Chapter 4
Project description

Contents

List of tables

List of figures

4 Project description

This chapter describes the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The description of the project presented in this chapter is indicative and subject to ongoing design development.

4.1 Overview

The project would comprise new twin tunnels between Blackheath and Little Hartley, and would form part of the broader upgrade of the Great Western Highway between Katoomba and Lithgow to a four lane carriageway (the Upgrade Program).

The key components of the project are summarised in Table 4-1. An overview of the project is shown in Figure 4-1.

The existing Great Western Highway would be retained between Blackheath and Little Hartley and would continue to function as an alternative route for local and tourist traffic. It would also be an alternative route if there are planned or unplanned closures of the tunnels.

Table 4-1 Key components of the project

Key project component	Summary
Tunnels	Twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends. Each tunnel would include two lanes of traffic and road shoulders and would range in depth from just below the surface near the tunnel portals, to up to around 200 metres underground at Mount Victoria.
Surface work	Surface road upgrade work would be required to connect the tunnels and surface road networks south of Blackheath and at Little Hartley. The twin tunnels would connect to the surface road network via: • mainline carriageways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road • mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Key project component	Summary
Operational infrastructure	Operational infrastructure provided by the project would include: • a tunnel operations facility adjacent to the Blackheath portal • in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities • one of two potential options for tunnel ventilation currently being investigated, being: – ventilation design to support emissions via ventilation outlets; or – ventilation design to support emissions via portals • drainage and water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley • fire and life safety systems, emergency evacuation and ventilation infrastructure and closed circuit television • lighting and signage including variable message signs (VMS) and associated infrastructure such as overhead gantries.
Utilities	Key utilities required for the project would include: • an electricity substation at Little Hartley for construction and operational power supply • a pipeline between Little Hartley and Lithgow for construction and operational water supply • other utility connections and modifications, including electricity substations in the project tunnels.
Other project elements	The project would also include: • integrated urban design initiatives • landscape planting.

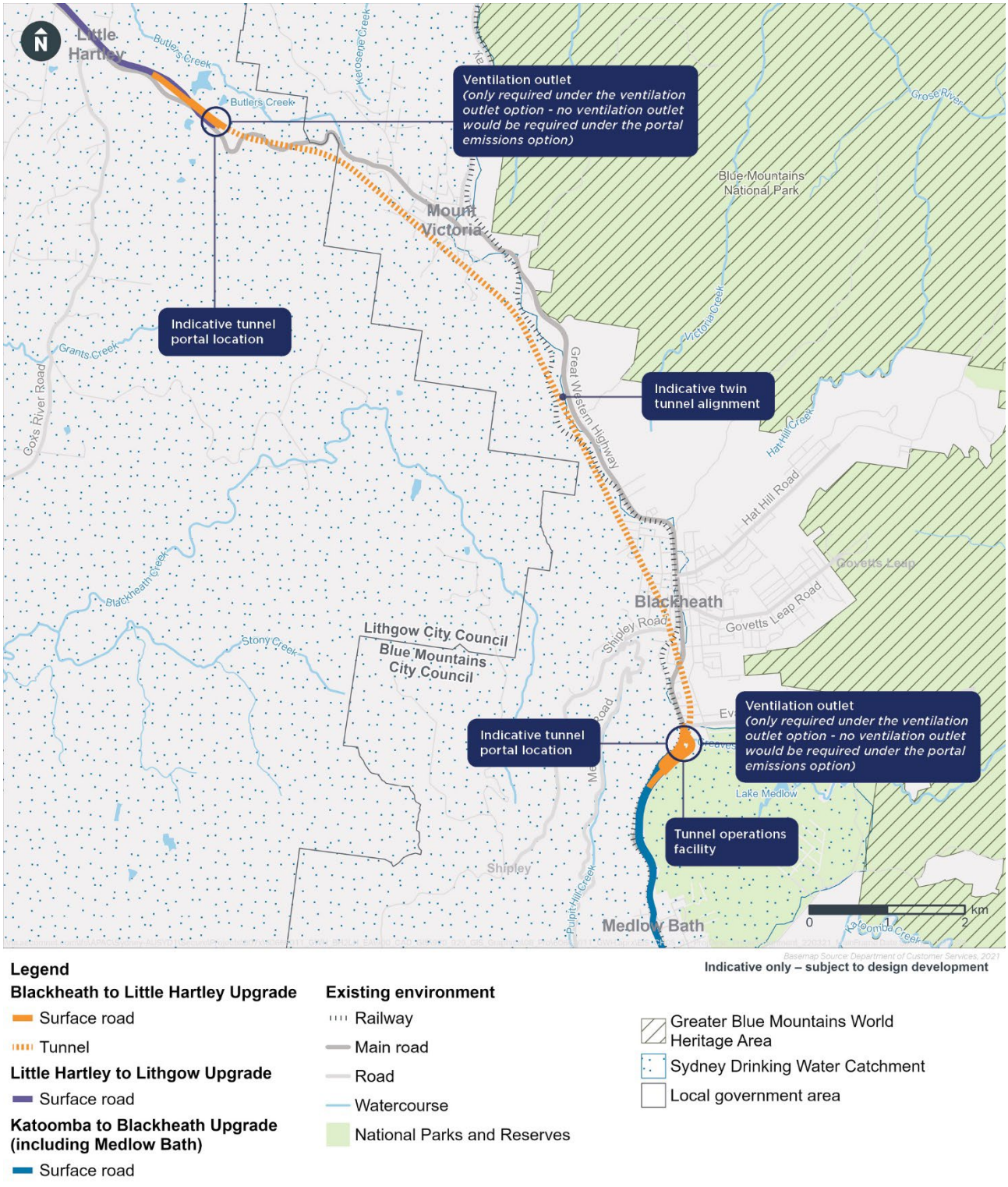

Figure 4-1 Overview of the project

4.2 Design process and evolution

4.2.1 Relevant policies and guidelines

The project design has been guided by several NSW Government policies and guidelines, including those developed by the Government Architect NSW. A summary of the relevant policies and guidelines relating to design, place and movement and how the project has considered these is provided in Table 4-2.

Table 4-2 Design, place and movement policies and guidelines relevant to the project

Policy / guideline	Project design response
Better Placed – An integrated design policy for built environment of New South Wales (Government Architect NSW, 2017)	The key objectives and project response include: • objective 1: Better fit – a design responsive to the landform, place and corridor context contributing to the richness of the area, views and vistas. The project design has taken a landscape led iterative design approach by placing the route below ground and by considering a portal emissions ventilation option, integrated with and supported by input from multiple technical disciplines and considers the surrounding heritage context including the Greater Blue Mountains World Heritage Area and Little Hartley valley • objective 2: Better performance – a design that provides an enduring purpose and amenity, responding positively to the environmental context to deliver enhanced economic and social outcomes • objective 3: Better for community – a design which supports the enhancement of place for local communities • objective 4: Better for people – a safe, user friendly design that enhances movement for all users and provides a place for the enjoyment and wellbeing of communities and end users • objective 5: Better working – a fit for purpose design that is innovative and practical, to ensure longevity of the tunnel and a world class transport asset • objective 6: Better value – a considered design that provides safer travel options and connectivity to places, as well as satisfying the existing social and economic needs of the community • objective 7: Better look and feel – an aesthetically pleasing and innovative design integrated into the surrounding landscape, adopting best practice place principles to minimise landscape and visual impacts.
Beyond the Pavement (Transport for NSW, 2020b)	Key design principles identified in Beyond the Pavement included in the project response: • principle 5: contributing to green infrastructure and responding to natural systems, and • principle 6: connecting with Country and incorporating heritage and cultural contexts into projects.

Policy / guideline	Project design response
Designing with Country (Government Architect NSW, 2020a)	Consultation with Aboriginal knowledge holders whose Country would be affected by the project has commenced so that Aboriginal culture and heritage is respected and integrated into the design. Feedback received to date highlights the importance of nature, language and connection. This feedback would continue to inform the design aspirations for the built form of the project and associated theming, balanced with other factors including potential visual and cumulative impacts on places of Aboriginal heritage significance, objects and cultural protocols. Transport is continuing to engage with Aboriginal knowledge holders with a view to incorporating Aboriginal culture and heritage into the design development of the project.
Connecting with Country Draft Framework (Government Architect NSW, 2020b)	The project as part of the Upgrade Program provides opportunities to improve connection to Country and connectivity through the Blue Mountains. The project would incorporate a visual interpretation of the cultural and physical identity of Country and has been designed in response to the following key principles for action in this policy: • respecting the rights of Aboriginal peoples through ongoing engagement mindful of their cultural and intellectual property with a goal to care for Country through considered and sensitive design • delivering an interpretive design that provides tangible and intangible benefits for current and future generations, with the Aboriginal people determining the representation of their cultural materials, customs and knowledge • prioritising consideration of the local, place specific cultural identities, supporting a reciprocal relationship with Country.
Aligning Movement and Place – Outline for understanding places in relation to movement infrastructure (Government Architect of NSW, 2019) Practitioner's Guide to Movement and Place (NSW Government, 2020a)	The project responds to the need to prioritise different customer groups based on their travel requirements, and to provide appropriate movement corridors, vibrant streets, local streets, and places for people. The project would reduce traffic volumes along the existing Great Western Highway between Blackheath and Little Hartley, leading to improved amenity on surface roads, particularly in and around Blackheath and Mount Victoria. Potential opportunities for placemaking and active transport initiatives would be subject to ongoing investigation and consultation with the relevant local councils. This would include consideration of opportunities to improve at-surface active transport infrastructure between Blackheath and Little Hartley, connecting to the active transport trails to be delivered by the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. This active transport infrastructure would be subject to separate assessment and approval and may be delivered by others.

Policy / guideline	Project design response
Healthy Urban Development Checklist (NSW Health, 2009), section 10	The project is largely focused on improving vehicle and freight access. The project would however integrate with existing infrastructure being the Great Western Highway. While active transport infrastructure is not permitted within the tunnel, the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade would include active transport trails.
Creating Walkable Neighbourhoods (Active Living NSW, 2018)	
Sydney Green Grid – Spatial Framework and Project Opportunities (Tyrrell Studio and Office of the Government Architect, 2017)	The design of the project has considered and integrated the following objectives and principles in green infrastructure policy: • providing increased access to open spaces, while improving connections to nature • providing enhanced connectivity by reducing restrictions and barriers to movement of people and fauna • minimising potential biodiversity impacts • retaining remnant vegetation where possible • providing a net increase in tree numbers and canopy within proximity of the impacted areas to mitigate the heat island effect and replace lost biodiversity and ecological values. The project design responds to these principles by: • focusing on a landscape led design response that holistically integrates the design of the project with the landscape and reflects water sensitive urban design • minimising impacts to existing vegetated areas by locating the majority of project infrastructure underground within a tunnel • designing disturbed areas using ecological principles that integrate soil management and regeneration of vegetation communities.
Greener Places – Establishing an urban Green Infrastructure policy for New South Wales (NSW Government, 2020b)	
AS4970-2009 Protection of trees on development sites	
AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting	Refer to Table 4-3.

4.2.2 Urban design

Six urban design objectives have been identified to guide the ongoing design development for the project. These objectives are shown in Figure 4-2, and:

- are consistent with key urban design guidelines and policies listed in Table 4-2
- outline the proposed direction of the urban design of the project
- govern the overall quality of the urban design outcomes.

A discussion of how the key project elements would consider urban design principles during design development is provided in Table 4-3. Further information regarding the urban design concept for the project is provided in Appendix N (Technical report – Urban design, landscape and visual).

Figure 4-2 Project urban design objectives

Table 4-3 Urban design principles for key project elements

Key project element	Urban design principles
Interchanges	• the design would be aesthetically simple and clean, applying the narrative and theming around connecting through and across Country • the urban design elements would contribute to a functional and legible design outcome, with increased user amenity • connectivity would be safe and visually appealing for the road users, guided by the consistent application of the established urban design objectives and principles • the materials, finishes and colours should respond to their immediate and diverse contexts in both locations in section and elevation.
Walls and dive structures	• walls would be consistent and continuous along the corridor and would relate to the surrounding context and place • materials would be considered for durability, weathering, vandal proof, graffiti and safety • the tops of the walls would run parallel to the road surface and would follow the road grade where possible • walls and dive structures would be designed in context as part of the visual experience and would be aesthetically consistent with the corridor design elements and tunnel experience.
Surface buildings	• surface buildings including the tunnel operations facility, water treatment plant, substation and maintenance and emergency facilities would be sustainable and used as expressions of place, identity and value • structures would be designed as high quality pieces of architecture sympathetic to and integrated as a best fit with the surrounding context • designs would attempt to reduce the visual impact of structures and buildings by locating them close to the tunnel • integrated art on surface buildings must be able to be appreciated at speeds of 80 kilometres per hour or more.
Ventilation outlets	Should ventilation outlets be identified as the preferred ventilation option, the ventilation outlet design would: • adopt a simple and refined design, responding to the surrounding rural character either in form and/or decoration • select colours to complement the bushland character, assist in the visual reduction of the form and provide visual calming where integrated with the portal structures • consider low maintenance planting cover to grow up and around the structure to assist in camouflaging the scale and providing a visually 'green' design • select outlet locations close to the portals and away from sensitive receivers and land uses.
Portals	The approach to design of the portals would consider: • avoiding signage including VMS in the vicinity of portals so the portals are clean, legible and free of distraction • avoiding large signage in the last 200 metres before the portal to avoid driver distraction and confusion.

Key project element	Urban design principles
	Design of the portals themselves would consider: • a distinctive portal design to mark the tunnel entrances and exits which is well considered and integrated into the surrounding environment, determined by existing landscape conditions and geomorphology • a simple, sculptural form, integrating the local landform against a background of vegetation, providing legibility and clarity of the journey experience • low maintenance and easily accessible landscape planting to soften the tunnel structure and integrated into the approach lanes to enhance the driving experience • framing views at the exit to continue the driver experience along the corridor.
Tunnels	• the tunnel design would create a narrative that references the surface features along the corridor through visual events in the tunnel • the tunnel design would include visual stimulation and movement with colour and feature panels relevant to the local context • the tunnel design would include features that add interest and variety and provide wayfinding cues and a smooth transition between inside and outside environments.
Lighting	Tunnel feature lighting would: • highlight the urban forms of walls, art and relevant signage structures to highlight the night-time experience • be low maintenance and energy efficient, integrated to meet functional requirements, and to meet general safety and amenity requirements.

4.2.3 Environment-led design

The project has been developed through an environment-led design process whereby preliminary environmental investigations, assessments and advice have informed the design to avoid where possible or otherwise minimise potential impacts to the sensitive environment and communities in this part of the Blue Mountains and Lithgow local government areas. Examples of design refinements adopted to minimise potential environmental and community impacts are discussed in Chapter 3 (Project alternatives and options).

This process has involved an integrated and collective approach to the project design, generated by collaboration across technical disciplines, the community, stakeholders and government agencies. This concept is presented in Figure 4-3.

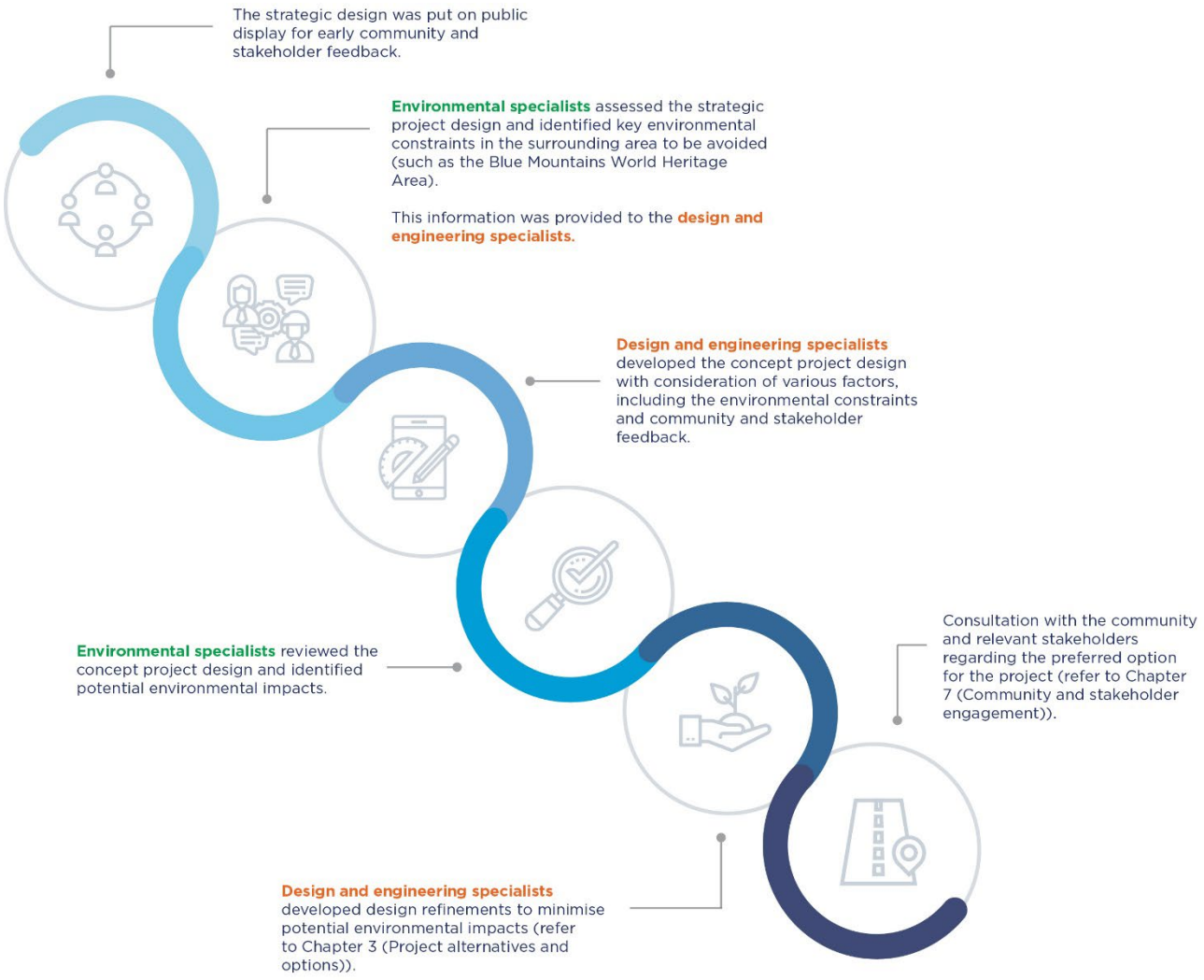

Figure 4-3 Environment-led design process

4.2.4 Connected with Country

The project travels across land which has been home to the Dharug, Deerubbin, Gundungurra and Wiradjuri Aboriginal cultural groups for thousands of years, who have an ongoing living culture and connection to Country. Everything starts with Country, connected through ceremony, living and ecological management.

The project would respond to place and movement through and across Country. Guidance documents prepared in consultation with Aboriginal people, of how to connect and design with Country, have guided the initial concept design and theming for the project. Representatives of the Dharug, Gundungurra and Wiradjuri peoples have been engaged with, and have led a process to provide a greater understanding of the cultural heritage and importance of connecting with and respecting Country. Transport is continuing this engagement as part of ongoing design development to provide stories to support and develop the design process further.

To integrate connection to Country, and Aboriginal culture and heritage into the project design, the following steps have commenced and will continue to be led by a specialist Aboriginal design and strategy consultant:

- engagement – initial engagement with identified Aboriginal stakeholders
- preliminary research and reporting – undertake desktop research to inform a preliminary Aboriginal narrative to identify cultural narratives and themes for the design of the project

- consultation – engagement with Aboriginal stakeholders to identify opportunities to deepen understanding of the Aboriginal context of the project
- reporting – provision of an Aboriginal Core Narrative Report incorporating stakeholder stories and culturally significant locations, to summarise processes and opportunities for consideration in design of the project
- design – develop designs that allow the themes identified in consultation to be expressed, including continued Aboriginal community consultation.

4.2.5 Landscape planting

Following construction, landscape planting would be carried out in areas subject to surface disturbance from the project (such as construction sites and surface road upgrades) consistent with the urban design concept presented in Appendix N (Technical report – Urban design, landscape and visual). Landscape planting for the project would be designed and implemented with the aim of:

- minimising the visual and landscape impacts of the project
- integrating the project into the surrounding visual catchment
- improving local and regional amenity
- providing a net increase in tree numbers and canopy within proximity of affected areas.

Areas of indicative landscape plantings for the project are shown in Figure 4-15 and Figure 4-19.

4.2.6 Ongoing design development process

As part of ongoing design development, the project design is being reviewed by the State Design Review Panel (SDRP). The SDRP is an independent panel established by the Government Architect NSW that provides a best-practice state-wide approach to the review of State significant projects, precincts and infrastructure. SDRP panellists are independent and highly qualified design professionals who bring a diversity of experience and insight. Panel members have cross disciplinary expertise in the areas of architecture, landscape architecture, urban design, Aboriginal and non-Aboriginal heritage and sustainability.

Transport has met with the SDRP to review the current project design and to seek advice and recommendations. Engagement with the SDRP would continue after public exhibition of this environmental impact statement (EIS) and as part of the ongoing design development process. Feedback received from the SDRP for the project to date relates to integrating engineering, design, and Country into a coherent approach that would have minimal impact on the landscape.

4.3 Tunnels

4.3.1 Tunnel design

The project would comprise twin tunnels around 11 kilometres long, connecting to the Great Western Highway at Blackheath and at Little Hartley.

Each tunnel would accommodate two lanes of traffic. The posted speed limit within the tunnel would be 80 kilometres per hour, and the tunnel on- and off-ramps at Blackheath would have an advisory speed of 25 kilometres per hour. During operation, each tunnel would have a carriageway width of around 10.5 metres (including two traffic lanes and shoulders) and a height clearance for vehicles of around 5.3 metres (total tunnel diameter inclusive of concrete segment lining would be around 14.8 metres). The tunnels would be designed to accommodate heavy vehicles including service and freight vehicles.

An indicative cross-section of the tunnels is shown in Figure 4-4.The lining for the tunnels would comprise precast concrete segments as described in Chapter 5 (Construction). The tunnel ventilation design is discussed in Section 4.5.2.

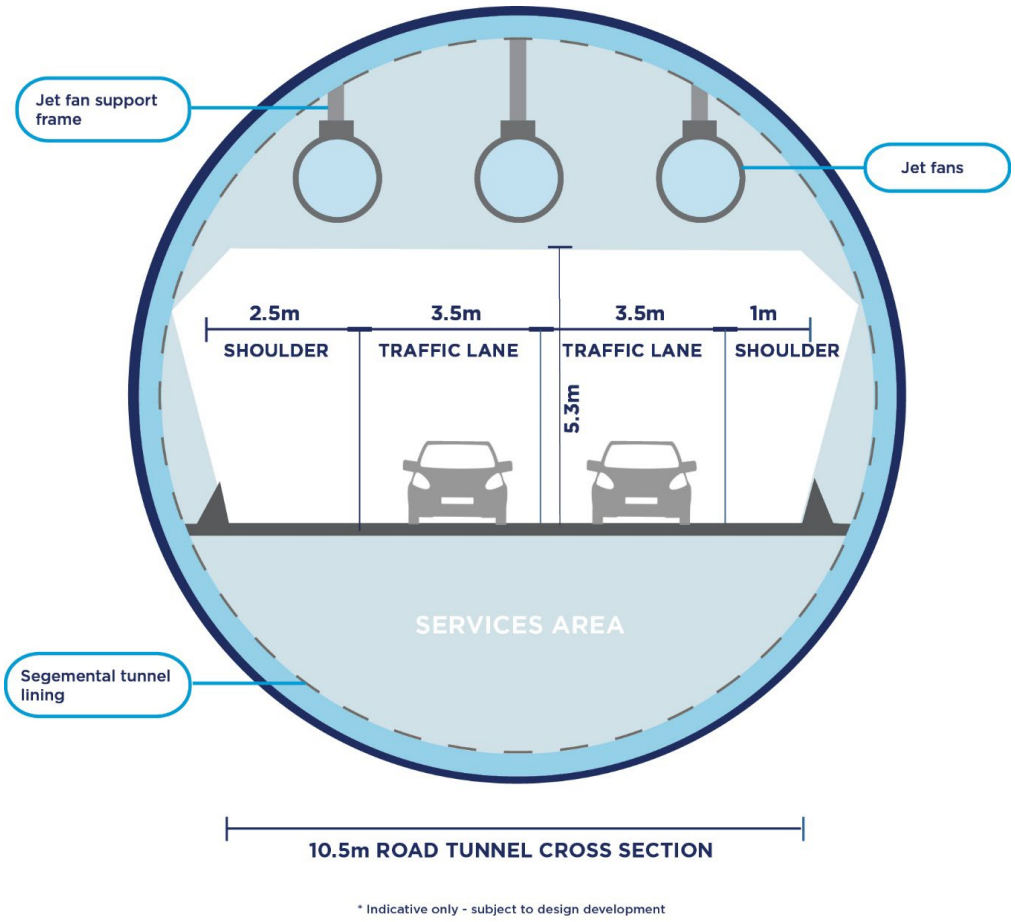

Figure 4-4 Indicative cross-section of the tunnel

4.3.2 Alignment

The horizontal alignment of the twin tunnels would generally be located to keep to the west of the existing Great Western Highway alignment as shown in Figure 4-1.

The tunnels would range in depth from just below the surface near the tunnel portals, to up to around 200 metres near Mount Victoria. The tunnels would provide a consistent grade of around 1.8 per cent in the eastbound (downgrade slope) and westbound (upslope) direction. The on- and off-ramps would vary depending on local topography and would have grades of between around 2.5 and six per cent.

A cross-fall would be incorporated into the design of the tunnel carriageways to allow for the collection and management of water in the tunnel as part of the tunnel water management system (see Section 4.5.3).

The indicative horizontal and vertical alignments of the twin tunnels are shown in Figure 4-5 to Figure 4-11 and would continue to be refined as part of design development. Depths presented in these figures are from the ground surface to the top of the tunnels.

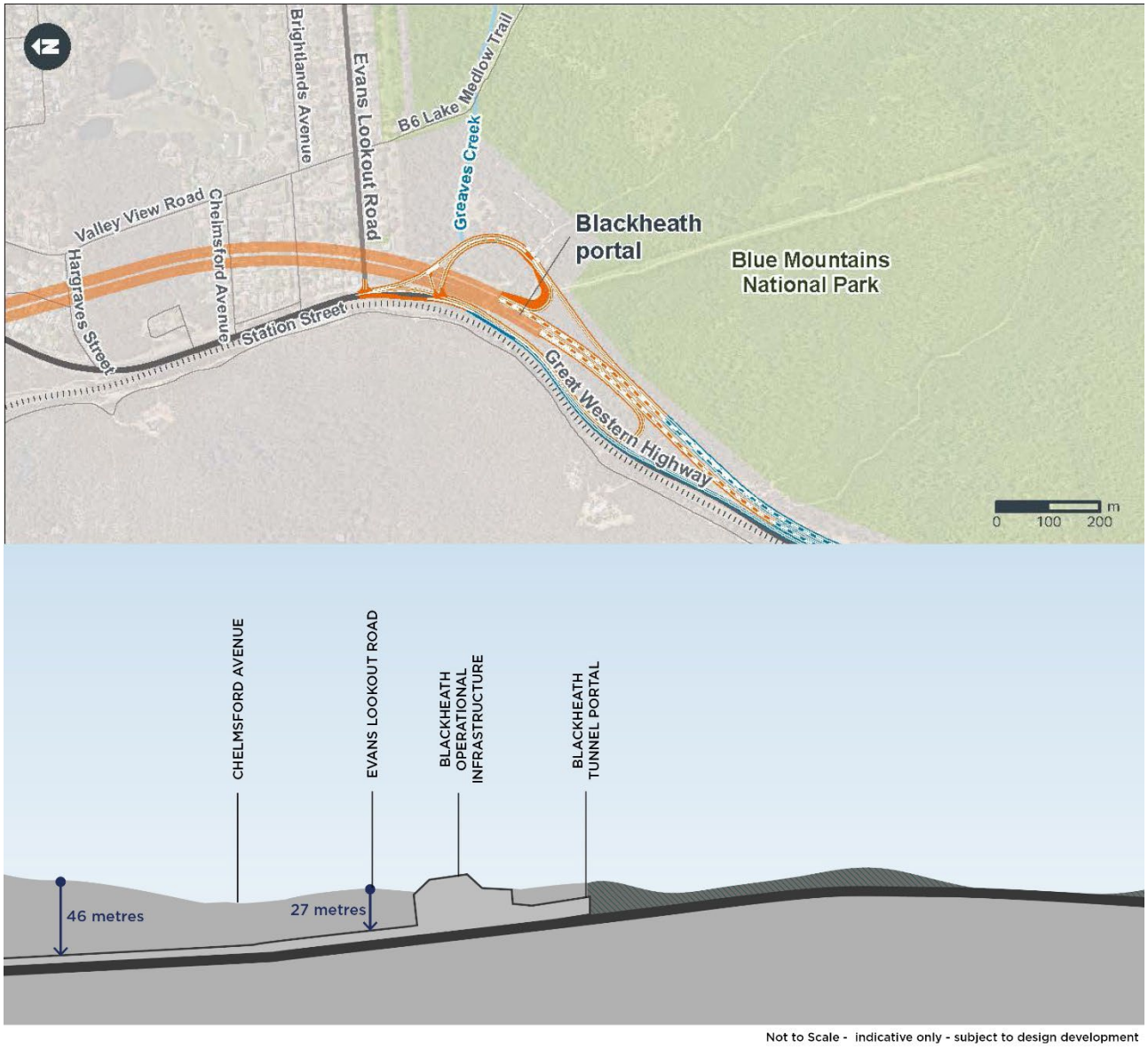

Figure 4-5 Horizontal and vertical alignments of the tunnels – map 1

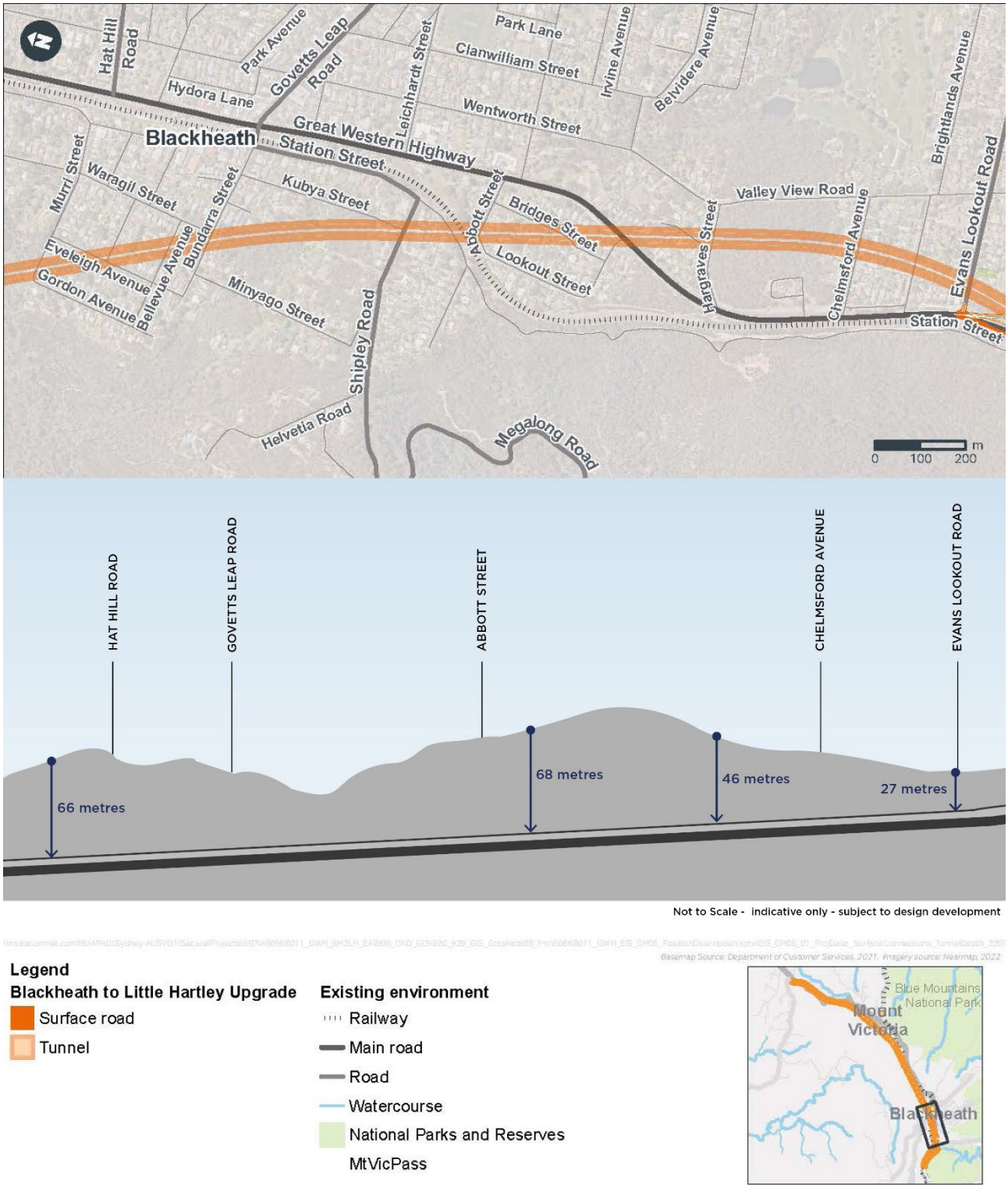

Figure 4-6 Horizontal and vertical alignments of the tunnels – map 2

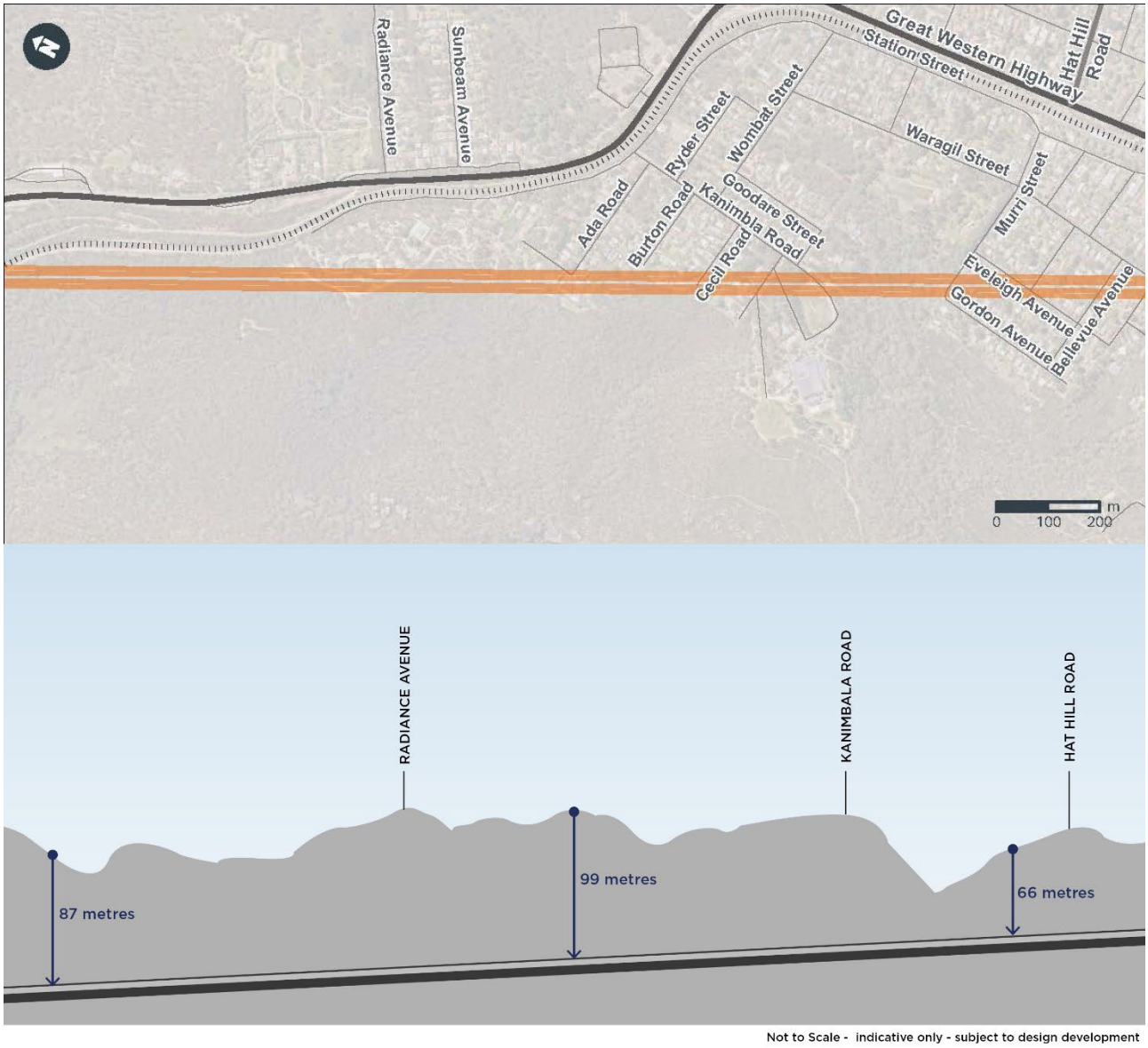

Figure 4-7 Horizontal and vertical alignments of the tunnels – map 3

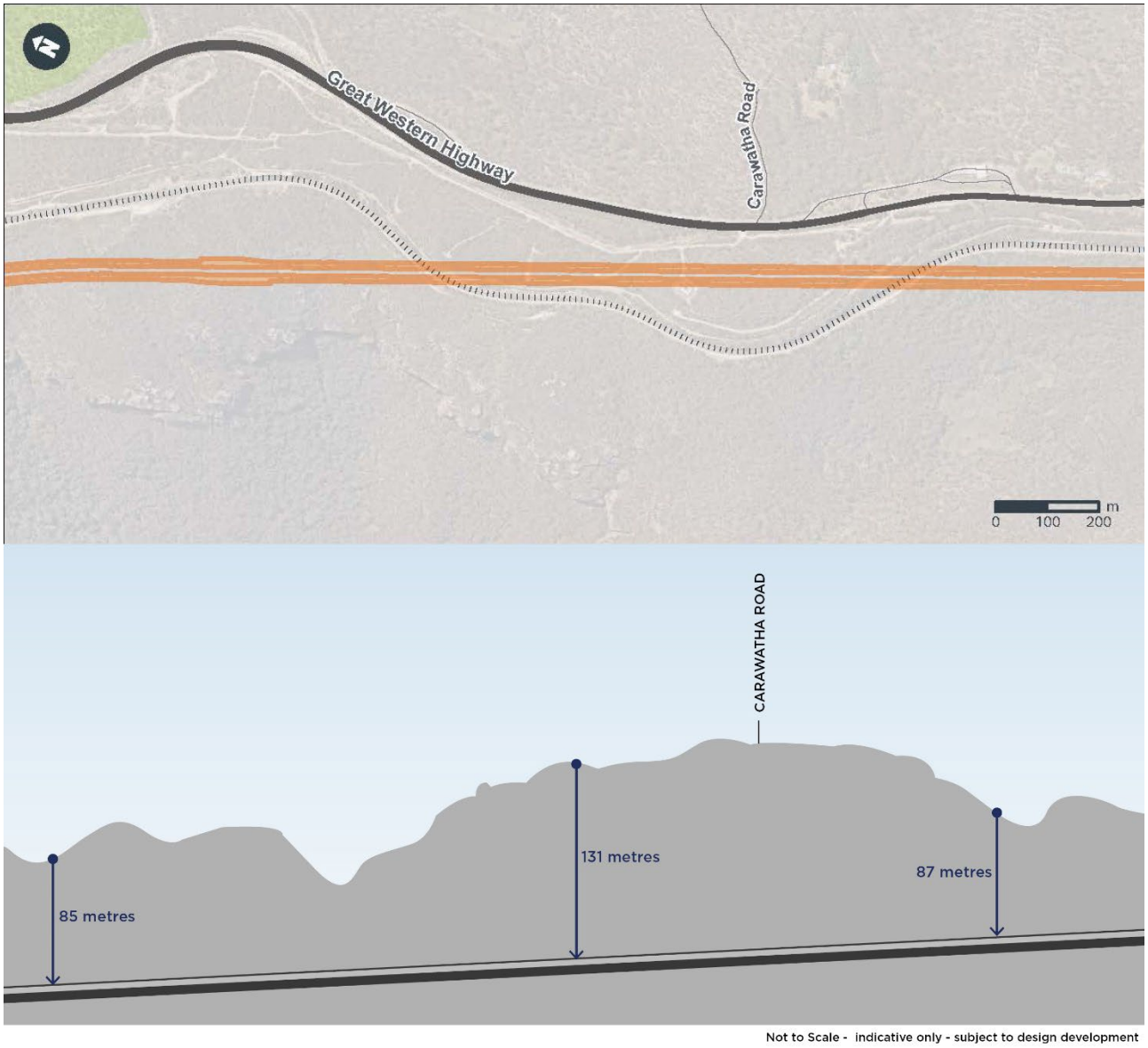

Figure 4-8 Horizontal and vertical alignments of the tunnels – map 4

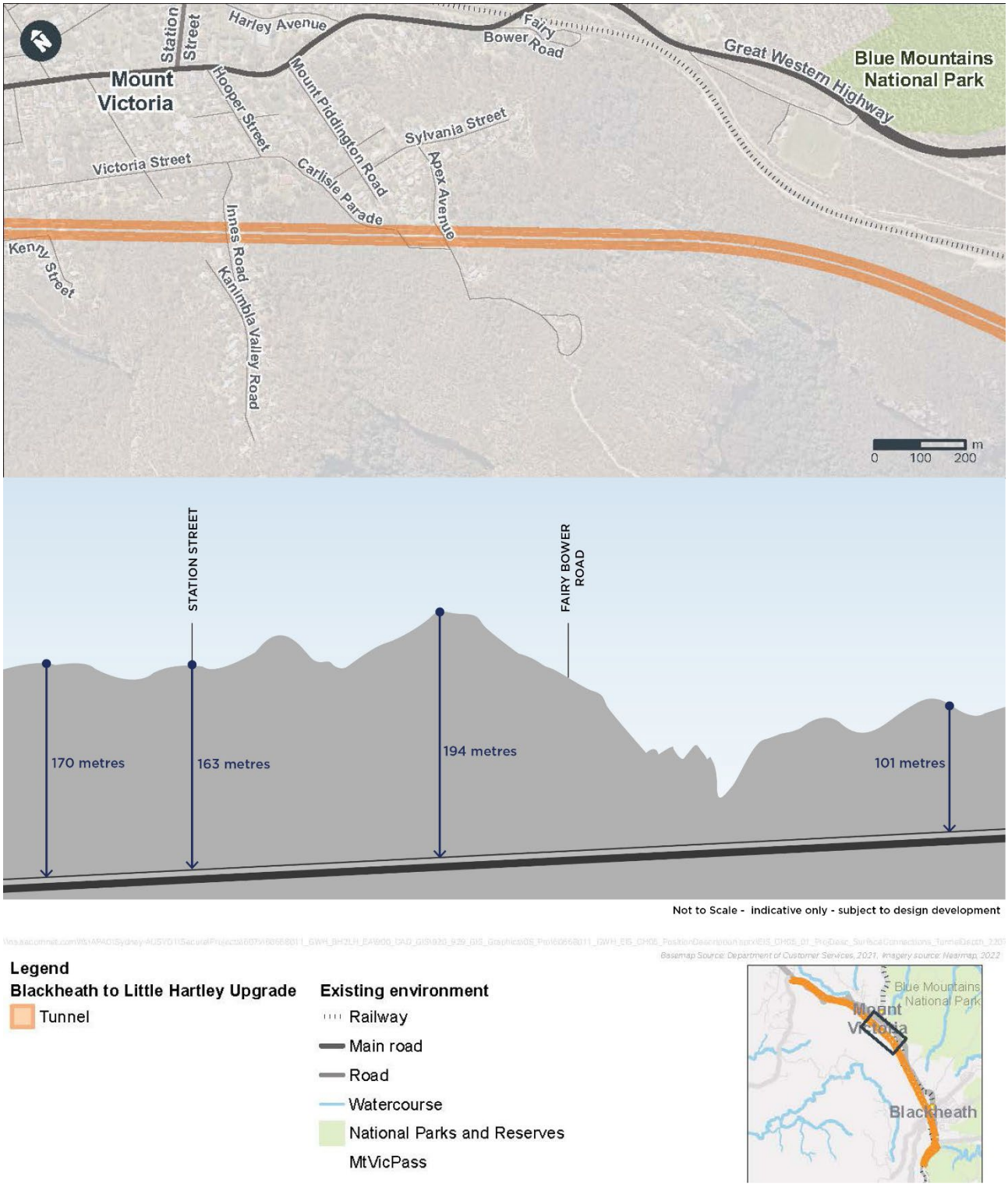

Figure 4-9 Horizontal and vertical alignments of the tunnels – map 5

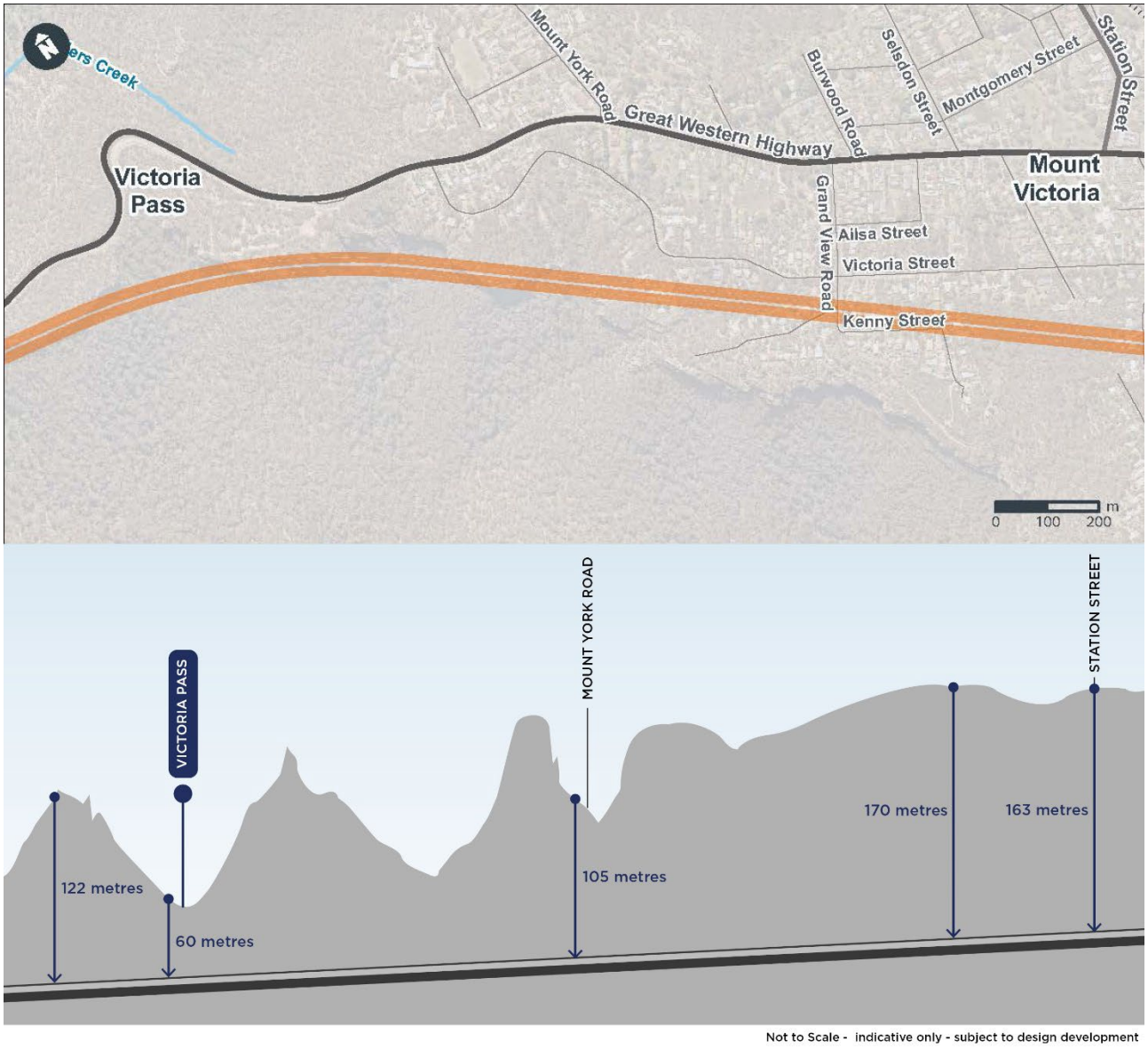

Figure 4-10 Horizontal and vertical alignments of the tunnels – map 6

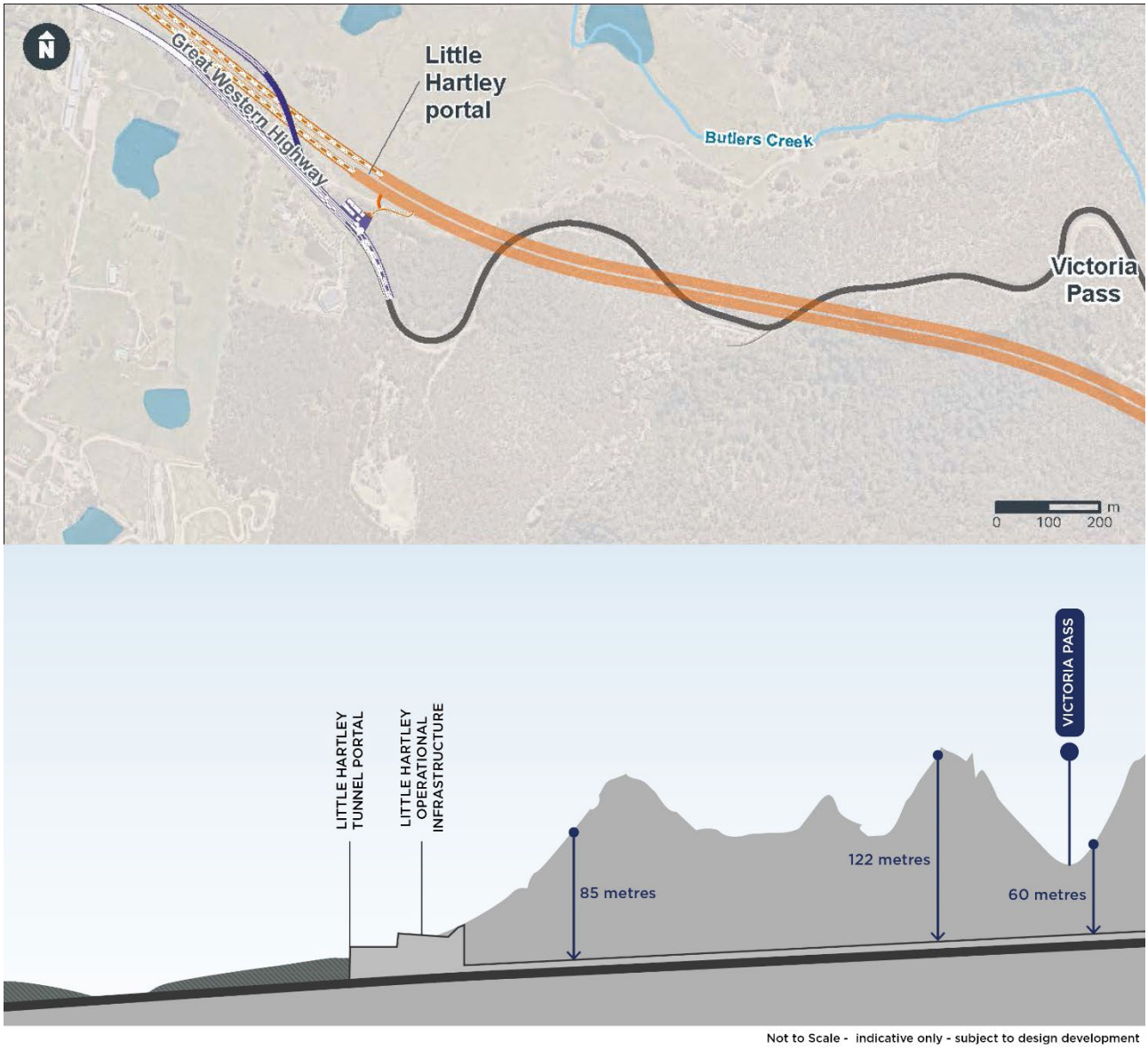

Figure 4-11 Horizontal and vertical alignments of the tunnels – map 7

4.3.3 Emergency breakdown facilities

The 2.5 metre shoulders provided in the tunnels would provide additional space for traffic, emergency personnel and operations crews in emergency situations or breakdowns. In addition, there would be a vehicle cross-passage between the tunnels for emergency service vehicles to switch between the westbound and eastbound tunnels around the tunnel mid-point. Further investigation into the need for this vehicle cross-passage is being carried out in consultation with relevant agencies, including emergency services. An indicative vehicle cross-passage layout is shown in Figure 4-12.

Pedestrian cross-passages would be provided at regular intervals around every 120 metres to allow for emergency pedestrian egress if an incident occurs in one of the tunnels. Investigations into the number and spacing of cross-passages within the tunnels are ongoing in consultation with relevant agencies, including emergency services.

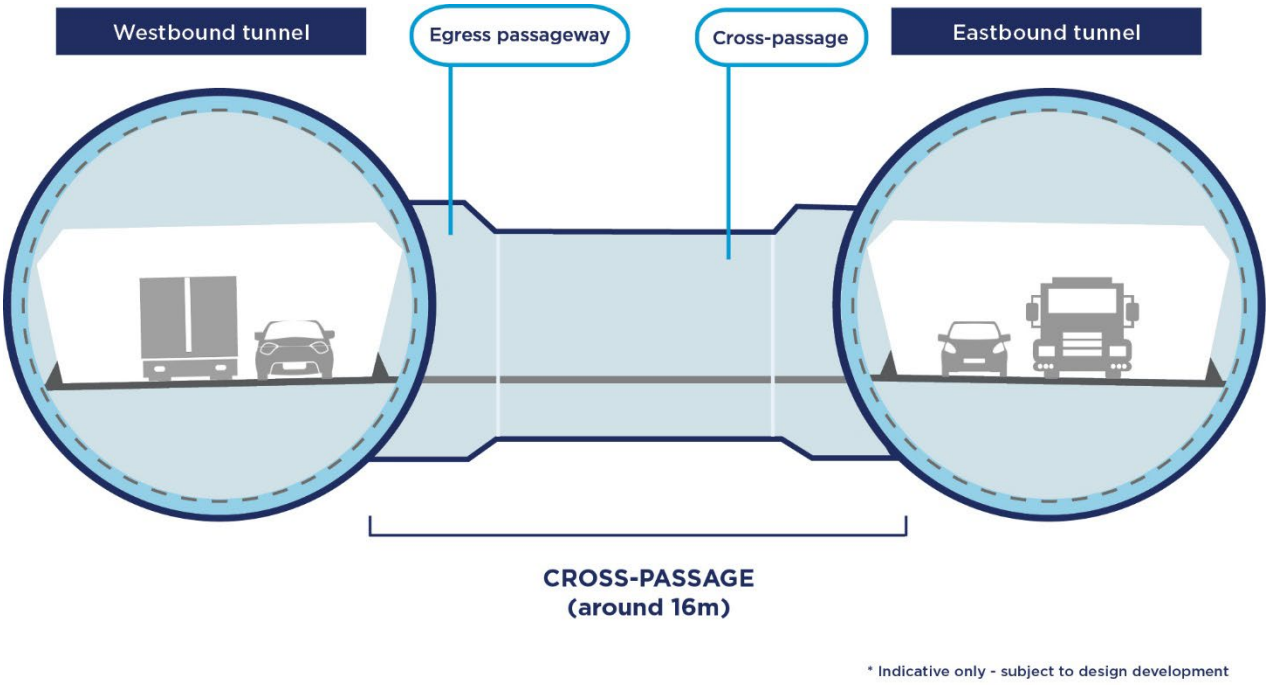

Figure 4-12 Indicative vehicle cross-passage layout

The tunnels would also include a breakdown and maintenance bay located around the midpoint of each tunnel. Further investigations into the need for these breakdown and maintenance bays are being carried out in consultation with the relevant agencies, including emergency services. An indicative layout of a breakdown and maintenance bay is shown in Figure 4-13.

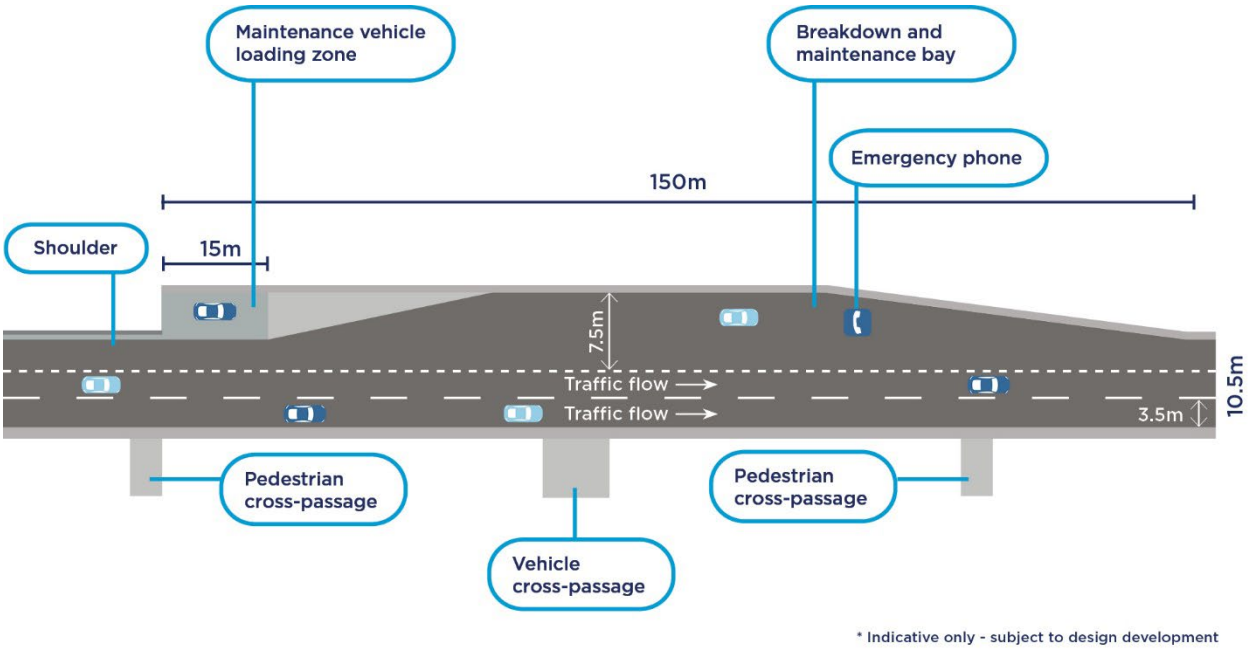

Figure 4-13 Indicative layout of a maintenance and breakdown bay

4.4 Surface work

The tunnels would be connected to the surface road network through portals and surface road upgrades located south of Evans Lookout Road in Blackheath and to the east of Little Hartley.

Dense grade asphalt has been adopted as the preferred road pavement surface type for the surface road works, and would be confirmed during detailed design.

4.4.1 Blackheath surface work

The Blackheath portal would be located to the east of the existing Great Western Highway alignment and south of Evans Lookout Road. Surface works at Blackheath would include tie-in works with the upgraded Great Western Highway as well as on- and off-ramps for all east and westbound movements and for access to Blackheath.

An artist's impression of the Blackheath portals showing an indicative visual concept of the project is presented in Figure 4-14. The requirement for the ventilation outlet presented in the artist's impression is subject to confirmation based on a decision on the preferred ventilation option.

The indicative operational configuration of the surface road network to be delivered as part of the project at Blackheath is shown in orange in Figure 4-15 and Figure 4-16. Figure 4-15 also shows how the project would connect to the Katoomba to Blackheath Upgrade. Operational infrastructure to be delivered as part of the Katoomba to Blackheath Upgrade is shown in blue and has been subject to separate assessment and approvals.

Connectivity at Blackheath is shown in Figure 4-17 and would include:

- mainline carriageway connection for vehicles heading westbound towards Lithgow via the new tunnel
- mainline carriageway connection for vehicles heading eastbound towards Katoomba via the upgraded Great Western Highway
- connection between the tunnel and the existing Great Western Highway at the Blackheath portal area, including:
  - westbound on-ramp into the tunnel from Blackheath town centre
  - eastbound connection from Blackheath onto the mainline carriageway
  - eastbound off-ramp from the tunnel to access Blackheath town centre
  - restricted access connections within the interchange to provide access from the east and the west to the operations facility, located south of Evans Lookout Road
- upgrade of the existing Great Western Highway / Evans Lookout Road intersection.

While active transport would not be permitted within the tunnel, the Katoomba to Blackheath Upgrade would include active transport connections to Blackheath as shown in Figure 4-15.

Figure 4-14 Indicative visual concept of the Blackheath portal looking westbound (subject to design development)

Figure 4-15 Indicative operational configuration at Blackheath

Figure 4-16 Indicative intersection details at Blackheath

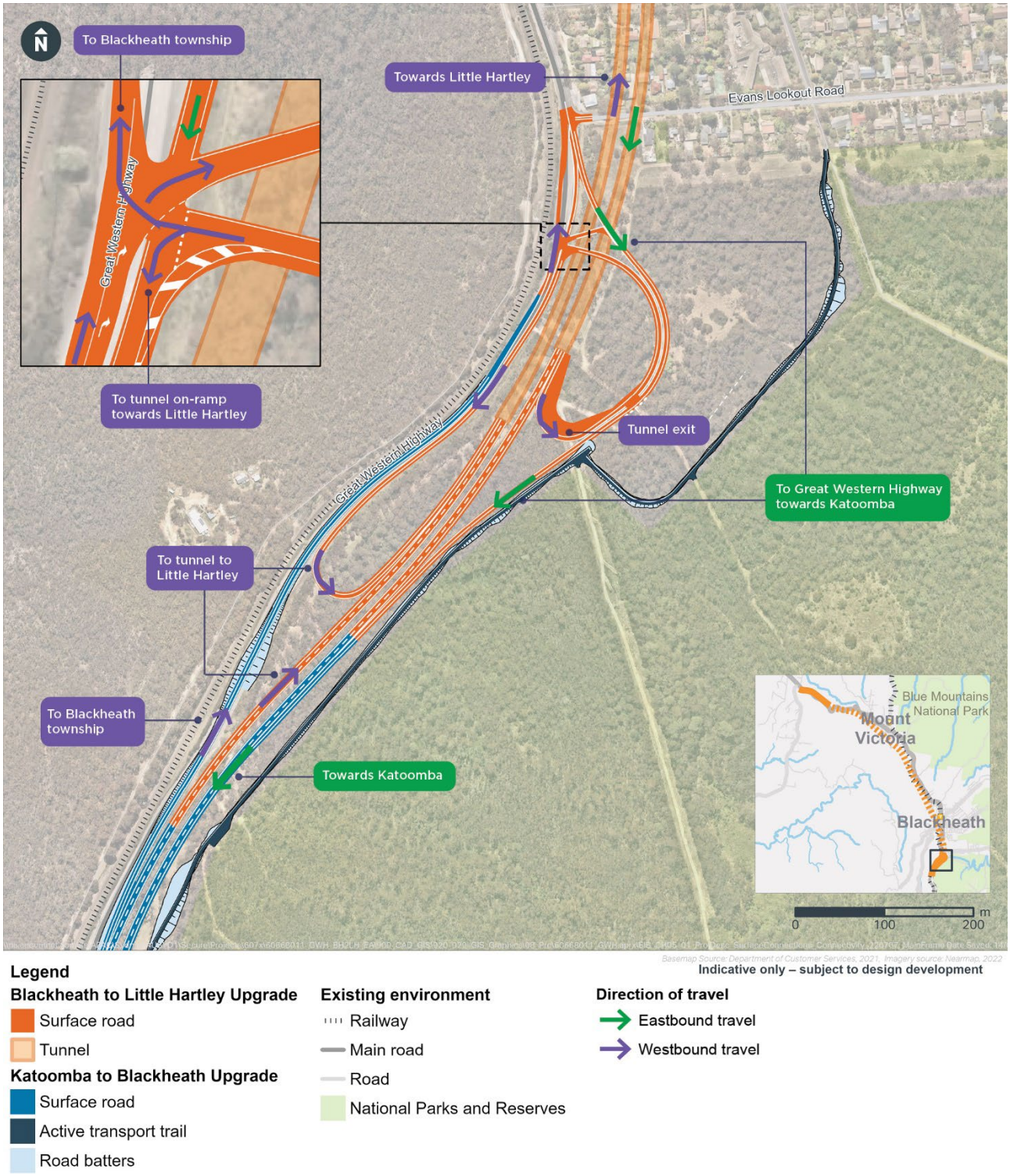

Figure 4-17 Indicative connectivity at Blackheath

4.4.2 Little Hartley surface work

The Little Hartley portal would be located at the base of the western Blue Mountains escarpment below Victoria Pass and southwest of Butlers Creek.

An artist's impression of the Little Hartley portal showing an indicative visual concept of the project is presented in Figure 4-18. The requirement for the ventilation outlet presented in the artist's impression is subject to confirmation based on a decision on the preferred ventilation option.

The indicative operational configuration of the surface road network at Little Hartley is shown in orange in Figure 4-19 and would include:

- mainline carriageway connection for vehicles heading eastbound towards Katoomba via the new tunnel
- mainline carriageway connection for vehicles heading westbound towards Lithgow via the upgraded Great Western Highway
- vehicle access to the tunnel ancillary site from Berghofer's Pass car park for operation and maintenance purposes.

Figure 4-19 also shows how the project would connect to the Little Hartley to Lithgow Upgrade. Operational infrastructure delivered by the Little Hartley to Lithgow Upgrade is shown in purple and has been subject to separate assessment and approvals.

While active transport would not be permitted within the tunnel, the Little Hartley to Lithgow Upgrade would include an active transport connection to Little Hartley as shown in Figure 4-19.

Figure 4-18 Indicative visual concept of the Little Hartley portal looking eastbound (subject to design development)

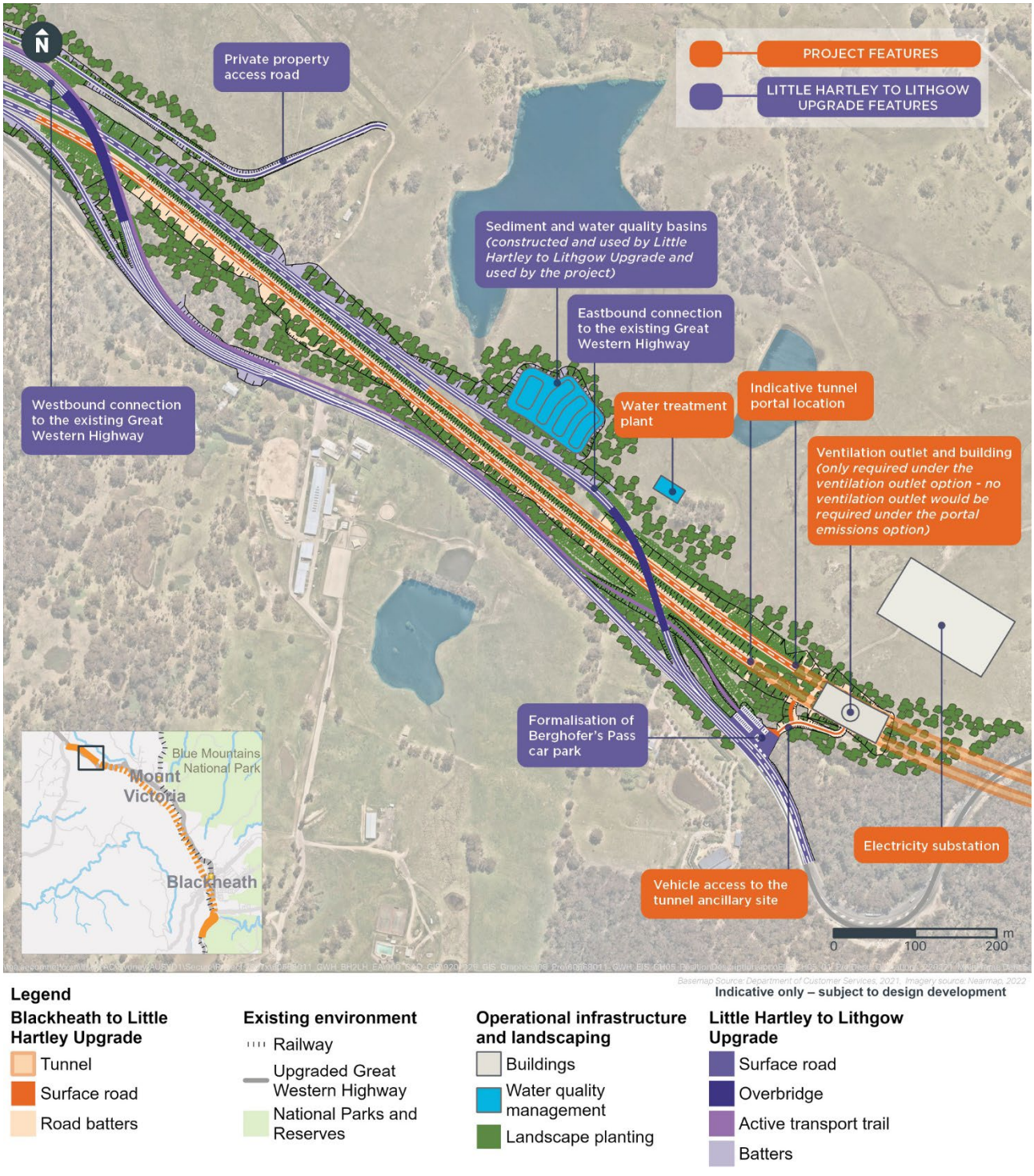

Figure 4-19 Indicative operational configuration at Little Hartley

4.5 Operational infrastructure

Operational infrastructure for the project would include:

- a tunnel operations facility at Blackheath
- in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities
- one of two potential options for tunnel ventilation currently being investigated including:
  - a ventilation building and ventilation outlet at Blackheath and another at Little Hartley (ventilation outlet option); or
  - portal emissions (portal emissions option)
- a new electricity substation at Little Hartley for construction and operational power supply (see Section 4.6.1)
- a new pipeline between Little Hartley and Lithgow is currently the preferred option for construction and operational water supply (see Section 4.6.2)
- water quality infrastructure including water quality basins at Blackheath and Little Hartley, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley
- fire and life safety systems, emergency evacuation and ventilation infrastructure, closed circuit television and other intelligent transport systems
- lighting and signage including VMS and associated infrastructure such as overhead gantries.

This operational infrastructure is described further below. The indicative locations and arrangements of this infrastructure at Blackheath and Little Hartley are shown in Figure 4-15 and Figure 4-19 respectively.

4.5.1 Tunnel operations facility

The tunnel operations facility would be located adjacent to the Blackheath portal, south of Evans Lookout Road as shown in Figure 4-15.

The tunnel operations facility would operate 24 hours a day, seven days a week. It would be staffed to monitor and respond to conditions in the tunnels and on surface road connections.

Access to the tunnel operations facility would be via the eastbound off-ramp from the tunnel that connects to the existing Great Western Highway or via the eastbound connection from Blackheath to the upgraded Great Western Highway. Operational staff parking would be provided adjacent to the tunnel operations facility (see Figure 4-15).

4.5.2 Tunnel ventilation system

Tunnel ventilation systems are designed to prioritise the safety and health of motorists using the tunnel at all times (including during emergency conditions) and so that air inside and outside the tunnel meets the air quality criteria relevant to the project as described in Chapter 9 (Air quality).

The tunnel ventilation system would include:

- jet fans
- one of two potential options for tunnel ventilation design, being ventilation buildings and ventilation outlets (ventilation outlet option), or portal emissions (portal emissions option).

The ventilation system options being considered for the project are shown conceptually in Figure 4-20.

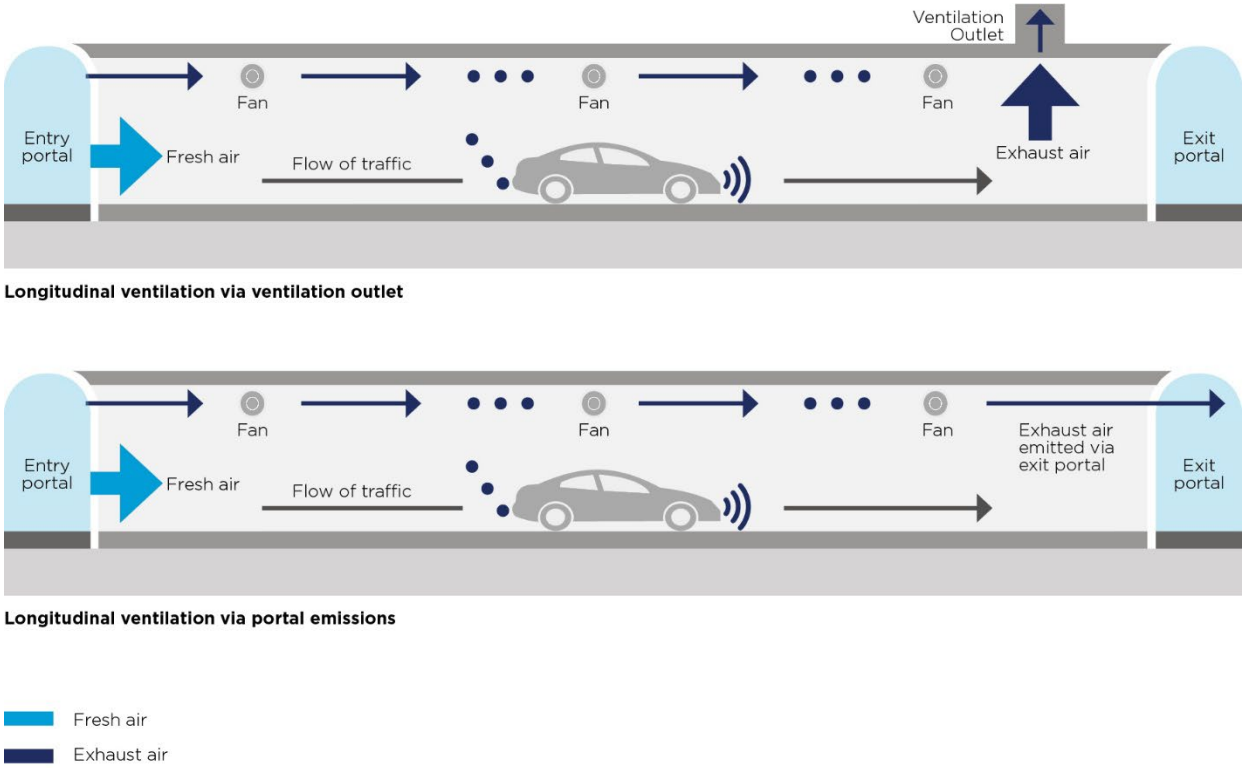

Figure 4-20 Overview of the two ventilation system options being considered for the project

Ventilation facilities

Ventilation infrastructure would be required for the project so that in-tunnel air quality and human health criteria can be achieved, and to manage fire and smoke in the event of an incident in the tunnels. Portal emissions would require the portals to be designed in a manner that potential smoke and tunnel emissions are not re-circulated from one tunnel into the other. Physical separation of the entry and exit portals at each end of the project as shown in Figure 4-14 and Figure 4-18 would minimise the potential for air re-circulation between the tunnels.

Two options for ventilation facilities are being considered for the project and have been assessed in the EIS. A summary of the differences in potential environmental impacts for both ventilation options is provided in Chapter 3 (Project alternatives and options).

A decision on the preferred ventilation option for the project will be made following the outcomes of further environmental assessment and consultation with key stakeholders and the community.

Ventilation outlet option

This option would include a ventilation building and ventilation outlet near the tunnel portals at Blackheath and at Little Hartley (shown in Figure 4-15 and Figure 4-19 respectively).

Each ventilation building would be located underground to minimise visual impacts and integrate with the surrounding landform. Each ventilation building would require an area of around 2,000 square metres. Each ventilation outlet would extend to around 10 metres above finished ground level. An artist's impression showing an indicative visual concept of a ventilation outlet is presented in Figure 4-21.

Figure 4-21 Indicative visual concept of a ventilation outlet (subject to design development)

Depending on the traffic volumes in the tunnels, air would be moved through the tunnels by the movement of vehicles (the piston effect), or jet fans shown in Figure 4-20. If required, jet fans would be used to assist with the movement of tunnel air to maintain acceptable in-tunnel air quality. For this ventilation option, the air pressure inside the exit portals would be maintained below atmospheric pressure to avoid the release of tunnel air from the portals. This would be achieved by having the jet fans located close to the exit portals to move air from the portal into the tunnel and towards the ventilation outlet. The ventilation outlet option would require the use of high-powered radial fans (larger fans several metres in diameter) to draw the air from the tunnel up through the ventilation outlets (for dispersion), resulting in larger operational power requirements than the portal emissions option.

Portal emissions option

For this option tunnel emissions would be dispersed via the tunnel portals. Tunnel portal emissions would mean that underground ventilation buildings and the ventilation outlets are not required to disperse tunnel emissions. Instead, air would be moved through the tunnels by the movement of vehicles (the piston effect), or by jet fans shown in Figure 4-20 and dispersed from each tunnel exit portal. The adoption of portal emissions for the project would be the most sustainable and cost-effective system as it would not require the constant use of high-powered radial fans in ventilation buildings to push tunnel air through ventilation outlets.

Air quality monitoring

Air quality monitoring would be carried out during operation of the project to monitor:

- in-tunnel air quality
- ambient air quality.

Equipment for monitoring tunnel emissions for nitrogen dioxide (NO_2), carbon monoxide (CO), visibility, particulate matter and air speed would be installed at appropriate locations within the tunnels and ventilation outlets, to confirm that the project is operating within the emission limits set for the project. Consultation with the Department of Planning (DPE) and the Environment Protection Authority (EPA) regarding licensing and emissions limits for the project is ongoing.

Ambient air quality monitoring stations would be established to monitor for potential pollutants discharging from the tunnel. Ambient air quality monitoring locations would be confirmed as part of ongoing design development.

4.5.3 Groundwater and drainage management

An operational water treatment plant would be located at Little Hartley as shown in Figure 4-15. The water treatment plant would primarily provide treatment of:

- groundwater collected within the tunnel prior to its reuse or discharge to the environment
- water collected by the tunnel surface drainage system (which, for example, would include treatment of deluge water associated with the fire and life safety system).

Surface drainage for the project would include a combination of sediment and water quality basins, drainage pits and pipes, onsite detention tanks, drains and headwalls with scour protection delivered by the project as well as the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade. This infrastructure at Blackheath and Little Hartley (including which project would deliver this infrastructure) is shown in Figure 4-15 and Figure 4-19 respectively. A range of stormwater treatment options would be considered including gross pollutant traps, bioretention basins, swales and scour protection to minimise potential impacts to water quality during operation and to ensure a neutral or beneficial effect (NorBE) on runoff water quality in the Sydney drinking water catchment.

The project would also include an extension of the Rosedale Creek culvert crossing under the existing Great Western Highway at Little Hartley. The Lithgow to Little Hartley Upgrade will construct a portion of this culvert as part of those proposed works, including realignment of the existing culvert on the existing Great Western Highway. The remainder of the culvert will be constructed as part of this project.

4.5.4 Fire and life safety

The fire and life safety system would be designed to protect life and assets, control incidents and facilitate intervention by emergency services. The tunnel would include the following fire and life safety systems compliant with Australian Standard AS 4825:2011 Tunnel Fire Safety:

- fire and incident detection equipment, a closed circuit television monitoring system and automatic incident detection systems
- communications systems, public address system and radio re-broadcast, break-in system and emergency telephones
- fire suppression systems, including a deluge water suppression system, a fire hydrant system, emergency equipment points containing hydrants, water storage tanks, fire hose reels and fire extinguishers
- emergency lighting, smoke management and power systems
- tunnel emergency access including pedestrian cross passages between the mainline tunnels to provide safe access or exit in the event of a fire or other emergency
- tunnel closure system.

Operational ancillary facilities would be located and designed taking into account Planning for Bush Fire Protection (NSW Rural Fire Service, 2019) and AS3959-2018 guidelines which prescribe minimum setback distances for infrastructure near bushfire prone land

A decision on whether vehicles carrying dangerous goods would be allowed to travel through the tunnel would be made during ongoing design development in consultation with relevant stakeholders. The capacity of fire and life safety measures to manage potential dangerous good incidents would be confirmed at that time.

Consultation has occurred and would continue with emergency services regarding fire and life safety design, which would be considered during ongoing design development for the project.

4.5.5 Lighting

Lighting would be provided within the tunnel and along upgraded surface roads consistent with:

- Australian/New Zealand Standard AS/NZS 1158.5:2007: Lighting for roads and public spaces
- International Standard CIE 88-2004: International Commission of Illumination Publication Guide for the Lighting of Road Tunnels and Underpasses
- Australian Standard AS 4282-1977 Control of Obtrusive Effects of Outdoor Lighting.

Emergency lighting would also be provided in the tunnel including fixed direction exit signage and illuminated signage.

Lighting would be designed in accordance with the urban design principles outlined in Table 4-3. It would be installed for safety and security, and to minimise the potential for light spill and nuisance impacts.

4.5.6 Signage, closed circuit television and other traffic management systems

Traffic, locational, directional, warning and VMS would be required as part of the project in accordance with the applicable Australian Standards and guidelines published by Austroads and Transport. Project signage would be highly visible and would provide clear and unambiguous direction to motorists.

The project would include intelligent transport systems technology and traffic control infrastructure on the surface roads leading up to the tunnels including:

- VMS, including associated infrastructure such as gantries (an example of an overhead VMS is shown in Figure 4-22)
- lane use management systems
- variable speed limit signs
- a closed circuit television system and automatic incident detection systems
- motorists' emergency telephone system
- vehicle enforcement systems
- driver advisory signs and traveller information
- over height detection and response system.

To provide sufficient notice for drivers of any change in conditions or incidents, VMS and other infrastructure is often required around one kilometre from the tunnel. Indicative locations for VMS and associated infrastructure such as gantries that may be required are shown in Figure 4-23. The locations for this infrastructure would be confirmed during design development. Where this infrastructure is required beyond the construction footprint of the project (i.e. to the east and west of the project), the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade projects have made provision for the installation of this infrastructure within the road reserve.

Figure 4-22 Example image of an overhead VMS gantry

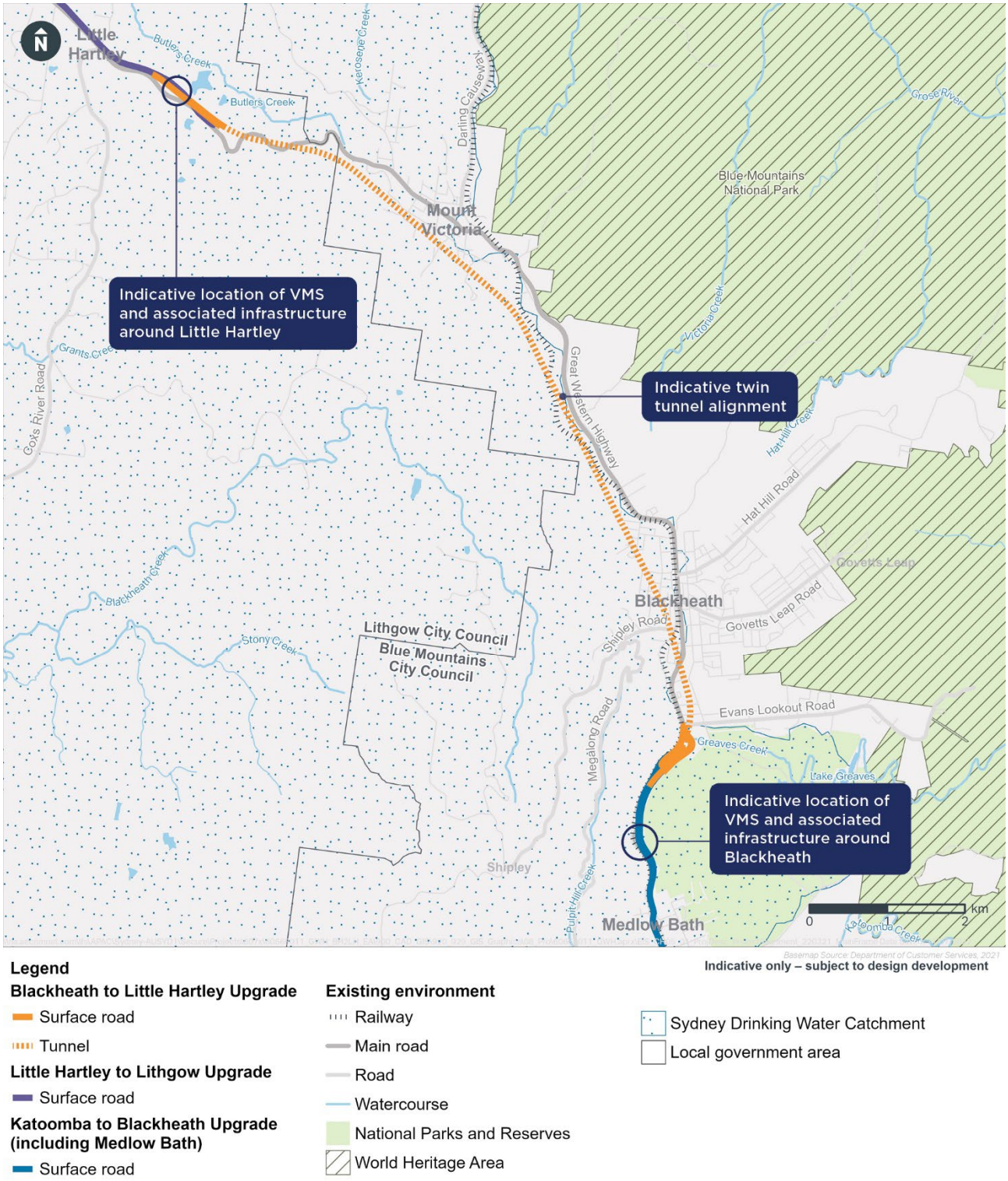

Figure 4-23 Indicative location of VMS and associated infrastructure

4.6 Utilities

The project would require the following utility works:

- installation of new utilities for the project, including communications, electricity and water
- connection to existing electricity, water and wastewater/ sewer utilities
- relocation, adjustment and/or protection of existing utilities, particularly within and around surface connections and surface road upgrades.

Utility works required for the project are further described in the sections below.

The location of existing utilities and any changes required would be confirmed during design development in consultation with the relevant utility provider.

4.6.1 Electricity

Electricity required to power the tunnel ventilation, lighting, signalling and communication systems would be supplied to the project from the existing electricity network via:

- a new aboveground substation at Little Hartley (see Figure 4-19)
- new underground substations along the length of the tunnels at around 1.5 kilometre intervals.

The aboveground substation at Little Hartley would connect to the existing electricity supply network and would be around 10 metres in height with a footprint of around 3,600 square metres.

Operational power requirements for the project are summarised in Chapter 21 (Resource use and waste management).

There is an existing 66kV Sydney Trains transmission line crossing the proposed Blackheath portal infrastructure. To avoid interference with construction machinery and activities, around one kilometre of this transmission line would be permanently adjusted as part of the project. This would also ensure access to this utility for Sydney Trains' maintenance.

4.6.2 Water

The project would be connected to the mains water supply network to provide water for essential services. Mains water would be used in cases where treated groundwater and rainwater harvesting are of insufficient quality or quantity to fully meet project needs.

During operation, water would be required for:

- cleaning and maintenance
- testing and operation of the tunnel fire suppression systems (which form part of the fire and life safety system)
- tunnel operational facilities including worker facilities
- landscape irrigation.

Operational water supply at Blackheath would be serviced via the existing network with upgrades to existing infrastructure carried out as required. The mains water supply network connection requirements, including connection location and design, would be determined in consultation with relevant local water supplier. Construction and operational water balances for the project are provided in Chapter 14 (Surface water and flooding).

Water to supply the tunnel hydrant and fire suppression systems would be stored with other operational ancillary infrastructure at Blackheath and Little Hartley (refer to Section 4.5). Operational water supply requirements are outlined in Chapter 21 (Resource use and waste management).

The currently preferred option for permanent water supply at Little Hartley would be via a water supply pipeline. This option is subject to design development in consultation with Lithgow City Council and would include around 14 kilometres of underground pipeline infrastructure with a corridor width of around 10 metres. The pipeline would primarily follow the alignment of the Great Western Highway and be located within the existing and/or new road reserve where possible.

The indicative alignment for the water supply pipeline is shown in Figure 4-24.

Key features of the water supply pipeline would include:

- installation of an underground pipeline between the Lithgow City Council potable water supply network at South Bowenfels and Little Hartley
- associated infrastructure which may include pumping stations and pressure valves
- connection of the pipeline to the Little Hartley tunnel supply point.

Investigations are ongoing to confirm the water supply option for the project and other options being investigated include the use of groundwater.

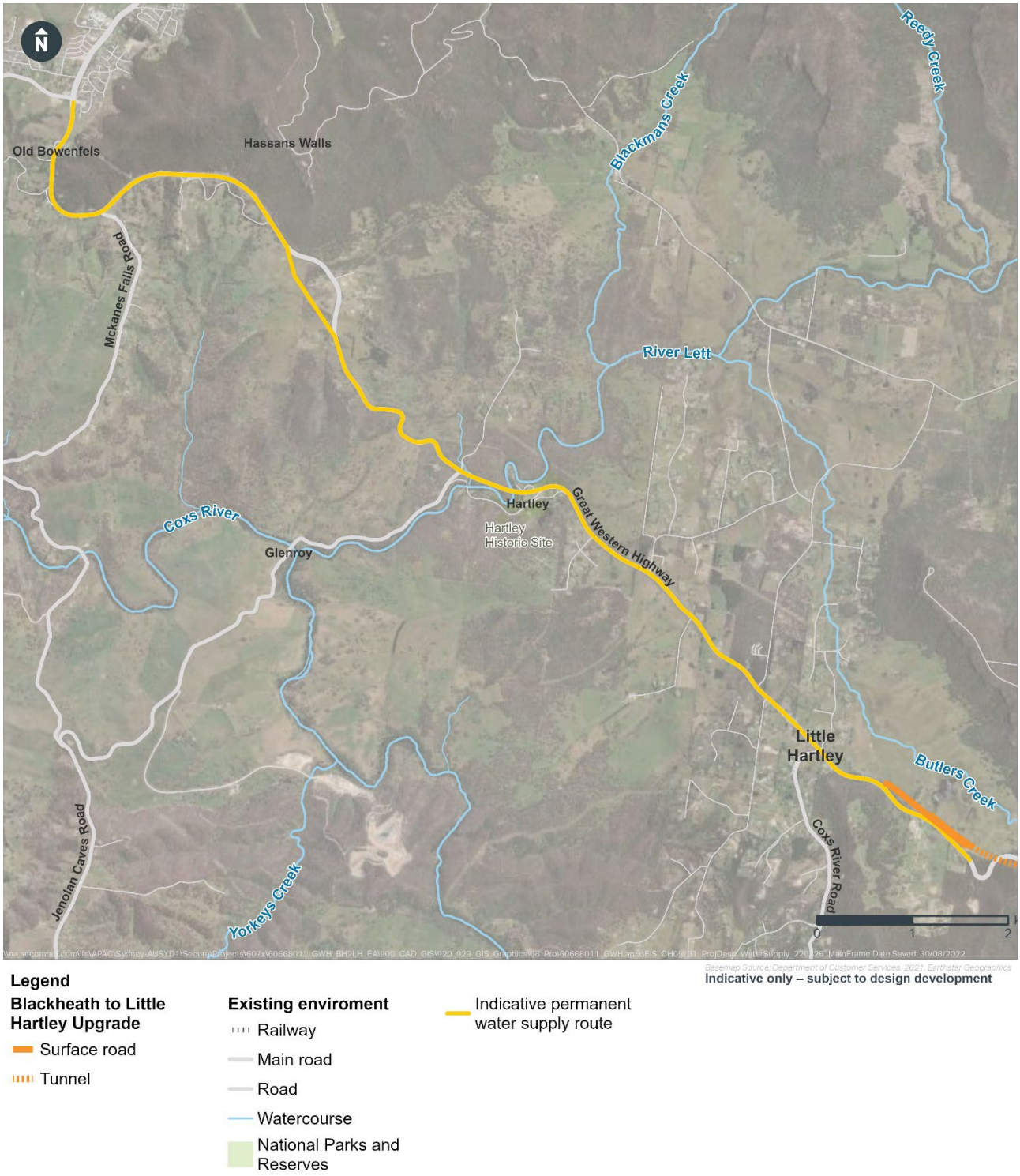

Figure 4-24 Indicative permanent water supply pipeline route

4.7 Project design uncertainties

The description of the project presented in this chapter is indicative and based on the current level of design. The project would continue to be refined as part of ongoing design development and where relevant, in response to feedback from the community and other stakeholders which may further minimise potential impacts.

Some flexibility has been provided in the design:

- so that proposed performance and technical requirements can be achieved
- to validate the feasibility and potential construction methodologies and techniques
- to identify key risks, constraints and potential environmental impacts and propose appropriate mitigation measures during construction and operation.

There remain some design uncertainties relating to the technical requirements of construction and operation of the project that would be resolved during further design development. A summary of the uncertainties that have the potential to impact on the environment, and how these would be resolved, is provided in Table 4-4.

Any changes to the project would be reviewed for consistency with the assessment contained in this EIS including relevant environmental mitigation measures, performance outcomes and any future conditions of approval.

Table 4-4 Resolution of project uncertainties

Project uncertainty	Proposed resolution	Timing	Where discussed
Tunnel ventilation	A decision on the preferred tunnel ventilation option for the project (ventilation outlet option or portal emissions option) would be made following the outcomes of further environmental assessment and consultation with key stakeholders and the community.	Design	Section 4.5.2
Configuration and detailed design of operational infrastructure	Refinement of the design and configuration for the ancillary infrastructure would be confirmed during ongoing design development. The design would be refined in accordance with performance requirements for elements such as the ventilation facilities, the urban design objectives and principles developed for the project, and the outcomes of community and stakeholder consultation.	Design	Section 4.5.1

Project uncertainty	Proposed resolution	Timing	Where discussed
Construction method and staging	Final construction methods (including selection of TBM type) and staging plans including road possessions would be prepared by the construction contractor, once appointed. The staging plans would be based on further design development and refinement of the construction method. The plans would describe how construction areas associated with road works would be established to safely maintain traffic flows in areas of reduced traffic capacity, and to minimise delays to motorists, public transport, pedestrians and cyclists.	Construction	Chapter 5 (Construction) Chapter 8 (Transport and traffic)
Off-site spoil reuse locations	Off-site spoil reuse locations would continue to be investigated during ongoing design development and confirmed by the construction contractor, once appointed. Spoil reuse locations would be located to the west of the project, avoiding the need to haul spoil eastbound from Little Hartley through the Blue Mountains.	Design	Chapter 5 (Construction) Chapter 21 (Resource use and waste management)
Requirement for the mid-tunnel access shaft and Soldiers Pinch construction footprint	Ongoing construction planning would confirm whether the mid-tunnel access shaft and Soldiers Pinch construction footprint is required to support construction of the project. Subject to managing construction-related issues, this infrastructure could be removed.	Construction	Chapter 5 (Construction)
Construction and operational water supply at Little Hartley	Ongoing investigation would confirm the construction and operational water supply for the project in consultation with relevant stakeholders.	Design	Chapter 4 (Project description) Chapter 5 (Construction)
Predicted groundwater drawdown impacts at the Blackheath portal	Additional groundwater data and further update of the numerical groundwater model for the project would occur to confirm potential groundwater impacts due to the project. Where potential impacts are different to those presented in the EIS, further environmental mitigation measures and/or design responses will be identified and applied where feasible and reasonable.	Design	Chapter 12 (Biodiversity) Chapter 13 (Groundwater) Chapter 14 (Surface water and flooding)