



Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Chapter 5

Project description

5 Project description

This chapter describes the project, including the route alignment, project footprint, main project elements, operational facilities and environmental controls.

The project design presented in this environmental impact assessment would continue to be refined during further design development, and where relevant, respond to feedback from the community and other stakeholders during public display.

The Secretary's environmental assessment requirements as they relate to the project description, and where in the environmental impact statement these have been addressed, are detailed in Table 5-1. Environmental controls to manage potential impacts are discussed in Section 5.2.11 and Section 5.3.8. Further environmental management measures are provided in Appendix Y (Compilation of environmental management measures).

Table 5-1 Secretary's environmental assessment requirements – Project Description

Secretary's requirement	Where addressed in EIS
Environmental impact statement	
1. The EIS must include, but not necessarily be limited to, the following: <ul style="list-style-type: none"> b) a description of the project and all components and activities (including ancillary components and activities) required to construct and operate it, including: <ul style="list-style-type: none"> – the proposed route; 	Section 5.1, Section 5.2 and Section 5.3 describe the proposed route.
<ul style="list-style-type: none"> – design of the tunnels, interchanges (inclusive of tunnel portals and entry and exit ramps), road user, pedestrian and cyclist facilities, and lighting; 	Section 5.1, Section 5.2 and Section 5.3 describe the design of the tunnels, including tunnel-to-tunnel connections and entry and exit ramps as well as road user, pedestrian and cyclist facilities, lighting and other operational ancillary infrastructure.
<ul style="list-style-type: none"> – surface road upgrade works, including road widening, intersection treatment and grade separation works, property access, parking, pedestrian and cyclist facilities (including appropriate locations for overbridges) and public transport facilities; 	Section 5.2 and Section 5.3 describe the surface road works and surface connections as well as pedestrian, cyclist and public transport facilities. Chapter 6 (Construction work), Section 6.5 describes the construction method for surface road works and associated infrastructure, including bridgeworks, active transport infrastructure, lighting and other operational ancillary infrastructure. Chapter 8 (Construction traffic and transport), Chapter 9 (Operational traffic and transport) and Chapter 20 (Land use and property) discuss property access.
<ul style="list-style-type: none"> – ancillary infrastructure and operational facilities, such as operational and maintenance facilities, ventilation structures and systems, and fire and emergency services and infrastructure for the proposal, including (if required) 	Section 5.2.7 and Section 5.3.4 describe operational facilities and ancillary infrastructure. Chapter 6 (Construction work), Section 6.8 describes the temporary construction support sites required to construct the project, while Section 6.4.6 outlines detail on the construction

Secretary's requirement	Where addressed in EIS
additional infrastructure (such as tolling infrastructure);	of operational facilities and ancillary infrastructure.
– location and operational requirements of construction ancillary facilities and access;	Section 5.2 and Section 5.3 describe operational facilities and ancillary infrastructure. Chapter 6 (Construction work), Section 6.8.2 describes the location and hours of construction at each of the temporary construction support sites and their respective access arrangements.
– land use changes as a result of the proposal and the acquisition of privately owned, Council and Crown lands, and impacts to Council and Crown lands; and	Chapter 20 (Land use and property), Section 20.4 discusses land use changes (including acquisition and impacts to local council and Crown lands).
– the relationship and/or integration of the project with existing and proposed public and freight transport services;	Chapter 3 (Strategic context and project need) and Chapter 8 (Construction traffic and transport) discuss the relationship and/or integration of the project with existing public and freight transport services. Additional information about the relationship and/or integration of the project with existing and proposed public and freight transport services is provided in Chapter 9 (Operational traffic and transport) and Chapter 27 (Cumulative impacts).

5.1 Project overview

The Beaches Link and Gore Hill Freeway Connection project (the project) forms a core component of the broader Western Harbour Tunnel and Beaches Link program of works. The program of works would unlock substantial travel time savings and journey time reliability for freight services, public transport and other road users travelling between the Northern Beaches region and strategic centres across Sydney. The Western Harbour Tunnel and Warringah Freeway Upgrade project is subject to separate environmental assessment and approval.

The project would deliver new strategic road links between the Northern Beaches and the existing motorway network near Artarmon and North Sydney, bypassing the congested Military Road/Spit Road and Warringah Road/Eastern Valley Way corridors. The project would provide links to both the Lane Cove Tunnel and Warringah Freeway, improving north–south and east–west connectivity for the Northern Beaches region. The project would also include the widening of the Wakehurst Parkway between Killarney Heights and Frenchs Forest to improve access to this strategic centre and areas further north.

A whole alignment overview of the Beaches Link and Gore Hill Freeway Connection project is shown in Figure 1-2 of Chapter 1 (Introduction).

The project is shown in Figure 5-1 to Figure 5-9 and would comprise:

- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights
- An upgrade of the Wakehurst Parkway to two lanes in each direction between the tunnel portals at Killarney Heights and the intersection with Warringah Road at Frenchs Forest linking to the Northern Beaches Hospital road upgrade project
- A new access road between the Burnt Bridge Creek Deviation and Sydney Road at Balgowlah, providing direct connectivity to Beaches Link from key catchments along Sydney Road east

and west, improving local network performance and providing direct local access to the new and improved open space and recreation facilities at Balgowlah

- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon.

The Gore Hill Freeway Connection may be staged and delivered separately to the Beaches Link component of the project if this yields improved construction efficiency and reduced disruption along the Gore Hill Freeway and Warringah Freeway corridors. For this reason, the Gore Hill Freeway Connection has been assessed and designed as a potentially separable component of the project.

For the purpose of the assessment of environmental impacts of the project, impacts from the project as a whole (ie the Beaches Link and Gore Hill Freeway Connection) have been identified and assessed. However, where possible, these impacts have been separated to identify impacts that would result from each component of the project. To account for possible staging, identification is made of those impacts that would result from each component of the project and the applicable environmental management measures.

Similarly, should the construction timeframes for Beaches Link be advanced, although unlikely, there may be an opportunity to operate it before the Western Harbour Tunnel is operational. Under this scenario, the Warringah Freeway Upgrade would need to be constructed and operational to facilitate Beaches Link connections to the Warringah Freeway at Cammeray. As such, for the purpose of assessing potential operational impacts of the project, the Warringah Freeway Upgrade (without Western Harbour Tunnel) is assumed to be delivered.

Project elements that would be constructed to safeguard delivery of tunnel-to-tunnel connections for the Western Harbour Tunnel and Warringah Freeway Upgrade project to the Beaches Link mainline tunnel (irrespective of construction program) are described in Section 5.2.4.

5.1.1 Beaches Link

Key features of the Beaches Link component of the project are summarised in Table 5-2 and detailed in the following sections. These key features are shown in Figure 5-1 to Figure 5-9.

Table 5-2 Key features of the Beaches Link component

Key project component	Summary
Tunnels	<p>The tunnels would comprise a mainline tunnel (about 5.6 kilometres in length) in each direction, together with entry and exit ramp tunnels to connections at the surface.</p> <ul style="list-style-type: none"> • The mainline tunnels comprise three lanes of traffic in each direction connecting Cammeray to ramp tunnels under Naremburn, Northbridge and Seaforth. <p>Each ramp tunnel comprises twin two lane tunnels:</p> <ul style="list-style-type: none"> • Eastbound and westbound connections between the mainline tunnel under Seaforth and the surface at Burnt Bridge Creek Deviation, Balgowlah (about 1.2 kilometres in length) • Northbound and southbound connections between the mainline tunnel under Seaforth and the surface at the Wakehurst Parkway, Killarney Heights (about 2.8 kilometres in length) • Eastbound and westbound connections between the mainline tunnel under Northbridge and the surface at the Gore Hill Freeway, Artarmon (about 2.1 kilometres in length).

Key project component	Summary
	<p>The tunnels comprise mostly driven tunnels, except for the crossing of Middle Harbour between Northbridge and Seaforth which would be twin, three lane immersed tube tunnels.</p>
<p>Tunnel-to-tunnel connections</p>	<p>The Beaches Link mainline tunnels would connect to the single-lane stub tunnels constructed beneath Cammeray as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project, providing direct connections to and from the proposed Western Harbour Tunnel and onward to the M4-M5 Link at Rozelle.</p>
<p>Surface connections and road works</p>	<p>Surface road works would be required to connect the Beaches Link mainline and ramp tunnels to surface roads and integrate these new connections with the surface road network.</p> <p>The following surface connections would be provided to the Warringah Freeway at Cammeray:</p> <ul style="list-style-type: none"> • A connection from the southbound mainline tunnel to the Warringah Freeway at Cammeray would provide access to the North Sydney area, the Sydney Harbour Bridge and the Cahill Expressway (via the Warringah Freeway) • A connection from the Warringah Freeway at Cammeray to the northbound mainline tunnel would provide access from the North Sydney area and the Sydney Harbour Bridge (via the Warringah Freeway). <p>Some elements of the Beaches Link connection to the Warringah Freeway would be delivered by the Western Harbour Tunnel and Warringah Freeway Upgrade project to improve construction efficiency and reduce ongoing construction in the Warringah Freeway corridor (refer to Chapter 6 (Construction work)).</p> <p>The following surface connections would be provided at the Gore Hill Freeway at Artarmon:</p> <ul style="list-style-type: none"> • An on ramp from the Gore Hill Freeway would provide connectivity from the Lane Cove Tunnel, Reserve Road and Epping Road/Longueville Road to the Beaches Link northbound mainline tunnel under Northbridge • An off ramp from the southbound mainline tunnel under Northbridge would provide connectivity to both the Lane Cove Tunnel and Reserve Road. <p>The following surface connections and road works would be provided at the Burnt Bridge Creek Deviation at Balgowlah:</p> <ul style="list-style-type: none"> • Upgrade and integration work along and around Burnt Bridge Creek Deviation and Sydney Road • A new access road between the Burnt Bridge Creek Deviation and Sydney Road at Balgowlah, to provide access to the Beaches Link and to the new and improved open space and recreation facilities • A connection from the eastbound ramp tunnel to Burnt Bridge Creek Deviation would provide access on to northbound Condamine Street, and to eastbound Sydney Road (via the new access road) • A connection from southbound Burnt Bridge Creek Deviation to the westbound ramp tunnel would provide access from southbound Condamine Street, and from westbound Sydney Road (via the new access road).

Key project component	Summary
	<p>The following surface connections and road works would be provided to the Wakehurst Parkway at Seaforth, Killarney Heights, and Frenchs Forest:</p> <ul style="list-style-type: none"> • An on ramp would connect from the Wakehurst Parkway at Killarney Heights to the southbound mainline tunnel under Seaforth • An off ramp would connect from the northbound mainline tunnel to the Wakehurst Parkway at Killarney Heights • Upgrade and integration work along the Wakehurst Parkway, at Killarney Heights and Frenchs Forest, through to Frenchs Forest Road East and Frenchs Forest Road West.
Operational facilities and ancillary infrastructure	<p>Operational facilities and ancillary infrastructure provided by the project would include:</p> <ul style="list-style-type: none"> • Motorway facilities and ventilation outlets, and ventilation tunnels to connect traffic tunnels to motorway facilities, at: <ul style="list-style-type: none"> - Warringah Freeway, Cammeray. Ventilation tunnels would connect the southbound mainline and ramp tunnels to the ventilation outlet at Cammeray. The ventilation outlet at the Warringah Freeway would be constructed as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project, with fitout and the ventilation tunnel connection of this structure completed by the project (refer to Chapter 6 (Construction work)) - Gore Hill Freeway, Artarmon. Ventilation tunnels would connect the westbound ramp tunnels to the ventilation outlet at Gore Hill Freeway at Artarmon - Burnt Bridge Creek Deviation, Balgowlah. Ventilation tunnels would connect the eastbound ramp tunnels to the ventilation outlet at Burnt Bridge Creek Deviation at Balgowlah - Wakehurst Parkway, Killarney Heights. Ventilation tunnels would not be required at the ventilation outlet at Killarney Heights as the outlet would be located above the tunnel portal • A motorway control centre at the Gore Hill Freeway • Tunnel support facilities at the Gore Hill Freeway and the Wakehurst Parkway, Frenchs Forest • Groundwater and tunnel drainage management and treatment systems, including a wastewater treatment plant at the Gore Hill Freeway, Artarmon • Signage, tolling, fire and life safety systems, lighting, emergency evacuation and emergency smoke extraction infrastructure • Closed Circuit Television (CCTV) and other traffic management systems.
Public and active transport infrastructure	<p>The project would include the following public and active transport infrastructure:</p> <ul style="list-style-type: none"> • The southbound mainline connection at the Warringah Freeway has been designed to integrate with the Warringah Freeway dedicated bus lane, providing high quality bus access to North Sydney and the Sydney CBD • The northbound mainline tunnel connection at the Warringah Freeway has been designed to provide direct access from Berry Street,

Key project component	Summary
	<p>providing high quality access for buses travelling northbound from the North Sydney CBD and the new Victoria Cross Metro Station at North Sydney</p> <ul style="list-style-type: none"> • The mainline and ramp tunnels and surface connections have been designed to allow use by buses, including double decker bus services • New and upgraded public and active transport infrastructure would be provided along the Burnt Bridge Creek Deviation and the new access road at Balgowlah • A new shared user path along the Wakehurst Parkway from Seaforth to Frenchs Forest, improving pedestrian and cyclist connectivity between these two areas, and to recreational areas including the Garigal National Park and Manly Dam Reserve • New shared user paths to service the new and improved open space and recreation facilities at Balgowlah. <p>Pedestrians and cyclists would be excluded from the mainline and ramp tunnels.</p>
Other project features	<ul style="list-style-type: none"> • New and improved open space and recreation facilities at Balgowlah • Landscape treatments • Environmental controls, surface drainage, utilities connections and modifications.

5.1.2 Gore Hill Freeway Connection

Key features of the Gore Hill Freeway Connection component of the project are summarised in Table 5-3 and detailed in the following sections. These key features are shown in Figure 5-2.

Table 5-3 Key features of the Gore Hill Freeway Connection component

Key project component	Summary
Surface road works	<p>The main surface works would comprise:</p> <ul style="list-style-type: none"> • Upgrade and reconfiguration of the Gore Hill Freeway between the T1 North Shore and Western Line and T9 Northern Line overpass and the Pacific Highway overpass • Modifications to the Reserve Road and Hampden Road bridges • Widening of Reserve Road between the Gore Hill Freeway and south of Dickson Avenue • Modification of the Dickson Avenue/Reserve Road intersection to allow for the Beaches Link off ramp. <p>Minor changes to local roads would include:</p> <ul style="list-style-type: none"> • Conversion of Dickson Avenue to the east of Reserve Road to a cul-de-sac • Conversion of Punch Street to a cul-de-sac, and removal of the existing connection between Punch Street and Lambs Road • Modifications to the traffic lights of Reserve Road, Artarmon • Upgrade and inclusion of traffic lights at the Dickson Avenue/Pacific Highway intersection and linemarking along Dickson Avenue west of Reserve Road

Key project component	Summary
	<ul style="list-style-type: none"> • Conversion of the existing eastbound T2 transit lane from the Lane Cove Tunnel to a general traffic link to Beaches Link eastbound and Reserve Road.
Public and active transport infrastructure	The existing shared user path along the southern side of the Gore Hill Freeway would be replaced in areas directly disturbed by the project and connect with the existing active transport network.
Operational ancillary infrastructure	Operational ancillary infrastructure would include: <ul style="list-style-type: none"> • Signage and lighting • CCTV and other traffic management systems.
Other project features	The project would also include: <ul style="list-style-type: none"> • Landscape treatments • Environmental controls, surface drainage, utilities connections and modifications.

5.1.3 Preparatory investigations and surveys

The project does not include preliminary works, including surveys, test drilling, test excavations, geotechnical or contamination investigations or other tests, sampling or investigations carried out for the purposes of the reference design or assessment of the project.

These works are currently permitted under separate existing approvals and/or are subject to separate assessment and determination in accordance with *Environmental Planning and Assessment Act 1979*. However, investigation and survey works would continue as part of further design development for the project following approval.

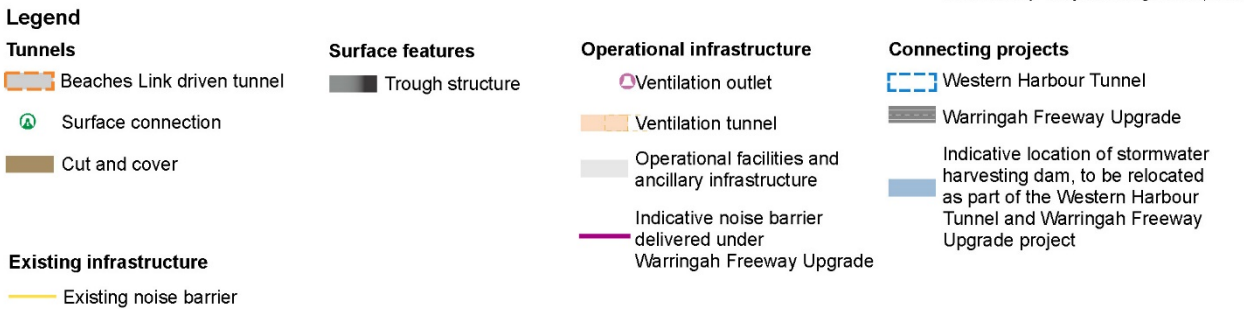
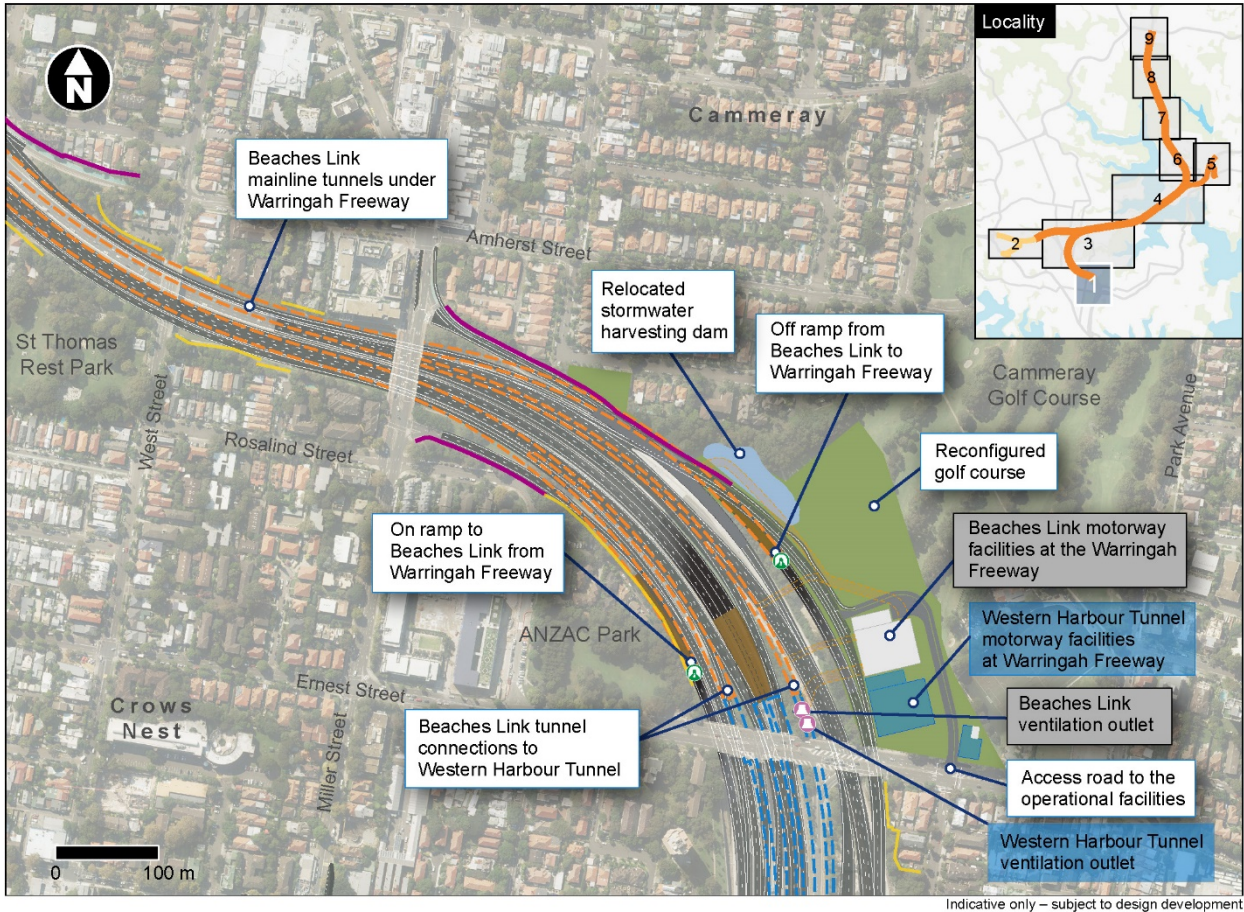
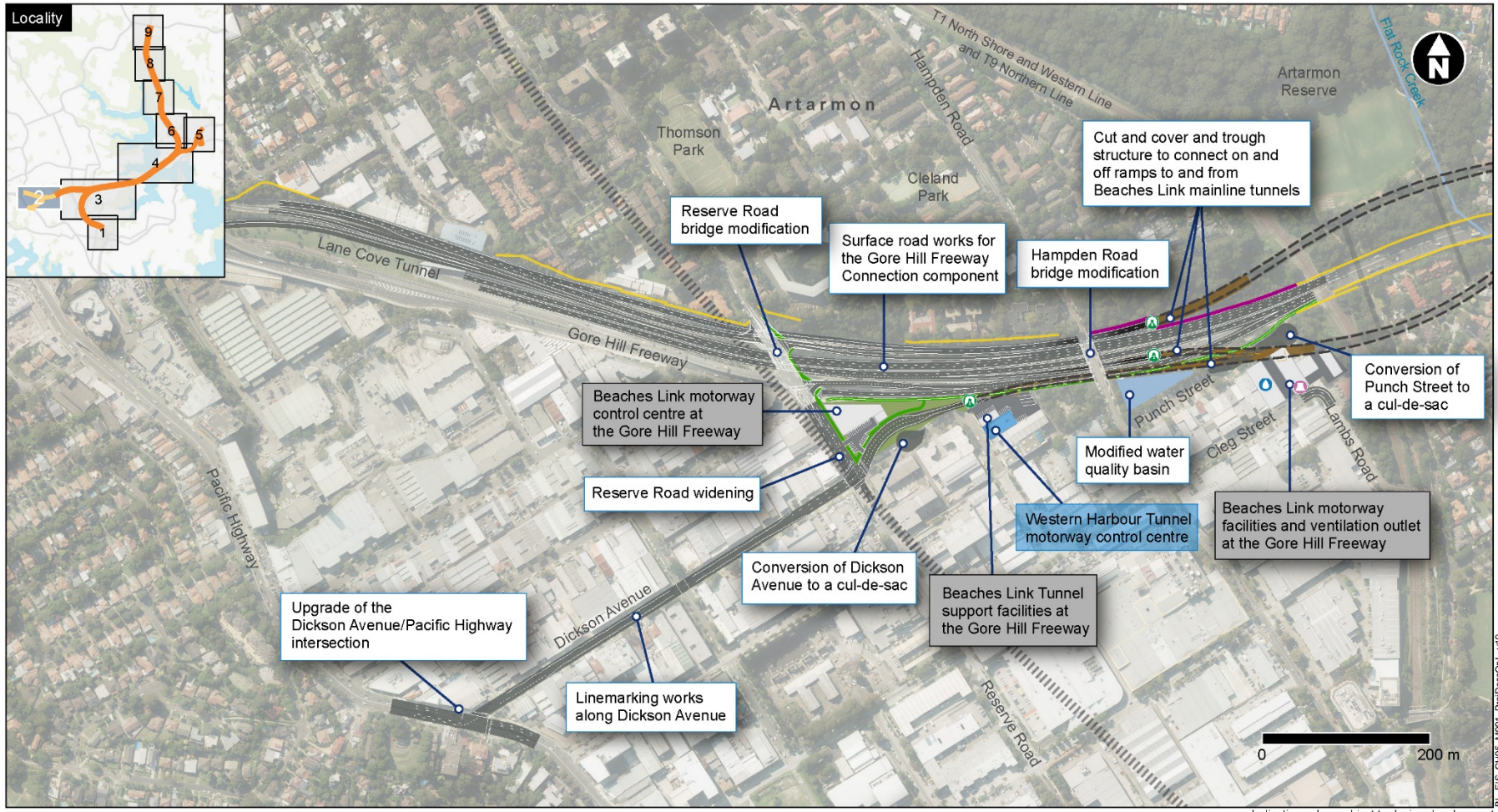


Figure 5-1 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 1)



Indicative only – subject to design development

Legend

Tunnels

- Beaches Link driven tunnel
- Surface connections
- Cut and cover

Surface features

- Surface road
- Pedestrian / active transport links
- Trough structure

Operational facilities

- Ventilation outlet
- Wastewater treatment plant
- Ventilation tunnel
- Operational facilities and ancillary infrastructure
- Indicative new noise barrier

Existing infrastructure

- Existing noise barrier
- Sydney Metro City & Southwest – Chatswood to Sydenham (under construction)

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Figure 5-2 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 2)



Legend

Tunnels

Beaches Link driven tunnel

Operational infrastructure

Maintenance and emergency breakdown bays

Indicative noise barrier delivered under Warringah Freeway Upgrade

Connecting projects

Warringah Freeway Upgrade

Existing infrastructure

Existing noise barrier

Flat Rock Creek in underground Box culvert

Figure 5-3 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 3)



Indicative only – subject to design development

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Legend

Tunnels




-  Beaches Link driven tunnel
-  Immersed tube tunnel
-  Maintenance and emergency breakdown bays

Figure 5-4 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 4)



Indicative only – subject to design development

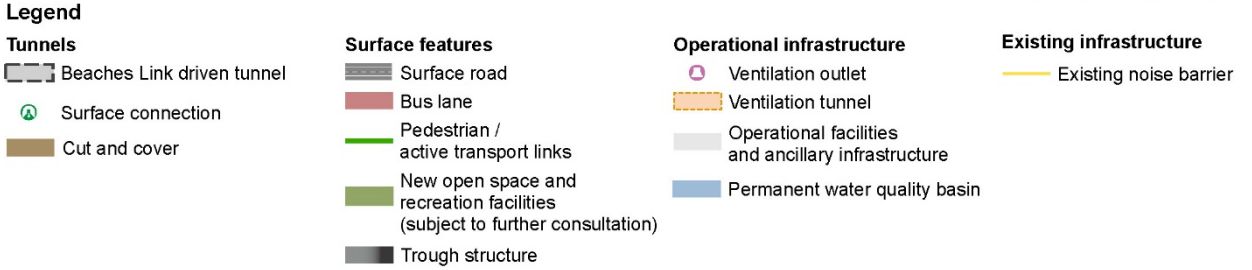
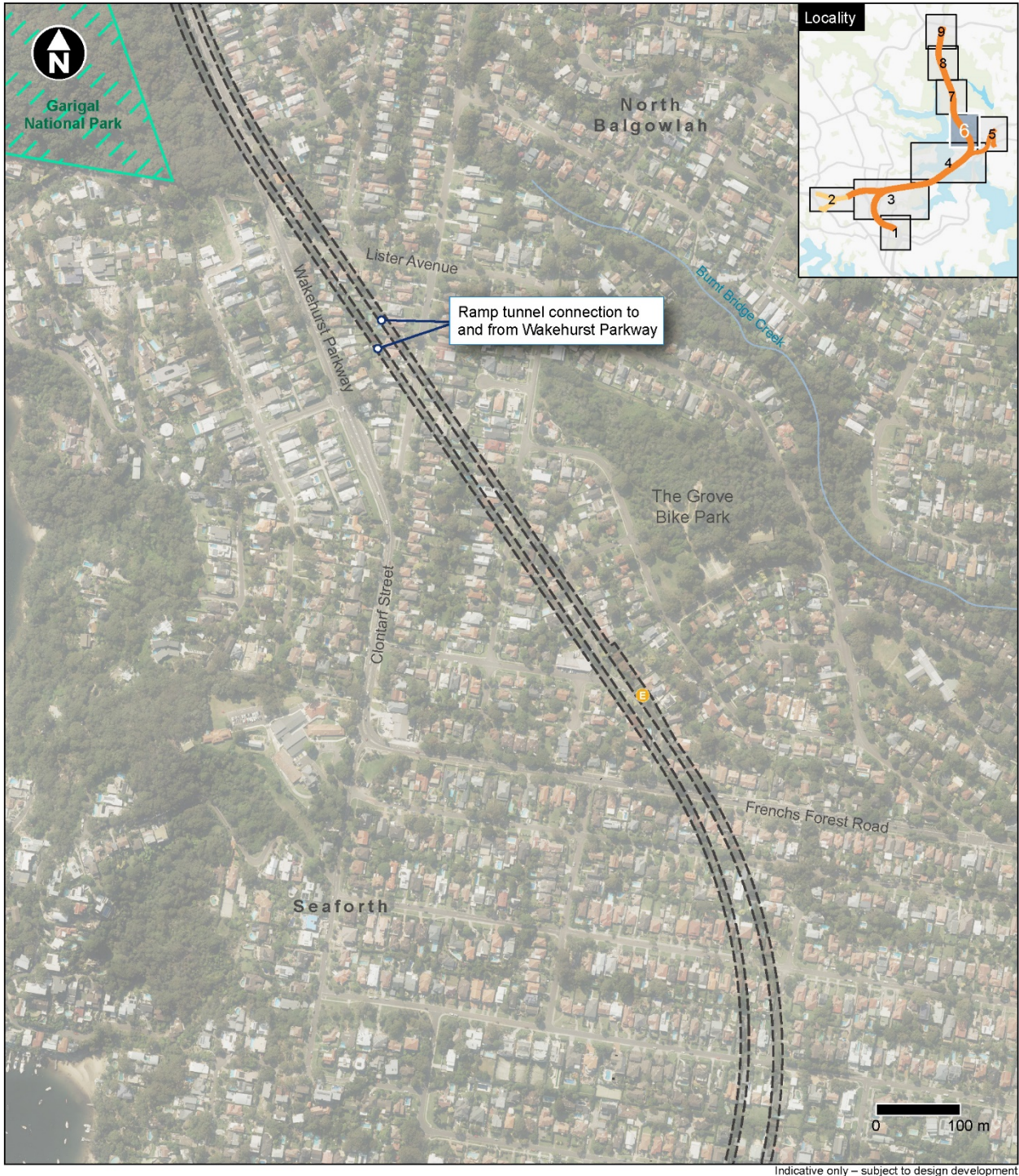


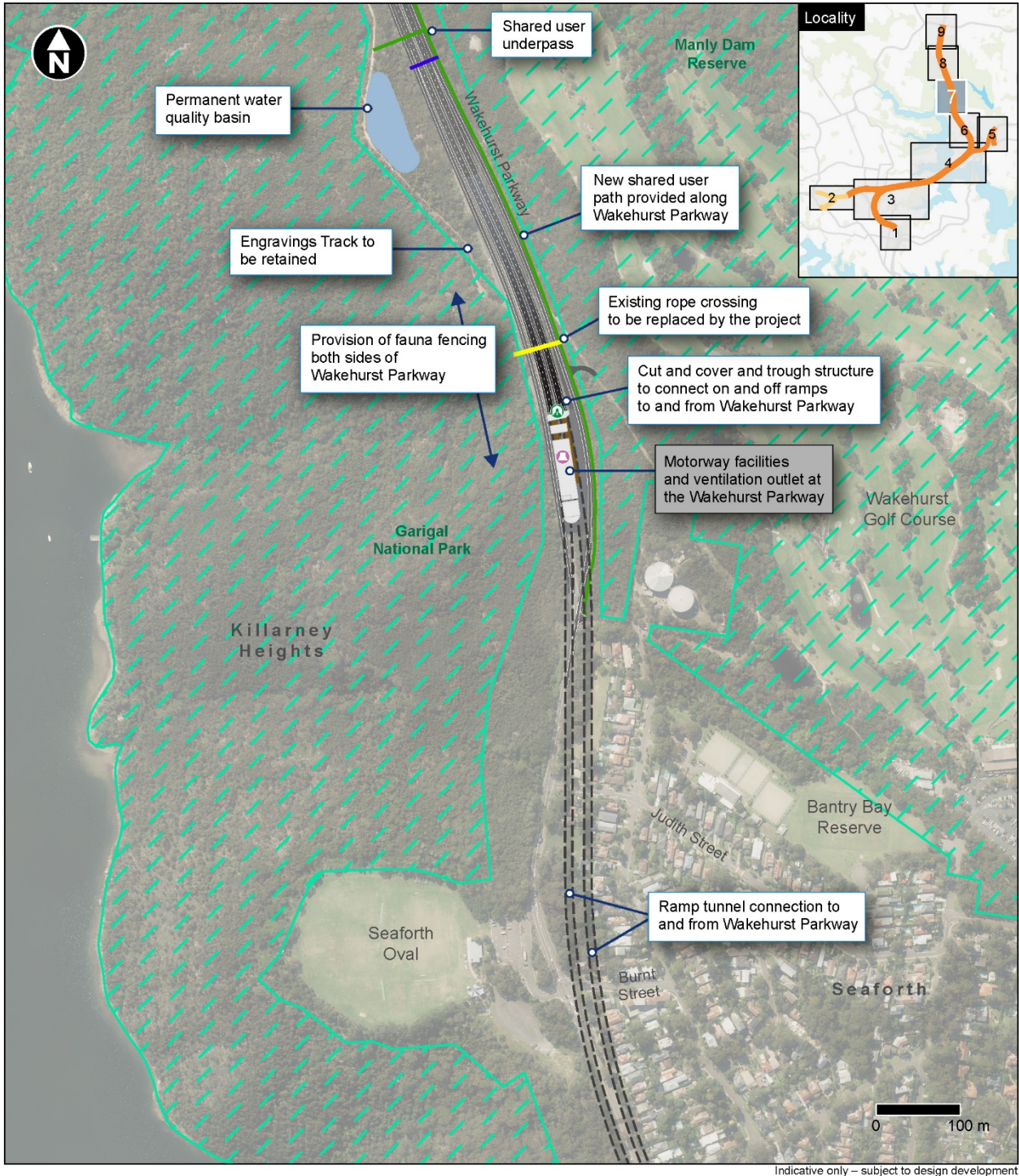
Figure 5-5 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 5)



Indicative only – subject to design development

- Legend**
- | | |
|--|-----------------------------|
| Tunnels | Natural features |
| Beaches Link driven tunnel | National parks and Reserves |
| Maintenance and emergency breakdown bays | |

Figure 5-6 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 6)



Indicative only – subject to design development

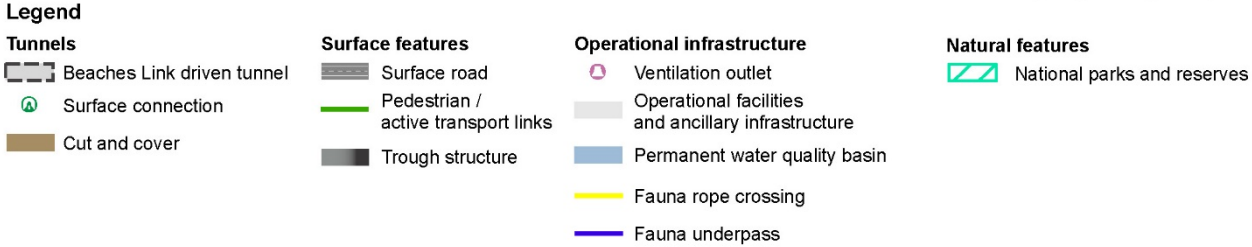
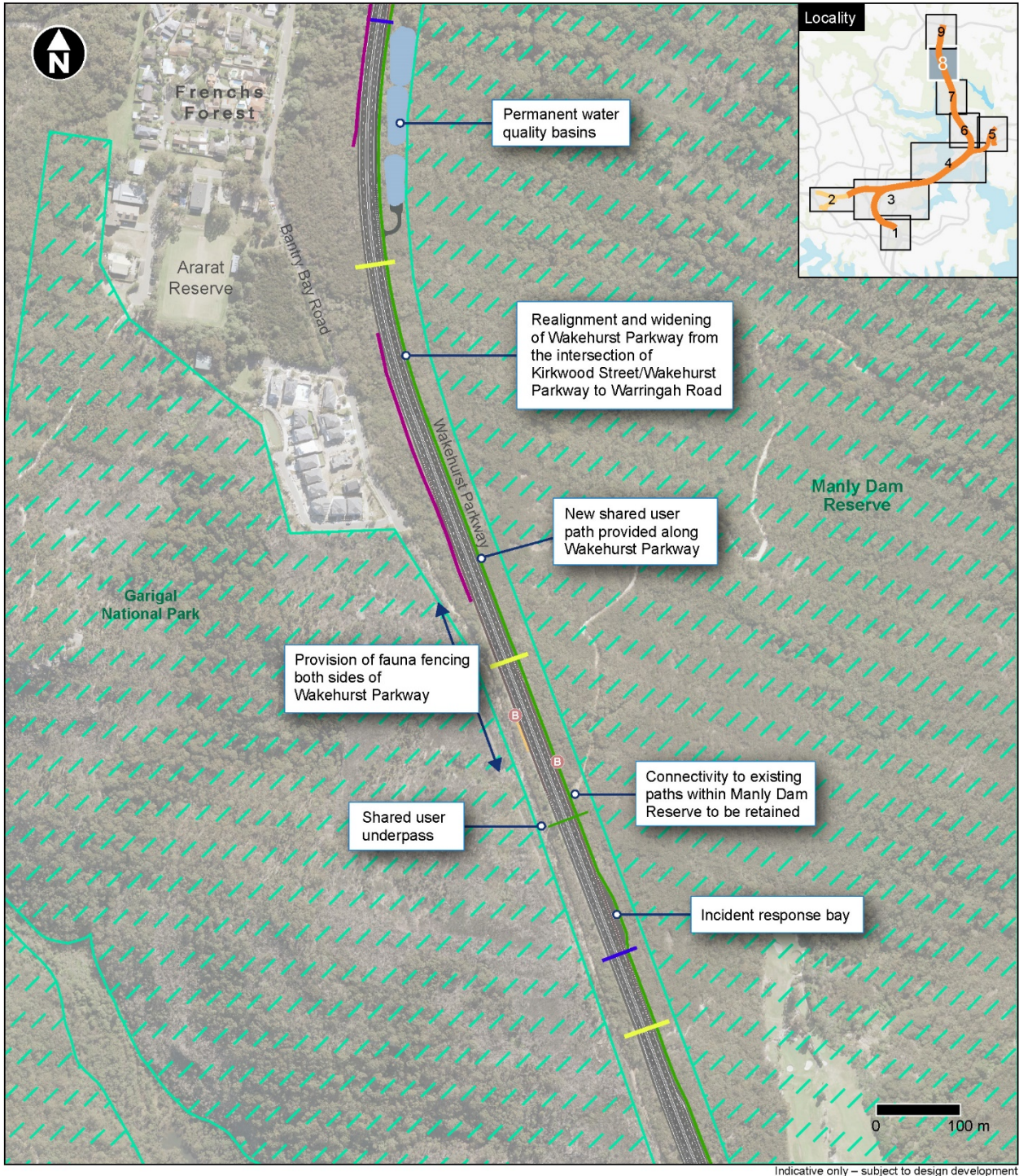


Figure 5-7 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 7)



Legend

Surface features

- Bus stops
- Surface road
- Pedestrian / active transport links

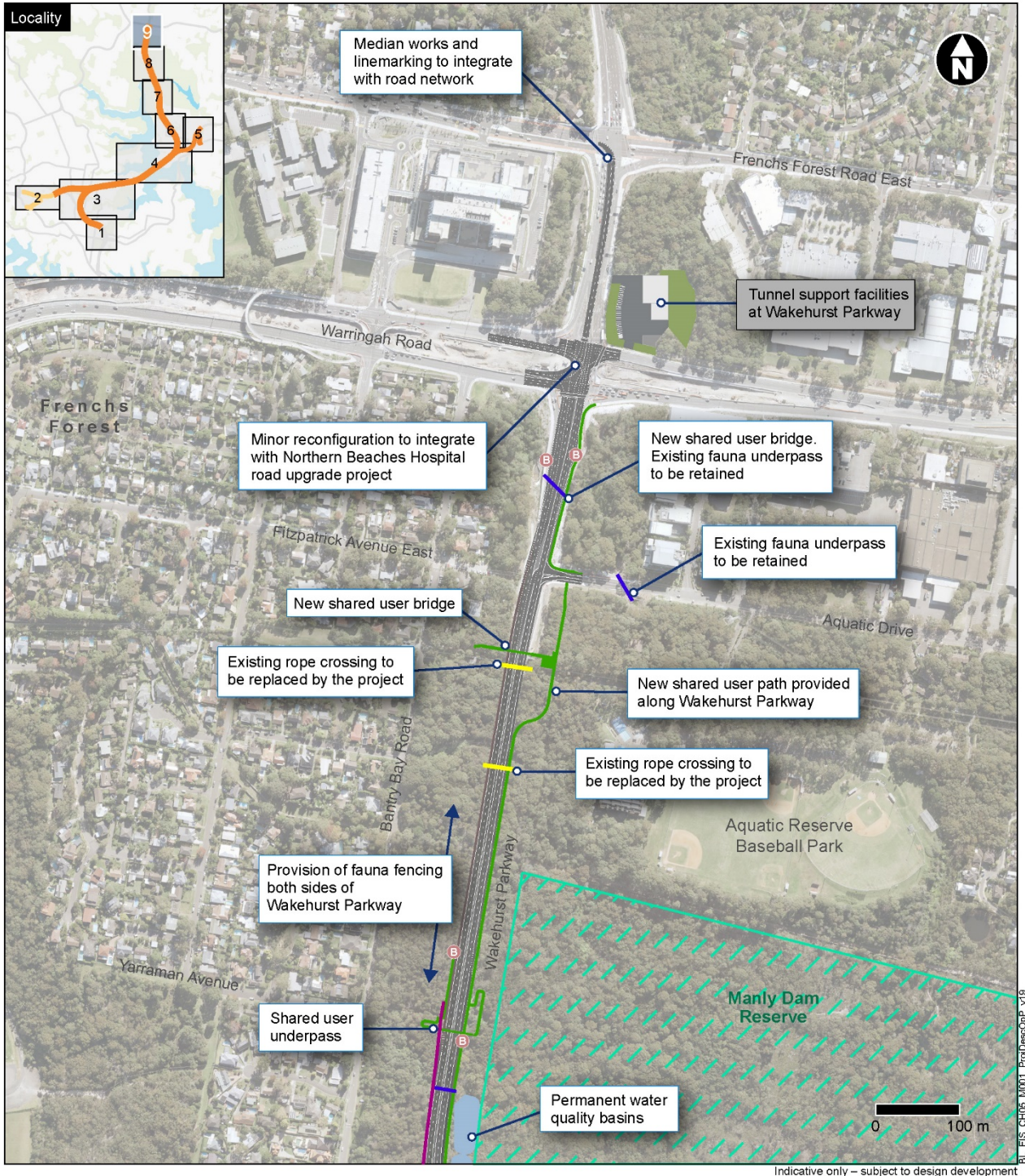
Operational infrastructure

- Fauna rope crossing
- Fauna underpass
- Indicative new noise barrier

Natural features

- National parks and reserves

Figure 5-8 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 8)



Legend

Surface features

- Bus stops
- Surface road
- Pedestrian / active transport links

Operational facilities

- Operational facilities and ancillary infrastructure
- Permanent water quality basin
- Fauna rope crossing
- Fauna underpass
- Indicative new noise barrier

Natural features

- National parks and reserves

Figure 5-9 Overview of the Beaches Link and Gore Hill Freeway Connection project (map 9)

5.2 Beaches Link

5.2.1 Overview

The Beaches Link component of the project would connect the Western Harbour Tunnel and Warringah Freeway at Cammeray with the Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights. It would also provide an east-west connection with the Gore Hill Freeway at Artarmon. The mainline and ramp tunnels would be mostly driven tunnels, with an immersed tube tunnel crossing of Middle Harbour between Northbridge and Seaforth.

Key operational infrastructure would include:

- A motorway control centre at the Gore Hill Freeway in Artarmon
- Tunnel support facilities at the Gore Hill Freeway in Artarmon and the Wakehurst Parkway in Frenchs Forest
- Ventilation outlets and motorway facilities at the Warringah Freeway in Cammeray, Gore Hill Freeway in Artarmon, Burnt Bridge Creek Deviation in Balgowlah and Wakehurst Parkway in Killarney Heights. Ventilation tunnels would connect traffic tunnels to motorway facilities at the Warringah Freeway, Gore Hill Freeway and Burnt Bridge Creek Deviation.

Surface road works would be required to integrate the new tunnels into the existing road and transport network, including:

- Realignment and upgrade of the Wakehurst Parkway to two lanes in each direction between the tunnel portals at Killarney Heights and the intersection with Warringah Road at Frenchs Forest
- Surface works to connect the Gore Hill Freeway and Reserve Road to the Beaches Link tunnels at Artarmon
- Realignment and widening of the Burnt Bridge Creek Deviation at Balgowlah
- A new access road between the Burnt Bridge Creek Deviation and Sydney Road at Balgowlah, to provide access to the Beaches Link and the new and improved open space and recreation facilities at Balgowlah
- Works to integrate the new Beaches Link tunnels into the Warringah Freeway at Cammeray
- Temporary road works required to provide access to construction sites along the proposed alignment

5.2.2 Alignment

Horizontal alignment

The horizontal alignment of the project is shown in Figure 5-1 to Figure 5-9. The main north-south tunnels would be about 5.6 kilometres long and would connect from the Warringah Freeway at Cammeray to ramp tunnels under Naremburn, Northbridge and Seaforth.

The mainline tunnels would pass beneath the suburbs of Cammeray, Crows Nest, Naremburn, Willoughby, Northbridge and Seaforth. At Seaforth, the mainline tunnels would separate into two ramp tunnels. The eastern ramp tunnel would continue beneath Seaforth and Balgowlah before surfacing at Burnt Bridge Creek Deviation at Balgowlah. The northern ramp tunnel would continue beneath Seaforth before joining the Wakehurst Parkway at Killarney Heights.

Under Northbridge, the mainline tunnels would connect with the Gore Hill Freeway ramp tunnels. The Gore Hill Freeway ramp tunnels would pass beneath the suburbs of Northbridge, Naremburn, Willoughby and Artarmon before surfacing at the Gore Hill Freeway and Reserve Road.

At Cammeray, the mainline tunnels would connect directly with the Western Harbour Tunnel via underground ramp tunnels and the Warringah Freeway via tunnel portals.

Vertical alignment

The vertical alignment of the mainline tunnels and ramp tunnel connections to and from the Warringah Freeway, the Gore Hill Freeway, Burnt Bridge Creek Deviation and Wakehurst Parkway are shown in Figure 5-10 to Figure 5-12. As discussed in Chapter 4 (Project development and alternatives), several key factors have influenced the vertical alignment of the project tunnels including:

- Required transport connectivity and network performance
- Geology and geotechnical conditions
- Constructability, design and engineering
- Reducing community and environmental impacts
- The elevation of land on each side of Middle Harbour
- Operational performance and safety
- Limited opportunity for the project tunnels to come to the surface in a highly developed urban environment.

The top of the mainline tunnels would be:

- About 100 metres below ground at their deepest point beneath Northbridge
- Between 16 metres and 22 metres below the water surface of Middle Harbour
- About 75 metres below ground beneath Seaforth.

The mainline and ramp tunnels would rise to the ground surface at the tunnel portals within the Warringah Freeway, Gore Hill Freeway, Burnt Bridge Creek Deviation and the Wakehurst Parkway.

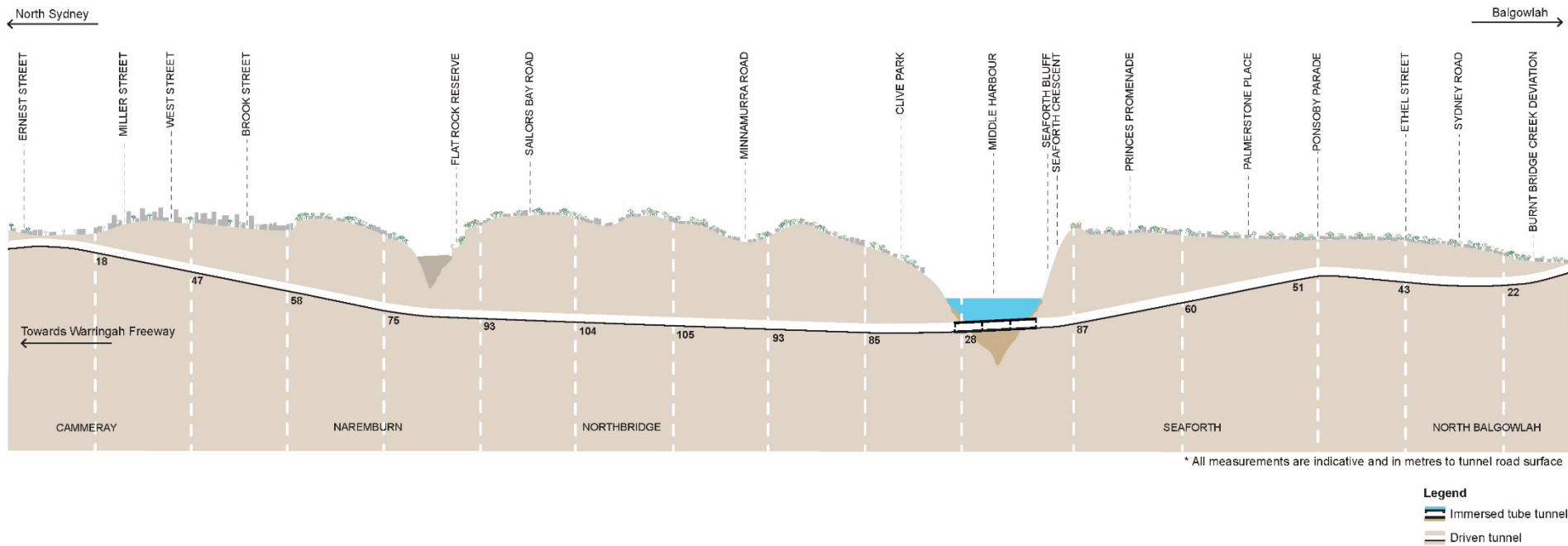


Figure 5-10 Indicative vertical alignment of the mainline tunnels and the ramp tunnel connection to the Burnt Bridge Creek Deviation (Cammeray to Balgowlah)

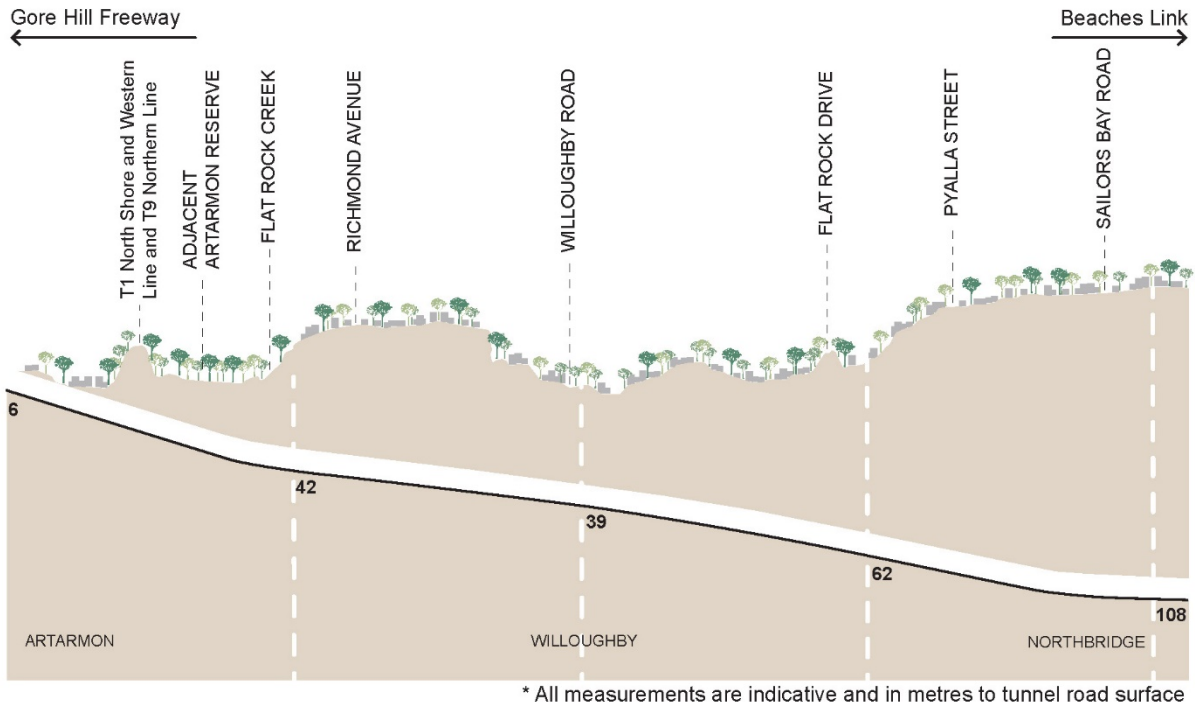


Figure 5-11 Indicative vertical alignment of the ramp tunnel connection to the Gore Hill Freeway

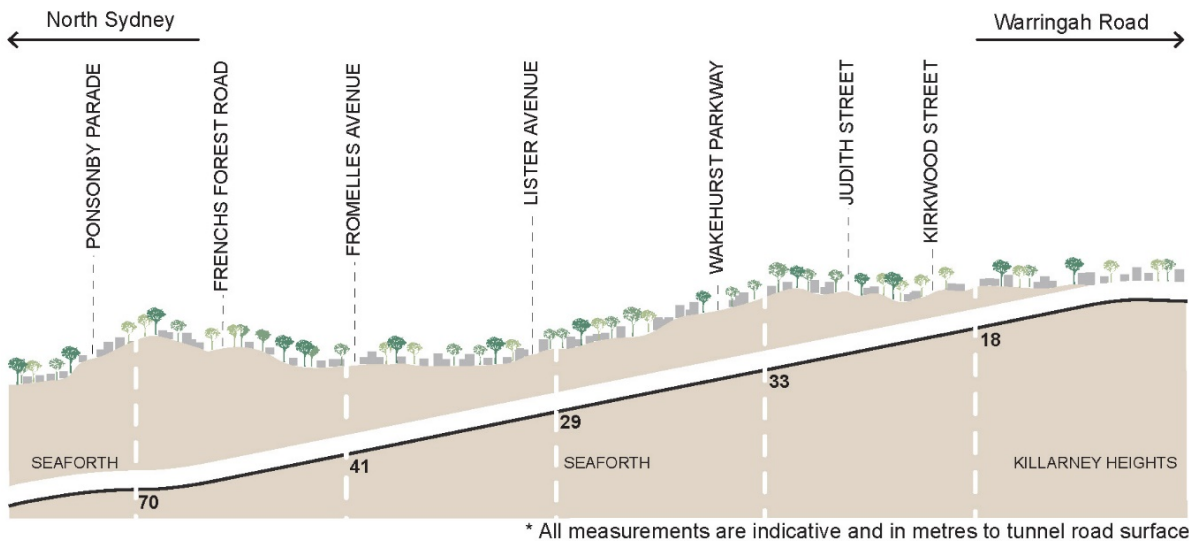


Figure 5-12 Indicative vertical alignment of the ramp tunnel connection to the Wakehurst Parkway

5.2.3 Tunnels

The project would comprise twin tunnels connecting the stub tunnels at Cammeray (constructed as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project) and the Gore Hill Freeway at Artarmon, to Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights. The project would comprise mostly driven tunnels, apart from the crossing of Middle Harbour between Northbridge and Seaforth which would be twin immersed tube tunnels.

The tunnels would provide:

- Three traffic lanes (about 5.6 kilometres in length) in each direction for the mainline tunnels between the Warringah Freeway at Cammeray and the ramp junction under Seaforth
- Two traffic lanes (about 1.2 kilometres in length) in each direction for the ramps that connect from the junction under Seaforth to the Burnt Bridge Creek Deviation at Balgowlah
- Two traffic lanes (about 2.8 kilometres in length) in each direction for the ramps that connect from the junction under Seaforth to the Wakehurst Parkway at Killarney Heights
- Two traffic lanes (about 2.1 kilometres in length) in each direction for the ramps that connect from the junction under Northbridge to the Gore Hill Freeway and Reserve Road at Artarmon.

The posted speed limit on the mainline tunnels would be 80 km/h.

On and off ramps would allow for one or two lanes of traffic, depending on location (refer to Section 5.2.5). The posted speed limit for on and off ramps will vary along their length to match the surface connection they will integrate with to enter and exit the mainline tunnel.

Driven tunnels

The driven tunnels would be located below the surface and would connect with the immersed tube tunnel crossing of Middle Harbour.

An indicative cross-section of the driven mainline tunnels is shown in Figure 5-13.

Driven tunnels would be mainly drained structures. This means a certain amount of groundwater would be allowed to seep through the tunnel walls. The drained tunnels would be designed and managed so that groundwater ingress would be no greater than one litre per second per kilometre on average.

The geology approaching the Middle Harbour crossing may result in higher levels of water ingress into the driven tunnels than encountered on other parts of the alignment. This may require the installation of a waterproof lining or similar treatment at these locations to prevent excessive ingress of water. This type of treatment may also be required at discrete locations along the alignment eg beneath Flat Rock Reserve where because of soil conditions or geological features, there is predicted to be high water ingress into the tunnel. The requirement for, and extent of, lining or similar treatment would be confirmed during further design development.

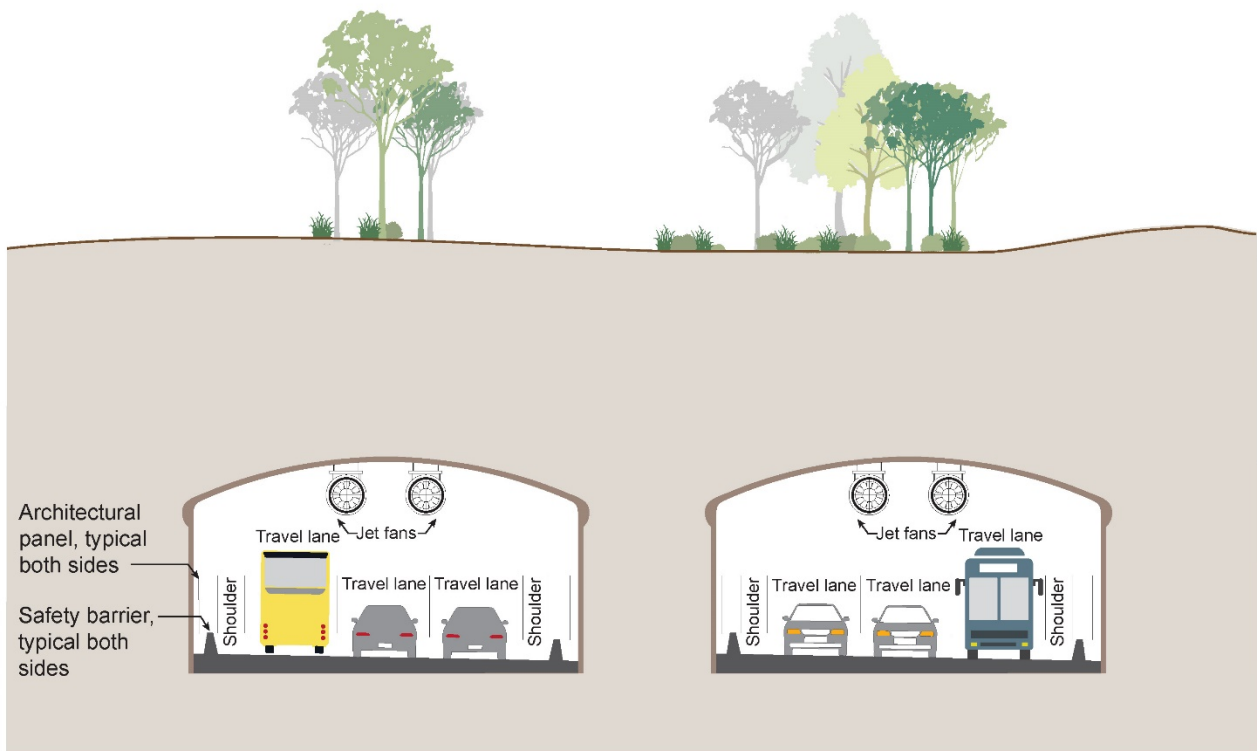


Figure 5-13 Indicative cross-section of the driven mainline tunnels

Immersed tube tunnels

To achieve suitable gradients, the vertical alignment would require the mainline tunnels to pass through rock and soft to very soft sediments forming the bed of Middle Harbour. Given the physical nature of these materials, immersed tube tunnels would be the most appropriate engineering solution to provide a safe, stable and effective method of crossing Middle Harbour.

The immersed tube tunnels would connect to the driven mainline tunnels in Middle Harbour offshore from Clive Park, Northbridge, and Seaforth Bluff, Seaforth.

An indicative long section of the immersed tube tunnel crossing of Middle Harbour is shown in Figure 5-14. Indicative cross-sections of the immersed tube tunnels are shown in Figure 5-15 (end sections) and Figure 5-16 (middle sections).

The immersed tube tunnels would be installed as a series of pre-cast units. Due to the profile of the bed of the harbour, the units would sit both partially within a trench closer to the shore and above the bed of the harbour towards the centre of the crossing. The middle sections would be placed with the tops of the tunnel units being about 9.2 metres above the existing level of the bed of the harbour.

Given the very soft sediments at the bed of Middle Harbour, supporting piles would be required at discrete locations along the immersed tube crossing. A locking fill would be placed around the end sections of the immersed tube tunnels for stability and protection.

The water depth above the immersed tube tunnels would vary between 16 metres and 22 metres, depending on the distance from the shore.

Each immersed tube tunnel would accommodate three traffic lanes in each direction.

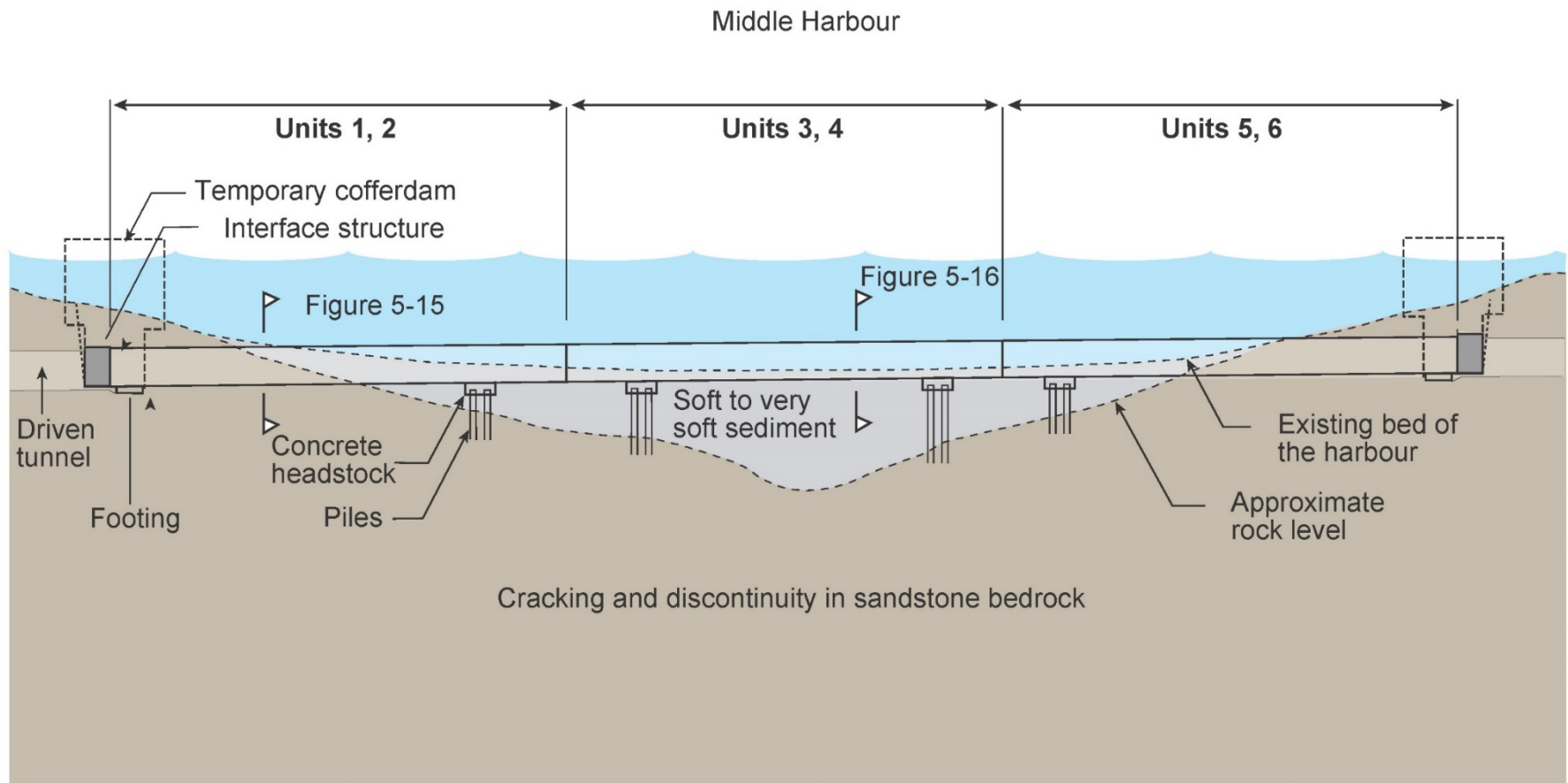


Figure 5-14 Indicative long section of the immersed tube tunnels (Middle Harbour)

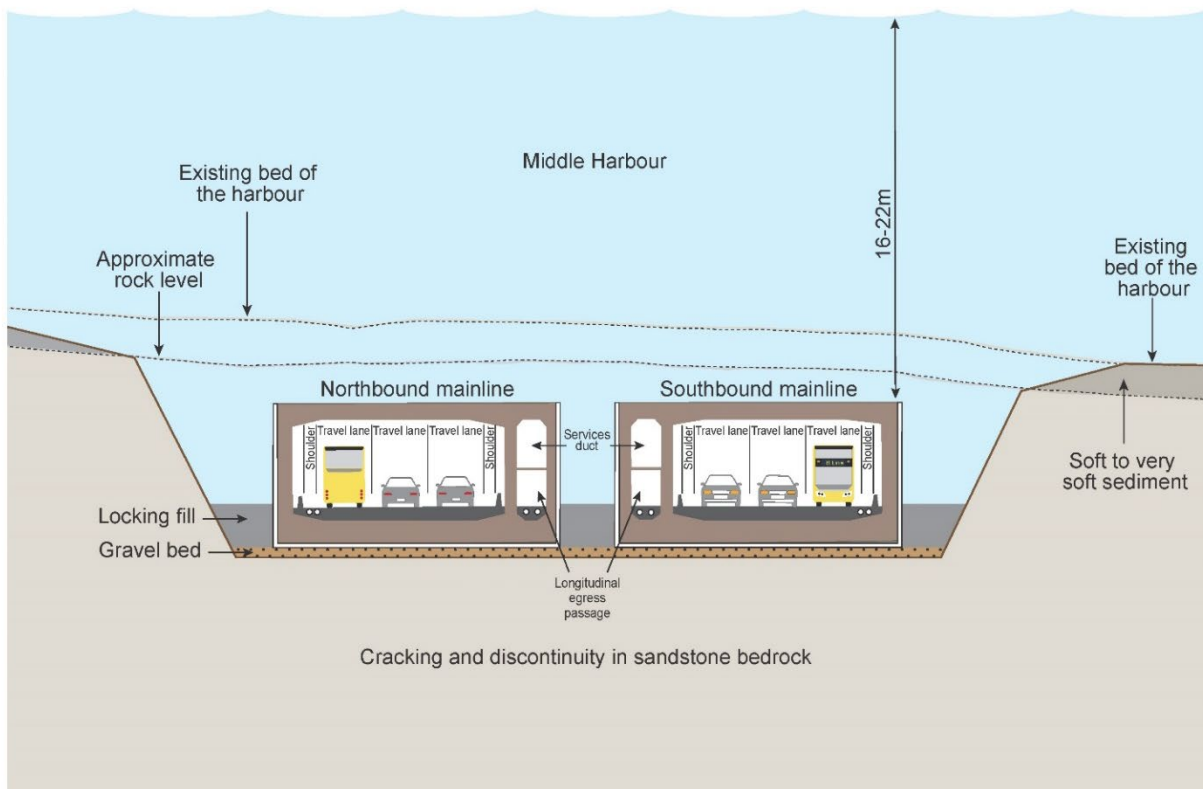


Figure 5-15 Indicative cross-section of the end sections of immersed tube tunnels (Middle Harbour)

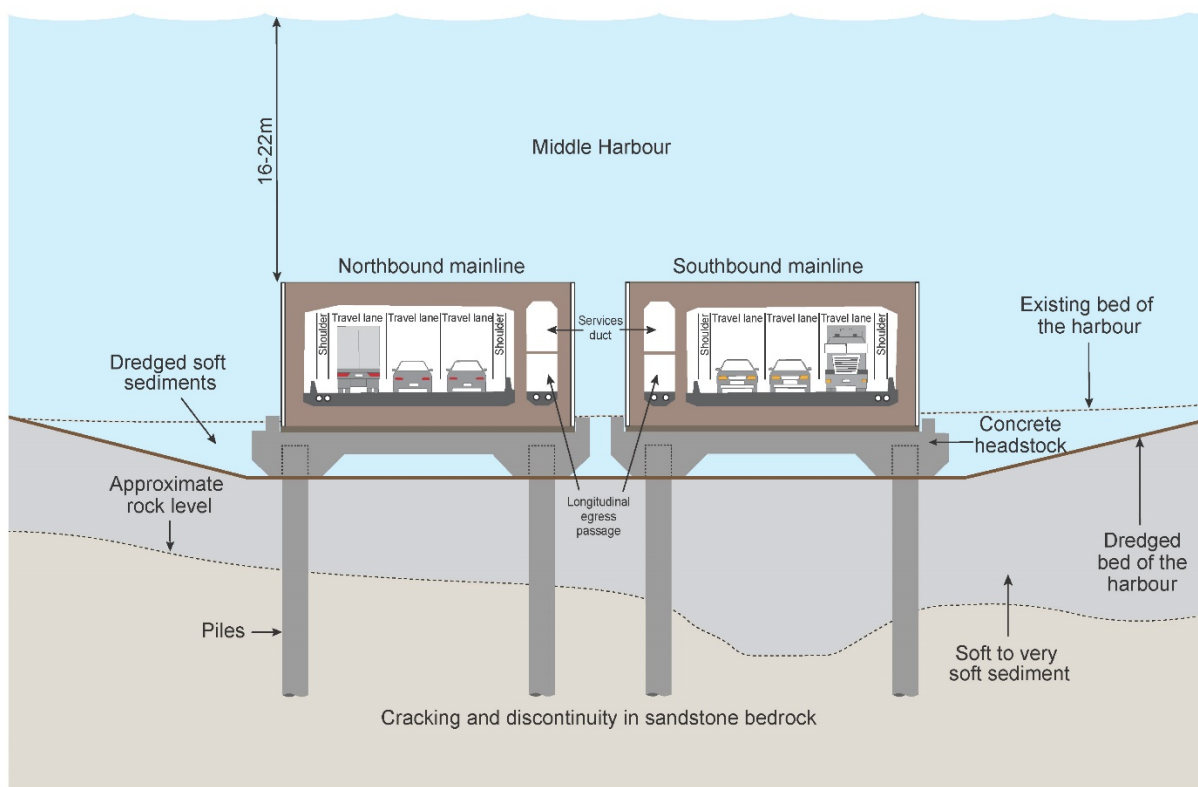
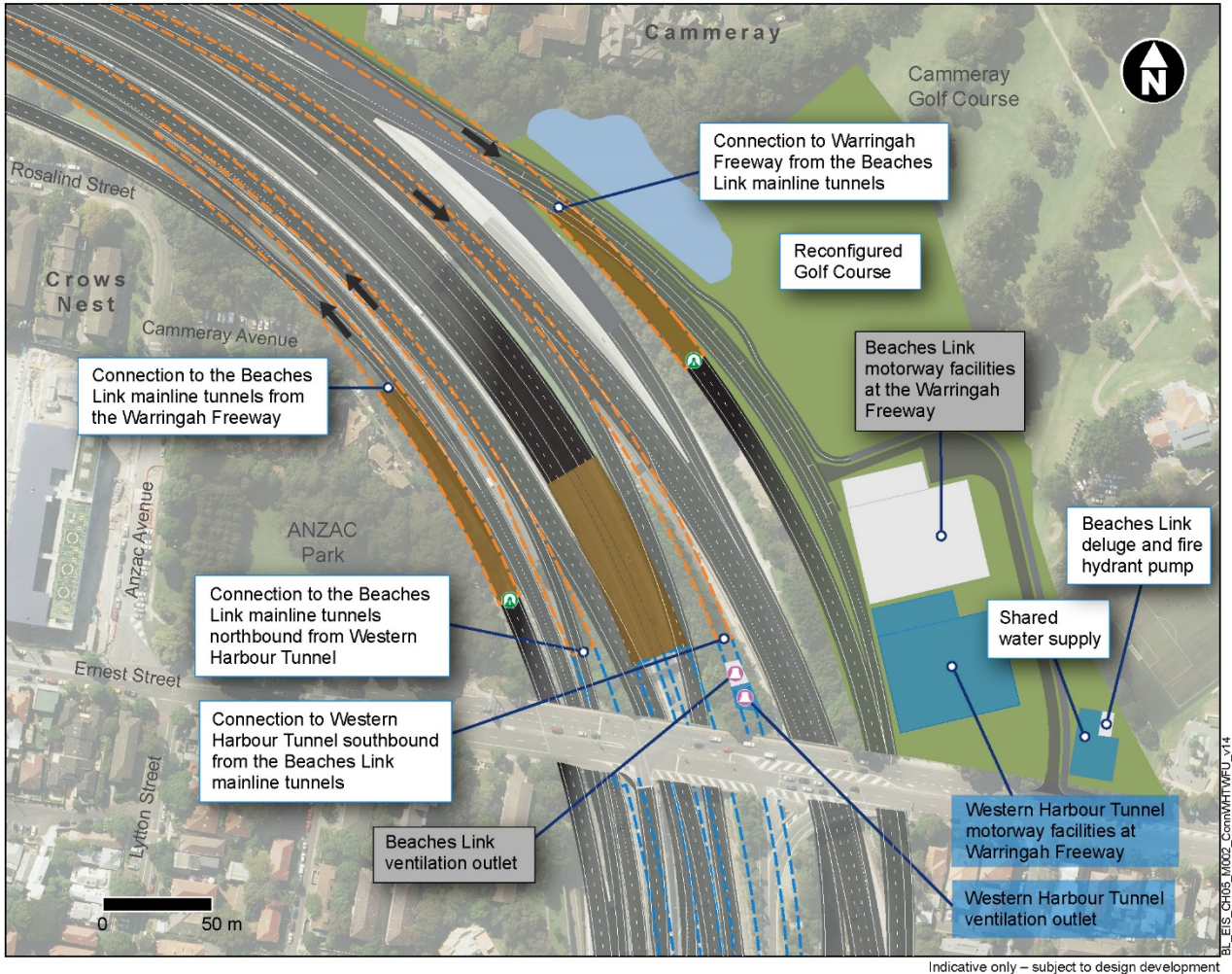


Figure 5-16 Indicative cross-section of the middle sections of immersed tube tunnels (Middle Harbour)

5.2.4 Tunnel-to-tunnel connections

The project would include a tunnel connection between the Western Harbour Tunnel and the Beaches Link component of the project at Cammeray (refer to Figure 5-17). Depending on the relative timing of construction of the mainline tunnels of the Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link component of the project, the tunnel-to-tunnel connection between the projects may be constructed at or around the same time, or consecutively.



Legend

Tunnels

- Beaches Link driven tunnel
- Surface connection
- Cut and cover

Operational infrastructure

- Ventilation outlet
- Operational facilities and ancillary infrastructure
- Direction of traffic

Connecting projects

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Indicative location for stormwater harvesting dam, to be relocated as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project

Figure 5-17 Indicative tunnel-to-tunnel connections to the Western Harbour Tunnel and Warringah Freeway Upgrade project tunnel

5.2.5 Surface connections

The tunnels would be connected to the surface road network at the following locations, with connections to and from the:

- Warringah Freeway at Cammeray
- Gore Hill Freeway at Artarmon
- Burnt Bridge Creek Deviation at Balgowlah
- Wakehurst Parkway at Killarney Heights.

Connections from the mainline tunnels to and from the Warringah Freeway

The Beaches Link component of the project would include on and on off ramps that connect the mainline tunnels to the Warringah Freeway. The on and off ramps between the Beaches Link mainline tunnels and the Warringah Freeway would be located around Ernest Street, Cammeray. Chapter 6 (Construction work) describes the elements of the on and off ramp structures and surface connections that would be delivered by the Warringah Freeway Upgrade.

Connections to and from the Warringah Freeway are shown in Figure 5-17 and would include two lanes connecting from the:

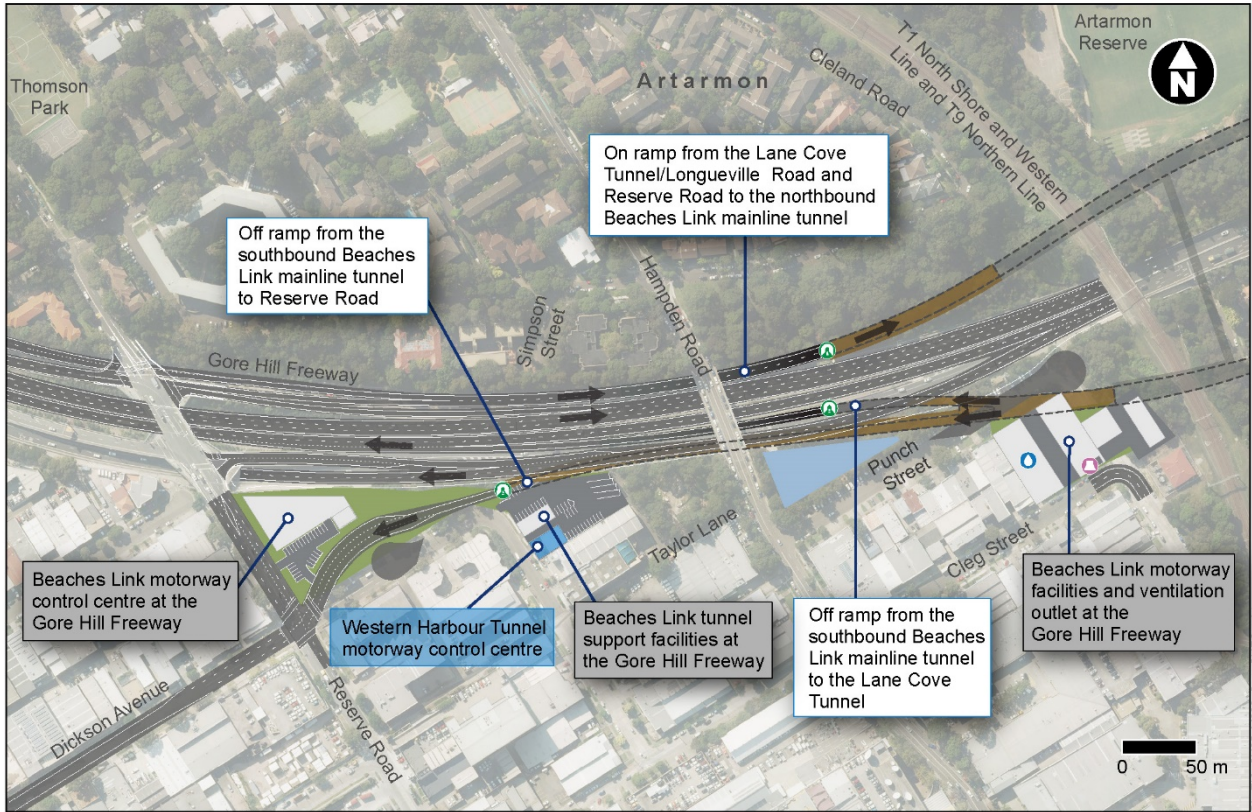
- Warringah Freeway to the northbound mainline tunnel
- Southbound mainline tunnel to the Warringah Freeway.

Connections to and from the Gore Hill Freeway

On and off ramps would connect the mainline tunnels under Northbridge with the Gore Hill Freeway at Artarmon as summarised in Table 5-4 and shown in Figure 5-18.

Table 5-4 Connections to and from the Gore Hill Freeway

Connection	Summary
On ramp from the Lane Cove Tunnel, Longueville Road and Reserve Road to the northbound mainline tunnel	This connection would include two traffic lanes (one carrying traffic from the Lane Cove Tunnel and Epping Road/Longueville Road and one carrying traffic from Reserve Road) with ramp tunnel sections that would be about 2.1 kilometres long. The two traffic lanes would merge to one lane prior to joining the northbound mainline tunnel. Most of the ramp would be a driven tunnel between the T1 North Shore and Western Line and T9 Northern Line and the northbound mainline tunnel. Cut and cover and trough structures would be located to the west of the T1 North Shore and Western Line and T9 Northern Line (refer to Section 5.3). This tunnelled ramp is part of the Beaches Link component of the project.
Off ramp from the southbound mainline tunnel to Reserve Road and the Gore Hill Freeway/Lane Cove Tunnel	This connection would include a single lane diverging from the southbound mainline tunnel, immediately widening to two traffic lanes. The tunnelled section of the ramp would be about two kilometres long. Before connecting to surface at the Gore Hill Freeway, the ramp would divide into two separate ramps to the west of the T1 North Shore and Western Line and T9 Northern Line. One lane would carry traffic to Reserve Road and the other would carry traffic to the Gore Hill Freeway/Lane Cove Tunnel. Most of the ramp would be driven tunnel between the T1 North Shore and Western Line and T9 Northern Line and the northbound mainline tunnel. Cut and cover and trough structures would be located to the west of the T1 North Shore and Western Line and T9 Northern Line (refer to Section 5.3). This tunnelled ramp is part of the Beaches Link component of the project.



Indicative only – subject to design development

Legend

Tunnels

- Beaches Link driven tunnel
- Cut and cover
- Surface connection

Surface features

- Surface road
- Permanent water quality basin
- Trough structure

Operational infrastructure

- Ventilation outlet
- Wastewater treatment plant
- Operational facilities and ancillary infrastructure
- Direction of traffic

Figure 5-18 Connections to and from the Gore Hill Freeway

Connections to and from the Burnt Bridge Creek Deviation

On and off ramps would connect the mainline tunnels with the Burnt Bridge Creek Deviation at Balgowlah, as summarised in Table 5-5 and shown in Figure 5-19.

Table 5-5 Connections to and from the Burnt Bridge Creek Deviation

Connection	Summary
On ramp from the Burnt Bridge Creek Deviation to the southbound mainline tunnel	This connection would include two traffic lanes, about 1.2 kilometres long. Most of the ramp would be driven tunnel, with cut and cover and trough structures at the Burnt Bridge Creek Deviation.
Off ramp from the northbound mainline tunnel to the Burnt Bridge Creek Deviation	This connection would include two traffic lanes, about 1.2 kilometres long. Most of the ramp would be driven tunnel, with cut and cover and trough structures at the Burnt Bridge Creek Deviation.



Indicative only – subject to design development

Legend

Tunnels

- Beaches Link driven tunnel
- Cut and cover
- Surface connection

Surface features

- Surface road
- Bus lane
- Pedestrian / active transport links
- Trough structure

Operational infrastructure

- Ventilation outlet
- Operational facilities and ancillary infrastructure
- Direction of traffic
- Permanent water quality basin

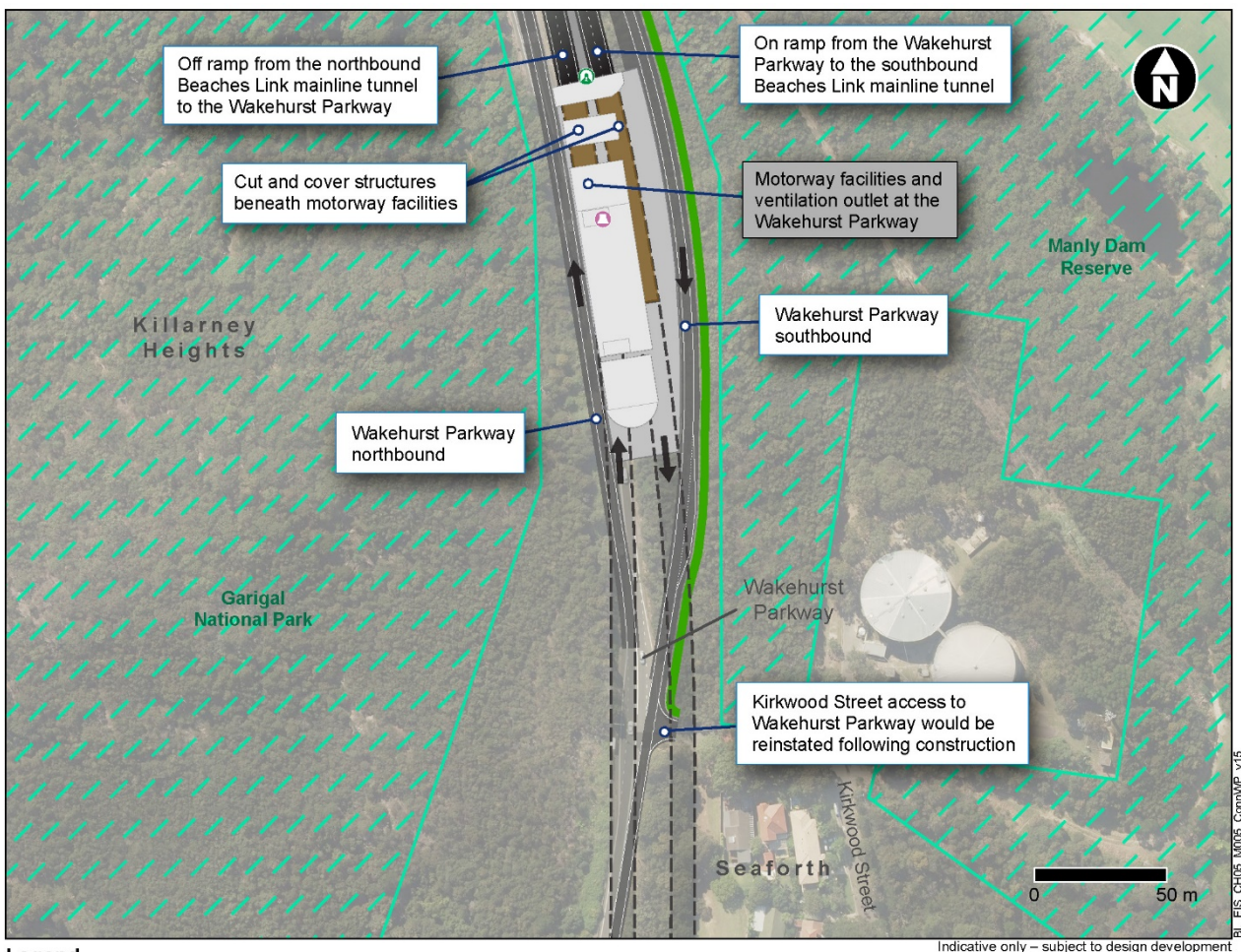
Figure 5-19 Connections to and from the Burnt Bridge Creek Deviation

Connections to and from the Wakehurst Parkway

On and off ramps would connect the mainline tunnels with the Wakehurst Parkway at Killarney Heights, as summarised in Table 5-6 and shown in Figure 5-20.

Table 5-6 Connections to and from the Wakehurst Parkway

Connection	Summary
On ramp from the Wakehurst Parkway to the southbound mainline tunnel	This connection would include two traffic lanes, about 2.8 kilometres long. Most of the ramp would be driven tunnel, with cut and cover and trough structures at the Wakehurst Parkway north of Kirkwood Street.
Off ramp from the northbound mainline tunnel to the Wakehurst Parkway	This connection would include two traffic lanes, about 2.8 kilometres long. Most of the ramp would be driven tunnel, with cut and cover and trough structures at the Wakehurst Parkway north of Kirkwood Street.



Legend

Tunnels

- Beaches Link driven tunnel
- Surface connection
- Cut and cover

Surface features

- Surface road
- Pedestrian / active transport links
- Trough structure

Operational infrastructure

- Ventilation outlet
- Operational facilities and ancillary infrastructure
- Direction of traffic

Natural features

- National parks and reserves

Figure 5-20 Connections to and from the Wakehurst Parkway

5.2.6 Surface road works

Key surface road works that would be carried out as part of the Beaches Link component include:

- Upgrade and integration work along and around the Burnt Bridge Creek Deviation and Sydney Road at Balgowlah, North Balgowlah and Seaforth, including a new access road
- Upgrade and integration work along the Wakehurst Parkway, at Seaforth, Killarney Heights and Frenchs Forest.

Surface road works that would be carried out as part of the Gore Hill Freeway Connection component of the project are detailed in Section 5.3.3.

Surface road works at Balgowlah

Surface road works would be required along and around the Burnt Bridge Creek Deviation, Manly Road and Sydney Road at Balgowlah, North Balgowlah and Seaforth to connect and integrate the project with the surrounding road network. The surface road works would include:

- Realignment and widening of the Burnt Bridge Creek Deviation including cut and cover and trough works east of Hope Street
- Localised adjustment of a small section of Burnt Bridge Creek for road widening and extension of the existing culvert and provision of scour protection
- A new access road which would:
 - Provide connectivity to new car parking facilities at Balgowlah for the new and improved open space and recreation facilities
 - Provide connectivity from the Beaches Link tunnel to and from Sydney Road via a new traffic light intersection on the Burnt Bridge Creek Deviation to a new traffic light intersection at Sydney Road/Maretimo Street
- Minor changes to local roads, including intersection works at Maretimo Street, and localised traffic calming measures, as required
- Retaining walls to support cut rock faces and retain fill embankments
- Relocation of existing utilities impacted by the project at various locations where surface works are required (refer to Section 5.2.9)
- Local access for motorway facilities
- A new cul-de-sac on Dudley Street to align with the new and improved open space and recreation facilities.

Details of the surface road works are summarised in Table 5-7 and shown in Figure 5-21. An indicative cross-section through the Burnt Bridge Creek Deviation and the ramp trough structures is shown in Figure 5-22.

Table 5-7 Surface road works at Balgowlah, North Balgowlah and Seaforth

Key project component	Description
Realignment and widening of the Burnt Bridge Creek Deviation	<p>The Burnt Bridge Creek Deviation would be realigned and widened to allow connection of the ramp tunnels with the surface road network, including:</p> <ul style="list-style-type: none"> • Surface road works from Sydney Road to around the existing Kitchener Street bridge to reconfigure Burnt Bridge Creek Deviation to integrate with the new Beaches Link tunnel connection • A new traffic light intersection on Burnt Bridge Creek Deviation at the end of the current configuration of Dudley Street to connect to a new

Key project component	Description
	<p>access road through to Sydney Road (see following section in this table for further information on the new access road)</p> <ul style="list-style-type: none"> • A two lane ramp from the northbound mainline tunnel, widening to four lanes at the surface to provide two free flow lanes for northbound through traffic on the Burnt Bridge Creek Deviation and two right turning traffic lanes into the new access road • Provision of two lanes connecting Burnt Bridge Creek Deviation southbound to the westbound ramp tunnel • Realignment of the Burnt Bridge Creek Deviation (east of Hope Street) around the Beaches Link trough structure to maintain a variable single/twin traffic lanes and single bus lane in each direction following completion of construction. This would require widening of the existing Burnt Bridge Creek Deviation corridor, mainly to the east of the existing alignment in the area of the existing Dudley Street • Median reconstruction, asphalt resurfacing and linemarking works to incorporate adjacent Burnt Bridge Creek Deviation widening works at the intersection of Sydney Road, Burnt Bridge Creek Deviation and Manly Road and further north along Burnt Bridge Creek Deviation.
New access road	<p>A new access road would be constructed at Balgowlah to connect the Burnt Bridge Creek Deviation with Sydney Road. The new access road would allow traffic from the ramp tunnel to access Sydney Road and travel to and from Manly, Balgowlah, North Balgowlah and Seaforth to access Beaches Link. The new road would also provide access for users of the new and improved open space and recreation facilities at Balgowlah. The new access road would include:</p> <ul style="list-style-type: none"> • Mostly two traffic lanes in each direction, with a posted speed limit of up to 60 km/h • New traffic light intersections at the Burnt Bridge Creek Deviation at the end of the current configuration of Dudley Street and at Sydney Road at the intersection of Maretimo Street • Widening of Sydney Road at the new intersection between the new access road, Sydney Road and Maretimo Street to allow for turning lanes and maintenance of through traffic lanes on Sydney Road. There would be no access between the new access road and Maretimo Street • A driveway off the new access road to access the motorway facilities • A new car park off the access road to provide parking for users of the new open space and recreation facilities • Pedestrian and cyclist facilities along and across the new access road (refer to Section 5.2.8).
Localised adjustment of Burnt Bridge Creek	<p>Due to the widening of the Burnt Bridge Creek Deviation, Burnt Bridge Creek would require localised adjustment to facilitate an extension of the existing box culvert crossing of Burnt Bridge Creek Deviation. Scour protection would also be required at the outlet of the extended culvert. It should be noted that the waterway was previously realigned during construction of Burnt Bridge Creek Deviation in 1982. The localised adjustment would be carried out within the previously modified section of Burnt Bridge Creek.</p>

Key project component	Description
Local road changes	<p>Minor changes to local road conditions would include permanent closure of the northern section of Dudley Street and the creation of a modified cul-de-sac at the southern end of Dudley Street. The design of the cul-de-sac would be refined during further design development and its extent minimised where possible.</p> <p>Traffic calming measures may also be required as part of the project. The final design and location of traffic calming measures would be developed in consultation with Northern Beaches Council.</p>
Retaining walls	<p>Several retaining walls are expected to be required. Each wall would range in length and height to suit the new works and existing surface levels. Finishes would be designed in line with the urban design framework for the project (refer to Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment)).</p>

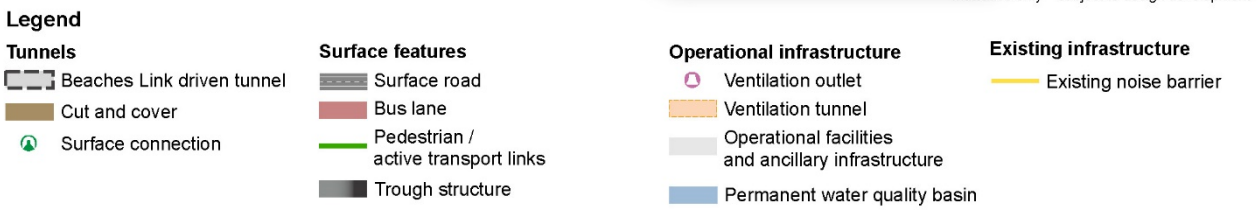


Figure 5-21 Surface road works at Balgowlah

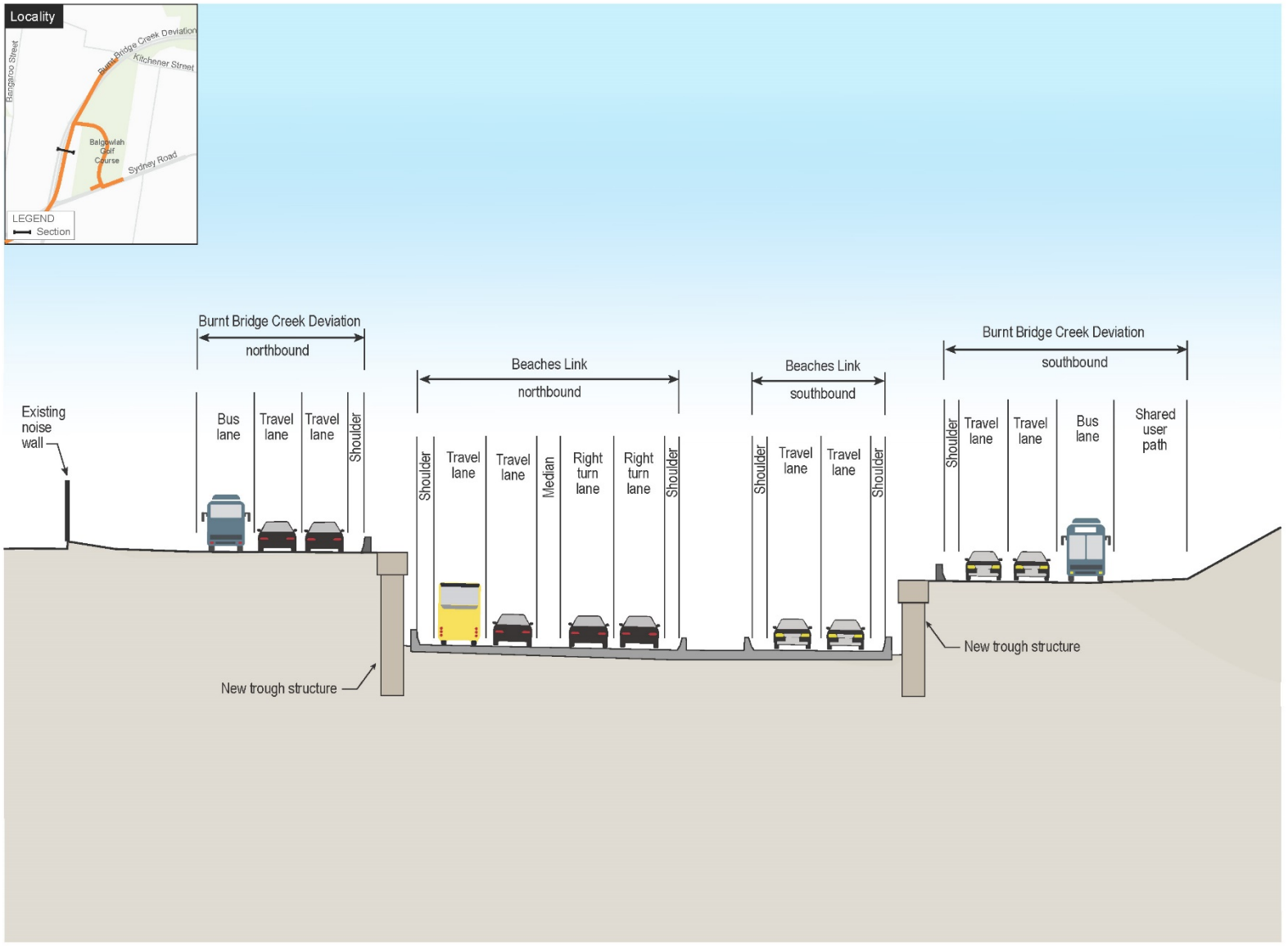


Figure 5-22 Indicative cross-section through the Burnt Bridge Creek Deviation and ramp trough structures

Surface road works at Seaforth, Killarney Heights and Frenchs Forest

Surface road works would be required along the Wakehurst Parkway between Seaforth and Frenchs Forest to connect and integrate the project with the surrounding road network. These works would also integrate the project with road network upgrades completed as part of the Northern Beaches Hospital road upgrade project. Surface road works in these areas would comprise:

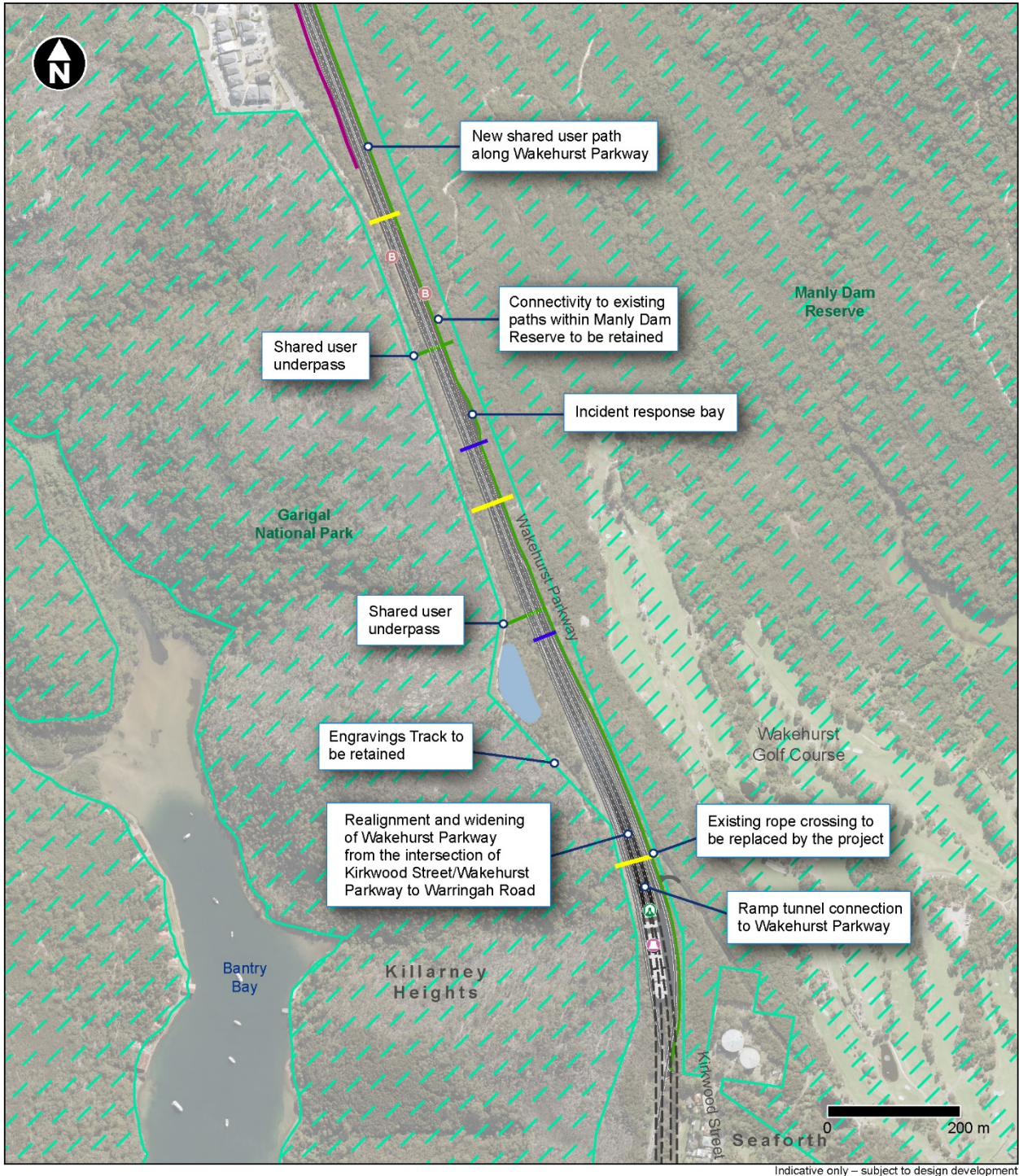
- Realignment and upgrade of the Wakehurst Parkway to two lanes in each direction, south of Warringah Road through to the new Beaches Link tunnel portals at Killarney Heights
- Minor changes to the intersections of the Wakehurst Parkway with Kirkwood Street, Fitzpatrick Avenue/Aquatic Drive, Warringah Road and Frenchs Forest Road East and Frenchs Forest Road West.

Details of the surface road works at Seaforth, Killarney Heights and Frenchs Forest are provided in Table 5-8 and shown in Figure 5-23 and Figure 5-24. An indicative cross-section through the Wakehurst Parkway and the ramp trough structures is shown in Figure 5-25.

Table 5-8 Surface road works at Seaforth, Killarney Heights and Frenchs Forest

Key project component	Description
Realignment and widening of the Wakehurst Parkway	<p>The Wakehurst Parkway would be realigned to allow connection of the ramp tunnels with the surface and widened between the ramp trough structure and Warringah Road to provide additional capacity. The surface works would include:</p> <ul style="list-style-type: none"> • Realignment of the Wakehurst Parkway around the ramp cut and cover and trough structures. The realignment would extend from the intersection with Kirkwood Street at Seaforth, to the merge with traffic lanes connecting to and from the tunnel ramps • Widening of the Wakehurst Parkway from one lane in each direction to two lanes in each direction, from the ramp trough structures to the intersection of the Wakehurst Parkway with Warringah Road, Frenchs Forest • A new shared user path along the Wakehurst Parkway between Seaforth and Frenchs Forest, with new underpasses and connections to existing bus stops, paths and surface trails at key locations (refer to Section 5.2.8) • New and replaced fauna fencing and crossing infrastructure along and across the Wakehurst Parkway (refer to Section 5.2.11) • Retaining walls to support cut or fill embankments. Each wall would range in length and height to suit the new works and existing surface levels. Finishes would be designed in line with the urban design framework for the project (refer to Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment)) • Replacement of the existing pedestrian bridge south of Aquatic Drive with a new shared user bridge structure to suit the road widening works • Driveway access to the motorway facility from the Wakehurst Parkway • Driveway access to the tunnel support facilities at the Wakehurst Parkway in Frenchs Forest via a left in and left out to Warringah Road and a left in and left out to the Wakehurst Parkway.

Key project component	Description
Minor intersection changes	<p>Minor changes would be required to intersections of the Wakehurst Parkway with Kirkwood Street, Fitzpatrick Avenue/Aquatic Drive, Warringah Road and Frenchs Forest Road East and Frenchs Forest Road West to integrate the project with the surface road network. These minor changes would include:</p> <ul style="list-style-type: none"> • Removal of the right turn movement from the Wakehurst Parkway northbound onto Frenchs Forest Road East • Alterations to linemarking, traffic signals and signage • Adjustments to medians • Asphalt resurfacing.
Water quality basins	<p>Construction of four permanent water quality basins along the Wakehurst Parkway, which would include:</p> <ul style="list-style-type: none"> • A new water quality basin to the west of the widened Wakehurst Parkway, next to Garigal National Park and about 600 metres north of Kirkwood Street, accessed via the Wakehurst Parkway • Three new water quality basins to the east of the widened Wakehurst Parkway about 800 metres to 900 metres south of the intersection with Warringah Road, accessed via the Wakehurst Parkway.



Legend

Mainline tunnels

- Beaches Link driven tunnel
- Surface connection

Surface features

- Bus stops
- Surface road
- Pedestrian / active transport links
- Trough structure

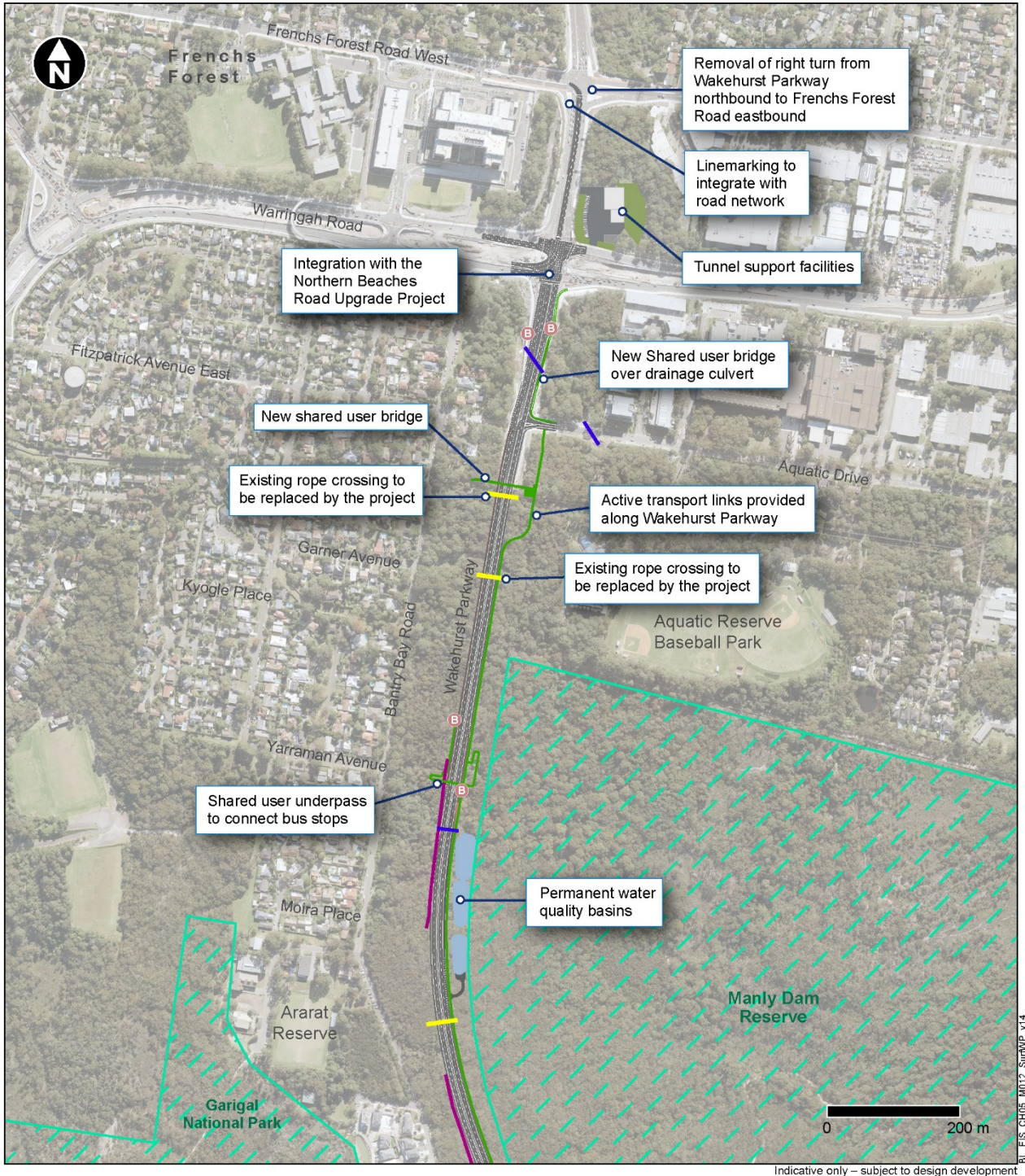
Operational infrastructure

- Ventilation outlet
- Operational facilities and ancillary infrastructure
- Permanent water quality basin
- Fauna rope crossing
- Fauna underpass
- Indicative new noise barrier

Natural features

- National parks and reserves

Figure 5-23 Surface road works at Seaforth, Killarney Heights and Frenchs Forest (map 1)



Legend

Surface features

- B Bus stops
- Surface road
- Pedestrian / active transport links

Operational facilities

- Operational facilities and ancillary infrastructure
- Permanent water quality basin
- Fauna rope crossing
- Fauna underpass
- Indicative new noise barrier

Natural features

- National parks and reserves

Figure 5-24 Surface road works at Seaforth, Killarney Heights and Frenchs Forest (map 2)

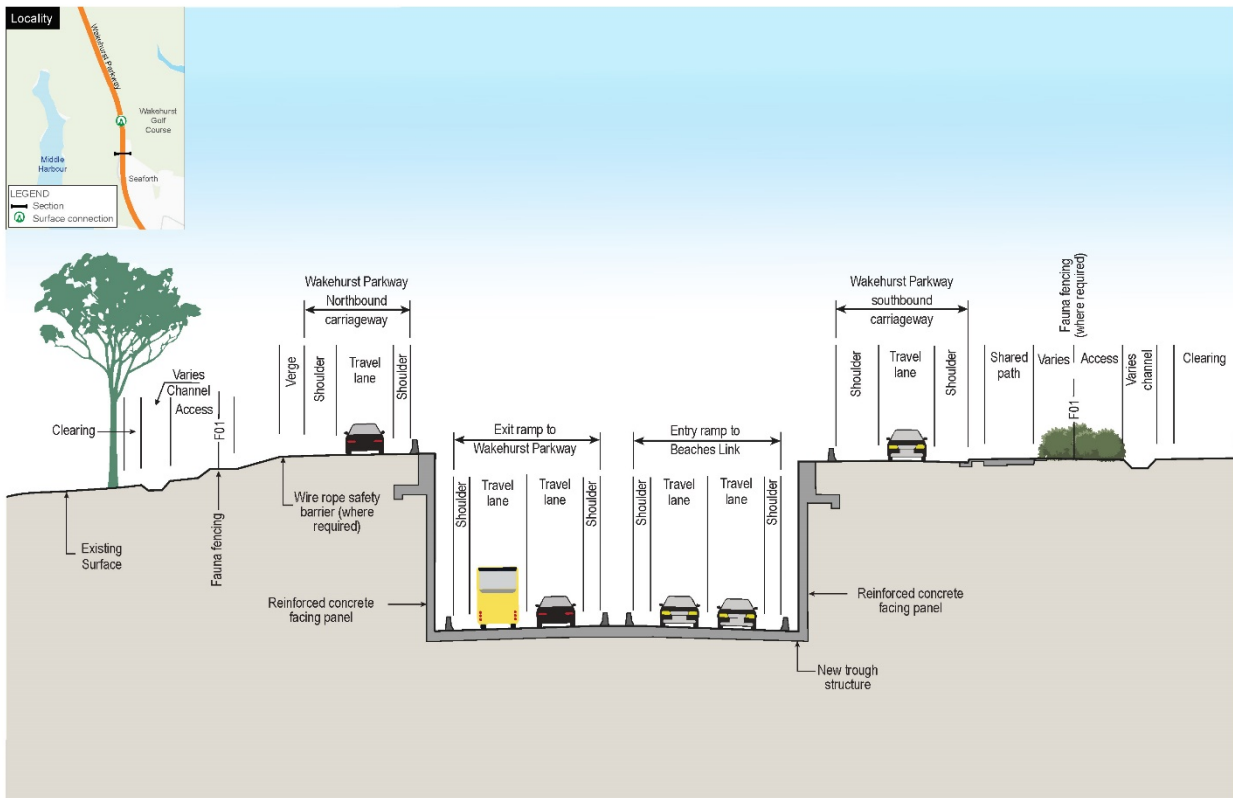


Figure 5-25 Indicative cross-section through the Wakehurst Parkway and ramp trough structure

5.2.7 Operational facilities and ancillary infrastructure

Operational facilities for the Beaches Link component of the project would include:

- Tunnel ventilation systems
- A motorway control centre
- Tunnel support facilities.

Operational ancillary infrastructure for the Beaches Link component of the project would include:

- Fire and life safety systems
- Tunnel drainage and wastewater treatment plant
- Lighting
- Signage, CCTV and other traffic control systems
- Tolling infrastructure
- Emergency breakdown bays
- Electrical substations (discussed in Section 5.2.9).

Tunnel ventilation systems

Tunnel ventilation systems would be installed to ensure in-tunnel air quality is protective of human health and amenity, and to manage fire and smoke in the event of an incident in the tunnels. The tunnel ventilation systems would include:

- Jet fans installed in the ceiling of the tunnels
- Axial fans within the motorway facilities to extract air from the tunnel via ventilation tunnels
- Axial fans within the motorway facilities to supply air to the tunnel via ventilation tunnels
- Ventilation outlets to effectively disperse tunnel air into the atmosphere
- Air quality monitoring systems in the tunnels and ventilation outlets to monitor and control the ventilation system.

The design and operation of the tunnel ventilation systems are detailed in Appendix I (Technical working paper: Air quality).

During normal operating conditions, most air would be forced through the tunnels by the movement of vehicles (the piston effect). Jet fans would be used to assist with the movement of tunnel air, if required, to maintain acceptable in-tunnel air quality.

The design of the ventilation system would ensure zero portal emissions. This would involve using jet fans to draw air back into the tunnel at the exit portals, to be emitted via the ventilation outlets. Tunnel air flow during normal operating conditions is shown in Figure 5-26.

If the tunnels become congested, or in instances of reduced traffic speeds, jet fans would be used to maintain air flow and acceptable in-tunnel air quality.

Air would be removed from the tunnels before it reaches the exit portals, and directed to motorway facilities at the Warringah Freeway (refer to Figure 5-1), Gore Hill Freeway (refer to Figure 5-2), Burnt Bridge Creek Deviation (refer to Figure 5-21) and the Wakehurst Parkway (refer to Figure 5-23).

In the case of a fire, the carriageway on which the incident has occurred would be closed to incoming traffic and traffic downstream of the fire would exit the tunnel. Jet fans would be used to control smoke and fire in the event of an incident in the tunnels, and would propel the smoke downstream and away from the stopped vehicles to the nearest ventilation outlet, or the tunnel portal(s), depending on the location of the fire. The ventilation system would be designed to prevent smoke spreading to adjoining tunnels.

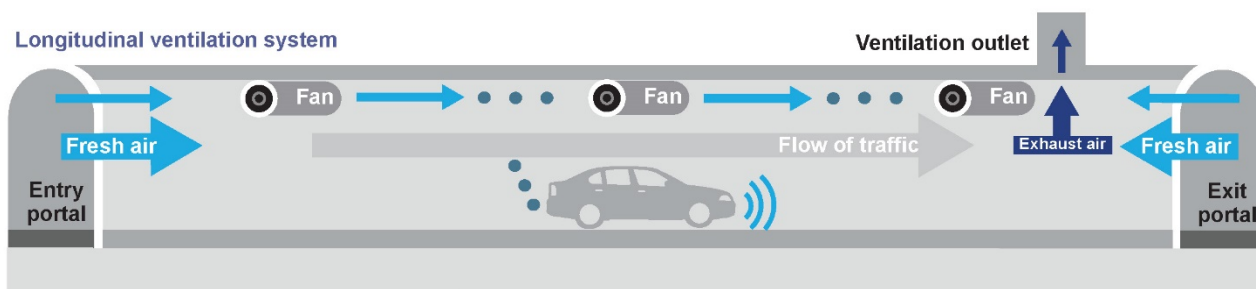


Figure 5-26 Tunnel air flow during normal operating conditions

Motorway control centre

The Beaches Link motorway control centre would be located at the Gore Hill Freeway, within the Artarmon industrial area, as shown in Figure 5-2.

The motorway control centre is anticipated to comprise a double-storey building with an area of about 650 square metres, and an adjoining car park. It would be continuously staffed and used to monitor, and if necessary, respond to, conditions in the tunnels and on surface road connections.

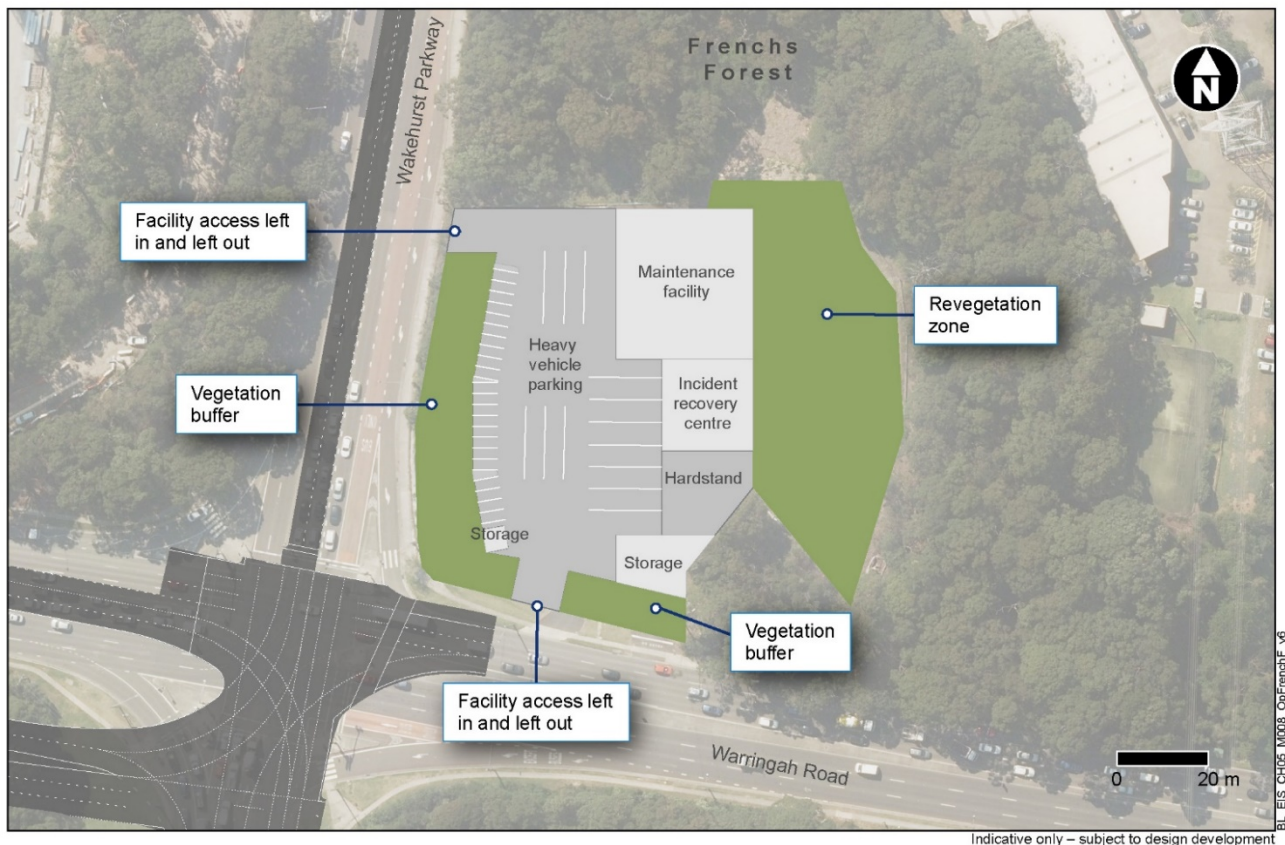
Tunnel support facilities

Tunnel support facilities would be located at the Gore Hill Freeway within the Artarmon industrial area (as shown in Figure 5-2) and next to the intersection of the Wakehurst Parkway and Warringah Road at Frenchs Forest (as shown in Figure 5-27).

The tunnel support facilities would include:

- A maintenance facility
- An incident recovery centre
- Materials storage and management areas.

The sites would be enclosed by high security fencing.



Legend

Surface features

Surface road

Operational infrastructure

Operational facilities and ancillary infrastructure

Figure 5-27 Tunnel support facilities at the Wakehurst Parkway in Frenchs Forest

Fire and life safety systems

The tunnels would be fitted with fire and life safety systems consistent with Australian Standard *AS 4825:2011 Tunnel Fire Safety*, applicable Austroads and Transport for NSW guidelines, and the outcomes of consultation with emergency services. Fire and life safety systems would include:

- Fire and incident detection equipment, a CCTV monitoring system, automatic video incident detection system and linear heat detection systems
- Communication systems, public and emergency broadcast services, and motorist emergency telephones
- Fire suppression systems, including a deluge water suppression system, a fire hydrant system, and emergency equipment points containing hydrants, fire hose reels and fire extinguishers

- Emergency lighting, smoke management and power systems
- Pedestrian cross passages between the tunnels, or longitudinal egress passages, to provide safe access or exit in the event of a fire or other emergency
- Tunnel closure systems.

Tunnel drainage and wastewater treatment plant

A drainage and sump system would be installed within the tunnels to collect:

- Groundwater ingress into the tunnels
- Deluge water in the event of an incident or during routine testing of emergency systems
- Washdown water
- Spills and leaks.

Wastewater intercepted by the tunnel drainage systems would be collected at a sump and pumped to the project wastewater treatment plant at the Gore Hill Freeway in Artarmon (refer to Chapter 17 (Hydrodynamics and water quality) for further details of the operational wastewater treatment plant for the project).

The wastewater treatment plant would consist of:

- A balance tank to regulate flows into the plant
- A treatment plant, including clarifier and control room, to treat water prior to discharge into the stormwater drainage system.

To minimise the impact on downstream water quality, the wastewater treatment plant would be designed to treat the wastewater to comply with the *National Water Quality Guidelines* (ANZG (2018) and Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) water quality guidelines (2000) default trigger values for physical and chemical stressors for estuarine and lowland river ecosystems and the 95 percent species protection levels for toxicants when designing wastewater treatment plants. For toxicants known to bioaccumulate, the 99 percent species protection level will be adopted. Additionally, where required, appropriate tunnel lining design would reduce water inflow into the tunnel thereby minimising the amount of wastewater treatment and disposal required during tunnel operation.

Lighting

Lighting would be provided within the tunnels and along surface roads, consistent with the guidelines published by Austroads and Transport for NSW, as well as the relevant and applicable Australian Standards.

Emergency lighting would also be installed in the tunnels. This would include fixed direction exit signage and illuminated signage. Aviation hazard lighting may be installed on motorway facilities if required as a result of consultation with the Civil Aviation Safety Authority.

Lighting of aboveground operational facilities would be provided, consistent with Australian Standard *AS 4282-2019 Control of Obtrusive Effects of Outdoor Lighting*. Lighting would be designed and installed to ensure safety and security, and to minimise the potential for light spill and nuisance impacts.

Signage, CCTV and other traffic control systems

Traffic, locational, directional, warning and variable message signs would be installed along the length of the project. Signage would be consistent with the requirements of applicable Australian Standards and guidelines published by Austroads and Transport for NSW.

The project would include intelligent transport system technology and traffic control infrastructure including:

- Variable message signs
- Lane use management systems
- Variable speed limit signs
- CCTV and automatic incident detection systems
- Ramp metering infrastructure
- Motorists emergency telephones within breakdown bays
- Vehicle enforcement systems.

Tolling infrastructure

Infrastructure would be installed as part of the project to provide the NSW Government with the option to apply tolls to traffic using the Beaches Link tunnel. Toll gantries would span one or more traffic lanes, depending on location. The toll gantries would be installed with lighting (where required) and electronic tolling units. The toll gantries would indicatively be located inside the tunnels at locations to be determined during further design development, between the ramp merge points between Northbridge and Seaforth, as shown in Figure 5-3 and Figure 5-4.

5.2.8 Public and active transport infrastructure

The Beaches Link component of the project has been designed to be a key piece of the public transport network of the Northern Beaches, allowing for the future provision of express bus connections with North Sydney, the Sydney CBD, Macquarie Park, St Leonards and other key centres across greater Sydney via the motorway network. Accordingly, the Beaches Link tunnels have been designed to allow use by buses, including taller double decker bus services. The tunnel portals at the Warringah Freeway have also been designed to integrate with a new southbound bus lane on the Warringah Freeway (delivered as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project), and provide the opportunity for efficient access and interchange with the new Victoria Cross Metro Station at North Sydney.

Public and active transport infrastructure included within the project would be delivered as part of the surface road connections at Artarmon, Balgowlah, Killarney Heights and Frenchs Forest and as part of the new and improved open space and recreation facilities at Balgowlah. Works at Artarmon would form part of the Gore Hill Freeway Connection component of the project and are detailed separately in Section 5.3.4. Further public and active transport infrastructure would be provided around Cammeray and North Sydney as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

Any new or modified public and active transport associated with the project would satisfy relevant accessibility requirements as per the *Disability Discrimination Act 1992* and the 'crime prevention through environmental design' principles as per Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment).

Pedestrians and cyclists would be excluded from the tunnels.

Public and active transport infrastructure that would be provided at Balgowlah, Seaforth, Killarney Heights and Frenchs Forest is summarised in Table 5-9 and shown in Figure 5-21, Figure 5-23 and Figure 5-24.

Table 5-9 Public and active transport infrastructure of the Beaches Link component

Infrastructure	Summary
Works at Cammeray	
Public transport infrastructure	<p>Beaches Link on and off ramps have been designed to provide for high quality bus access to and from North Sydney (including the new Victoria Cross Metro Station) and the Sydney CBD via upgraded bus infrastructure along the Warringah Freeway, and North Sydney access arrangements to be delivered as part of the Warringah Freeway Upgrade.</p> <p>Bus priority would be provided by allowing buses travelling southbound in the Beaches Link tunnel direct access to a new southbound bus lane on the Warringah Freeway.</p>
Works at Balgowlah	
Public transport infrastructure	<p>A northbound and a southbound bus lane would be maintained along the Burnt Bridge Creek Deviation as part of the realignment and widening of the road. This would be consistent with existing bus provisions in this area, but would benefit from the new Beaches Link tunnels, which would enable express services to bypass the Military Road/Spit Road corridor to access North Sydney, the Sydney CBD, Macquarie Park, St Leonards and other strategic centres.</p>
Active transport infrastructure (final layouts subject to further consultation)	<p>The following pedestrian and cyclist facilities would be provided:</p> <ul style="list-style-type: none"> • Realignment and reconstruction of the shared user path along the south eastern side of the Burnt Bridge Creek Deviation between the Kitchener Street bridge and Dudley Street. The realigned and reconstructed shared user path would connect with the existing shared user path at Dudley Street and extension of the existing active transport underpass beneath the Burnt Bridge Creek Deviation to the north of Dudley Street • A new shared user path along the eastern side of the new access road between Burnt Bridge Creek Deviation and Sydney Road • New at-grade pedestrian crossings of the new access road adjacent to the: <ul style="list-style-type: none"> - Intersection with Sydney Road - Intersection with Burnt Bridge Creek Deviation - New public car park within the new and improved open space and recreation facilities at Balgowlah. <p>The existing pedestrian bridge over Sydney Road would be retained. The final layout of the new and improved open space and recreation facilities at Balgowlah, including shared user paths, are subject to further consultation with Northern Beaches Council and the community.</p>
Works at Seaforth, Killarney Heights and Frenchs Forest	
Public transport infrastructure	<p>Four new dedicated bus bays and bus stops would be provided along:</p> <ul style="list-style-type: none"> • Wakehurst Parkway northbound, near Yarraman Avenue and about 930 metres south of Yarraman Avenue • Wakehurst Parkway southbound, near Yarraman Avenue and about 990 metres south of Yarraman Avenue.

Infrastructure	Summary
	The new bus bays and stops would be integrated with new active transport infrastructure including new underpasses to improve accessibility and user safety.
Active transport infrastructure	<p>The following pedestrian and cyclist facilities would be provided to improve safety:</p> <ul style="list-style-type: none"> • A new shared user path along the eastern side of the Wakehurst Parkway, from the northern end of Kirkwood Street at Seaforth to the intersection with Warringah Road at Frenchs Forest. The new shared user path includes a new bridge over a drainage culvert and fauna underpass (constructed as part of Northern Beaches Hospital road upgrade project), about 150 metres south of the intersection with Warringah Road • A new shared user underpass beneath the Wakehurst Parkway about 700 metres north of Kirkwood Street to connect Garigal National Park and the Engravings Trail to Manly Dam Reserve • A new shared user underpass beneath the Wakehurst Parkway about 1150 metres north of Kirkwood Street to connect Garigal National Park to Manly Dam Reserve • A new shared user underpass beneath the Wakehurst Parkway about 750 metres south of the intersection with Warringah Road at Frenchs Forest • Replacement of the existing pedestrian bridge across the Wakehurst Parkway, with a new shared user bridge about 350 metres south of Warringah Road at Frenchs Forest.

5.2.9 Utilities

The project would require the installation, relocation, adjustment and/or protection of utilities, particularly within and around surface connections and surface road works (refer to Section 5.2.5 and Section 5.2.6). The Utilities management strategy for the project (refer to Appendix D (Utilities management strategy)) provides a framework for utility installations, relocations, adjustments and protection. The Utilities management strategy provides information in relation to utility installations, relocations and adjustments which are currently:

- Known and proposed within the construction footprint
- Unknown and/or located outside of the construction footprint. The Utilities management strategy provides the framework for how these utility relocations and adjustments would be identified, assessed and managed.

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

The project would also require connection with electricity and water supply networks, as outlined below.

Electricity supply

Electricity would be supplied to, and distributed through, the project via:

- Underground substations along the length of the tunnels
- Aboveground substations that would be co-located with motorway facilities at the Warringah Freeway, Gore Hill Freeway, Burnt Bridge Creek Deviation and Wakehurst Parkway.

The aboveground substation at the Wakehurst Parkway at Killarney Heights would be connected to the existing electricity supply network via new conduits installed along the Wakehurst Parkway

upgrade works. Subject to further consultation with Ausgrid, it is expected that electricity supply connections would be made with the Warringah sub-transmission substation.

Access for the service provider would be maintained to the existing 132kV cable adjacent to operational facilities at the Gore Hill Freeway.

Water supply

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:

- Testing and operation of the tunnel deluge water suppression system (which forms part of the fire and life safety system)
- Motorway facilities ablutions
- Landscape irrigation.

The mains water supply network connection requirements, including connection location and design, would be determined in consultation with Sydney Water prior to the start of construction. Connection to water supply infrastructure would be subject to separate assessment and approval.

Water storage tanks to supply the tunnel hydrant and deluge water suppression systems would be located with other operational ancillary infrastructure at Cammeray and Artarmon (refer to Section 5.2.7).

5.2.10 Property acquisition

The project has been designed to minimise land acquisition and limit the severance of private properties. Property impacts are discussed further in Chapter 20 (Land use and property).

The total area and number of properties that would be acquired for the project may change as the project continues to be refined, or in response to changes resulting from the exhibition of the environmental impact statement and conditions of approval that may be applied by the Minister for Planning and Public Spaces.

The project would also involve the subdivision of private and public land. In some cases, whole lots would be acquired to avoid creating small unusable lots. Where a part of any lot is identified as being usable post construction and surplus to operational requirements, or requiring boundary adjustment following the completion of construction, Deposited Plans of subdivision, would be lodged at NSW Land Registry Services.

5.2.11 Environmental controls

The project has been designed to avoid or minimise environmental impacts as detailed in Chapter 4 (Project development and alternatives). Key environmental controls that would be provided as part of the Beaches Link component of the project are summarised in Table 5-10. Environmental controls forming part of the Gore Hill Freeway Connection component of the project are detailed in Section 5.3.8.

Table 5-10 Environmental controls of the Beaches Link component

Infrastructure	Summary
General environmental controls	
Ventilation outlets	A description of the proposed tunnel ventilation system is provided in Section 5.2.7. The tunnel ventilation method adopted for the project is based on a longitudinal ventilation system, where fresh air is typically introduced into the tunnels via the entry portals, extracted prior to the

Infrastructure	Summary
	<p>exit portals and discharged into the atmosphere via the ventilation outlets. This ventilation method delivers and disperses tunnel air high into the atmosphere and avoids impact to ambient air quality around the tunnel portals.</p> <p>The primary motive force for airflow through the tunnel is the vehicle piston effect, which can be supplemented by jet fan operation, typically at lower average traffic speeds, if required. The location of ventilation outlets is considered in Chapter 4 (Project development and alternatives).</p>
<p>Air quality monitoring and management systems</p>	<p>Continuous emission monitoring and ambient air quality monitoring would be carried out during operation of the project to monitor:</p> <ul style="list-style-type: none"> • In-tunnel air quality • Air quality within ventilation outlets • Ambient air quality at representative locations for a defined period of project operation. <p>Air quality monitoring and ventilation for the project would be coordinated across the broader road network (including the Western Harbour Tunnel and Warringah Freeway Upgrade, and WestConnex network) to ensure:</p> <ul style="list-style-type: none"> • Air quality remains within specified limits for motorists and road workers • Required airflows can be achieved for safety outcomes in the event of an incident or emergency • Ventilation systems are used efficiently to minimise day-to-day energy usage and cost and to maximise asset life • Airflows required for safety outcomes in the event of an incident can be achieved. <p>Continuous emissions monitoring equipment for key contaminants (nitrogen dioxide and carbon monoxide), visibility and potentially other pollutants would be installed at appropriate locations within tunnels and ventilation outlets to ensure the project is operating within the prescribed emission limits for the project set by the conditions of approval, and the NSW Environment Protection Authority. Periodic manual monitoring of ventilation outlet emissions would also be carried out as required, to validate the accuracy of the continuous emissions monitoring equipment.</p> <p>Continuous ambient air quality monitoring of key contaminants (particulate matter (PM_{2.5} and PM₁₀), oxides of nitrogen (NO and NO₂) and carbon monoxide would also be carried out at representative locations in the vicinity of the ventilation outlets to allow for the review of the predicted air quality outcomes. Monitoring would be in accordance with <i>Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales</i> (DEC, 2007) or as otherwise agreed with the NSW Environment Protection Authority. Ambient air quality monitoring would occur at least 12 continuous months prior to operation and continue for two years following the commencement of operation. At the conclusion of the two year operational monitoring period, the need for continued use of ambient air quality monitoring stations would be reviewed in consultation with the NSW Environment Protection Authority and the Department of Planning, Industry and Environment.</p>
<p>Environmental controls at Artarmon</p>	

Infrastructure	Summary
Tunnel water drainage and management infrastructure	A wastewater treatment plant would be located at the Gore Hill Freeway in the Artarmon industrial area, to treat stormwater, groundwater, deluge water, or spills collected within the Beaches Link tunnels to comply with ANZECC/ARMCANZ (2000) and ANZG (2018) guidelines before reuse or discharge (refer to Section 5.2.7).
Noise attenuation measures	Noise attenuators would be fitted on axial fans within the motorway facilities.
Surface water drainage and management infrastructure	Key surface water drainage and management that would be provided at Artarmon would include flood walls along the top of the Beaches Link on and off ramp portals to the west of the T1 North Shore and Western Line and T9 Northern Line.
Environmental controls at Balgowlah	
Surface water drainage and management infrastructure	<p>Key surface water drainage and management that would be provided at Balgowlah would include:</p> <ul style="list-style-type: none"> • A new drainage network at the tunnel portals to minimise the potential for ingress of water • Replacement of existing drainage infrastructure directly affected by surface works where required • Extension of the existing box culvert beneath Burnt Bridge Creek Deviation to the north of Dudley Street • Culverts beneath the new access road to carry drainage from around Sydney Road • A new water quality basin and provision of flood storage capacity • Localised adjustment of a small section of Burnt Bridge Creek (as discussed in Section 5.2.6).
Noise attenuation measures	<p>Noise attenuation measures as part of the project at Balgowlah would include noise attenuators fitted on axial fans within the motorway facilities.</p> <p>No new noise barriers are proposed. The two existing noise barriers on Burnt Bridge Creek Deviation northbound would be maintained at the existing extent and height.</p>
Environmental controls at Seaforth, Killarney Heights and Frenchs Forest	
Surface water drainage and management infrastructure	<p>Key surface water drainage and management that would be provided at Seaforth, Killarney Heights and Frenchs Forest would include:</p> <ul style="list-style-type: none"> • A new drainage network at the tunnel portals to minimise the potential for ingress of water • Replacement of existing drainage infrastructure directly affected by surface works where required • Extension and replacement where necessary of the six existing cross drainage structures beneath the Wakehurst Parkway • A new water quality basin to the west of the widened Wakehurst Parkway, adjacent to Garigal National Park and about 600 metres north of Kirkwood Street • Three new water quality basins to the east of the widened Wakehurst Parkway about 800 metres to 900 metres south of the intersection with Warringah Road.

Infrastructure	Summary
Noise attenuation measures	<p>Noise attenuation measures as part of the project at Killarney Heights and Frenchs Forest would include two new noise barriers along the northern end of the Wakehurst Parkway in Frenchs Forest, with a nominal height between four and five metres installed where required. The final height and design of the noise barriers would be confirmed during further design development.</p>
Fauna crossings and fencing at the Wakehurst Parkway	<p>New and replacement fauna crossings would be provided over and beneath the Wakehurst Parkway, including:</p> <ul style="list-style-type: none"> • Two new fauna underpasses about 1000 metres north of Kirkwood Street and 620 metres south of Aquatic Drive. The underpasses would be 1.8 metres high and three metres wide • A separate fauna underpass would be located about 725 metres north of Kirkwood Street • Three new rope crossings about 910 metres and 1370 metres north of Kirkwood Street and 885 metres south of Aquatic Drive • Replacement of the existing fauna rope crossing about 330 metres north of Kirkwood Street • Replacement of two fauna rope crossings about 110 metres and 200 metres south of Aquatic Drive constructed as part of the Northern Beaches Hospital road upgrade project • Retention of the existing fauna underpass north of Aquatic Drive constructed as part of the Northern Beaches Hospital road upgrade project • Fauna fencing as required along the Wakehurst Parkway. <p>Fauna crossings are discussed in more detail in Chapter 19 (Biodiversity) and Appendix S (Technical working paper: Biodiversity development assessment report).</p>

5.2.12 Landscape treatments

Landscape treatments for the project would be consistent with the project urban design framework in Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment). Landscape treatments would be designed and implemented with the aims of:

- Minimising the visual and landscape impacts of the project
- Integrating the project into the surrounding visual catchment
- Improving local and regional amenity
- Maximising the use of endemic species, including consideration of current and future climate conditions
- Providing opportunity for improvements in urban ecology.

Landscape treatments would be provided along and around surface road works, including around tunnel portals and bridges, and around operational ancillary infrastructure. Key features of landscape treatments for the Beaches Link component of the project are summarised in Table 5-11. Landscape treatments for the Gore Hill Freeway Connection component of the project are outlined in Section 5.3.9.

Land used for construction but not required for operational infrastructure would be reinstated as outlined in Chapter 6 (Construction work).

The landscape design for the project would continue to be refined through further design development in line with the principles established in Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment).

Table 5-11 Landscape treatments of the Beaches Link component

Area	Key features of landscape treatments
Cammeray surface works	<p>Landscape treatments around the Cammeray surface works and operational ancillary infrastructure would include:</p> <ul style="list-style-type: none"> • Restoration of areas disturbed during construction, however reconfiguration of Cammeray Golf Course would be carried out as part of the Western Harbour Tunnel and Warringah Freeway Upgrade project • Screen planting around the motorway facilities at the Warringah Freeway • Landscape planting to assist the integration of the Beaches Link tunnel portals into the surrounding landscape.
Balgowlah surface works	<p>Landscape treatments around the Balgowlah surface works and operational ancillary infrastructure would include (refer to Figure 5-28):</p> <ul style="list-style-type: none"> • Screening of motorway facilities using landscape planting • Landscape planting to assist the integration of the tunnel portals into the surrounding landscape • Revegetation of minor disturbed area of Burnt Bridge Creek with an appropriate mix of native vegetation • A vegetated screening buffer between residential dwellings along the eastern boundary of the new and improved open space and recreation facilities at Balgowlah.
Seaforth, Killarney Heights and Frenchs Forest surface works	<p>Landscape treatments around the Seaforth, Killarney Heights and Frenchs Forest surface works and operational ancillary infrastructure would include:</p> <ul style="list-style-type: none"> • Bushland type seeding and planting of appropriate size and scale for restoration of areas disturbed during construction • A vegetated screening buffer around motorway facilities and supporting infrastructure • Bushland type planting of appropriate size and scale above the tunnel portals with an appropriate mix of native vegetation.

5.2.13 New and improved public open space

Balgowlah

The project has identified the potential for residual land at Balgowlah to be re-purposed as new and improved open space and recreation facilities for the community.

A dedicated consultation process jointly led by Transport for NSW and Northern Beaches Council will take place to give the community an opportunity to provide input into the final layout of the new and improved open space and recreation facilities at Balgowlah. This consultation will be separate to the consultation for the environmental impact statement. This process will start after the environmental impact statement public exhibition period and well in advance of construction starting. As part of this consultation process, a community reference group will be established, with representative stakeholder groups and the community, to support Transport for NSW and Northern Beaches Council with the development of this important public space.

The project would return an area, equivalent to around 90 per cent of the current open space, to the community as new and improved open space and recreation facilities. Residual land, primarily to the east and north of the new access road, would progressively become available through the construction period, which would facilitate re-purposing it to the new open space and recreation facilities. This would allow it to be handed over progressively for use by the community. The new open space and recreation facilities to the west of the proposed access road, between the access road and Burnt Bridge Creek Deviation, would be constructed and handed over to Northern Beaches Council after completion of the project. Construction of the new and improved open space and recreation facilities is discussed further in Chapter 6 (Construction work).

An indicative layout of the new and improved open space and recreation facilities at Balgowlah is provided in Figure 5-28. This layout is subject to consultation, but as shown could include new cricket nets, playgrounds, soccer fields, amenities blocks, a multi-purpose oval, netball/basketball courts, and general public open space areas and pathways. An access road and centrally located car park would also be provided.

Bantry Bay Reservoir

The project proposes to use an area north of the Bantry Bay Reservoir to enable construction of Beaches Link. This site is currently a non-operational part of the Sydney Water Bantry Bay Reservoir site. As part of the project, Transport for NSW would acquire this parcel of land from Sydney Water. During the construction period, the project would use this site as part of the Wakehurst Parkway east construction support site (BL13) (refer to Chapter 6 (Construction work)). Use of this site would enable construction of the project, while reducing impacts to private property in the Seaforth and Killarney Heights area.

The site would be rehabilitated and revegetated as soon as practicable after construction completion and land that is surplus to Sydney Water's operational requirements would be transferred to the Manly Dam Reserve. This would add about 4000 square metres of new public space to the Manly Dam Reserve.



Indicative only – subject to design development

Legend

Tunnels

- Beaches Link driven tunnel
- Surface connection

Surface features

- Surface road
- Bus lane
- Pedestrian / active transport links
- New open space and recreation facilities (subject to further consultation)
- Trough structure

Operational infrastructure

- Ventilation outlet
- Operational facilities and ancillary infrastructure
- Permanent water quality basin

Indicative open space and recreation facilities

- A Amenity block
- C Cricket nets
- N Netball/ Basketball
- O Open space
- P Playground

Figure 5-28 Indicative Balgowlah new and improved open space and recreation facilities layout

5.3 Gore Hill Freeway Connection

5.3.1 Overview

The Gore Hill Freeway Connection component of the project would connect and integrate the Beaches Link tunnels with the Gore Hill Freeway and Lane Cove Tunnel at Artarmon. This connection would facilitate a more direct and efficient east-west link between the Northern Beaches and key strategic centres in the north west including St Leonards, Macquarie Park and Chatswood, and provide high quality connectivity with the Hills M2 Motorway, the Westlink M7 and NorthConnex.

Key features of the Gore Hill Freeway Connection are shown in Figure 5-1. The Gore Hill Freeway Connection would comprise a series of surface road works to the Gore Hill Freeway and parts of the surrounding surface road network, as shown in Figure 5-29.

5.3.2 Surface connections

Tunnel ramps would connect the mainline tunnels under Northbridge with the Gore Hill Freeway and Reserve Road at Artarmon as outlined in Section 5.2.5. Surface connections between the Beaches Link ramp tunnels and the Gore Hill Freeway are shown in Figure 5-18.

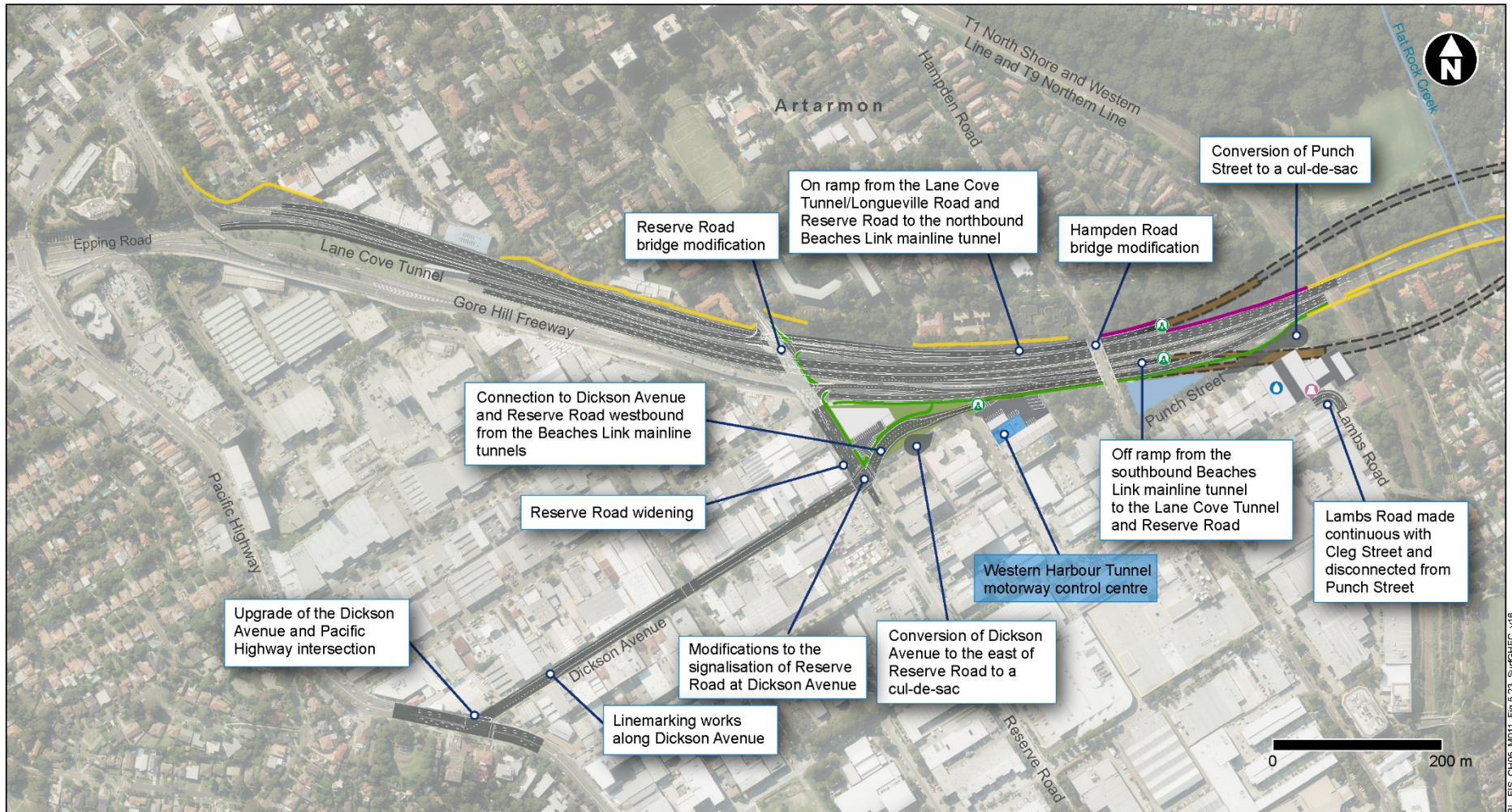
5.3.3 Surface road works

Surface road works forming part of the Gore Hill Freeway Connection would include realignment and adjustment of the existing freeway, and associated changes to the surrounding road network, as summarised in Table 5-12 and shown in Figure 5-29.

Table 5-12 Surface road works of the Gore Hill Freeway Connection component

Key project component	Summary
Realignment and upgrade of the Gore Hill Freeway	<p>The Gore Hill Freeway would be realigned and adjusted, including:</p> <ul style="list-style-type: none"> • Adjustment and reconfiguration of the Gore Hill Freeway between the T1 North Shore and Western Line and T9 Northern Line and the Pacific Highway to accommodate the Beaches Link tunnel portals and the on and off ramps • Modification of existing lanes from Epping Road/Longueville Road to the Gore Hill Freeway west of Reserve Road to provide connections to the Beaches Link tunnel and Gore Hill Freeway • Realignment of the existing Gore Hill Freeway westbound lanes towards Epping Road/Longueville Road to further south to accommodate the Beaches Link tunnel portals and connection to Reserve Road at Artarmon • Conversion of the existing T2 transit lane on the Gore Hill Freeway to a general traffic lane • Pedestrian and cyclist infrastructure (refer to Section 5.3.5).
Modified and upgraded road bridges	<p>Existing road bridges across the Gore Hill Freeway would be modified, including:</p> <ul style="list-style-type: none"> • Increasing the capacity of the northbound Reserve Road bridge lanes from two traffic lanes to three lanes. This would require conversion of the existing pedestrian footpath on the eastern side of the existing bridge and construction of a new pedestrian footpath (refer to Section 5.3.5)

Key project component	Summary
	<ul style="list-style-type: none"> • Partial rebuild of the eastbound (east-facing) on ramp from the Reserve Road bridge connecting to the Gore Hill Freeway and the Beaches Link tunnel • Strengthening works to the foundations of the Hampden Road bridge, including modifications to existing retaining walls and embankments.
Changes to local roads	<p>Minor changes to local roads around the Gore Hill Freeway Connection would include:</p> <ul style="list-style-type: none"> • Removal of the connection between Dickson Avenue east and Reserve Road, Artarmon, with conversion of Dickson Avenue to the east of Reserve Road to a cul-de-sac • Removal of the connection between Punch Street and Lambs Road, Artarmon, with conversion of Punch Street to a cul-de-sac • Modifications to the Dickson Avenue west/Reserve Road intersection to accommodate the new Beaches Link off ramp • Modifications to the traffic lights of Reserve Road, Artarmon • Upgrade and inclusion of traffic lights at the Dickson Avenue/Pacific Highway intersection and linemarking along Dickson Avenue west of Reserve Road • Integration work along Dickson Avenue between Reserve Road and the Pacific Highway.
Retaining walls	<p>Several existing retaining walls would be modified, and several new retaining walls would be constructed to accommodate changes in surface levels. Each wall would range in length and height to suit the new works and existing surface levels. Finishes would be designed in line with the urban design framework for the project (refer to Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment)).</p>



Indicative only – subject to design development

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Figure 5-29 Surface works of the Gore Hill Freeway Connection component

5.3.4 Operational ancillary infrastructure

Operational ancillary infrastructure forming part of the Gore Hill Freeway Connection component of the project would include:

- Lighting
- Signage and traffic control systems.

Lighting

The Gore Hill Freeway Connection component of the project would be provided with lighting consistent with the guidelines published by Austroads and Transport for NSW as well as the relevant and applicable Australian Standards. Lighting would be designed and installed to ensure safety and security, and to minimise the potential for light spill and nuisance impacts.

Signage, CCTV and traffic control systems

Traffic, locational, directional, warning and variable message signs would be installed along the reconfigured Gore Hill Freeway Connection component of the project. Signage would be consistent with the requirements of applicable Australian Standards and guidelines published by Austroads and Transport for NSW.

The project would include intelligent transport system technology and traffic control infrastructure including:

- Variable message signs
- Vehicle detection sites
- Lane use management systems
- Variable speed limit signs
- CCTV and automatic incident detection systems
- Ramp metering infrastructure
- Motorists emergency telephones within breakdown bays
- Vehicle enforcement systems.

5.3.5 Public and active transport infrastructure

Public and active transport infrastructure that would be provided as part of the Gore Hill Freeway Connection component of the project is summarised in Table 5-13 and shown in Figure 5-29.

Table 5-13 Public and active transport infrastructure of the Gore Hill Freeway Connection component

Infrastructure	Summary
Public transport infrastructure	The configuration of the surface roads and ramps at the Gore Hill Freeway Connection component are designed to enable high quality bus connectivity between the Beaches Link tunnels and St Leonards, Chatswood, and strategic centres to the north west via the Lane Cove Tunnel. Additional surface road public transport infrastructure would not be provided as part of the project.
Active transport infrastructure	The following pedestrian and cyclist facilities would be provided as part of the Gore Hill Freeway Connection component:

Infrastructure	Summary
	<ul style="list-style-type: none"> • Realignment and reconstruction of the shared user path along the southern side of the Gore Hill Freeway between Reserve Road and the T1 North Shore and Western Line and T9 Northern Line • Replacement of the existing pedestrian footpath along the eastern side of the Reserve Road bridge.

5.3.6 Utilities

The project would require the installation, relocation, adjustment and/or protection of utilities, particularly within and around surface connections and surface road works (refer to Section 5.3.2 and 5.3.3). The Utilities management strategy for the project (refer to Appendix D (Utilities management strategy)) provides a framework for utility installation, relocations, adjustments and protection, including consultation with relevant utility providers. The Utilities management strategy provides information in relation to utility installations, relocations and adjustments which are currently:

- Known and proposed within the construction footprint
- Unknown and/or located outside of the construction footprint. The Utilities management strategy provides the framework for how these utility relocations and adjustments would be identified, assessed and managed.

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

The project would also require connection with electricity and water supply networks.

5.3.7 Property acquisition

The project has been designed to minimise land acquisition and limit the severance of private properties. Property impacts are discussed further in Chapter 20 (Land use and property).

The total area and number of properties that would be acquired for the project may change as the project continues to be refined, or in response to changes resulting from the exhibition of the environmental impact statement and conditions of approval that may be applied by the Minister for Planning and Public Spaces.

The project would also involve the subdivision of private and public land. In some cases, whole lots would be acquired to avoid creating small unusable lots. Where a part of any lot is identified as being usable post construction and surplus to operational requirements, or requiring boundary adjustment following the completion of construction, Deposited Plans of subdivision, would be lodged at NSW Land Registry Services.

5.3.8 Environmental controls

The project has been designed to avoid or minimise environmental impacts, as detailed in Chapter 4 (Project development and alternatives). Key environmental controls that would be provided as part of the Gore Hill Freeway Connection component of the project would include:

- Surface water drainage and management infrastructure
- Noise attenuation measures.

Environmental controls to be provided at Artarmon as part of the Gore Hill Freeway Connection component of the project are summarised in Table 5-14. Environmental controls forming part of the Beaches Link component of the project are detailed in Section 5.2.11.

Table 5-14 Environmental controls of the Gore Hill Freeway Connection component

Infrastructure	Summary
Surface water drainage and management infrastructure	<p>Key surface water drainage and management infrastructure that would be provided at Artarmon would include:</p> <ul style="list-style-type: none"> • A new drainage network around the Beaches Link on and off ramp portals to minimise the potential for ingress of water • A new drainage line between Reserve Road and Hampden Road at Artarmon, connecting to the existing water quality basin between Punch Street and the Gore Hill Freeway • Extension of the existing water quality basin at Punch Street • Relocation of the existing drainage infrastructure around the Hampden Road bridge • Diversion of existing stormwater drainage infrastructure from around the Beaches Link tunnel on and off ramp portals into Flat Rock Creek, with energy dissipation and scour protection measures provided • Upgrade of the concrete lined drainage line between Punch Street and Flat Rock Creek via Chelmsford Avenue.
Noise attenuation measures	<p>New noise barrier on the northern side of the Gore Hill Freeway east of Hampden Street with a nominal height of five metres.</p> <p>The use of quieter pavements to reduce operational road traffic noise would be further investigated during further design development. Pavements would ultimately be selected by balancing performance, design life, durability, serviceability and noise emissions.</p>

5.3.9 Landscape treatments

Landscape treatments for the Gore Hill Freeway Connection component of the project would be consistent with the project urban design framework in Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment). Landscape treatments would be designed and implemented with the aims of:

- Minimising the visual and landscape impacts of the project
- Integrating the project into the surrounding visual catchment
- Improving local and regional amenity
- Maximising the use of endemic species, including consideration of current and future climate conditions
- Providing opportunity for improvements in urban ecology.

Key features of landscape treatments which would form part of the Gore Hill Freeway Connection component of the project include:

- Restoration of areas disturbed during construction
- Replacement of the existing green edge to the Gore Hill Freeway where feasible
- Screen planting around the motorway facilities and motorway control centre
- Landscape planting to assist the integration of the Beaches Link tunnel portals into the surrounding landscape.

Landscape treatments for the Beaches Link component of the project are outlined in Section 5.2.12.

Land used for construction but not required for operational infrastructure would be reinstated as outlined in Chapter 20 (Land use and property).

The landscape design for the project would continue to be refined through further design development in line with the principles established in Appendix V (Technical working paper: Urban design, landscape character and visual impact assessment).