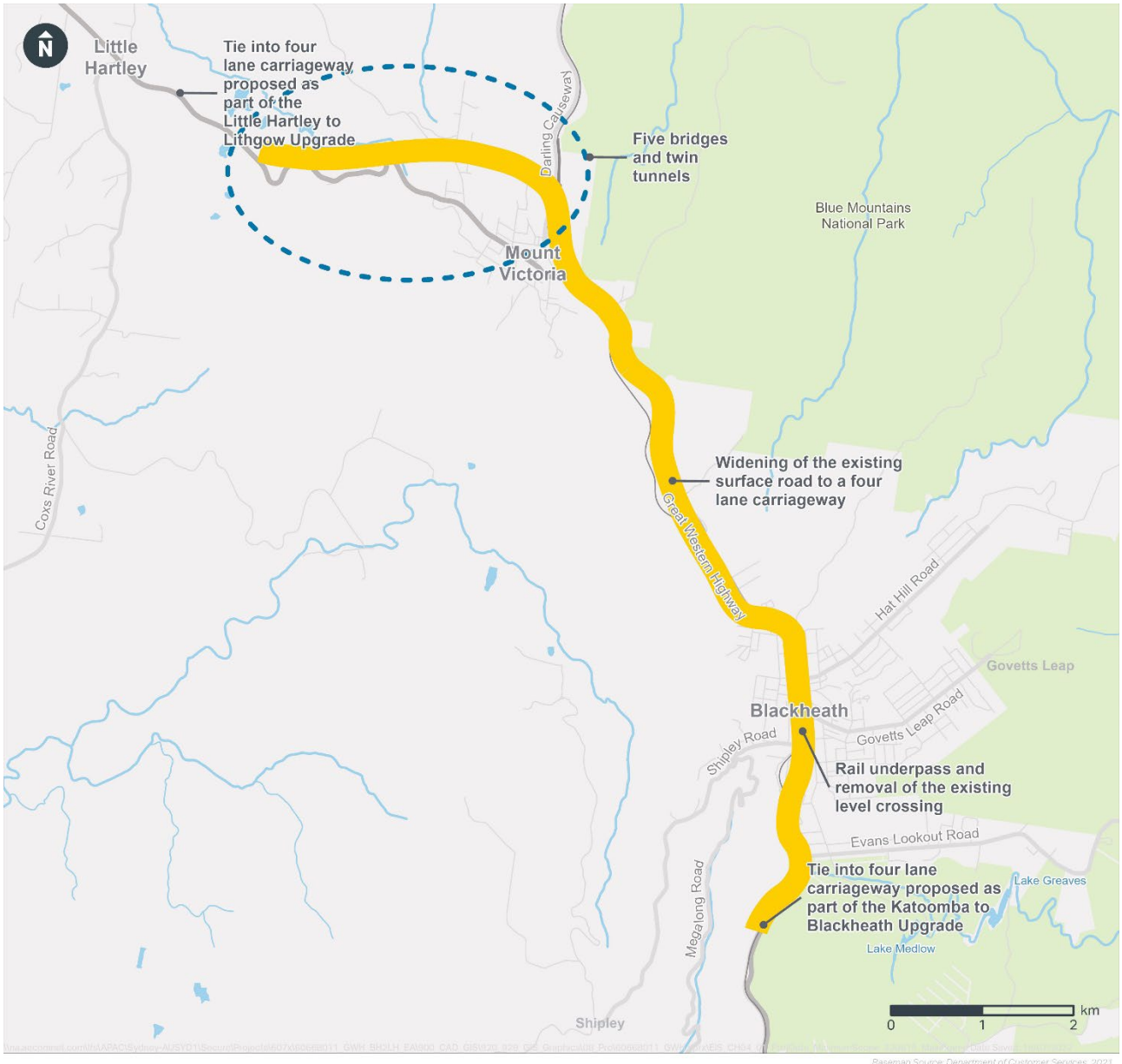


Figure 3-6 Surface road upgrade option overview

Table 3-7 Performance of the surface road upgrade option (between Blackheath and Little Hartley) against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would provide additional transport capacity across the Blue Mountains and would enhance connection between the regions • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d) • would not provide a separated carriageway for through (freight) traffic, which would continue to share the Great Western Highway with local traffic.	
Resilience	• would enable increased capacity and safety opportunities given the road corridor would have an additional two lanes in each direction, allowing essential services better access to the area during vehicle incidents or extreme weather events • would not provide an alternative route in the event of road closure along the Great Western Highway.	
Transport network performance	• additional transport capacity would alleviate current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d) • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction such as through Victoria Pass • shared use of the Great Western Highway road network would not address current speed differences between through (freight) traffic and local traffic.	
Safety	• would improve safety of the corridor for road transport users by providing additional traffic lanes, overtaking opportunities, and opportunities to separate private and commercial vehicles through measures such as heavy vehicle lane restrictions • would alleviate congestion on the Great Western Highway and adjacent local roads through additional traffic lanes which would likely result in less idling time • would address existing steep gradients and clear zones (a roadside area free of objects where an out-of-control vehicle can traverse safely) that do not meet current safety standards through the provision of additional road space, bridges and tunnels • would not address all tight curves around mountains, given the surface road upgrade would utilise the existing Great Western Highway alignment in most areas.	

Objective	Project option performance against the project objectives	Rating
Environment	• would require more property acquisition when compared to a tunnel option • while utilising an existing road corridor, this option would require native vegetation removal where widening of the existing Great Western Highway would occur (which would encroach on the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area) • would have comparatively greater environmental impacts from Mount Victoria to Little Hartley where large construction footprints would be required to construct the five bridges and twin tunnels • would involve increased traffic noise and vehicle emissions given the predominantly at-surface nature of the option • would be inconsistent with stakeholder feedback received indicating a preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	
Value for money	• would result in cost savings associated with freight transportation efficiency, reduced congestion and would encourage goods production and agricultural trade between Sydney and the regions • would not be value for money given comparatively greater environmental and amenity impacts.	

3.5.3 Blackheath and Mount Victoria tunnel bypasses

This option would include tunnel infrastructure and surface road upgrades between Blackheath and Little Hartley. It would include two separate tunnel bypasses (one of Blackheath and one of Mount Victoria) and surface road upgrades between these two locations. The two tunnels would be twin tunnels with two lanes in each direction. This option would include:

- twin tunnels underneath Blackheath from around Evans Lookout Road to around the existing Mount Boyce heavy vehicle safety station around 4.3 kilometres long (the Blackheath tunnel)
- twin tunnels from east of Mount Victoria to Little Hartley around 4.3 kilometres long (the Mount Victoria tunnel)
- surface road upgrades to provide four lanes along the existing Great Western Highway between the Blackheath tunnel and the Mount Victoria tunnel.

The Blackheath and Mount Victoria tunnel bypasses option is shown in Figure 3-7. A summary of how this option performs against the project objectives is provided in Table 3-8.

This option would address the project need and partially meet the project objectives and was therefore progressed for further consideration.

Ultimately this option was not selected as the preferred option for the project based on its performance compared with the Blackheath to Little Hartley tunnel option.

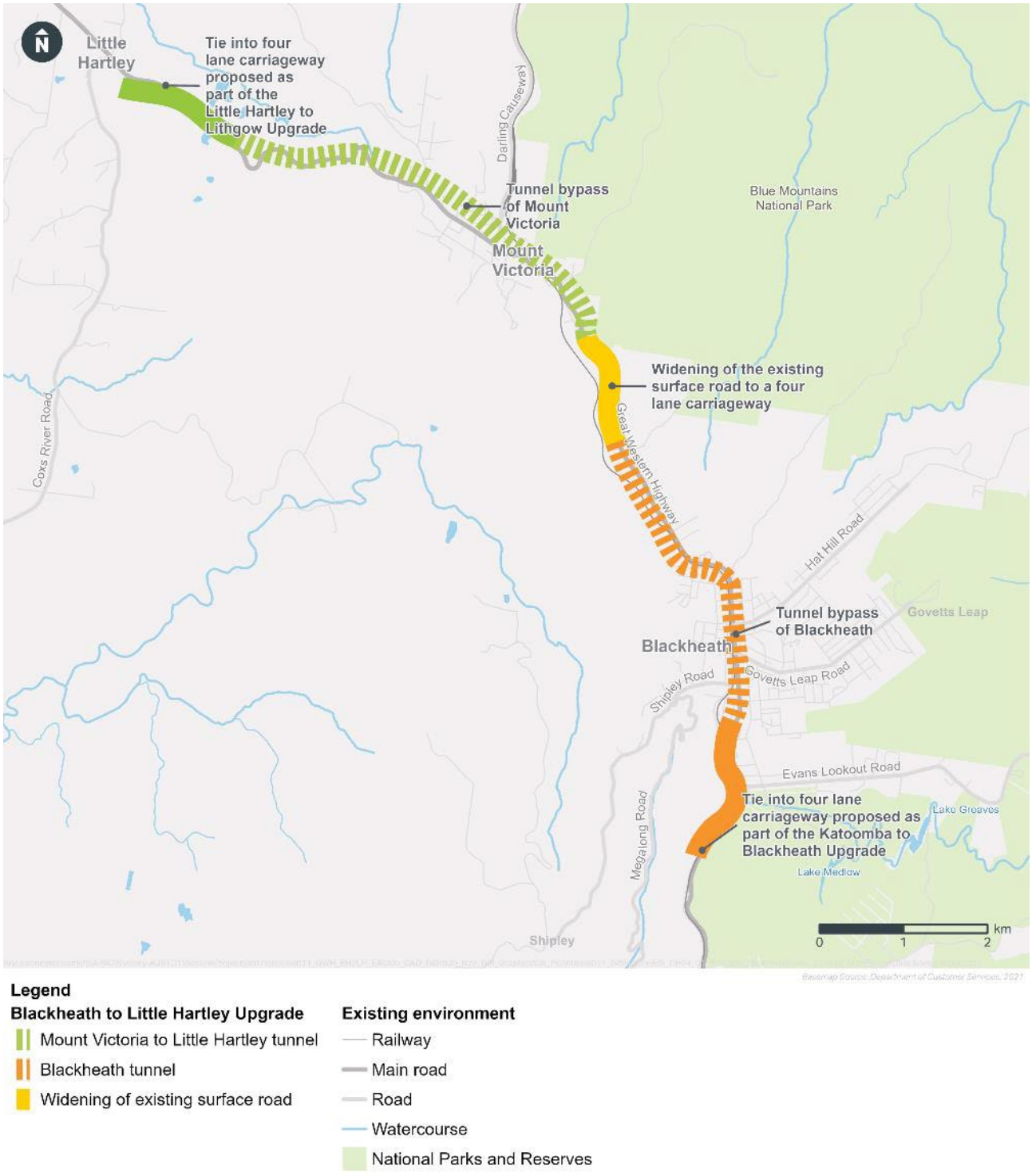


Figure 3-7 Blackheath and Mount Victoria tunnel bypasses option overview

Table 3-8 Performance of the Blackheath and Mount Victoria tunnel bypasses option against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would provide additional freight transport accessibility across the Blue Mountains and would enhance connection between the regions • would improve freight accessibility by providing access for B-doubles and PBS level 2 vehicles up to 36 metres long • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d).	
Resilience	• would partially improve resilience through additional lanes which would enable increased capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events • would partially provide an alternative route, for those parts of the project in tunnels, in the event of road closure along the Great Western Highway. Merging with local traffic would continue to occur between the Blackheath and Mount Victoria tunnel portals.	
Transport network performance	• would provide additional transport capacity by alleviating current traffic queues for both private and commercial vehicles on the Great Western Highway, which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d) • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction, such as through Victoria Pass • would positively affect the local surface road network performance at Blackheath and Little Hartley, given through traffic would likely utilise the tunnel infrastructure. While the connection to Darling Causeway at Mount Victoria would cause some traffic impacts on the local surface road network, this option would perform better than the Blackheath to Little Hartley tunnel option with regards to connectivity and accessibility (creating a greater number of connections to local destinations).	
Safety	• would improve the safety of the corridor for road transport users by providing additional traffic lanes, contributing to a reduction in congestion • would separate through (freight) traffic travelling at higher speeds, more likely to use the tunnel, from local traffic likely to use the existing Great Western Highway, apart from at Mount Victoria where the surface road would combine local and through traffic to provide a connection to Darling Causeway • would improve the safety of the road corridor at Victoria Pass with the tunnel bypassing steep grades and tight curves on the current highway alignment • would have a slightly steeper in-tunnel gradient, which would result in greater speed differences between the in-tunnel and the surface road network than the Blackheath to Little Hartley tunnel option.	

Objective	Project option performance against the project objectives	Rating
Environment	• would require some property acquisition along the existing Great Western Highway, particularly around the four tunnel portal locations (Blackheath, Mount Victoria and Little Hartley) • would require comparatively greater native vegetation removal than the Blackheath to Little Hartley tunnel option to accommodate four portals (compared with two), additional construction sites and a surface road upgrade in Mount Victoria connecting the Great Western Highway to Darling Causeway. This would result in around an additional 300,000 square metres required for the surface construction footprint for this option with some of this potentially encroaching into the Blue Mountains National Park, and social and recreational facilities • would result in increased traffic noise and vehicle emissions at Mount Victoria due to the additional surface road capacity • would be generally consistent with stakeholder feedback received indicating preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	
Value for money	• would be more expensive than the minimum scope and surface road upgrade options however would provide value for money given this option would perform better on the above project objectives • would be less expensive than the Blackheath to Little Hartley option, however, would have greater construction impacts, particularly at Blackheath and Mount Victoria due to a larger surface footprint, and greater construction duration and accessibility impacts given local roads would be significantly impacted by construction staging • would provide additional transport capacity and improve freight accessibility between Sydney and the Central West and Orana regions. This would result in cost savings associated with freight transportation efficiency and encourage goods production and agricultural trade between the regions.	

3.5.4 Blackheath to Little Hartley tunnel

The Blackheath to Little Hartley tunnel option would include twin tunnels around 11 kilometres long between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends.

This option was identified as the preferred project and is described in full in Chapter 4 (Project description). A summary of how this option performs against the project objectives is provided in Table 3-9.

Table 3-9 Performance of the Blackheath to Little Hartley tunnel option against the project objectives

Objective	Project option performance against the project objectives	Rating
Economic development	• would provide additional transport capacity across the Blue Mountains and enhances the connection of the regions • would improve freight accessibility by providing access for B-doubles and PBS level 2 vehicles up to 36 metres long • would help to address the predicted 30 per cent rise in truck volumes on the Great Western Highway by 2036 (Transport for NSW, 2021d).	
Resilience	• would enable improved resilience through additional lanes which would enable increased road capacity and safety opportunities, allowing essential services better access to the area during vehicle incidents or extreme weather events • would provide an alternative route for transport and essential services between Blackheath and Little Hartley, in the event of road closure along the Great Western Highway.	
Transport network performance	• would provide additional transport capacity by reducing current traffic queues for both private and commercial vehicles on the Great Western Highway which can be up to eight kilometres in length and incur delays of up to 80 minutes in peak periods (Transport for NSW, 2021d). This option would reduce congestion due to freight movement and weekend and peak holiday traffic to a greater extent than the Blackheath and Mount Victoria tunnel bypasses option • would not provide the same level of local connectivity as the Blackheath and Mount Victoria tunnel bypasses option • would allow opportunities for overtaking, currently not available in certain areas where there is a single lane arrangement in each direction, such as through Victoria Pass • would positively impact the local surface road network performance between Blackheath and Little Hartley, given through traffic would likely utilise the tunnel infrastructure.	
Safety	• would improve safety of the corridor for road transport users by providing additional traffic lanes, reducing congestion • would separate through (freight) traffic travelling at higher speeds, more likely to use the tunnel, and local traffic likely to use the existing Great Western Highway • would improve the safety of the road corridor at Victoria Pass by bypassing steep grades and tight curves on the current highway alignment • would have improved in-tunnel gradient which would allow for a more consistent travel speed and lower speed differentials between the surface road and in-tunnel road networks as compared with the Blackheath and Mount Victoria tunnel bypasses option.	
Environment	• would require the least surface property acquisition of all options except the do minimum option, given the majority of the duplicated road network would be located underground • would require less native vegetation removal than the Blackheath and Mount Victoria tunnel bypasses, given vegetation removal	

Objective	Project option performance against the project objectives	Rating
	would be required at two portal locations and a reduced number of associated construction sites • would reduce amenity impacts for local residents and businesses, such as noise, vibration, visual impacts, given the predominantly underground nature of the option • would minimise impacts to groundwater dependent ecosystems as compared to the Blackheath and Mount Victoria tunnel bypasses option due to deeper excavation/tunnelling leading to less interaction with the perched aquifers the ecosystems rely on • would result in greater fuel efficiency for tunnel users and less greenhouse gas emissions given the lower in-tunnel gradient • would be generally consistent with stakeholder feedback received indicating preference for tunnel options, further described in Chapter 7 (Community and stakeholder engagement).	
Value for money	• would result in a slight reduction in vehicle travel times as compared to the Blackheath and Mount Victoria tunnel bypasses option due to reduced tunnel grades • would be slightly more expensive than the Blackheath and Mount Victoria tunnel bypasses option, however this would be value for money given this option would perform better on the above project objectives than all other options including a shorter construction duration, and less construction staging and associated accessibility impacts.	

3.5.5 Preferred project option

The Blackheath to Little Hartley tunnel project option would address the identified project need and would best meet the project objectives. It was therefore selected as the preferred project option.

A discussion of how the project would meet ecologically sustainable development principles is provided in Chapter 25 (Justification and conclusion).

3.6 Further project development

Following identification of the preferred project option, further design development has been carried out. This has included indicative construction staging analysis and preliminary environmental assessments for traffic, drainage, flooding and urban design. Key areas of focus included the tunnel construction and ventilation system options. These are described further in this section.

3.6.1 Construction strategy

Tunnel excavation method alternatives

Alternative mainline tunnel excavation methods were considered during the development of the project, including tunnel boring machines (TBMs) and roadheader options. Indicative descriptions of TBM and roadheader construction methods are provided in Chapter 5 (Construction).

TBMs were identified as the preferred tunnelling methodology for the mainline tunnels as they can excavate at a faster rate than roadheaders and are able to install precast structural, waterproof tunnel lining progressively as they tunnel (i.e., tanked structures which prevent groundwater from entering the structure as opposed to a drained structure which captures, diverts and treats groundwater ingress). This tunnel construction method would minimise groundwater drawdown and potential impacts to groundwater dependent ecosystems. Tanked structures are also likely to reduce long-term settlement as groundwater drawdown is virtually eliminated due to the segment

lining, although higher settlement may occur where the tunnel is shallowest near the Blackheath and Little Hartley portals. An assessment of settlement is provided in Chapter 20 (Business, land use and property). The effect of different tunnel lining in relation to groundwater ingress is shown in Figure 3-8.

To construct the mainline tunnels using roadheaders, a minimum of eight tunnel access points would be needed to support construction activities to maintain a similar construction program by comparison to TBMs. This would require multiple construction work sites at Blackheath, Soldiers Pinch and Little Hartley. Roadheader tunnelling from Blackheath in particular would add substantial numbers of heavy vehicles to local roads and the existing Great Western Highway corridor to transport spoil, shotcrete concrete and other construction materials to and from the work sites.

The option for roadheader tunnelling would have substantial, temporary impacts on the groundwater table, as the excavation would allow groundwater ingress until such time as a permanent, waterproof structural lining is constructed within the tunnel, which would take longer compared to progressive TBM lining. This drawdown could potentially affect groundwater dependent ecosystems reliant on groundwater seepage. Further discussion of potential impacts to groundwater and groundwater dependent ecosystems is provided in Chapter 13 (Groundwater and geology) and Chapter 12 (Biodiversity).

The selection of the TBM tunnel construction method would ensure that tunnel construction is sensitive to the unique environmental and cultural surroundings of the Blue Mountains. It would also provide a value for money and sustainable construction method, given the precast tunnel lining would add to the tunnel's longevity.

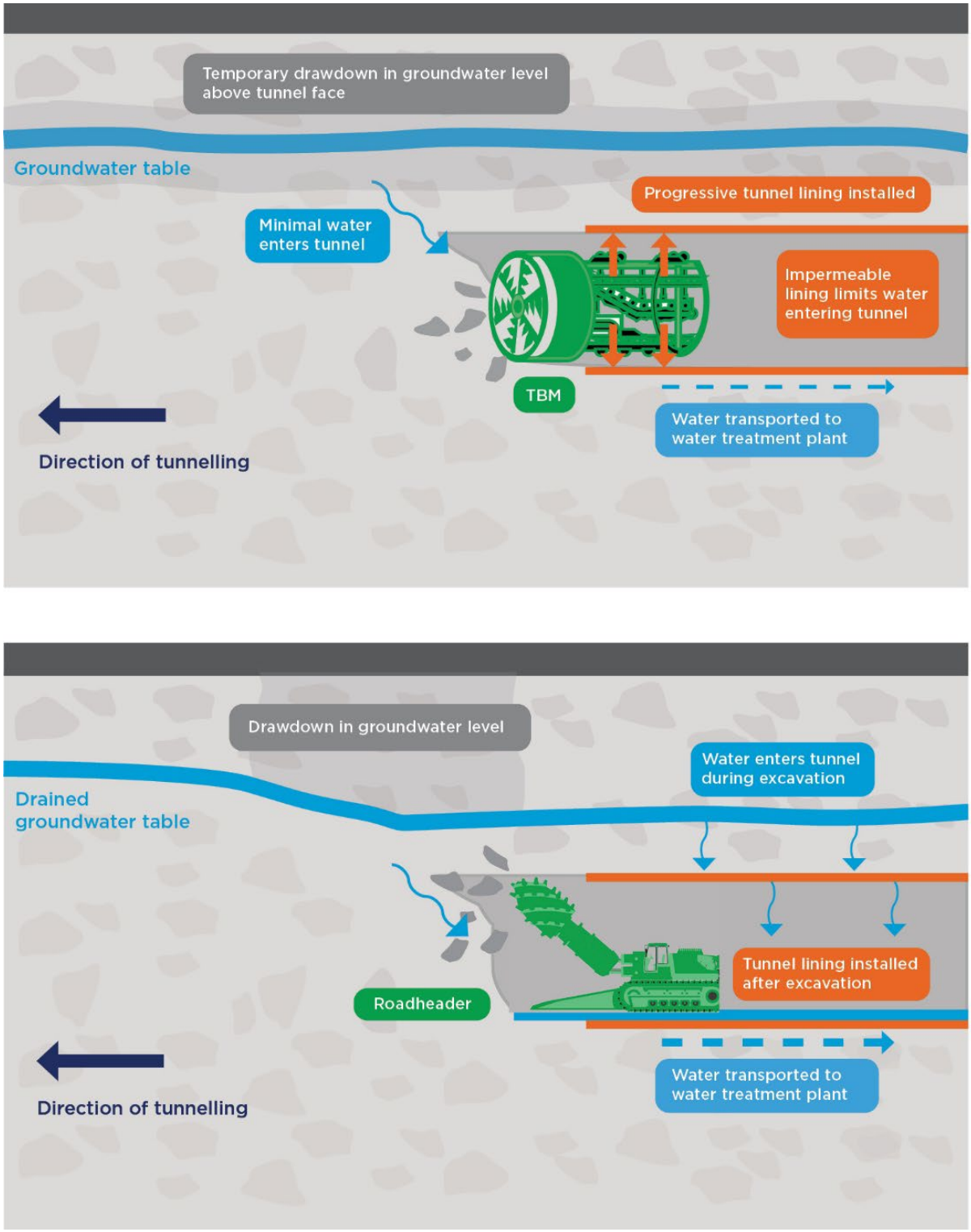


Figure 3-8 Comparison of TBM vs roadheader tunnelling methods on groundwater drawdown

Number of TBMs

The project considered scenarios using two and four TBMs to construct the tunnels. Using two TBMs launched from Little Hartley was identified as the preferred option to minimise impacts at the eastern portion of the project. A two TBM option, while resulting in a slightly longer construction program overall, would reduce the resource demand for labour and construction materials during the course of the tunnel construction, resulting in a considerably reduced number of daily vehicle movements within the construction corridor. Heavy vehicle traffic relating to tunnelling activities would be largely confined to the western end of the project (Little Hartley), minimising construction related impacts for Mount Victoria and Blackheath communities.

Under a four TBM scenario, two TBMs would be launched from Blackheath and two from Little Hartley, both tunnelling towards the mid-tunnel point. This option would require a larger construction footprint at Blackheath to provide a TBM launch site. A larger construction footprint at Blackheath would have had a greater impact on the community, including additional property acquisition and increased construction traffic, but would reduce the overall construction program. In addition, this option would require spoil haulage and increasing heavy vehicle movements including precast segment supply through Blackheath. As the heavy vehicle route including for spoil haulage would be primarily westbound from the project, the addition of heavy vehicles westbound on the Great Western Highway between Blackheath and Little Hartley would result in safety impacts due to potential conflicts with general traffic, particularly around the tight curves and steep grades at Victoria Pass. Additional heavy vehicle movements through Blackheath and Mount Victoria would also further impact the amenity of these localities.

Consideration was given to launching TBMs from the Soldiers Pinch construction footprint, however availability of land is constrained at this location, and a larger construction footprint at Soldiers Pinch would have potentially encroached into the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area.

Using two TBMs would minimise potential traffic impacts at Blackheath and through the Blue Mountains during construction. It would also be sensitive to the unique environmental and cultural surroundings by minimising impacts to the Blue Mountains National Park and Sydney's drinking water catchment, avoiding direct impacts to the Greater Blue Mountains World Heritage Area and reducing amenity impacts to the community by minimising spoil haulage through Blackheath and Mount Victoria.

Spoil transport alternatives

The preferred spoil transport would be via road to minimise multiple handling of materials. Spoil transport via freight rail was considered as an alternative to reduce the number of heavy vehicles required on the roads. However, the use of rail would require multiple handling of the spoil with trucks required to move the material from the project to the railway loading area, and then again from an unloading area at the railway destination.

Analysis of haulage routes to potential railway loading / unloading points showed that the distance required to access these locations would be at least equivalent to the potential spoil reuse sites identified in Chapter 5 (Construction). Given the rail corridor is used by passenger and freight railway services, there may be capacity constraints or complex coordination required to achieve an effective rail spoil transport arrangement.

3.6.2 Ventilation design

Ventilation system design options

Tunnel ventilation systems provide a safe environment for tunnel users and adjacent receivers by regulating in-tunnel air quality, including the management of portal emissions, and emissions from any fire or other polluting incidents that may occur within the tunnel. There are a variety of tunnel ventilation system options that remove vehicle exhaust air from tunnels. The requirements for tunnel ventilation are determined by predicted vehicle emissions against pollutant limits set by regulatory authorities (described in Chapter 9 (Air quality)).

Table 3-10 outlines the advantages and disadvantages of the various ventilation systems. The project would be designed with longitudinal ventilation as shown in Figure 3-9. This is the preferred ventilation design given that:

- the length of the tunnel is too long for natural ventilation
- the concentration of in-tunnel pollutants would not require transverse or semi-transverse ventilation, which can require substantial amounts of energy to operate.

Table 3-10 Types of ventilation systems

Ventilation system	Description
Natural ventilation	Natural ventilation relies on the movement of vehicles, prevailing winds and differences in air pressure between the tunnel portals to move air without any mechanical assistance such as the assistance of ventilation fans. Natural ventilation is only suitable for short tunnels, typically less than one kilometre long. In longer tunnels vehicle emissions can build inside the tunnel if there is no mechanical assistance to move the air out of the tunnel. Natural ventilation would not achieve acceptable air quality within the tunnels given their length and therefore this ventilation option was not considered appropriate for the project.
Longitudinal ventilation	Longitudinal ventilation relies on the movement of vehicles, winds and differences in air pressure with mechanical assistance from jet fans. The in-tunnel air can be exhausted via the tunnel portals, or through an elevated ventilation outlet, usually above the tunnel. Most long road tunnels in Australia use longitudinal ventilation, including NorthConnex, which is around nine kilometres long, the WestConnex New M4 which is around 5.5 kilometres long, and the WestConnex M8 which is around nine kilometres long
Transverse ventilation	Transverse ventilation relies on provision of two ventilation ducts along the entire length of the tunnel with one providing fresh air and the other for expelling exhaust air with emissions via the tunnel portals, or through an elevated ventilation outlet. The fresh air ducts are located along the road surface, whilst exhaust air ducts are located along the roof of the tunnel. This type of ventilation system is more expensive to run due to the power required to manage air flows. These systems have been traditionally used in the past when emissions from vehicles produced greater concentrations of toxic pollutants than they do today.
Semi transverse ventilation	Semi-transverse ventilation relies on both longitudinal ventilation and transverse ventilation, with the provision of one ventilation duct along the length of the tunnel providing fresh air with emissions via the tunnel portals, or through an elevated ventilation outlet. The fresh air ducts are usually located along the road surface.
Air exchange stations	In the last decade an alternative to transverse ventilation systems for long and/or heavy trafficked road tunnels has been the use of air exchange stations. An alternative to reach the required air quality standards within the tunnel is to split a long tunnel into shorter sections, where air exchange is achieved through ventilation outlets or via the tunnel portals. A mid-point air exchange was considered however in-tunnel air quality modelling demonstrated that this was not necessary to achieve compliance with in-tunnel air quality criteria and would increase the construction and maintenance cost, and power consumption.

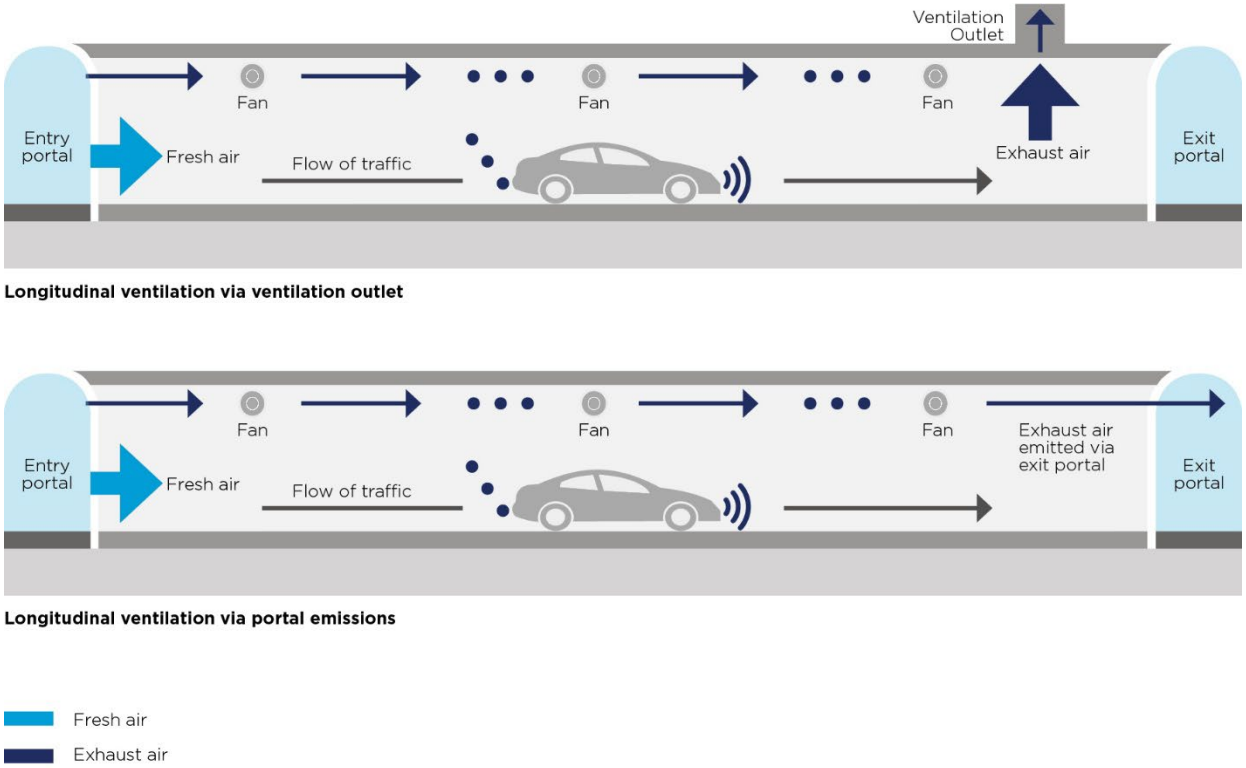


Figure 3-9 Ventilation system options being considered for the project

Tunnel emissions options

Two options for the management of tunnel emissions are being considered for the project including emissions via a ventilation building and outlet at each exit portal (ventilation outlet option) and portal emissions (portal emissions option). These options are described in Table 3-11.

Both tunnel emissions options have been assessed in this EIS, including potential impacts on air quality (Chapter 9 (Air quality)), human health (Chapter 10 (Human health)), noise and vibration (Chapter 11 (Noise and vibration)) and landscape and visual amenity (Chapter 18 (Landscape and visual)). A summary of the key differences in potential impacts from each tunnel emissions option is presented in Table 3-12. A decision on the preferred tunnel emissions option for the project will be made following the outcomes of further environmental assessment and consultation with key stakeholders and the community.

Table 3-11 Tunnel emissions options considered

Tunnel emissions option	Description
Ventilation outlet option	Ventilation outlets are usually used for longer tunnels, moving emissions release further away from ground level by pushing the air to a higher point in the atmosphere. Under this option, a ventilation building and outlet would be located at the Blackheath and Little Hartley portals. The ventilation buildings would be located underground to minimise visual impacts and integrate with the surrounding landform. Each ventilation outlet would be around 10 metres above the finished ground level.

Tunnel emissions option	Description
Portal outlet option	Portal emissions occur where tunnel emissions pass directly from the tunnel portals. The longitudinal ventilation system pushes emissions to the tunnel portals where they disperse. The potential benefits of portal emissions would include reduced operational power requirements and costs, reduced construction costs and durations, and neutral as opposed to adverse qualitative visual impacts (especially given the surrounding Greater Blue Mountains World Heritage Area). No ventilation buildings or outlets would be required under the portal emissions option.

Table 3-12 Key difference in operational impacts between tunnel emissions options

Potential impacts	Key differences between tunnel emissions options
Transport and traffic	Nil
Air quality	Compared to the ventilation outlet option for the typical daily traffic, the portal emissions option would result in: • 2.1% to 2.8% higher (as a percentage of the EPA criterion) 2030 annual average $PM_{2.5}$ (particulate matter equal to or less than 2.5 micrometres in diameter) concentrations for the most affected receptors • 3.6% to 4.4% higher (as a percentage of the EPA criterion) 2030 24-hour maximum $PM_{2.5}$ concentrations for the most affected receptors • 16% higher (as a percentage of the EPA criterion) 2030 maximum one-hour nitrogen dioxide concentrations for the most affected receptors, but yielding similar results by 2040 • 6.4% higher (as a percentage of the EPA criterion) 2030 annual average nitrogen dioxide concentrations for the most affected receptors.
Human health	Compared to the portal emissions option, the ventilation outlet option would result in: • a lower maximum localised/ individual particulate matter risk, potentially reducing the risk of adverse health outcomes associated with particulate matter such as cardiovascular and respiratory illness. However, both ventilation design options would result in localised impacts that are considered low and acceptable • more exceedances in noise management levels, however the differences are relatively minor. Where noise levels are mitigated during normal operations there would be no changes in noise that would result in adverse impacts to community health, such as annoyance or sleep disturbance which can lead to other long-term health effects.
Noise and vibration	Compared to the portal emissions option, the ventilation outlet option would exceed the noise criteria for: • two more receivers under normal traffic conditions at Blackheath • three more receivers under low flow traffic conditions at Blackheath • five more receivers under emergency conditions at Blackheath. These predicted noise exceedances can be reduced with the implementation of mitigation measures.
Biodiversity	Nil

Potential impacts	Key differences between tunnel emissions options
Groundwater and geology	Nil
Surface water and flooding	Nil
Soils and contamination	Nil
Aboriginal cultural heritage	Nil
Non-Aboriginal heritage	Nil (including nil difference in indirect visual impacts to the World Heritage listed area of the Blue Mountains National Park)
Landscape and visual	Compared to the portal emissions option, the ventilation outlet option would have the same overall impact rating (high to moderate) but would have an adverse qualitative rating (rather than a neutral qualitative rating) for the following landscape character zones: • landscape character zone 1b • landscape character zone 1c. Different visual impacts would be experienced at the following locations: • viewpoint 3 – both options would have the same overall impact rating (moderate) but the ventilation outlet option would have an adverse qualitative rating (rather than a neutral qualitative rating) • viewpoint 7– the ventilation outlet option would have a high (adverse) visual impact compared to the portal emissions option which would have a high to moderate (neutral) visual impact. All other landscape character zones and viewpoints assessed would experience the same visual impacts, irrespective of the ventilation design option selected for the project.
Social impacts	Nil
Business, land use and property	Nil
Resource use and waste management	Compared to the portal emissions option, the ventilation outlet option would require: • around 73,000 kWh/day of additional operational power supply • additional materials for the construction of the ventilation buildings and outlets.
Hazards and risk	Nil
Sustainability, climate change and greenhouse gas	Compared to the portal emissions option, the ventilation outlet option would produce (over the design life of the project (100 years)): • around 2,087,800 tonnes of carbon dioxide equivalent from additional scope 2 greenhouse gas emissions • around 187,370 tonnes of carbon dioxide equivalent from additional scope 3 greenhouse gas emissions.

3.7 Design refinements for impact avoidance and minimisation

Table 3-13 contains a summary of project design elements adopted to avoid or minimise potential environmental impacts. Ongoing design development would continue to consider opportunities to avoid and minimise environmental impacts.

Table 3-13 Environmental considerations during design development and refinement

Design development and refinement item	Environmental impact minimised and/or avoided
Construction	
Using TBMs as primary tunnel excavation method rather than roadheaders	• minimised construction duration due to faster rate of excavation compared to roadheaders • ability to progressively install precast structural, waterproof tunnel lining to minimise the extent of groundwater drawdown and potential impacts on groundwater dependent ecosystems • reduced number of tunnel excavation access points compared with using roadheaders, minimising the construction footprint and length of the spoil haulage route.
Excavating from west only rather than from both east and west	• minimised construction footprint at Blackheath, reducing native vegetation clearance, as the site would not need to accommodate TBM launch • reduced spoil haulage through Blackheath and Mount Victoria (including associated potential safety and amenity impacts), as spoil would primarily be hauled westbound from the Little Hartley construction footprint.
Optimised construction methodology which has reduced the construction footprint and number of construction sites	The project would repurpose the construction footprints used for the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade to minimise native vegetation clearance. Potential construction footprints at Browntown Oval and at the old Blackheath tip site were considered (and discounted) to support construction. Avoiding use of these sites would result in: • reduced amenity impacts for residents near Browntown Oval and the old Blackheath tip site associated with use of, and access to and from, these sites • avoidance of impacts to social infrastructure at Browntown Oval which would continue to be available for recreational purposes • reduced impacts to human and ecological health (by limiting the risk of exposure to contaminated lands and friable asbestos at the old Blackheath tip site) • minimised biodiversity impacts (to the observed wetland and Commonwealth listed threatened species (Gang-gang Cockatoos and Blue Mountains Water Skink) identified near the old Blackheath tip site) • minimised construction noise impacts and construction traffic impacts through Blackheath • shorter construction duration at Blackheath, and reduced construction impacts to the community.

Design development and refinement item	Environmental impact minimised and/or avoided
Revised tunnel alignment deviating from the existing Great Western Highway alignment to achieve a shorter and straighter tunnel	• less spoil, and shorter construction duration associated with a shorter tunnel length.
Operation	
Revised tunnel alignment deviating from the existing Great Western Highway alignment to achieve a shorter and straighter tunnel	• improved sustainability outcomes associated with reduced vehicle emissions from travelling along a shorter and straighter tunnel alignment • improved sustainability outcomes given the lower resource use and energy consumption associated with a shorter tunnel alignment • improved driver safety outcomes (minimising curvature and extending sight distance).
Reduced operational footprint at the Blackheath portal	• minimised visual impacts for road users, tourists and residents near the Blackheath portal • simplification of the Blackheath interchange and associated improved driver safety outcomes • increased opportunities for landscaping and better visual outcomes.
Physical separation of tunnel entry and exit portals at Blackheath and Little Hartley	• reduced localised air quality impacts if the portal emissions option is preferred • avoidance of portal emissions from the exit portal of one tunnel re-entering the entry portal of the adjacent tunnel • allows space for ventilation buildings and outlets for the ventilation outlet option (if identified as the preferred option), without requiring a change to the project footprint.
Use of portal emissions option instead of ventilation outlets option (if identified as the preferred option)	• minimised visual impacts as a result of removing the need for ventilation outlets • improved sustainability outcomes given the lower resource use, greenhouse gas emissions and energy consumption associated with operating under a portal emissions option.