ES

Executive summary

January 2020

Executive Summary

Western Harbour Tunnel and Warringah Freeway Upgrade Project

Strategic context

The population of Sydney is forecast to grow from six million to eight million people over the next 40 years. To accommodate this growth, The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services.

The Western Harbour tunnel and Warringah Freeway Upgrade project is located in the Eastern City District, including the Harbour Central Business District (CBD) and the North District of the Eastern Harbour City as shown in Figure E-1. Together, the Eastern City and North Districts support 40 per cent of the population and 60 per cent of the jobs in Greater Sydney.

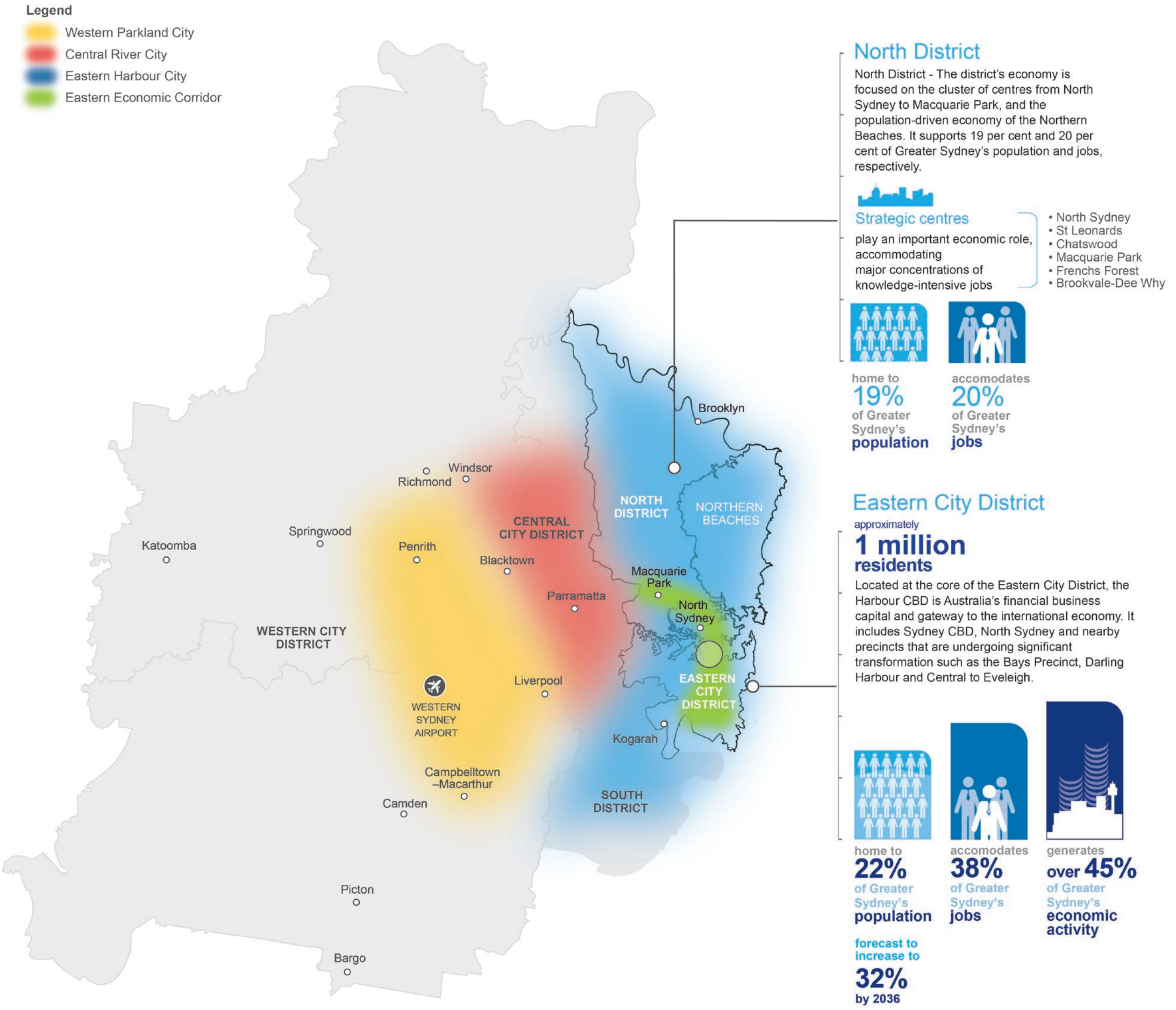


Figure E-1 Greater Sydney's Eastern City and North districts

Supporting the current needs and future growth of the Eastern Harbour City and Eastern Economic Corridor through an efficient transport network is fundamental to the liveability, productivity and sustainability of Greater Sydney. Accordingly, the *Greater Sydney Region Plan* was prepared concurrently with the *Future Transport Strategy 2056* (NSW Government, 2018) and the *State Infrastructure Strategy 2018 – 2038* (Infrastructure NSW, 2018) to align land use, transport and infrastructure outcomes for Greater Sydney.

Project need

The motorway crossings of Sydney Harbour, including the Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge, are critical links in Sydney's motorway and arterial road network. Key metrics for the Eastern Harbour City's road transport network are shown in Figure E-2.

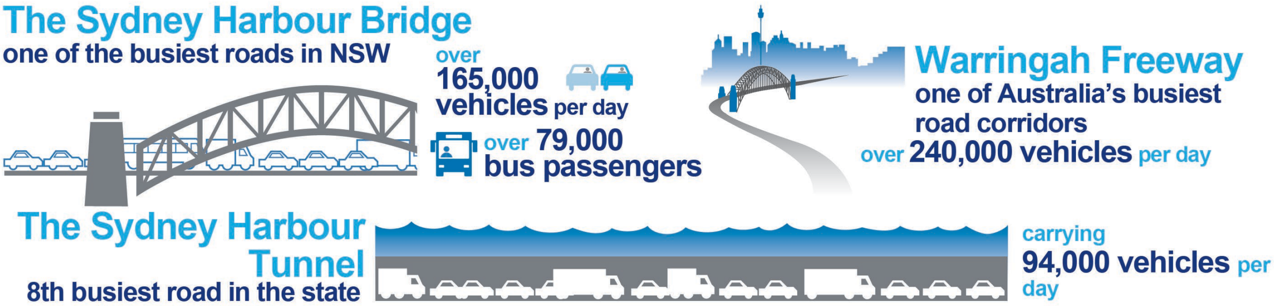


Figure E-2 Key metrics for the Eastern Harbour City's transport network

The high demand and limited capacity on the Sydney Harbour crossings result in delays and unreliable journey times for a significant number of customers who directly rely on these corridors. Furthermore, the limited number of alternate routes for crossing Sydney Harbour makes these corridors critical to the performance of the broader motorway and arterial road network. Network data demonstrates that incidents on the Sydney Harbour Bridge, Sydney Harbour Tunnel and their approaches can quickly and severely impact transport movements across Sydney.

Further to the large traffic volumes and limited alternative routes, a major contributor to congestion around the Harbour CBD is that many of the most critical road corridors – including Sydney Harbour Bridge, Sydney Harbour Tunnel, ANZAC Bridge, Western Distributor, and the Warringah Freeway – perform both bypass and access functions. The dual function of these corridors is reflected in the high proportion of vehicles that use them to travel to destinations other than Sydney CBD. These conflicting functions, combined with high traffic volumes, result in congestion and poor network performance experienced by freight, public transport and private vehicle users.

The Eastern Distributor, Sydney Harbour Bridge, Warringah Freeway and the Gore Hill Freeway corridor are among Australia's most congested road corridors, generating a congestion cost of around $65,000 per day in 2016 (Infrastructure Australia, 2019). These corridors are integral to the economic growth of Sydney's Eastern Economic Corridor. As Sydney's population and economy continues to grow, so will the pressure on access to this corridor. Demand for this corridor is forecast to increase by 17 per cent by 2037, putting substantial pressure on roads that are already operating at capacity and leading to increases in travel time along these routes. Improvements to transport networks are essential for Sydney to continue to be competitive.

The project is also identified as a priority initiative under Infrastructure Australia's *Australian Infrastructure Plan: The Infrastructure Priority List (*Infrastructure Australia, 2018) for its importance in addressing urban congestion on Sydney's road network and providing cross-harbour connectivity.

Further detail on these transport challenges and their influence on the proposed design for the Western Harbour Tunnel and Warringah Freeway Upgrade is provided in Chapter 3.

Project objectives

To ensure the design for project meets the identified transport needs, the objectives summarised in Figure E-3 have been developed for the Western Harbour Tunnel and Warringah Freeway Upgrade project.

Transport challenges

- High volumes of commuter traffic on roads around the Harbour CBD[1]
- Congestion on key roads around the Harbour CBD[1], including Sydney Harbour Bridge, Sydney Harbour Tunnel and Anzac Bridge, add additional strain on capacity of the road network
- The Harbour CBD[1] road network is unable to cope with traffic incidents – an incident can quickly cause long delays across the broader network and take a long time to clear afterwards
- The performance of the Warringah Freeway is impacted by high traffic volumes, congestion on harbour crossings, and merges and weaves
- Congestion impacting the streetscapes, sustainability and liveability across the Eastern City and North Districts[1]

Project objectives

- Reduce congestion on key roads around the Harbour CBD[1], including the Sydney Harbour Bridge, Sydney Harbour Tunnel and Anzac Bridge
- Create faster, safer and more reliable journeys across Sydney Harbour, particularly for traffic bypassing the Harbour CBD[1] to the west
- Improve productivity by allowing commuters and freight to reach their destination faster, safer and more reliably
- Increase the ability for the Harbour CBD[1] road network to cope with traffic incidents
- Reduce travel times, delays and queuing on the Warringah Freeway by improving cross-harbour capacity and reducing merges and weaves, supporting long-term increased demand
- Improve streetscapes, sustainability and liveability across the Eastern City and North Districts[1] by reducing congestion

Project benefits

- A third harbour crossing to reduce congestion and pressure on Sydney Harbour Bridge, Sydney Harbour Tunnel and Anzac Bridge – leading to faster and more reliable journeys to, from and around the Harbour CBD[1]
- Enable local businesses to have better and more efficient access to Greater Sydney, making it easier to move goods and provide services, as well as bringing employees and businesses closer together
- Make journeys on the Warringah Freeway easier and safer by improving lane configuration and providing clear directions on the best way to cross the harbour and reach your destination
- Contribute to an integrated transport network by enabling direct bus access to North Sydney and an efficient transfer to the new Metro
- Return local streets to communities by moving traffic underground, freeing up local streets for local traffic, and supporting the sustainability of local town centres
- Opportunities to enhance the local community by improving shared user connections and providing new public open space

Note 1: Refer to figure E-1 for more information about the location of the Harbour CBD, Eastern City District and North District

Figure E-3 Project challenges, objectives and benefits

Overview of the Western Harbour Tunnel and Beaches Link program

The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project (the project) which comprises a new motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to enable the future connection of the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Killarney Heights. This project also includes a surface upgrade of Wakehurst Parkway from Killarney Heights to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

The components of the Western Harbour Tunnel and Beaches Link program of works are shown in Figure E-4.

The delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster and more reliable travel times for journeys between the strategic centres along the Eastern Economic Corridor of Sydney – an area between Port Botany and north-west that accounts for over 40 per cent of the NSW gross State product. For example, with the combined program of works, journeys from Dee Why to Sydney Kingsford Smith Airport are expected to be 56 minutes faster. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides additional capacity and an alternative to heavily congested existing harbour crossings and their approaches.

The program of works would also provide an opportunity to improve existing, and introduce new, bus services between key employment and education centres, directly and reliably linking North Sydney to the Inner West region of Sydney and the Northern Beaches. This opportunity would better integrate employment, residential and education centres and provide improved road transport access to a wider range of services and facilities.

The Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project are subject to separate but coordinated environmental assessment and approval processes.

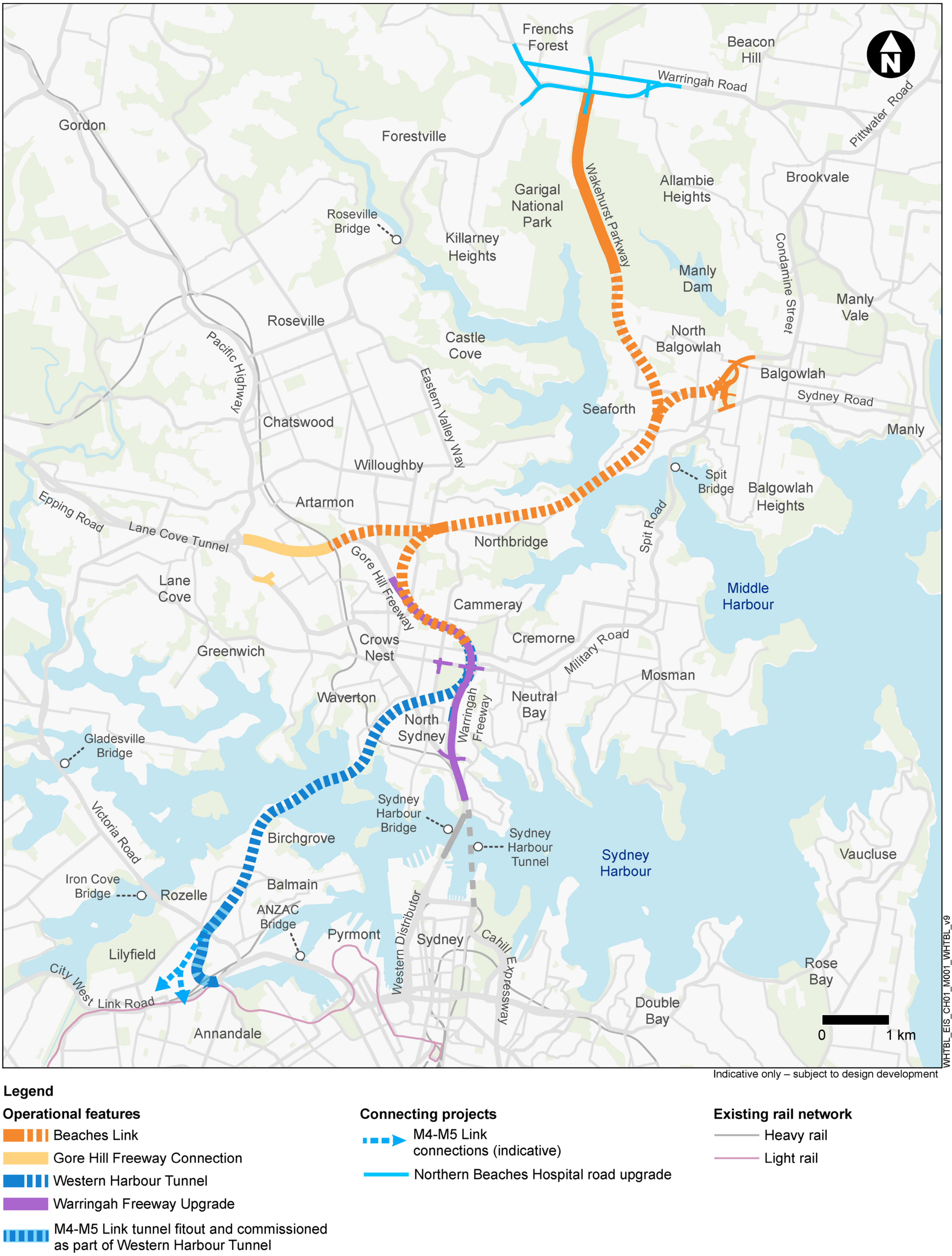


Figure E-4 The Western Harbour Tunnel and Beaches Link program of works

The Western Harbour Tunnel and Warringah Freeway Upgrade project

This environmental impact statement relates to the Western Harbour Tunnel and Warringah Freeway Upgrade project. The project would comprise:

- A new crossing of Sydney Harbour involving twin motorway tunnels connecting the M4-M5 Link at Rozelle and the Warringah Freeway at North Sydney (the Western Harbour Tunnel)
- Upgrade and integration works along the existing Warringah Freeway, including infrastructure required for connections to and from the Western Harbour Tunnel (the Warringah Freeway Upgrade). This would also include some infrastructure required to integrate the future Beaches Link and Gore Hill Freeway Connection project to reduce ongoing disruption to the Warringah Freeway.

Key features of the Western Harbour Tunnel component of the project are shown in Figure E-5 and would include:

- Twin mainline tunnels about 6.5 kilometres long connecting the M4-M5 Link at Rozelle to the Warringah Freeway, near Cammeray
- An immersed tube tunnel crossing of Sydney Harbour between Birchgrove and Balls Head
- Underground connections to the M4-M5 Link project beneath Rozelle
- Tunnelled ramps and surface connections at Rozelle, North Sydney and Cammeray, including direct connections to and from the Warringah Freeway (including integration with the Warringah Freeway Upgrade), an off ramp to Falcon Street and an on ramp from Berry Street at North Sydney
- Tunnelled stubs for future underground connections to the Beaches Link and Gore Hill Freeway Connection project under the Warringah Freeway near Cammeray
- Fitout and commissioning of a ventilation outlet and motorway facilities at the Rozelle Interchange
- Construction of a ventilation outlet and motorway facilities at the Warringah Freeway in Cammeray
- Operational facilities including a motorway control centre at Waltham Street, in the Artarmon industrial area, and tunnel support facilities at the Warringah Freeway in Cammeray
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, signage, tolling infrastructure, fire and life safety systems, lighting, emergency evacuation and emergency smoke extraction infrastructure, CCTV and other traffic management systems.

Key features of the Warringah Freeway Upgrade component of the project are shown in Figure E-6 and would include:

- Upgrade and reconfiguration of the Warringah Freeway from immediately north of the Sydney Harbour Bridge through to Willoughby Road at Naremburn
- Upgrades to interchanges at Falcon Street in Cammeray and High Street in North Sydney
- New and upgraded pedestrian and cyclist infrastructure
- New, modified and relocated road and shared user bridges across the Warringah Freeway
- Connection of the Warringah Freeway to the portals for the Western Harbour Tunnel mainline tunnels and the Beaches Link tunnels, which would consist of a combination of trough and cut and cover structures
- Upgrades to existing roads around the Warringah Freeway to integrate the project with the surrounding road network

- Upgrades and modifications to bus infrastructure, including relocation of the existing bus layover along the Warringah Freeway, and improvements to the geometry and connectivity of the existing southbound bus lane
- Other operational infrastructure, including surface drainage and utility infrastructure, signage, tolling, lighting, CCTV and other traffic management systems.

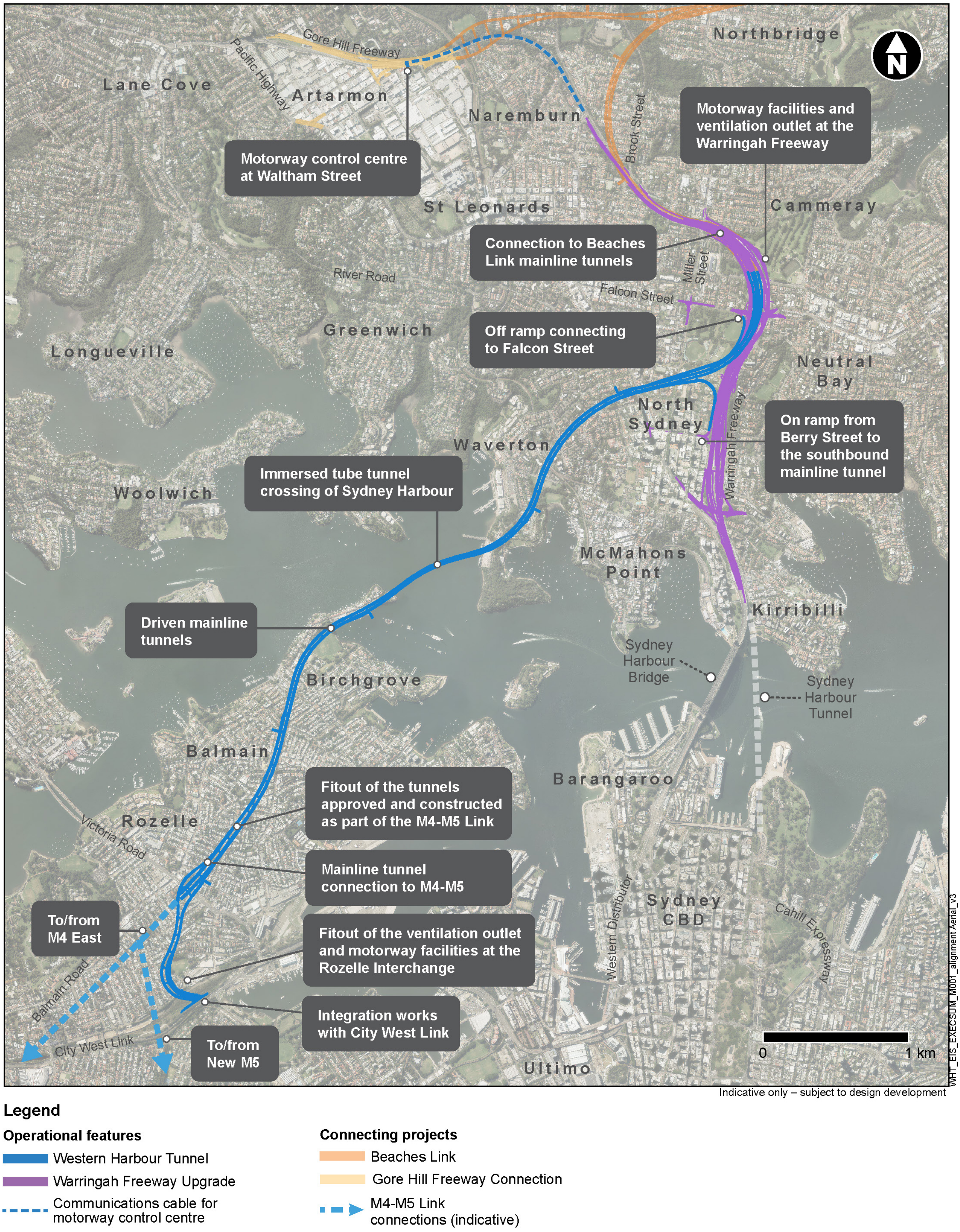
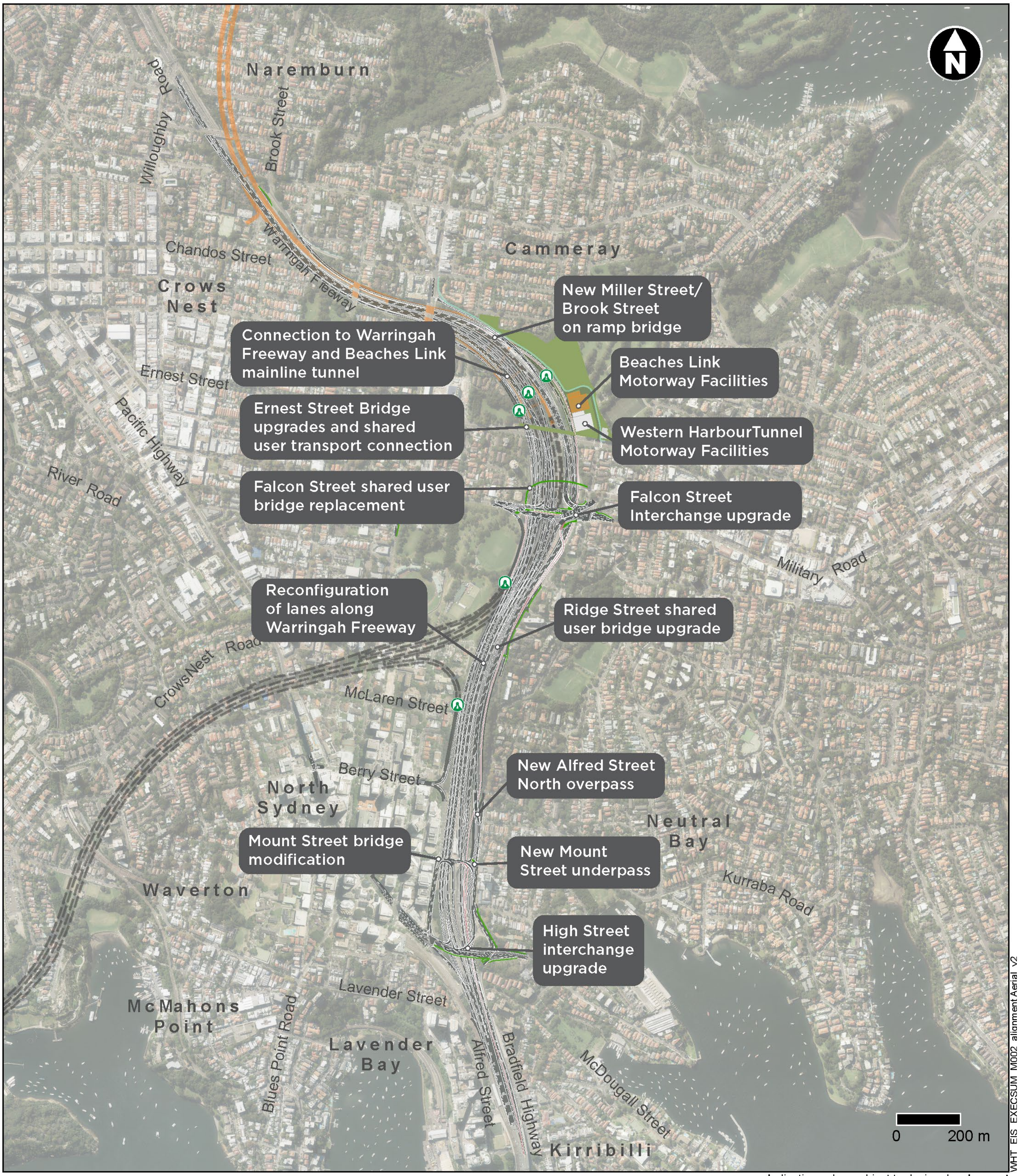


Figure E-5 Key features of the Western Harbour Tunnel component of the project



Indicative only – subject to design development

Legend

Tunnels
- Western Harbour Tunnel driven tunnel
- Surface connection

Surface features
- Surface road
- Bus lane
- Cycleway
- Pedestrian / shared user path

Operational infrastructure
- Operational facilities and ancillary infrastructure

Connecting projects
- Beaches Link and Gore Hill Freeway Connection project

Figure E-6 Key features of the Warringah Freeway Upgrade component of the project

Major transport benefits

The project would provide vital additional capacity on the busiest road corridor in Sydney, improving liveability and amenity for local communities who would benefit from reduced through traffic and congestion at surface and improved connectivity. It would also deliver meaningful productivity benefits for NSW.

The project would leverage the underground WestConnex network to deliver a new western bypass of the Harbour CBD, significantly increasing the efficiency and capacity of the transport crossings of Sydney Harbour. The additional core motorway capacity delivered by this project would significantly improve journey times and journey time reliability for about 2.5 million trips for people who use the Sydney Harbour Bridge and Sydney Harbour Tunnel road crossings every week, as well as users of many arterial roads whose performance is affected by these crossings.

The Warringah Freeway Upgrade would connect the new tunnel with the existing road corridor and streamline traffic movements to optimise the future use of the three harbour crossings.

This new western bypass of the Sydney CBD would serve through journeys between the south and west of Sydney, including the international gateways of Sydney Airport and Port Botany, and strategic centres north of the harbour including North Sydney, St Leonards, Chatswood and Macquarie Park. Increased road network capacity and connectivity as a result of the project would also result in travel time savings for freight movements, further serving the growth of Sydney's Eastern Economic Corridor.

The increase in harbour crossing capacity and efficiency delivered by the project would also remove a major bottleneck that constrains the road transport capacity of areas north of the harbour, including the Northern Beaches area. This enables future connections, such as the Beaches Link and Gore Hill Freeway Connection project, which would deliver significant benefits for public transport, freight and other road users over an increased catchment.

The major transport benefits of the project include:

- A third harbour crossing to reduce congestion on the Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge – leading to faster and more reliable journeys to, from and around the Harbour CBD
- Return local streets to communities by moving traffic underground, freeing up local streets for local traffic, and supporting the sustainability of local town centres
- Make journeys on the Warringah Freeway easier and safer by improving lane configuration and providing clear directions on the best way to cross the harbour and reach your destination
- Enable local businesses to have better and more efficient access to Greater Sydney, making it easier to move goods and provide services, as well as bringing employees and businesses closer together
- Contribute to an integrated transport network by enabling direct bus access to North Sydney and an efficient transfer to the new Metro
- Opportunities to enhance the local community by improving shared user connections and providing new public open space.

Project construction

Construction for the Western Harbour Tunnel component of the project would include works underground, underwater and at the surface. The majority of the tunnel for the project would be constructed using roadheaders. The combination of the high quality Sydney Sandstone beneath most of the city, and the wide cross section required for road tunnels make this the most efficient and common method for constructing road tunnels in Sydney.

The poorer geology at the Sydney Harbour crossing and the large elevation change to North Sydney requires the use of a different methodology to cross Sydney Harbour. An immersed tube tunnel, similar to the existing Sydney Harbour Tunnel, has been selected as the preferred solution as it would reduce the risk of deep tunnelling through poor geology and deliver the best transport product by providing the lowest possible gradient for the connections to the Warringah Freeway.

This section of the tunnel would be constructed by dredging a trench across the bed of the harbour between Birchgrove and Waverton and installing pre-fabricated tunnel units to form the harbour crossing. The immersed tube tunnel units would be fabricated at a construction support site at White Bay and transported by tug boats to a temporary mooring at Snails Bay in Sydney Harbour before being placed.

Temporary cofferdams would be constructed within Sydney Harbour off Yurulbin Point and Balls Head near the Coal Loader. The cofferdams would be used to build underground adaptors, called transition structures, which are required to connect the immersed tube tunnels to the mainline driven tunnels.

Although the majority of construction works for the Western Harbour Tunnel component of the project would be underground, surface works would also be required to support tunnelling activities and to construct the construction support sites, surface connections, tunnel portals and operational facilities. Construction activities for the Warringah Freeway Upgrade would generally include surface earthworks, bridgeworks, construction of retaining walls, installation of stormwater drainage and pavement construction.

Construction of the Western Harbour Tunnel and Warringah Freeway would require around 20 construction support sites including tunnelling and tunnelling support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities. About seven of these sites are areas within the existing Warringah Freeway corridor. An overview of these sites is provided in Figure E-7.

Tunnel spoil generated by the driven tunnels would be removed from acoustic sheds at tunnelling construction support sites. Most of the construction support sites have direct access to the arterial road network, and spoil would generally be removed using trucks. The Yurulbin Point and Berrys Bay construction support sites would use barges to remove spoil to reduce haulage impacts on narrow local streets.

Most of the material dredged for the immersed tube crossing would be transported to the existing designated offshore disposal site managed by the Commonwealth Department of Energy and Environment in accordance with the *Environment Protection (Sea Dumping) Act 1981.* This disposal site is over 20 square kilometres in area, about 120 metres deep, and non-dispersive, meaning that material disposed of stays within the disposal site. The disposal site is currently active and receiving material under permit from other marine maintenance and capital projects. An application for the project to dispose of suitable dredged material at the offshore disposal site has been submitted to the Department of the Environment and Energy.

Dredged materials not suitable for offshore disposal would be transported by barge to White Bay and stabilised, transferred to trucks and transported to a licensed facility. This would be a similar process to the Garden Island works carried out in 2019, which also stabilised and transferred material not suitable for offshore disposal at Glebe Island.

Subject to planning approval, construction of the project is planned to commence in 2020, with completion of construction anticipated in 2026.

For further details on the construction aspects of the project refer to Chapter 6.

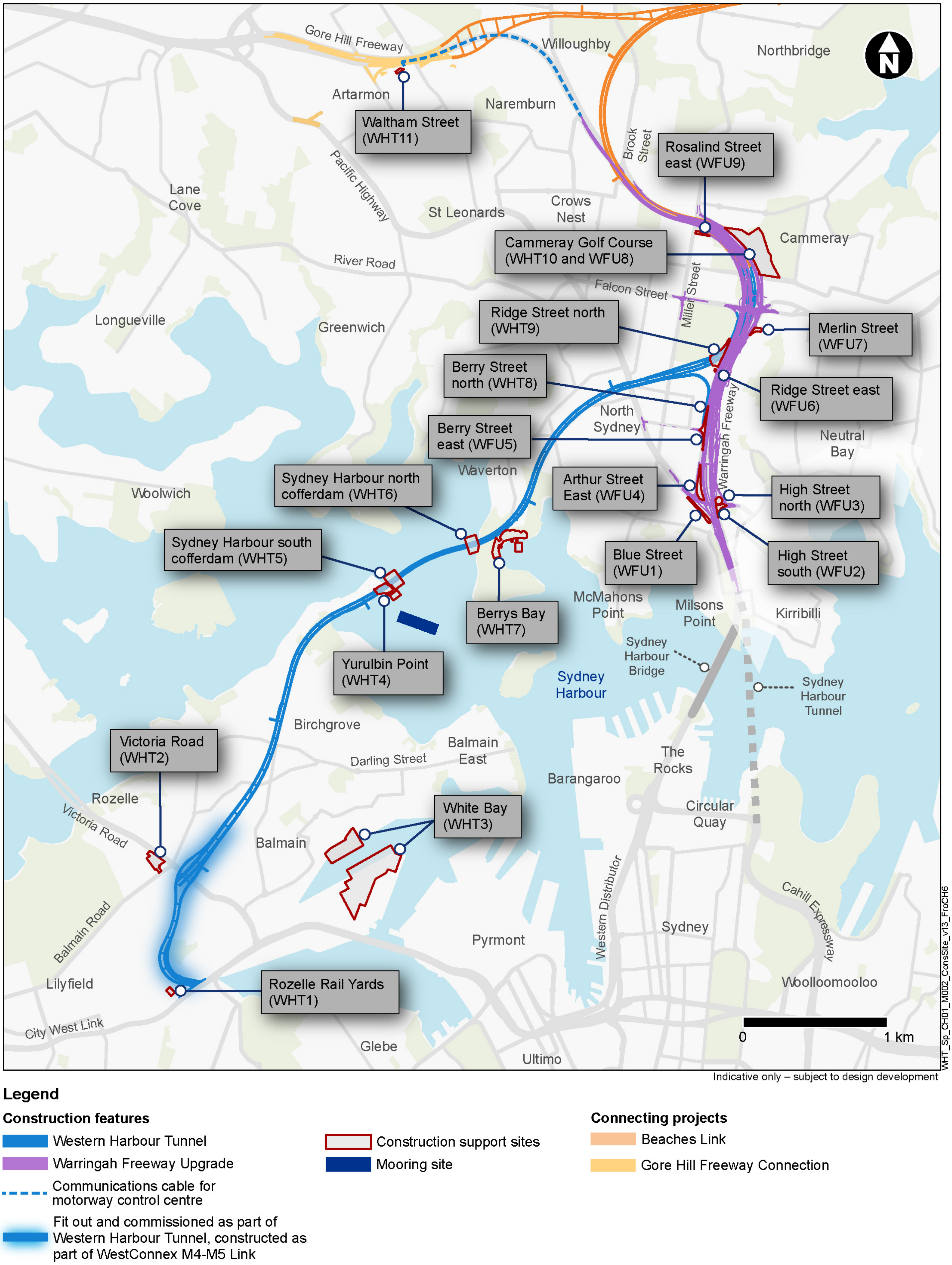


Figure E-7 Overview of the construction support sites for the project

Alternatives considered

The need for additional core motorway capacity at the crossings of Middle and Sydney Harbour was identified as key to development of an appropriate multi-modal Sydney transport network in the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012) and subsequent *Future Transport Strategy 2056* (NSW Government, 2018).

Considering the requirements identified within the *NSW Long Term Transport Master Plan* and the *Future Transport Strategy 2056*, a number of strategic alternatives were considered for delivering the required road capacity at the crossing of Sydney Harbour. The project has undergone extensive evaluation of alternatives from pre-feasibility and strategic investigations through to design development and refinement. The process of developing and assessing project alternatives is outlined in Figure E-8.

Following identification of a new motorway tunnel as the preferred strategic alternative, a design development process was carried out to determine the most appropriate alignment and construction method to deliver the tunnel. The process for selection of the preferred tunnel alignment and construction method included consideration of ten strategic corridors and over fifteen different combinations of tunnelling methods.

Options were developed and assessed by a multidisciplinary team including design engineers, construction engineers, transport planners and environmental advisors with direct experience in delivering major transport infrastructure in NSW, Australia and internationally.

Following preliminary technical and environmental analysis, four corridor alternatives were shortlisted for a new tunnelled motorway connection between Rozelle and the northern side of Sydney Harbour (refer to Figure E-9). Selection of the preferred corridor required consideration of various technical and environmental factors, including:

- Strategic traffic demands and how they define the required connectivity to achieve transport outcomes
- Results of geotechnical, groundwater and contamination investigations
- Basements and foundations of major structures in North Sydney
- Marine heritage, biodiversity and marine ecology
- Turbidity and hydrodynamic monitoring and modelling for Sydney Harbour
- Opportunities for viable temporary intermediate tunnelling sites that minimise community, environmental and heritage impacts
- Physical and operational interfaces with other major infrastructure (eg Sydney Metro Tunnels, Rozelle Interchange, the Warringah Freeway)
- Integration with the proposed Beaches Link and Gore Hill Freeway Connection project in the future
- Horizontal alignments and waterway crossing methodologies that allow the tunnel to achieve acceptable vertical gradients to achieve the desired transport product, reduce whole of life emissions, operational costs, and improve safety outcomes
- Interfaces with commercial and recreational maritime traffic
- Construction and operational costs.

The blue corridor was selected as the preferred corridor alternative for the new motorway (refer to Figure E-9). This corridor was selected based on its superior performance on a number of assessment criteria. Further development of this corridor then considered tunnelling methods (land-based and the preferred harbour crossing), surface connections, ventilation alternatives (including outlet locations), construction support site alternatives, and spoil transport, reuse and disposal alternatives in detail. Community and stakeholder engagement was carried out throughout the process of developing the design to identify key issues to be considered.

For further details on the development of the preferred design and the alternatives considered refer to Chapter 4.

Strategic alternatives

- Strategic alternatives assessed included:
  - Do nothing
  - Travel demand management
  - Improvements to the existing harbour crossing capacity and arterial road network
  - A new motorway (the project)
  - Improvements to alternative transport modes
- New motorway selected as the preferred strategic alternative

Corridor alternatives

- Four corridor alternatives (brown, red, orange and blue as shown on Figure E-9) were assessed against:
  - Project objectives
  - Evaluation criteria:
    - Transport product and customer needs
    - Design, constructability, cost and program
    - Operation
    - Environment, planning and community
- Blue corridor selected as the preferred corridor alternative (the project)

Further project alternatives development

- Project development work included consideration of the following:
  - Tunnelling method alternatives (including harbour crossing methodologies)
  - Connection alternatives to North Sydney
  - Ventiltation alternatives
  - Construction support site location alternatives
  - Spoil transport alternatives
  - Tunneling spoil reuse and disposal alternatives
  - Dredged material management alternatives
  - Community and stakeholder feedback

The project as described in this environmental impact statement

We are here

Figure E-8 Alternatives development process

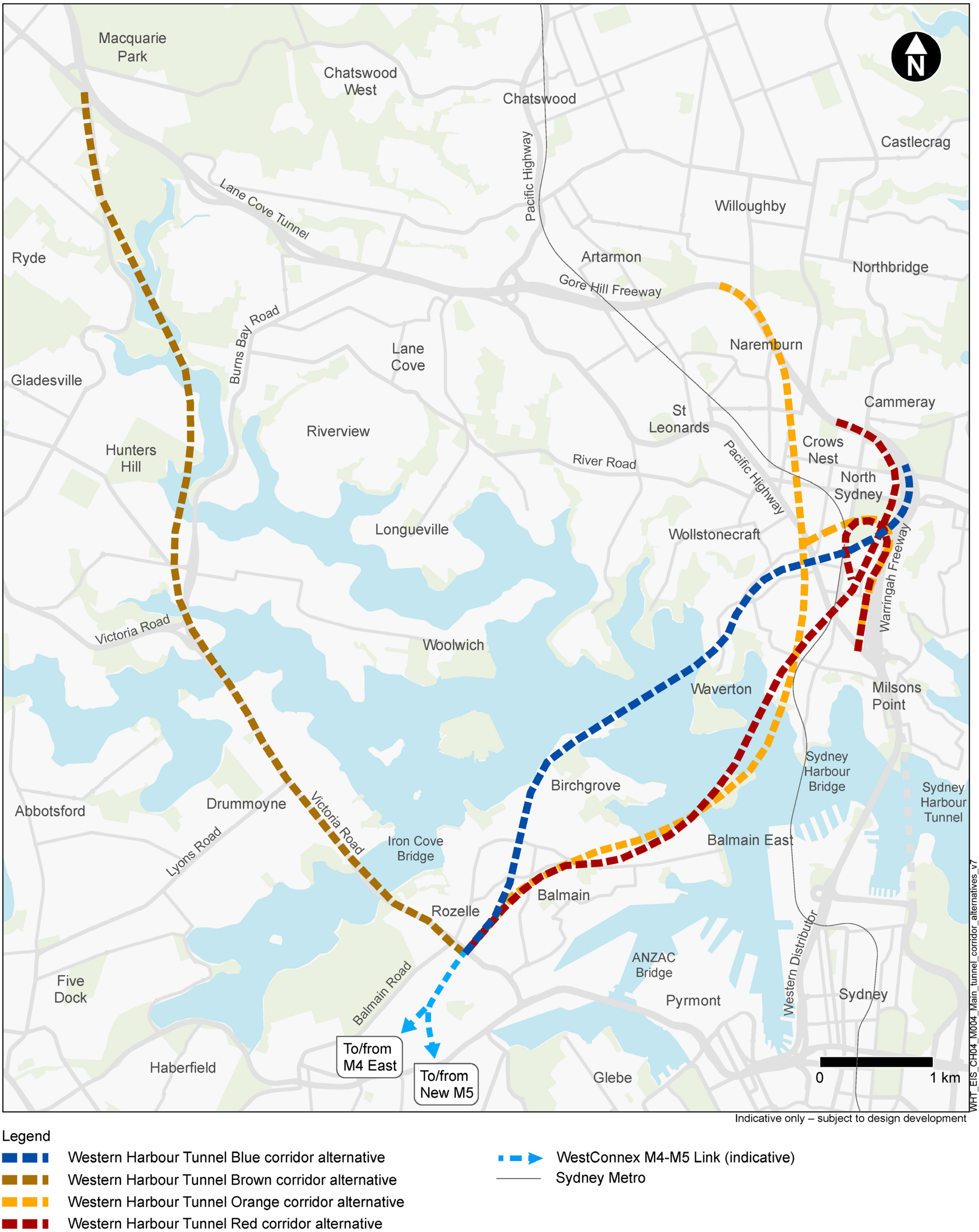


Figure E-9 Shortlisted main corridor alternatives

The proponent

The proponent for the project is Transport for NSW (formerly Roads and Maritime Services). Transport for NSW is the lead agency of the NSW transport portfolio, with primary responsibility for:

- Transport coordination
- Transport policy and planning
- Transport services
- Transport infrastructure.

As of 1 December 2019, legislation came into effect (*Transport Administration Amendment (RMS Dissolution Bill) 2019*) such that all functions of Roads and Maritime Services are now performed by the integrated Transport for NSW organisation. However, due to the timing of the preparation of this environmental impact statement, there are still references to Roads and Maritime in some of the appendices to the environmental impact statement. All references to Roads and Maritime are legally taken to mean Transport for NSW.

Transport for NSW would manage the planning, procurement and delivery of the project.

Planning approval process

Transport for NSW formed the opinion that the construction and operational impacts of the project would require an environmental impact statement, in accordance with clause 1 of Schedule 3 of State Environmental Planning Policy (State and Regional Development) 2011. Transport for NSW requested the Minister for Planning and Public Spaces to declare the project as critical State significant infrastructure under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

This environmental impact statement is publicly exhibited to provide the community, government agencies and stakeholders with an understanding of what is proposed and to invite comment. Transport for NSW will consider the comments and submit to the Department of Planning, Industry and Environment (the Department) a submissions report that documents and responds to issues raised during the exhibition period. The Department will prepare an assessment report for the Minister for Planning and Public Spaces who will then determine whether to grant project approval and specify project conditions.

The assessment and approval process is shown in Figure E-10.

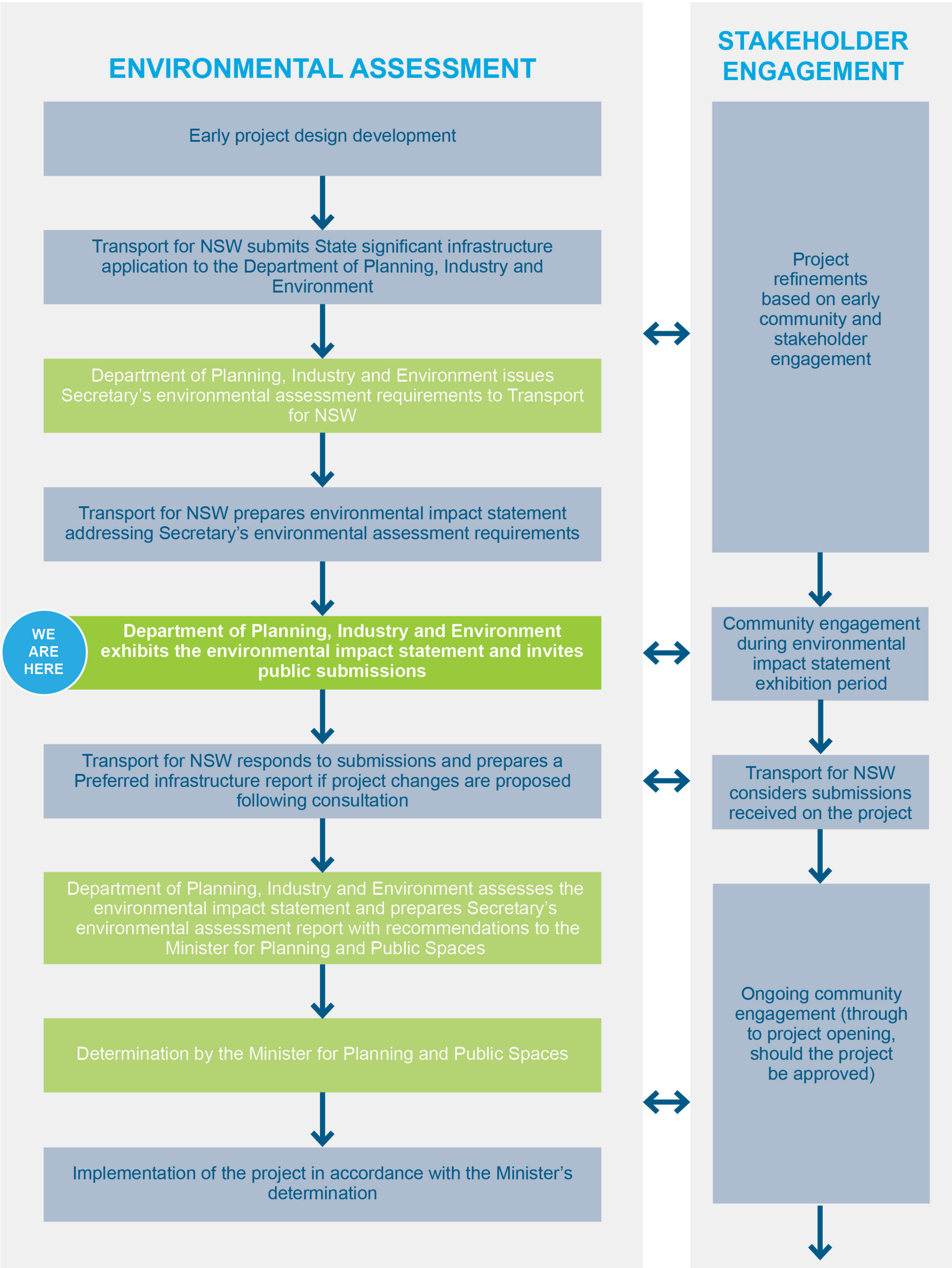


Figure E-10 The assessment and approval process for the project

Environmental assessment

This environmental impact statement has been prepared in accordance with the provisions of Part 5.2 of the *Environmental Planning and Assessment Act 1979*. In particular, it addresses the requirements of the Secretary of the Department of Planning, Industry and Environment. It also includes consideration of the issues raised by the community and stakeholders during the development of the project.

It is inevitable that delivery of a project of this scale within a heavily urbanised environment would have some adverse impacts, particularly during construction. These impacts need to be considered within the context of the overall objectives of the project and the significant transportation and other benefits it would provide over the medium to longer term, and for future generations.

Key environmental issues have been considered throughout the design and development process. Consultation has been carried out with affected stakeholders to identify potential impacts at an early stage. Where possible, these would be avoided or appropriate management measures developed. These considerations have resulted in a number of design changes and refinements that have mitigated many of the potential significant impacts.

Some project impacts would be largely temporary and confined to the construction period.

The following sections provide an overview of the benefits and impacts identified within the environmental assessment.

Traffic and transport

Traffic and transport beneficial outcomes

Beneficial outcomes from the project would include:

- Significant improvements to the capacity and reliability of the critical cross harbour road corridors near the CBD, reducing the impacts of incidents on these links across the broader Sydney road network
- A reduction in traffic demands on the Sydney Harbour Bridge, Sydney Harbour Tunnel, Gladesville Bridge and the Victoria Road corridor southbound with a corresponding reduction in travel times – up to 75 per cent between North Sydney and Rozelle during peak periods
- Returning local streets to communities by moving traffic underground, freeing up local streets for local traffic, and supporting the sustainability of local town centres
- Improvements to the efficiency of the city's critical bus network, by reducing pressure on key surface roads and delivering opportunities for new connections, and enabling direct bus access to North Sydney and an efficient transfer to the new Metro. Travel times for buses from Gore Hill Freeway to the Sydney Harbour Bridge would be substantially reduced, particularly southbound in the morning peak. Travel times for buses to and from Falcon Street, and travelling along the ANZAC Bridge corridor would also improve
- Substantial travel time savings for freight and service vehicles travelling along the Eastern Economic Corridor, improving their productivity and increasing the efficiency of the freight network, particularly for trips that currently use the Sydney Harbour Bridge
- Generally improved vehicle travel times along the key traffic routes through Rozelle, resulting from changes in traffic patterns with trips using the Western Harbour Tunnel in preference to ANZAC Bridge and Western Distributor
- Substantial improvements to road safety, with reduced traffic demands along key road transport corridors, resulting in a forecast crash rate reduction across the network of around 375 vehicles per year
- Make journeys on the Warringah Freeway easier and safer by improving lane configuration and providing clear directions on the best way to cross the harbour and reach your destination

- Substantial improvements in journey times and journey time reliability between the Lower North Shore and centres south of Sydney Harbour
- Delivering core capacity that would allow future strategic connections to the north, including the Beaches Link, which would provide significant travel time and reliability improvements for busses, freight, services and private vehicles travelling to and from the Northern Beaches region.

Traffic and transport impacts during construction

During construction, temporary impacts would include:

- Increased heavy vehicle movements. The impacts associated with the increase in heavy vehicles would be minimised through scheduling of haulage and deliveries outside of peak periods (where feasible and reasonable), using construction sites with direct or proximate arterial road access, and through the use of barges to move spoil by water where appropriate
- Temporary full or partial closures of the Warringah Freeway for short periods of time to carry out key construction activities. Any closure of the Warringah Freeway would generally only be carried out at night and in accordance with an extensive consultation strategy to notify the community and affected residents of the closures and detour routes
- Temporary increase in travel times and reduction in bus speeds, particularly along bus routes in North Sydney
- Changes to access in and around North Sydney. Impacts would be minimised by ensuring all properties have alternative routes to maintain their access
- Impacts on recreational, commercial and passenger maritime traffic caused by marine construction activities in Sydney Harbour during the construction of the immersed tube tunnel. There would also be an increase in maritime traffic movements in Sydney Harbour as a result of the movement of boats and barges for the transportation of construction workers and movement of spoil from water-based construction support sites.

For further information on construction traffic and transport, refer to Chapter 8.

Traffic and transport impacts during operation

During operation of the project, potential localised negative impacts include:

- Localised delays in North Sydney and surrounds, resulting from increased traffic demands and changes to road network operations. The Western Harbour Tunnel and Warringah Freeway Upgrade project would deliver works to improve pedestrian safety and amenity around the future Victoria Cross metro station in North Sydney CBD, by reconfiguring road traffic movements in the North Sydney CBD. Transport for NSW is continuing to develop the North Sydney Integrated Transport Program to improve multi-modal transport outcomes in this area
- Increased demand on the Gore Hill Freeway to the north/west of the project, leading to localised increases in travel times. Potential management options for this impact include the early delivery of Gore Hill Freeway Connection integration works to increase network efficiency in the Artarmon area
- Potential for increased local traffic on the local road network in Rozelle and surrounds, as a result of reduced through traffic in the area. An increase in local traffic movements could impact network efficiency and travel times in the area
- While some localised impacts are possible, they are expected to be significantly outweighed by travel time and reliability benefits on the broader strategic transport network, resulting in net benefits for the majority of future road transport customers.

For further information on operational traffic and transport, refer to Chapter 9.

Noise and vibration impacts

Noise and vibration impacts during construction

Proposed construction support sites and activities have been designed to minimise noise and vibration impacts on sensitive receivers. Design considerations to reduce noise and vibration impacts include the proximity of construction support sites to sensitive receivers, construction of acoustic sheds and noise barriers, and positioning of vehicle entrances and exits to allow access directly to the arterial road network where possible.

Most of the surface construction for the Western Harbour Tunnel component of the project would be carried out between 7am and 6pm Monday to Friday and between 8am and 1pm on Saturdays. Tunnelling activities would be carried out 24 hours a day, seven days a week underground, supported by activities within purpose-built acoustic sheds. Spoil haulage from the Western Harbour Tunnel construction support sites would occur between 7am and 6pm Monday to Friday and between 8am and 1pm on Saturdays.

Construction of the Warringah Freeway Upgrade surface road works would require extensive out of hours work, to minimise traffic disruptions and maintain safety for workers and road users.

Key results of construction noise modelling include:

- Airborne noise from the project construction support sites would be generally within the noise management levels, with the exception of early works, site establishment and site restoration works, when noise management levels may be exceeded at some receivers for short periods
- Airborne noise levels from surface road works would generally be within the relevant noise management levels, with the exception of the operation of high noise generating equipment such as rock-hammers or concrete saws or when noisy works occur close to sensitive receivers. Where airborne noise management levels are exceeded, there would be a requirement to implement reasonable and feasible noise mitigation
- Most of the ground borne noise generated by roadheader tunnelling would be within the noise management levels. The use of rock-hammers for tunnelling activities has the potential to exceed noise management levels at various locations; however, such activities would be scheduled outside evening and night time periods (where feasible and reasonable) to avoid or reduce ground borne noise level exceedances on receivers
- Vibration from tunnelling works is predicted to be below the vibration limits for human disturbance at all receivers. Some receivers have the potential to experience vibration levels above the human comfort criteria when rock-hammers are operating nearby. For these receivers, mitigation measures from the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016) would be implemented, and may include notification and respite provisions
- Construction road traffic management and vehicle movements associated with the project are unlikely to increase road traffic noise levels by more than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible. The number of maximum noise events from construction traffic that could disturb sleep are not likely to substantially increase, because the maximum number of truck movements generated by the project at night would be small compared to existing truck movements along the proposed haulage routes

Construction noise and vibration impacts would be managed using reasonable and feasible mitigation and management measures including scheduling of works, noise reduction measures for plant and equipment, and provision of respite periods or offers of alternative accommodation for sensitive receivers if appropriate. Temporary noise barriers or solid hoarding would be used at construction support sites where required to minimise noise impacts on residential receivers.

For further information on construction noise and vibration, refer to Chapter 10.

Noise and vibration impacts during operation

The project has been designed to include traffic noise mitigation measures where feasible and reasonable. When Western Harbour Tunnel and the Warringah Freeway Upgrade are operational the noise assessment indicates that:

- The project is predicted to reduce traffic noise for about 57 per cent of receivers within the study areas
- About 42 per cent of receivers within the noise study areas are predicted to experience traffic noise level increases of less than 2 dB(A), which is a minor impact and likely to be barely perceptible.
- One per cent of receivers within the noise study areas are predicted to experience increases in traffic noise of more than 2 dB(A) as a result of the project
- The Warringah Freeway Upgrade component of the project is predicted to reduce traffic noise levels at a substantial number of receiver buildings (around 75 per cent), mainly due to traffic diverting to the new tunnels

For permanent operational infrastructure (such as the motorway facilities and ventilation outlets, wastewater treatment plants etc), no noise criteria would be exceeded. For further information on operational noise and vibration, refer to Chapter 11.

Air quality

Air quality impacts during construction

Air quality modelling has been carried out to assess the potential air quality impacts that construction of the project may generate. Air quality impacts during construction would typically include dust and the effects of airborne particles on human health and amenity as well as potential odour emissions from dredging activities. Spoil handling within acoustic sheds would minimise dispersion of dust at tunnelling sites. A comprehensive range of mitigation measures would be used so that any residual dust and associated human health impacts would be negligible.

Odour impacts from handling dredged material at the White Bay construction support site (WHT3) would be undetectable for all sensitive receivers near the site. This is consistent with the outcomes of stabilisation and transfer of material dredged from Garden Island at Glebe Island earlier in this year.

Air quality impacts during operation

Extensive air quality modelling has been carried out to assess the project's in-tunnel and ambient air quality outcomes.

The tunnel ventilation system would be designed to maintain in-tunnel air quality within applicable criteria for nitrogen dioxide (NO_2), carbon monoxide and visibility for all modelling scenarios including a worst case trip scenario.

The ventilation system would be designed so that there would be no emissions from tunnel portals. All emissions would be via ventilation outlets.

The ventilation outlets would be designed to effectively disperse emissions from the tunnels. The heights of the ventilation outlets have been optimised to provide the most effective dispersion. For some short-term air quality measures (1-hour NO_2 and 24-hour PM_{10} and $PM_{2.5}$), exceedances of the criteria are predicted to occur both with and without the project. However, the project would result in a better outcome for ambient air quality than conditions without the project.

For $PM_{2.5}$, the background levels are already at or slightly above the criterion for both the annual and 24 hour means at some community receivers. The project would result in a reduction to these levels because of the reduction in surface road traffic caused by diversion to the tunnels.

For further information on air quality, refer to Chapter 12.

Human health impacts

As the project would deliver an underground motorway, there would be a redistribution of vehicle emissions associated with a reduction of traffic on surface roads. For much of the community this would result in no change or a small improvement to local air quality (ie reduced concentrations and fewer health impacts); however, for some areas located near key surface roads, a small increase in pollutant concentration may occur. Potential health impacts associated with changes in air quality (specifically nitrogen dioxide and particulates) within the local community have been assessed and are considered to be acceptable.

Concentrations of pollutants from vehicle emissions would be higher within the tunnel (compared to outside the tunnel). With the completion of a number of tunnel projects (approved or proposed), there is the potential for exposures to occur within a network of tunnels over varying periods of time. However, exposure to nitrogen dioxide inside vehicles is expected to be well within the current health guidelines.

Congestion inside the tunnels is not considered likely to result in adverse health effects, due to the operation of the tunnel ventilation systems and the temporary nature of the potential exposure. For motorcyclists, there is the potential for higher levels of exposure to nitrogen dioxide but these exposures, under normal conditions, are not expected to result in adverse health effects.

For further information on human health, refer to Chapter 13.

Social and economic impacts

The *Australian Infrastructure Audit 2019* (Infrastructure Australia, 2019) lists the Eastern Distributor, Sydney Harbour Bridge, Warringah Freeway and the Gore Hill Freeway corridor among Australia's most congested road corridors, generating a congestion cost of $65,000 per day in 2016. If no action is taken, this is forecast to rise to $98,000 per day by 2031. As congestion on these corridors increases so too will the costs. Infrastructure for NSW has estimated that the economic risk to growth and productivity posed by traffic congestion in the Eastern City District is about $5 billion a year, and is forecast to increase to about $8 billion annually by 2020. Infrastructure NSW has observed that, "*without corrective action, congestion will worsen – and the costs to business and the community will escalate – as the city's population grows*" (Infrastructure NSW, 2014).

As traffic demands for the Sydney Harbour Bridge and Warringah Freeway corridor continue to increase, so too will the costs associated with incidents on these critical links. Without action, it is estimated that the annual cost of incidents (excluding congestion) on this corridor alone will be more than $66 million per annum by 2036. Creating alternatives to this route is necessary to increase network resilience and reduce the impact of incidents on Greater Sydney's productivity.

Augmenting capacity and reducing the conflict between access and bypass functions for the Sydney Harbour Bridge, Sydney Harbour Tunnel, ANZAC Bridge and Western Distributor is thus a key element of the integrated transport network required to support the productivity of the Eastern Economic Corridor and its connections with international gateways and their surrounds.

When operational, the project would:

- Relieve pressure on the critical cross harbour road network and thus reduce the cost of freight, provision of goods and services, and other business travel along and through the Eastern Economic Corridor and around the Harbour CBD. The combination of freight and business travel time savings as a result of the project would generate significant productivity benefits for the Harbour CBD
- Enable local businesses to have better and more efficient access to Greater Sydney, making it easier to move goods and provide services, as well as bringing employees and businesses closer together
- Improve access and connectivity to local and regional infrastructure through improved and more reliable travel times to facilities

- Reduce the impact of incidents on the critical cross harbour transport corridor by increasing capacity and providing a viable underground bypass route
- Improve pedestrian and cyclist accessibility and connectivity of active transport routes, which would bring long-term benefits for community cohesion.

For further information on socio-economics, refer to Chapter 21.

Non-Aboriginal heritage impacts

The proposed Western Harbour Tunnel component of the project would pass beneath the harbour-side suburbs of Balmain, Birchgrove and Waverton, which are generally highly urbanised areas with narrow residential streets. This presents a significant challenge to establishing viable intermediate construction support sites that are required to deliver the mainline tunnels.

The construction strategy for the Western Harbour Tunnel component of the project aims to mitigate impacts to communities along the proposed alignment by:

- Minimising the number of intermediate sites whilst maintaining a viable construction program
- Avoiding major spoil haulage through harbour-side communities by adopting water-based spoil handling for intermediate tunnelling sites with poor arterial road access
- Prioritising temporary impacts to public open space over direct impacts to residential properties where reasonable
- Minimising the volume of spoil being removed through selection of an efficient tunnelling technique.

This strategy requires the establishment of intermediate tunnelling sites close to the proposed alignment with direct access to Sydney Harbour for barging spoil, materials and major equipment. The temporary use of an area at Yurulbin Park in Birchgrove as a construction support site (WHT3) for the project would enable efficient delivery whilst minimising private property acquisition and haulage through local streets.

Yurulbin Park has local heritage significance and it has been identified that the proposed works within Yurulbin Park would be of medium-large scale and moderate intensity. As such, the level of impact on the heritage item overall would be major.

The design of the project works at Yurulbin Park have been developed in consultation with Bruce MacKenzie AM, the original designer of the park. This has resulted in a design that minimises impacts to significant features and changes to the permanent landform at Yurulbin Park. Some mature trees within the park would be directly impacted, but areas of exclusion have been identified and replacement plantings would be provided on completion of construction as part of the redesign. Opportunities to temporarily remove, store and reinstate certain elements such as stone flagging, stone walls and steps would be investigated and implemented if these elements need to be temporarily removed.

While permanent impacts would occur to areas of archaeological potential during site establishment, specialist investigations would provide an opportunity to obtain information about the archaeology and history of the site not available from other sources. Reinstatement works following the completion of construction would be designed in consultation with Bruce MacKenzie. The new design would seek to retain and enhance the existing character and the original design intent as much as possible. These works would also improve the quality and long-term viability of landscaping and useability of the park.

For further information on non-Aboriginal heritage, refer to Chapter 14.

Biodiversity (terrestrial and marine) impacts

The majority of the project footprint and surrounding area is highly modified and disturbed, and contains exotic species, weeds and planted native or non-indigenous species. Most of the project footprint is considered to be in a poor ecological condition, with little ecological value and unlikely to have any native resilience or recovery potential. Construction of the project would require removal of about 7.29 hectares of vegetation which comprises native plantings, planted medians, non-native species or weeds. The project would not have a significant impact on any threatened flora species, or vegetation consistent with any plant community types or threatened ecological communities.

No riparian vegetation would be removed as part of the project and no instream works would be carried out in the waterways traversed by the project.

There is potential for noise and vibration impacts on roosting Eastern Bentwing-bats (*Miniopterus schreibersii oceanensis*) within the coal loader tunnels at Waverton during construction. Adaptive management strategies would be developed in consultation with the Department of Premier and Cabinet (Heritage), Department of Planning, Industry and Environment and/or an appropriately qualified expert in microbat biology and behaviour, and implemented to minimise potential adverse impacts as required. The project would not have a significant impact on any other threatened fauna species.

Potential direct impacts on threatened marine species in Sydney Harbour, such as the Black Rock Cod and White's Seahorse, would be low. Potential impacts on marine mammals and marine turtles would also be low.

Potential underwater noise impacts on marine mammals, reptiles and sharks may occur through dredging and piling activities. Noise modelling carried out for the project indicates that impacts would largely be limited to the immediate location of piling and dredging activities. Visual monitoring from the harbour surface would be carried out to identify any underwater noise related impacts on fish, and appropriate protection measures would be considered, where required.

For further information on biodiversity, refer to Chapter 19.

Hydrodynamics and water quality impacts

Site investigations and hydrodynamic modelling has been completed to assess and refine the construction methodology for works required within Sydney Harbour for the immersed tube tunnel. Dredge plume modelling indicates that the dredging would not have a significant impact on marine water quality. Dredging and construction activities for the project are likely to cause localised increases in suspended sediment concentrations, but due to the rapid dispersion in Sydney Harbour it is not likely to result in significant water quality impacts. Monitoring during dredging would assess the compliance of the activities associated with the project. Where appropriate, silt curtains would be installed to mitigate potential impacts on ecologically sensitive areas.

The behaviour of sediment-bound contaminants when re-suspended into the water column has been previously assessed (Geotechnical Assessments, 2015) for other construction projects (Sydney Metro City & Southwest). These assessments have determined that contaminants are likely to remain bound to sediment particles and not be released into the water column. As an additional control, a backhoe dredge with a closed environmental bucket would be used to remove areas of sediments with elevated levels of contaminants (about the top 1.5 metres of sediment in some areas). This would reduce the potential for release of contaminated sediments into the water column, and it is therefore unlikely that marine water quality would be significantly impacted by contaminants.

For further information on hydrodynamics and water quality, refer to Chapter 17.

Land use and property impacts

The project has been designed to minimise the need for property acquisition. The need to reduce these impacts has been balanced with temporary and permanent impacts to areas of open space.

For the Western Harbour Tunnel component of the project, four properties would require permanent acquisition and three properties would require temporary lease. Of the four properties that would be permanently acquired, all would be full acquisitions. Of the three properties required temporarily, one would be a full property lease and two would be partial leases.

For the Warringah Freeway Upgrade component of the project, 20 properties would be permanently acquired and one property would be temporarily leased. Of the 20 properties to be permanently acquired, 16 would be full acquisitions and four would be partial acquisitions.

Any compulsory property acquisitions required for the project would be carried out in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and the land acquisition reforms announced by the NSW Government in 2016.

Temporary land use changes (loss of open space) would occur during establishment and operation of temporary construction support sites and other construction areas at Yurulbin Park, ANZAC Park, St Leonards Park and Cammeray Golf Course.

Permanent land use changes would occur at Cammeray Golf Course, for widening of the Warringah Freeway and where the motorway facilities would be established within the Cammeray Golf Course next to the Warringah Freeway. The golf course would be reconfigured to ensure it remains operational.

For further details on properties impacted by the project refer to Chapter 20 (Landuse and Property).

When completed, the project would deliver new and improved public spaces at Berrys Bay and Yurulbin Park to improve urban amenity.

The proposed Berrys Bay construction support site would be located on Government owned land, formally used as an industrial site. In addition to the construction efficiency and reduction in community impacts that use of this waterside site provides, the proposed site at Berrys Bay provides a significant opportunity for Transport for NSW, North Sydney Council and other relevant stakeholders to rehabilitate this residual industrial location to create an area of high quality public space for the wider community following completion of construction.

The project has engaged Mr Bruce Mackenzie AM, a renowned Australian landscape architect who was responsible for creation of Yurulbin Park in the mid-1970's when the site was rehabilitated following its use as a shipyard. This work has informed the plan for establishment of the temporary construction support site to minimise major long-term impacts to key features of the site. Bruce Mackenzie has also provided the guiding principles for rehabilitation of the site post-construction to ensure that the final form of the park remains a sustainable high quality pubic space long into the future.

The final form of these sites, and other areas to be rehabilitated post construction, would be subject to consultation with local councils, stakeholders and the local community.

For further information on land use and property, refer to Chapter 20.

Cumulative impacts

When completed, the Western Harbour Tunnel and Beaches Link program of works is expected to deliver beneficial cumulative impacts including significant improvements to travel speeds through sections of the surface road network, increased reliability and a reduction in average travel times.

Adverse cumulative impacts could occur when impacts from the project interact or overlap with impacts from other projects, potentially resulting in a larger overall impact. Cumulative impacts may also occur when projects are constructed consecutively, resulting in construction fatigue for local receivers.

The implementation of environmental management measures for the project would avoid, to the greatest extent possible, cumulative impacts with surrounding development. Project design has carefully considered minimising construction fatigue as far as practical. The intent is to reduce the overall cumulative or consecutive impacts on the community over a longer period.

For further information on cumulative impacts, refer to Chapter 27.

Management of impacts

This environmental impact statement identifies comprehensive environmental management measures to avoid, manage, mitigate, offset and/or monitor impacts during construction and operation of the project. These include best practice construction environmental planning and management techniques, urban design and landscaping treatments and noise mitigation measures. Further mitigation opportunities are likely to be identified during detailed design and construction planning and in consultation with communities and relevant stakeholders.

The design, construction and operation of the project would be carried out in accordance with extensive environmental management commitments identified in this environmental impact statement, as well as any additional measures identified in the conditions of approval for the project.

Stakeholder and community engagement

Since the initial project announcement in March 2017, there has been extensive and ongoing community and stakeholder engagement. This has included:

- Toll free community information line
- Project email
- Project website
- Interactive web feedback map
- Project database to record correspondence relevant to the project, including contact details and issues raised during the life of the project
- Community update newsletters and letters to residents
- Community information sessions, information displays and staffed pop-ups
- Registered stakeholder database email updates
- Stakeholder briefings, meetings, workshops and presentations
- Interest group correspondence including letters and phone calls
- Face-to-face meetings and doorknocks with individual property owners and residents of properties which may be affected by the project
- Advertisements and proactive media articles in the local press
- Letterbox drops
- Media events at key milestones of the project.

The design has been continually refined throughout the community engagement to improve transport, environmental, amenity, community, heritage and sustainability outcomes.

The project team has developed a community and stakeholder engagement program to continue to proactively engage with local communities, key stakeholders and government agencies.

Next steps

Transport for NSW is seeking approval from the Minister for Planning and Public Spaces for the construction and operation of the project. Steps in the process include:

- Exhibition of the environmental impact statement for a minimum of 28 days in accordance with statutory requirements and invitation for the community and stakeholders to make submissions
- Consideration of submissions. Submissions received by the Secretary of Department of Planning, Industry and Environment would be provided to Transport for NSW and any relevant public authorities. Transport for NSW may then be required to prepare and submit:
  - A submissions report, responding to issues raised in the submissions

- A preferred infrastructure report, outlining any proposed changes to the project to minimise its environmental impacts or to deal with any other issues raised

- Determination of the environmental impact statement. The Minister for Planning would then make a decision on the project and, if approved, set conditions of approval.

Consultation with the community and stakeholders would continue throughout the detailed design and construction phases as required.

The NSW Department of Planning, Industry and Environment will make this environmental impact statement publicly available for a minimum period of 28 days. During the exhibition period, the environmental impact statement will be available for viewing at the following locations:

- The Department of Planning, Industry and Environment major project planning portal: www.planningportal.nsw.gov.au/major-projects
- The Transport for NSW project website: https://nswroads.work/whtbl
- Electronically at NSW Services centres: www.service.nsw.gov.au/
- The Transport for NSW office in Milsons Point, selected local council offices and libraries in the Inner West, North Sydney and Willoughby local government areas
- Various staffed displays.

Details of the location and opening hours of staffed displays would be provided through a community update, letters to interest groups who have registered for the project, email notifications to registered stakeholders, information on the project website and advertisements in local and metropolitan media.

During the exhibition period, a project information line (1800 931 189) and email address (whtbl@rms.nsw.gov.au) will be available for the community and stakeholders.

Written submissions can be made to the Secretary of the Department of Planning, Industry and Environment. All submissions received will be placed on the Department of Planning, Industry and Environment website.

Submissions can be made by creating an account at www.planningportal.nsw.gov.au/major-projects/have-your-say. This allows you to save a submission in progress and stay up to date with the progress of an application.

If you are unable to make a submission online, you can send a physical copy to the Department by post or hand deliver it to one of the Department's offices. Your submission must include:

- Your name and address, at the top of the letter only
- The name of the application and the application number
- A statement on whether you support or object to the proposal
- The reasons why you support or object to the proposal
- A declaration of any reportable political donations made in the previous two years.

Written postal submissions are to be directed to:

Director, Transport Assessments

Department of Planning, Industry and Environment

Application number SSI-8863

Locked Bag 5022

Parramatta NSW 2124

Chapter

1

Chapter 1

Introduction

January 2020

1 Introduction

This chapter provides an overview of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project), including its key features and location.

1.1 Overview

The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth, the NSW Government is implementing the *Future Transport Strategy 2056* (NSW Government, 2018), a plan that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and to improve transport connectivity with Sydney's Northern Beaches. The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and Gore Hill Freeway to Balgowlah and Killarney Heights including the surface upgrade of Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

The components of the Western Harbour Tunnel and Beaches Link program of works are shown in Figure 1-1.

A combined delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and south, west and north-west of Sydney Harbour. For example, with the combined program of works, journeys from Dee Why to Sydney Kingsford Smith Airport are expected to be 56 minutes faster. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested harbour crossings. These key benefits are discussed further in Chapter 3 (Strategic context and project need).

The project would also provide an opportunity to introduce new express bus services to key employment and education centres, directly linking North Sydney to the Inner West region of Sydney. This opportunity would better integrate employment, residential and education centres and provide improved road transport access to a wider range of services and facilities.
The Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project are subject to separate and coordinated environmental assessment and approval processes.

This environmental impact statement relates to the Western Harbour Tunnel and Warringah Freeway Upgrade project.

Legend

Operational features
- Beaches Link
- Gore Hill Freeway Connection
- Western Harbour Tunnel
- Warringah Freeway Upgrade
- M4-M5 Link tunnel fitout and commissioned as part of Western Harbour Tunnel

Connecting projects
- M4-M5 Link connections (indicative)
- Northern Beaches Hospital road upgrade

Existing rail network
- Heavy rail
- Light rail

Figure 1-1 The Western Harbour Tunnel and Beaches Link program of works

1.2 The project

Transport for NSW (formerly Roads and Maritime Services) is seeking approval under Division 5.2, Part 5 of the *Environmental Planning and Assessment Act 1979* to construct and operate the Western Harbour Tunnel and Warringah Freeway Upgrade, which would comprise two main components:

- A new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel)
- Upgrade and integration works along the existing Warringah Freeway, including infrastructure required for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

The project is an integrated transport solution that will address urban congestion on Sydney's road network. It would provide a new western bypass of the Sydney Central Business District (CBD), providing an alternative to the heavily congested Sydney Harbour Bridge, Western Distributor and ANZAC Bridge. It would reduce pressure and provide faster and more reliable journeys on roads around the Sydney CBD and increase the resilience of the road network to incidents and delays. The project would also provide major benefits to public transport with a free-flowing continuous bus lane southbound on Warringah Freeway – removing weaving between buses and other traffic and improving bus transit times for all buses using Warringah Freeway. The project would also provide direct bus access to North Sydney.

A detailed discussion on the project benefits is presented in Chapter 3 (Strategic context and project need).

Key features of the Western Harbour Tunnel component of the project are shown in Figure 1-2 and would include:

- Twin mainline tunnels about 6.5 kilometres long and each accommodating three lanes of traffic in each direction, connecting the stub tunnels from the M4-M5 Link at Rozelle to the Warringah Freeway and to the Beaches Link mainline tunnels at Cammeray. The crossing of Sydney Harbour between Birchgrove and Balls Head would involve a dual, three lane, immersed tube tunnel
- Connections to the stub tunnels at the M4-M5 Link project in Rozelle and to the mainline tunnels at Cammeray (for a future connection to the Beaches Link and Gore Hill Freeway Connection project)
- Surface connections at Rozelle, North Sydney and Cammeray, including direct connections to and from the Warringah Freeway (including integration with the Warringah Freeway Upgrade), an off ramp to Falcon Street and an on ramp from Berry Street at North Sydney
- A ventilation outlet and motorway facilities (fitout and commissioning only) at the Rozelle Interchange
- A ventilation outlet and motorway facilities at the Warringah Freeway in Cammeray
- Operational facilities including a motorway control centre at Waltham Street within the Artarmon industrial area and tunnel support facilities at the Warringah Freeway in Cammeray
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, signage, tolling infrastructure, fire and life safety systems, lighting, emergency evacuation and emergency smoke extraction infrastructure, CCTV and other traffic management systems.

Key features of the Warringah Freeway Upgrade component of the project are shown in Figure 1-3 and would include:

- Upgrade and reconfiguration of the Warringah Freeway from immediately north of the Sydney Harbour Bridge through to Willoughby Road at Naremburn
- Upgrades to interchanges at Falcon Street in Cammeray and High Street in North Sydney
- New and upgraded pedestrian and cyclist infrastructure
- New, modified and relocated road and shared user bridges across the Warringah Freeway
- Connection of the Warringah Freeway to the portals for the Western Harbour Tunnel mainline tunnels and the Beaches Link tunnels via on and off ramps, which would consist of a combination of trough and cut and cover structures
- Upgrades to existing roads around the Warringah Freeway to integrate the project with the surrounding road network
- Upgrades and modifications to bus infrastructure, including relocation of the existing bus layover along the Warringah Freeway
- Other operational infrastructure, including surface drainage and utility infrastructure, signage, tolling, lighting, CCTV and other traffic management systems.

A detailed description of the project is provided in Chapter 5 (Project description). Construction of the project is described in Chapter 6 (Construction work). The project alignment at the Rozelle Interchange shown in Figure 1-2 reflects the arrangement presented in the environmental impact statement for the M4-M5 Link, and as amended by the proposed modifications. The project would be constructed in accordance with the now finalised M4-M5 Link detailed design. Refer to Section 2.1.1 of Chapter 2 (Assessment process) for further details.

The project does not include ongoing motorway maintenance activities during operation or future use of residual land occupied or affected by project construction activities, but not required for operational infrastructure. These would be subject to separate planning and approval processes at the relevant times.

Subject to the project obtaining planning approval, construction is anticipated to commence in 2020 and is expected to take around six years to complete.

1.3 Project location

The project would be located within the Inner West, North Sydney and Willoughby local government areas, connecting Rozelle in the south with Naremburn in the north. The regional context of the project is shown in Figure 1-1. The local context of the project is shown in Figure 1-2 and Figure 1-3.

Commencing at the Rozelle Interchange, the mainline tunnels would pass under Balmain and Birchgrove, then cross Sydney Harbour between Birchgrove and Balls Head. The tunnels would then continue under Waverton and North Sydney, linking directly to the Warringah Freeway to the north of the existing Ernest Street bridge.

The motorway control centre would be located at Waltham Street, Artarmon while the communication connection cable linking the Western Harbour Tunnel with the motorway control centre would be located along the Gore Hill Freeway and Warringah Freeway road reserves.

The Warringah Freeway Upgrade would be carried out on the Warringah Freeway from around Fitzroy Street at Milsons Point to around Willoughby Road at Naremburn. Upgrade works would include improvements to bridges across the Warringah Freeway, and upgrades to surrounding roads.

1.4 Purpose of this environmental impact statement

This environmental impact statement has been prepared in accordance with the relevant provisions of the *Environmental Planning and Assessment Act 1979*. It has been prepared to address the requirements issued by the Secretary of the NSW Department of Planning, Industry and Environment (formerly Department of Planning and Environment) on 15 December 2017 and the relevant provisions of Schedule 2 of the Environmental Planning and Assessment Regulation 2000.

In accordance with Division 5.2 of the *Environmental Planning and Assessment Act 1979*, this environmental impact statement presents an assessment of potential environmental issues identified during the planning and assessment of the project. The assessment considers the area directly or indirectly affected by construction and operation of the project, as relevant to each technical assessment.

As of 1 December 2019, legislation came into effect (*Transport Administration Amendment (RMS Dissolution Bill) 2019*) such that all functions of Roads and Maritime Services are now performed by the integrated Transport for NSW organisation. However, due to the timing of the preparation of this environmental impact statement, there are still references to Roads and Maritime in some of the appendices to the environmental impact statement. All references to Roads and Maritime are legally taken to mean Transport for NSW.

This environmental impact statement will be placed on public exhibition and will provide an opportunity for the community, government agencies and other interested parties to comment on the project. Transport for NSW will consider this feedback and respond to issues raised in a submissions report. The assessment process for the project is discussed further in Chapter 2 (Assessment process).

The Secretary's environmental assessment requirements are detailed in Appendix A, along with a reference to where these have been addressed in this environmental impact statement.

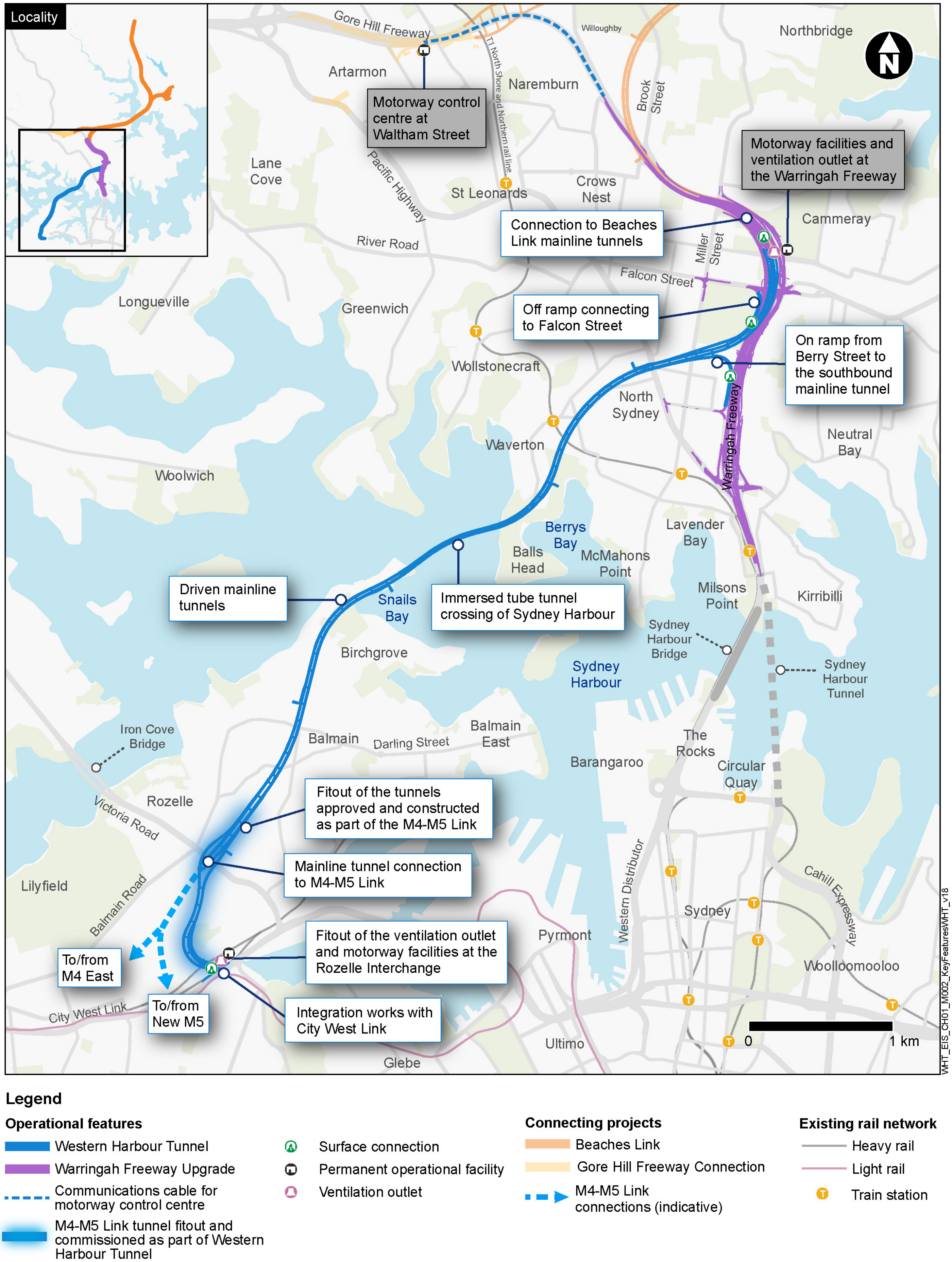
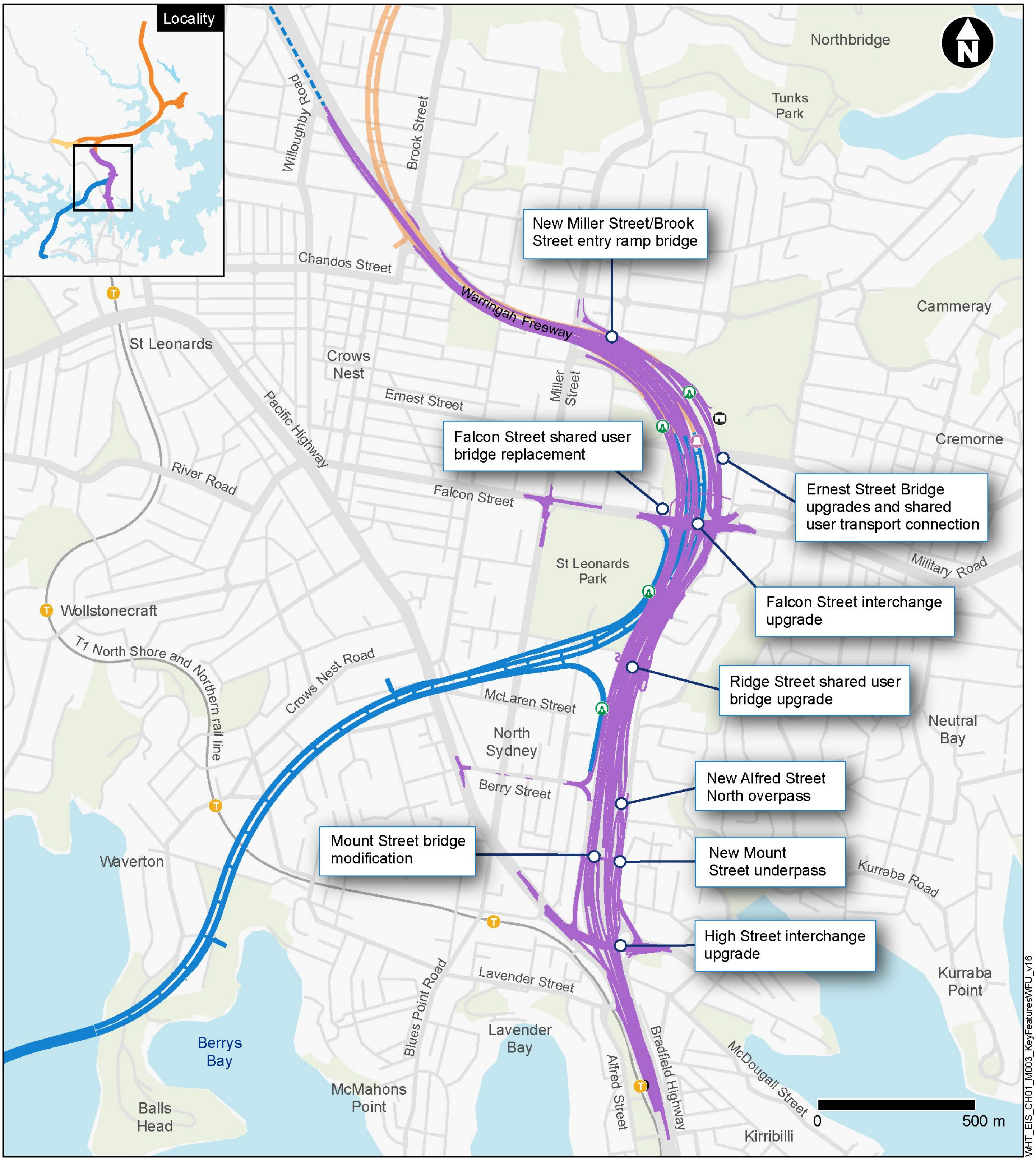


Figure 1-2 Key features of the Western Harbour Tunnel component of the project



Legend

Operational features
- Warringah Freeway Upgrade
- Western Harbour Tunnel
- Communications cable for motorway control centre
- Surface connection
- Permanent operational facility
- Ventilation outlet

Connecting projects
- Beaches Link

Existing rail network
- Heavy rail
- Train station

Figure 1-3 Key features of the Warringah Freeway Upgrade component of the project

Chapter

2

Chapter 2

Assessment process

January 2020

2 Assessment process

This chapter describes the environmental impact assessment and approval process for the project as well as other relevant environmental planning and statutory approval requirements.

2.1 Assessment and approval framework

2.1.1 Environmental Planning and Assessment Act 1979

Transport for NSW (formerly Roads and Maritime Services) is seeking approval for the Western Harbour Tunnel and Warringah Freeway Upgrade project as State significant infrastructure under Part 5, Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

Clause 94 of the State Environmental Planning Policy (Infrastructure) 2007 (the Infrastructure SEPP) applies to development for the purpose of a road or road infrastructure facilities and provides that these types of works are development which is permissible without consent. The project is appropriately classified as being for the purpose of a 'road' and a 'road infrastructure facility' under the Infrastructure SEPP.

Clause 14 of the State Environmental Planning Policy (State and Regional Development) 2011 (the State and Regional Development SEPP) declares development as State significant infrastructure if it is permissible without consent and specified in Schedule 3.

Transport for NSW has requested that the Minister for Planning and Public Spaces declare the project as critical State significant infrastructure. Section 5.13 of the *Environmental Planning and Assessment Act 1979* provides for the declaration of critical State significant infrastructure by means of an environmental planning instrument. Clause 16 of the State and Regional Development SEPP declares development listed in Schedule 5 to be critical State significant infrastructure. Transport for NSW's request is that the Western Harbour Tunnel and Warringah Freeway Upgrade project be listed in Schedule 5.

The Department of Planning, Industry and Environment (formerly the Department of Planning and Environment) issued the Secretary's environmental assessment requirements for the project on 15 December 2017. A copy of the Secretary's environmental assessment requirements and where they have been addressed in this environmental impact statement is provided in Appendix A (Secretary's environmental assessment requirements checklist).

The assessment and approval process under Division 5.2 of the *Environmental Planning and Assessment Act 1979* is shown in Figure 2-1.

Further information on the assessment process is available on the Department of Planning, Industry and Environment website (www.planning.nsw.gov.au).

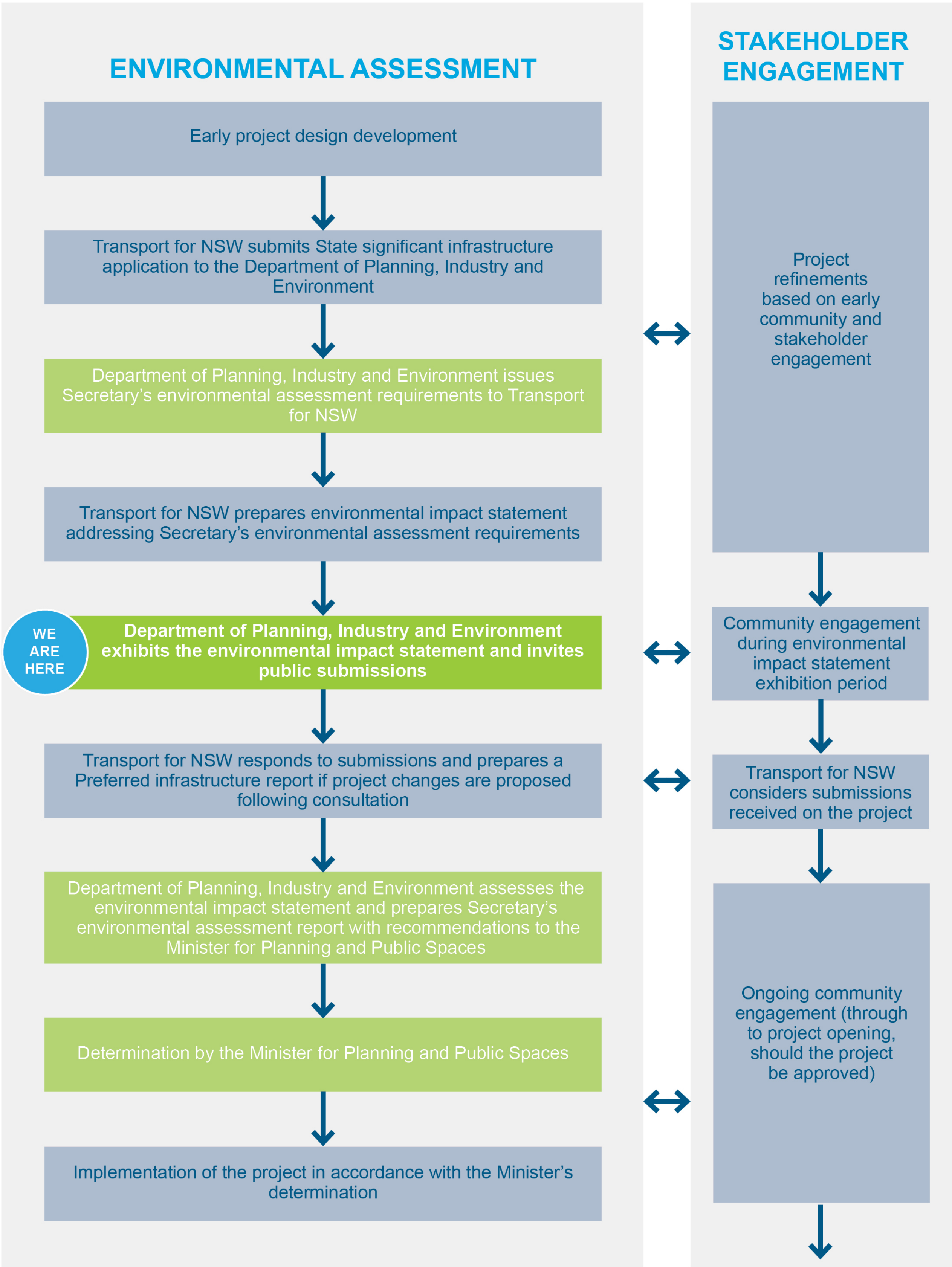


Figure 2-1 The assessment and approval process for the project

2.2 Other legislation

2.2.1 NSW legislation

Key approvals

Approvals under other NSW legislation that may apply to the project include:

- An environment protection licence for road construction and road tunnel emissions under Chapter 3 of the *Protection of the Environment Operations Act 1997*. In accordance with section 5.24 of the *Environmental Planning and Assessment Act 1979*, such a licence cannot be refused for an approved project and is to be substantially consistent with any approval under Division 5.2.

Other relevant legislation

Other NSW legislation that would apply to the project includes:

- The *Land Acquisition (Just Terms Compensation) Act 1991* (NSW), which applies to the acquisition of any land by an Authority of the State which is authorised to acquire the land by compulsory process. Acquisition is discussed in Chapter 5 (Project description) and Chapter 20 (Land use and property)
- The *Contaminated Land Management Act 1997* (NSW) outlines the circumstances in which the notification of the NSW Environmental Protection Authority is required in relation to contamination of land. This is discussed in Chapter 16 (Geology, soils and groundwater)
- The *Heritage Act 1977* (section 146) requires that the Heritage Council be notified if a relic is uncovered during construction and if it is reasonable to believe that the Heritage Council is unaware of the location of the relic. This provision has been incorporated into mitigation measures for the project, summarised in Chapter 28 (Synthesis of the environmental impact statement). Non-Aboriginal heritage is further discussed in Chapter 14 (Non-Aboriginal heritage)
- The *Crown Land Management Act 2016* provides for the ownership, use and management of Crown land in NSW. Ministerial approval is required to grant a 'lease, licence, permit, easement or right of way over a Crown Reserve'. Crown land is further discussed in Chapter 20 (Land use and property)
- The *Local Government Act 1993* includes provisions for leases and permits in respect to works on community land that has not been acquired by the project
- The *Native Title (New South Wales) Act 1994* provides for the recognition of native title in NSW in accordance with the Commonwealth *Native Title Act 1993* (see Section 2.2.2). Native title is further discussed in Chapter 15 (Aboriginal cultural heritage) and Chapter 20 (Land use and property)
- *Fisheries Management Act 1994* (section 199) aims to manage dredging and reclamation works to conserve marine biodiversity and fish habitats. Under section 199, a public authority is required to give the Minister for Planning, Industry and Environment written notice of proposed dredging or reclamation work prior to carrying out or authorising the carrying out of such work, and to consider any matters raised by the Minister in response to the notification. Dredging work in Sydney Harbour would be required during installation of the immersed tube tunnels for the project

- The *Marine Pollution Act 2012* includes provisions to protect the sea and waters from pollution by oil and other noxious or harmful substances discharged from vessels. The use of marine vessels in the construction of the project would comply with the requirements of this Act and the Marine Pollution Regulation 2014 to prevent marine pollution. Works requiring access by boat or barge are further discussed in Chapter 6 (Construction work) and Chapter 17 (Hydrodynamics and water quality)
- The provisions in the *Marine Safety Act 1998*, Marine Safety Regulation 2016, *Ports and Maritime Administration Act 1995* and Ports and Maritime Administration Regulation 2012 aim to ensure the safe operation of vessels in ports and other waterways in NSW. A number of authorisations, approvals or permits may be required with respect to the placement of any structures in the water in Sydney Harbour and/or with respect to obstruction to navigation. Permission of the Harbour Master would be required prior to the disturbance of the bed of the harbour under Part 6D of the Ports and Maritime Administration Regulation 2012. Construction activities within Sydney Harbour and potential impacts to navigation are further discussed in Chapter 6 (Construction work) and Chapter 8 (Construction traffic and transport) respectively
- The *Waste Avoidance and Resource Recovery Act 2001* encourages the most efficient use of resources in order to reduce environmental harm in accordance with the principles of ecological sustainable development. Resource use and waste management are further discussed in Chapter 24 (Resource use and waste management).

Approvals not required for State significant infrastructure

A number of approvals are not required for a project approved under section 5.23 of Division 5.2 of the *Environmental Planning and Assessment Act 1979*. Those approvals not required for the project are:

- Permits under sections 201, 205 and 219 of the *Fisheries Management Act 1994*
- Approvals under Part 4 and excavation permits under section 139 of the *Heritage Act 1977*
- Aboriginal heritage permits under section 90 of the *National Parks and Wildlife Act 1974*
- Various approvals under the *Water Management Act 2000*, including water use approvals under section 89, water management work approvals under section 90, and activity approvals (other than aquifer interference approvals) under section 91.

Special dispensations for critical State significant infrastructure

If the project is declared as critical State significant infrastructure, section 5.23(3) of the *Environmental Planning and Assessment Act 1979* precludes the following directions, orders or notices being made to prevent or interfere with the carrying out of the project once approved:

- An interim protection order (within the meaning of the *National Parks and Wildlife Act 1974*)
- An order under Division 1 (Stop work orders) of Part 6A of the *National Parks and Wildlife Act 1974* or Division 7 (Stop work orders) of Part 7A of the *Fisheries Management Act 1994*
- A remediation direction under Division 3 (Remediation directions) of Part 6A of the *National Parks and Wildlife Act 1974*
- An order or direction under Part 11 (Regulatory compliance mechanisms) of the *Biodiversity Conservation Act 2016*
- An environment protection notice under Chapter 4 of the *Protection of the Environment Operations Act 1997*

- An order from a council to demolish or move a building, to repair or make structural alterations to a building, or to do or refrain from doing things under section 124 of the *Local Government Act 1993*.

2.2.2 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999* proposed 'actions' that have the potential to significantly impact on matters of national environmental significance, the environment of Commonwealth land, or are being carried out by a Commonwealth agency must be referred to the Australian Government. If the Australian Minister for the Environment determines that a referred project is a 'controlled action', the approval of that Minister would be required for the project in addition to the NSW Minister for Planning and Public Spaces' approval.

Based on the results of the environmental investigations carried out for this environmental impact statement, it is considered that matters of national environmental significance and the environment of Commonwealth land are not likely to be significantly impacted by the project. Accordingly, Transport for NSW has determined that no referral is required at this stage.

Environment Protection (Sea Dumping) Act 1981

The *Environment Protection (Sea Dumping) Act 1981* aims to regulate permitted sea (offshore) disposal activities to ensure environmental impacts are minimised and prohibit the disposal of harmful waste at sea. Offshore disposal is regulated by permits issued by the Commonwealth Department of the Environment and Energy and informed by detailed environmental assessments.

Dredged material associated with the construction of the crossing of Sydney Harbour would be eligible for offshore disposal under the Act. This would comprise dredged sediments that are considered suitable for offshore disposal which have been removed during the construction of cofferdams and immersed tube tunnels within Sydney Harbour.

Transport for NSW has submitted an application to the Department of the Environment and Energy for an offshore disposal permit relating to sediments dredged from Sydney Harbour. The application proposes offshore disposal at a designated disposal site, which is located about 10 to 15 kilometres offshore of Sydney Heads. A detailed assessment has been completed and submitted to the Department of the Environment and Energy, which documents sediments suitable for offshore disposal and details impacts associated with the disposal activity, as required by the permit application process.

Offshore disposal of sediments would be conducted outside NSW and is therefore not regulated under the *Environmental Planning and Assessment Act 1979*. As the offshore disposal grounds, excavation activity and transport to the disposal grounds are regulated by the Department of the Environment and Energy, further details of the offshore disposal assessment, contained within the submission to the Department of the Environment and Energy, are not included in this environmental impact statement.

Daily maximum construction maritime traffic volumes and routes to navigational channels that lead to Sydney Heads, including barge movements for offshore disposal of suitable dredged spoil, are summarised in Chapter 6 (Construction work) and considered in Chapter 8 (Construction traffic and transport) and Section 5.5 of Appendix F (Technical working paper: Traffic and transport). It is anticipated that six barge movements per day would be required for transportation of dredged spoil to the offshore disposal site.

Measures to manage noise from barges would be included in construction noise and vibration planning to be developed during further design development. Barges would be operated and maintained to comply with the Protection of the Environment Operations (Noise Control) Regulation 2017, particularly Clauses 37 and 38 of the regulation which require vessels to have properly maintained noise controls. Noise impacts related to the loading and unloading of barges at water-based construction support sites have been considered in Chapter 10 (Construction noise and vibration) and Appendix G (Technical working paper: Noise and vibration).

Sediments that are not suitable for offshore disposal would be brought to land. These sediments would be managed and, if necessary, made suitable for land disposal before being directed to an appropriately licensed waste facility. Further discussion on disposal of dredged sediments not suitable for offshore disposal is provided in Chapter 24 (Resource use and waste management).

Native Title Act 1993

The main objective of the *Native Title Act 1993* is to recognise and protect native title. A successful native title claim results in the recognition of the particular rights, interests or uses claimed by the registered party. If a native title claim is recognised under the Act, any actions by Government on that land must be consistent with the claim.

Searches of the register maintained by the National Native Title Tribunal indicate there are no native title claims registered with respect to the land within the project footprint.

Notification requirements under section 24KA of the *Native Title Act 1993* apply where construction work is required on Crown land and where the land has not been acquired by Transport for NSW. Notification in accordance with this section will occur concurrently with the public display of the environmental impact statement.

Airports Act 1996 and Civil Aviation Act 1988

Under the *Airports Act 1996*, ‘prescribed airspace’ is the airspace above any part of either an obstruction limitation surface (OLS) or procedures for air navigation systems operations (PANS-OPS) surface for Sydney Airport. Approval is required from the Secretary of the Commonwealth Department of Infrastructure, Transport, Cities and Regional Development if the project affects ‘prescribed airspace’, either by a structure physically protruding into the airspace or activities that result in disturbance to the airspace, such as turbulence caused by emissions from a ventilation outlet. Through provisions under the *Civil Aviation Act 1988,* the Civil Aviation Safety Authority can stipulate requirements for the design, construction and operation of new infrastructure that has the potential to influence aviation safety that support the provisions of the *Airports Act 1996*.

The emission from the ventilation outlet and motorway facilities at the Rozelle Interchange and at the Warringah Freeway have the potential to affect prescribed airspace.

A plume rise assessment was carried out in accordance with the *CASA Advisory Circular Plume Rise Assessments AC 139-5(1) November 2012* to determine whether plume rise resulting from the operation of these ventilation outlets and motorway facilities would be a controlled activity as defined in section 183 of the *Airports Act 1996*. This assessment considered an expected case, reflective of typical operational conditions of the project, and a capacity case, based on the maximum theoretical airflow that could be discharged from each ventilation outlet. In addition, the assessment also considered the merged ventilation outlets at the Warringah Freeway for the Western Harbour Tunnel and Beaches Link program of works.

The plume extent from the ventilation outlets and motorway facilities would not interfere with the OLS and PANS-OPS surfaces under the expected case scenarios. However, under the capacity case scenario, the plume from the ventilation outlet and motorway facilities at Rozelle Interchange and at the Warringah Freeway may penetrate the PANS-OPS and OLS layers respectively. As such, a plume rise application would be prepared for approval under the *Airports Act 1996* to cover both the ventilation outlet and motorway facilities at the Rozelle Interchange and at the Warringah Freeway where they may constitute a controlled activity.

Further discussion of potential impacts on prescribed airspace is provided in Chapter 23 (Hazards and risks).

2.3 Next steps

As is normally the case for complex major infrastructure projects progressing through an environmental planning and assessment process, the design and construction approach presented in this environmental impact statement is at planning stage and is indicative only. It is subject to refinement once project approval is obtained and the contractor(s) delivering the project have further developed the design and construction methodologies (commonly referred to as detailed design).

Issues raised during exhibition of the environmental impact statement may result in changes to the project design and construction approach, and if so, these would be identified in a Preferred Infrastructure Report.

Any refinements to the approved project during the contractor's detailed design would be reviewed for consistency with the approval. This consistency review would be undertaken to consider whether the refinement would:

- Result in any of the conditions of approval not being met
- Be consistent with the objectives and operation of the project as described in the environmental impact statement
- Result in a significant change to the approved project
- Result in any potential environmental or social impacts of a greater scale or impact than that considered by the environmental impact statement.

Where design refinements do not meet these criteria, a modification would be sought from the Minister for Planning and Public Spaces in accordance with the requirements of Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

2.3.1 M4-M5 Link interface

The Rozelle Interchange forms part of the approved M4-M5 Link project. In broad terms, it is proposed that, under the M4-M5 Link project, stub tunnels would be constructed to enable the Western Harbour Tunnel to connect at the Rozelle Interchange. The connection is part of the Western Harbour Tunnel and Warringah Freeway Upgrade project.

The interface of the project with the Rozelle Interchange reflects the arrangement as presented in the environmental impact statement for the M4-M5 Link, and as amended by the proposed modifications.

The contractor for the Rozelle Interchange was appointed in December 2018 and has carried out detailed design. The detailed design includes a number of design refinements and optimised arrangements which aim to achieve improved construction and operational outcomes, or are required to meet the conditions of approval granted for the M4-M5 Link.

The ultimate alignment of the Western Harbour Tunnel at the Rozelle Interchange would be in accordance with the now finalised M4-M5 Link design. This final detailed design varies from the project alignment presented in this environmental impact statement due to the timing and different stages of the two projects, with the Western Harbour Tunnel project being at the planning stage and the M4-M5 Link project now being at the detailed design stage. Refinements and adjustments made to the Rozelle Interchange by the contractor during detailed design would be reflected in the Western Harbour Tunnel design in either Western Harbour Tunnel preferred infrastructure report or in a modification. Coordination between the two projects at the M4-M5 Link interface is ongoing.

Any required changes to the project would be considered by following the processes as detailed in Section 2.1 above.

Figure 2-2 shows the relationship between the status of the Rozelle Interchange and the project.

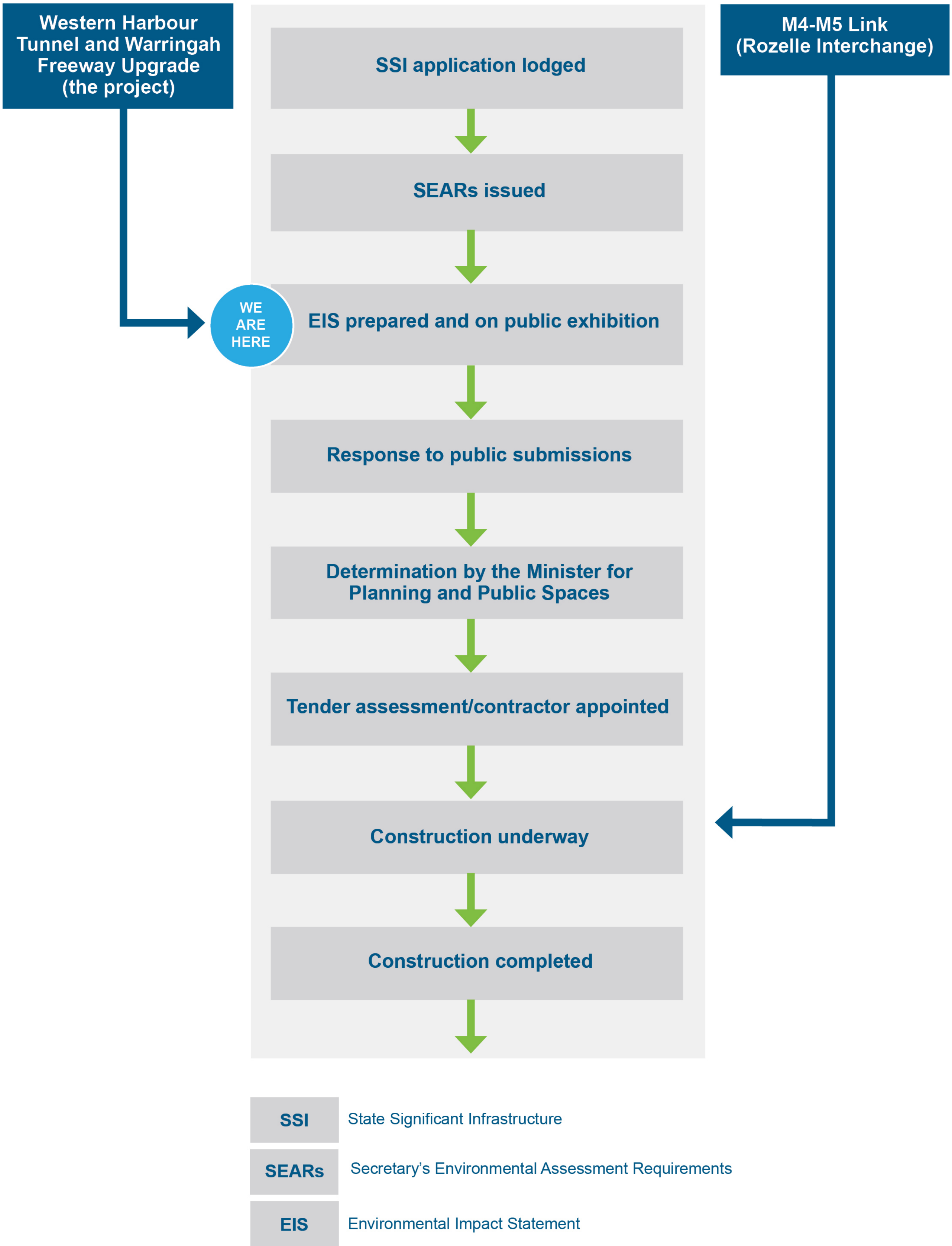


Figure 2-2 Relationship between the status of the Rozelle Interchange and the project

Chapter

3

Chapter 3

Strategic context and project need

January 2020

3 Strategic context and project need

This chapter outlines the strategic context and need for the project, taking into account the current and future transport challenges Sydney is facing, and describes the benefits of the project for people across Greater Sydney. It also describes how the project aligns with national and State strategic planning and transport policies.

The Secretary's environmental assessment requirements as they relate to the strategic context and project need, and where in the environmental impact statement these have been addressed, are detailed in Table 3-1.

Table 3-1 Secretary's environmental assessment requirements – Strategic context and project need

Secretary's requirement	Where addressed in EIS
Environmental impact statement	
1. The EIS must include, but not necessarily be limited to, the following: b. a description of the project and all components and activities (including ancillary components and activities) required to construct and operate it, including: - the relationship and/or integration of the project with existing and proposed public and freight transport services	The relationship and integration of the project with existing and proposed public and freight transport services is described in **Section 3.5** and **Section 3.6**. Additional information about the relationship and integration of the project with existing and proposed public and freight transport services is in **Chapter 5** (Project description), **Chapter 8** (Construction traffic and transport), **Chapter 9** (Operational traffic and transport) and **Chapter 27** (Cumulative impacts).
c. a statement of the objective(s) of the project	**Section 3.3** states the project objectives.
d. a summary of the strategic need for the project with regard to its State significance and relevant State Government policy	**Section 3.2** outlines the strategic need for the project. Reference to the project's State significance and relevant State Government policies are provided in **Section 3.6**.
g. a description of how alternatives and options within the project were analysed to inform the selection of the preferred alternative / option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to, and options(s) within, the project were selected, including: - details of the short-listed route and tunnel options considered, and the criteria that was considered in the selection of the preferred route and tunnel design; - details of the alternative construction methods that were considered for tunnel	The benefits of the overall program of works and the project are provided in **Sections 3.4** and **3.5** respectively. The assessment of strategic and design alternatives considered is presented in **Chapter 4** (Project development and alternatives. Justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979* is presented in **Chapter 28** (Synthesis of the environmental impact statement).

Secretary's requirement	Where addressed in EIS
construction, particularly those areas spanning Sydney Harbour; - the alternative tunnel design and ventilation options considered to meet the air quality criteria for the proposal; and - a justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979*.	

3.1 Sydney's future

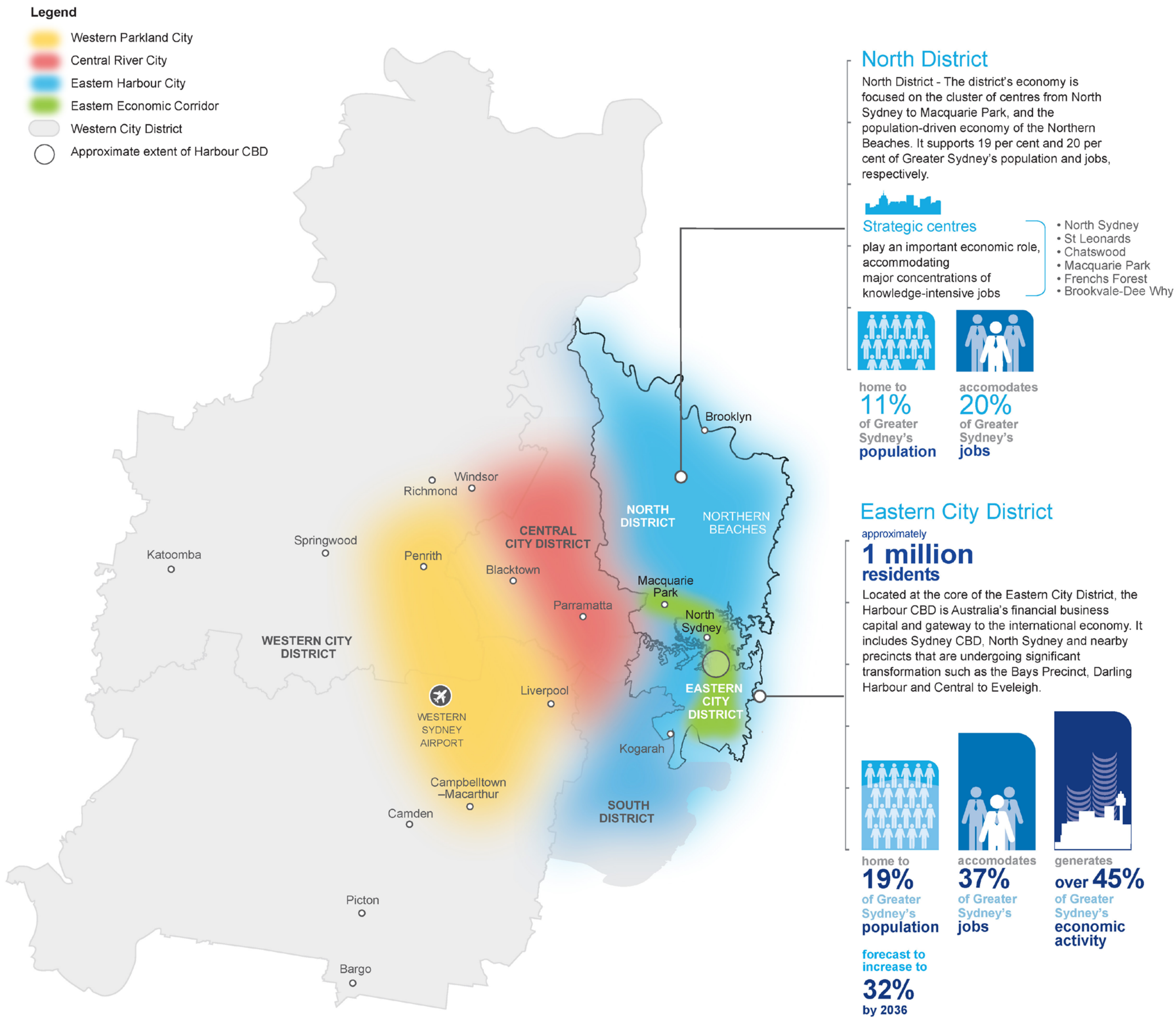
The population of Sydney is forecast to grow from six million to eight million people over the next 40 years. To accommodate this growth, the Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) envisages a global metropolis of three liveable, productive and sustainable cities.

The Western Harbour Tunnel and Warringah Freeway Upgrade project (the project) is located in the Eastern City District, including the Harbour Central Business District (CBD), and the North District of the Eastern Harbour City. The Eastern City District and North District areas are of strategic economic importance for Sydney. The districts and their key metrics are shown in Figure 3-1.

Sydney's key employment and economic areas are clustered along a corridor that runs from Port Botany and Sydney Airport to Macquarie Park; this is known as the Eastern Economic Corridor. The Eastern Economic Corridor contributed two thirds of the NSW economic growth for the 2015/16 Financial year (Greater Sydney Commission, 2018b), and provides jobs in a range of knowledge-based sectors including education, financial and other business services, communications, high-tech manufacturing and biotechnology (NSW Government, 2014). Given the Harbour City CBD focus of the current arterial road network, many road based trips generated by the Eastern Economic Corridor must pass through the Harbour CBD area to cross Sydney Harbour.

Supporting the current needs and future growth of the Eastern Harbour City and Eastern Economic Corridor through an efficient transport network is fundamental to the liveability, productivity and sustainability of Greater Sydney. Accordingly, the *Greater Sydney Region Plan* was prepared concurrently with the *Future Transport Strategy 2056* (NSW Government, 2018) and the *State Infrastructure Strategy 2018 – 2038* (Infrastructure NSW, 2018) to align land use, transport and infrastructure outcomes for Greater Sydney.

Additional key strategic planning and policy documents relevant to the project are discussed in Section 3.6.



Source: Greater Sydney Region Plan – A Metropolis of Three Cities (Greater Sydney Commission, 2018a)

Figure 3-1 Greater Sydney's Eastern City and North districts

3.2 Overview of the Eastern Harbour City's road transport challenge

The motorway crossings of Sydney Harbour, including the Sydney Harbour Bridge, Sydney Harbour Tunnel and ANZAC Bridge, are critical links in Sydney's motorway and arterial road network. Key metrics for the Eastern Harbour City's road transport network are shown in Figure 3-2.

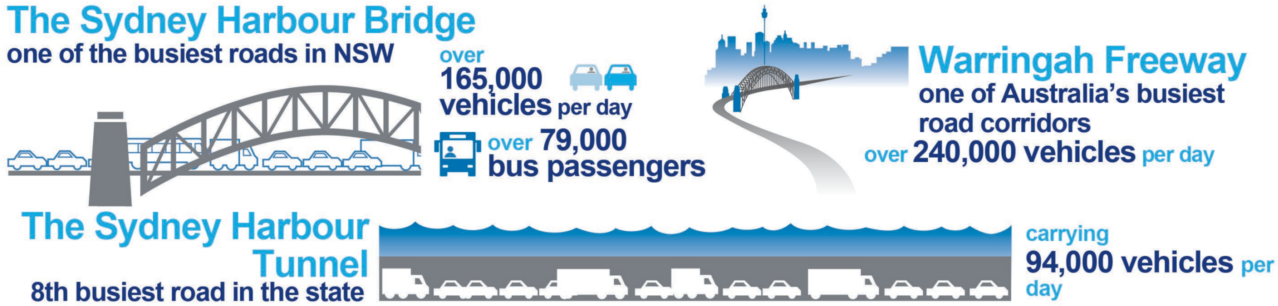


Figure 3-2 Key metrics for the Eastern Harbour City's transport network

In addition to the large number of customers who rely on these corridors, the limited capacity and number of alternate routes for crossing Sydney Harbour make these corridors critical to the performance of the broader motorway and arterial road network. Network data demonstrates that incidents on the harbour crossings and their approaches impact journey times for freight, buses and private vehicles travelling on the arterial network across the region.

During the period of 2014 to 2017, there were an average of 1418 incidents per year on Sydney Harbour Bridge and its approaches (including the Warringah Freeway) impacting journey times for customers. Without intervention, the predicted growth in traffic demand over time will result in further increases in journey time delays and deterioration of reliability over time.

In addition to large traffic volumes, a major contributor to congestion around the Harbour CBD is that many of the most critical road corridors – including the Sydney Harbour Bridge, the Sydney Harbour Tunnel, ANZAC Bridge, Western Distributor and the Warringah Freeway – perform both bypass and access functions. The dual function of these corridors is reflected in the high proportion of vehicles that use them to travel to destinations other than the Sydney CBD (see Figure 3-3). This contributes to high levels of congestion as well as poor network outcomes, as bypassing traffic is impacted by congested collector/distributor roads.

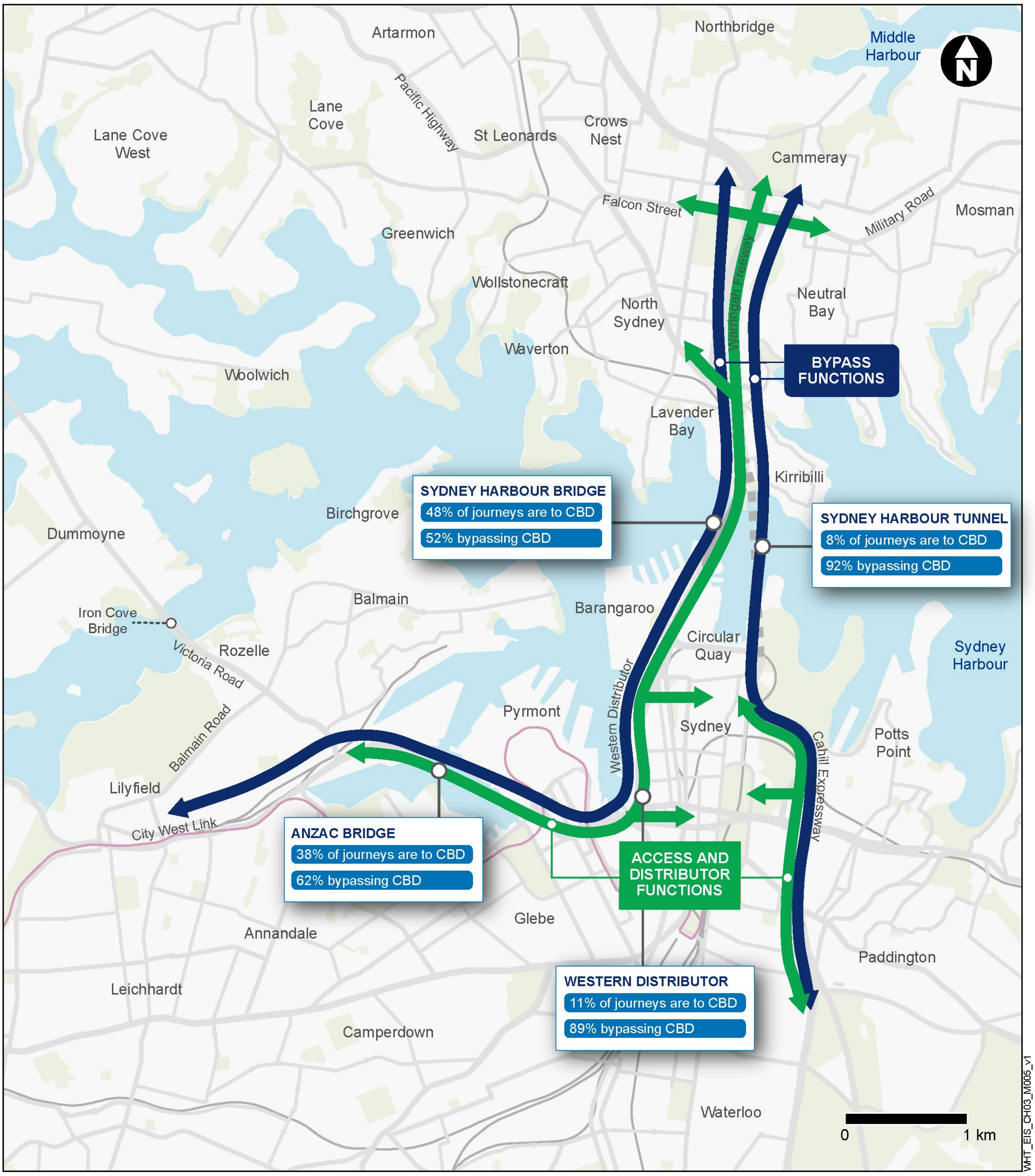


Figure 3-3 Function of critical road corridors around the Harbour CBD

The *Australian Infrastructure Audit 2019* (Infrastructure Australia, 2019) listed the Eastern Distributor, Sydney Harbour Bridge, Warringah Freeway and the Gore Hill Freeway corridor among Australia's most congested road corridors, generating a congestion cost of $65,000 per day in 2016. If no action is taken, this is forecast to rise to $98,000 per day by 2031. As congestion on these corridors increases so too will the costs.

Infrastructure NSW has estimated that the economic risk to growth and productivity posed by traffic congestion in the Eastern City District is about $5 billion a year, and is forecast to increase to about $8 billion annually by 2020. Infrastructure NSW has observed that "*without corrective action, congestion will worsen – and the costs to business and the community will escalate – as the city's population grows*" (Infrastructure NSW, 2014).

Augmenting capacity and reducing the conflict between access and bypass functions for the Sydney Harbour Bridge, the Sydney Harbour Tunnel, ANZAC Bridge and Western Distributor is thus a key element of the integrated transport network required to support the liveability and productivity of the Eastern Economic Corridor and its connections with international gateways and their surrounds.

Further detail on these transport challenges and their influence on the proposed design for the Western Harbour Tunnel and Warringah Freeway Upgrade project is provided in the subsequent sections of this chapter.

3.2.1 High traffic volumes on roads around the Harbour CBD

The Eastern Harbour City has the largest concentration of jobs in Greater Sydney, accommodates the most productive industries and is home to a highly skilled workforce.

The major transport corridors around the Harbour CBD are the busiest in Greater Sydney and Australia. The cross-harbour network is particularly critical, including:

- **Sydney Harbour Bridge (Bradfield Highway and Cahill Expressway)** – one of the busiest roads in NSW, carrying over 165,000 vehicles a day (Roads and Maritime, 2017b)
- **Sydney Harbour Tunnel** – the eighth busiest road in NSW, carrying 94,000 vehicles a day (Roads and Maritime, 2017b)
- **Sydney Harbour Bridge railway crossing** – an essential link on the Sydney Trains network, accommodating T1 North Shore, Northern and Western Line services (Sydney Trains, 2015).

3.2.2 Congested corridors and conflicting functions of roads around the Harbour CBD

The road corridors around the Harbour CBD were developed during a period where traffic demands were CBD focused. Since this time traffic patterns have evolved, with demands to bypass the CBD now larger than those looking to access the CBD (see Figure 3-3). This has resulted in the most critical arterial roads surrounding the Harbour CBD, including the Sydney Harbour Bridge, the Sydney Harbour Tunnel, ANZAC Bridge, Western Distributor and the Warringah Freeway, serving conflicting functions – providing local access to a constrained CBD road network and a bypass route for through traffic.

The Sydney Harbour Tunnel is one of the primary north–south corridors for journeys between centres north of Sydney Harbour and the trade gateways of Sydney Airport and Port Botany and the south-west. This link also provides access to the eastern side of the Harbour CBD.

The Warringah Freeway is a key element of the main north–south and east–west motorway network, but is also used to service shorter trips within the Lower North Shore via closely spaced entry and exits.

The Sydney Harbour Bridge is an important route for vehicles travelling between the North District and centres to the west, including Greater Parramatta and Sydney Olympic Park, and to the south, including Sydney Airport and Port Botany, but also acts as the primary CBD access road to and from the north.

The ANZAC Bridge and Western Distributor were primarily designed to provide access between the Harbour CBD and the west, rather than function as the primary arterial corridor between the Inner West and centres north of the Harbour CBD. This is evidenced by the southbound capacity from the Sydney Harbour Bridge through to the ANZAC Bridge being limited to one lane on the

Western Distributor. The current and future traffic demands indicate that the majority of customers using this corridor are attempting to bypass the Harbour CBD.

These conflicting functions combined with the high traffic volumes on these corridors is a major contributor to the congestion and poor network performance for freight, public transport and private vehicle users on these routes and other tributaries. This is because traffic attempting to bypass the CBD is hampered by congested collector/distributor roads. This conflict results in travel speeds that are low in the AM and PM peaks and are forecast to deteriorate even further as traffic demand grows over time.

3.2.3 Low resilience on the Harbour CBD road transport network

The combination of high demand and full capacity on road corridors around the Harbour CBD has a detrimental impact on the resilience of Greater Sydney's wider road network. Given the critical role these corridors play in the wider arterial road network, incidents on these corridors have broad impacts on the Sydney road network, leading to traffic queues and unreliable travel time for private vehicle and bus users.

As there are only a few alternative harbour crossing routes, the impact of incidents is particularly pronounced if they occur on the harbour crossings or their approaches. With limited alternative routes for freight, commercial vehicles and buses, incidents on these crossings take a long time to clear, often causing significant and widespread delays. Incidents on the Sydney Harbour Bridge and Warringah Freeway corridor between 2014 and 2017 are shown in Figure 3-4.

Figure 3-4 Incidents on the Sydney Harbour Bridge and Warringah Freeway corridor (2014 to 2017)

As traffic demands for the Sydney Harbour Bridge and Warringah Freeway corridor continue to increase, so too will the costs associated with incidents on these critical links. Without action, it is estimated that the annual cost of incidents (excluding congestion) on this corridor alone will be more than $66 million per annum by 2036. Creating alternatives to this route is necessary to increase network resilience and reduce the impact of incidents on Greater Sydney's productivity.

3.2.4 Sub-optimal performance on the Warringah Freeway

Carrying around 240,000 vehicles per day, including more than 30,000 bus passengers during the two-hour AM peak, the Warringah Freeway is one of the busiest road corridors in Australia, and is critical to the operation of the Sydney arterial road network (Roads and Maritime, 2017b). Demand on this corridor is forecast to increase by 17 per cent by 2037.

The Warringah Freeway Corridor has evolved in a piecemeal fashion between 1968 and 2006 and performs a number of distinct functions, including:

- The main M1 corridor linking the Sydney Harbour Tunnel through to Gore Hill Freeway for onward journeys on the M2 and future NorthConnex/M1 corridors

- Servicing key centres along the Eastern Economic Corridor
- Providing access for commuters and services to economic centres including the Harbour CBD, North Sydney, St Leonards, Chatswood and Macquarie Park via the Gore Hill Freeway and Lane Cove Tunnel
- Connections with the west and Inner West, linking the ANZAC Bridge, City West Link and to roads to the north, including Gore Hill Freeway and Lane Cove Tunnel
- Local trips on the Lower North Shore, such as from Willoughby Road to Falcon Street.

These competing functions have resulted in a complex corridor where:

- Ramps are very closely spaced, resulting in traffic weaving across multiple lanes
- Ramps converge and diverge in each of the three carriageways, and sometimes from the right hand lane, creating turbulence and impacting wayfinding
- There is poor separation of vehicles using the mainline and those making shorter local and regional trips.

These competing functions, coupled with the evolution of the corridor over time and high traffic volumes, impact the efficiency, safety, and capacity of the corridor.

The safety and operational issues inherent in the current configuration of the Warringah Freeway are illustrated by the fact there were 387 crashes on the Warringah Freeway (including interchanges) between 2012 and 2016. Of these crashes, 154 occurred on the mainline and involved multiple vehicles.

3.2.5 Congestion impacting urban amenity across the Eastern City and North Districts

Across the Eastern and North Districts, several parts of the arterial road network perform a ‘place’ function. This means that, as well as being transport corridors, parts of the road network are destinations in their own right, including for shopping and dining. These places play an important role in supporting the liveability, productivity and sustainability of Greater Sydney, and the transport network has an important role in supporting this objective, as reflected by ‘Successful Places’ being one of the six NSW-wide outcomes established by *Future Transport Strategy 2056*.

Congestion on the arterial network across the Eastern City and North City Districts result in compromised streetscapes, views, physical safety, air pollution and noise levels, and impairs efforts to improve liveability in these areas.

3.3 The Western Harbour Tunnel and Beaches Link program of works

The Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project are being delivered as separate projects, but have been developed as an integrated program of works known as the Western Harbour Tunnel and Beaches Link program.

In conjunction with other road, rail, bus and light rail projects, the Western Harbour Tunnel and Beaches Link program of works has been developed to meet the current and future transport needs of Sydney. The program of works represents an important step in the long-term development of Greater Sydney's strategic transport network. The design has been developed to address critical transport constraints on the motorway and arterial network, and support the growth of the city and NSW, by improving the capacity, reliability, and journey time performance of the critical cross-harbour transport corridors near the Harbour CBD.

As well as relieving road congestion for freight operators, service vehicles, bus passengers and commuters the program has been designed to provide a platform to deliver significant improvements to public transport services. This includes opportunities for reliable and efficient express bus services between the Northern Beaches, North Sydney, the Harbour CBD and strategic centres to the south and west.

The core capacity improvement offered by the Western Harbour Tunnel and Warringah Freeway project is key to enabling the proposed Beaches Link and Gore Hill Freeway Connection project and the associated significant change in connectivity and reliability for the northern transport network.

To ensure the design for the program of works meets the transport challenges of the Eastern Harbour City, the following objectives have been developed for the Western Harbour Tunnel and Warringah Freeway Upgrade project:

- Reduce congestion on distributor roads around the Harbour CBD, including the Sydney Harbour Bridge, Western Distributor and ANZAC Bridge
- Create faster, safer and more reliable journeys across Sydney Harbour, particularly for traffic bypassing the Harbour CBD to the west
- Improve productivity by allowing commuters and freight to reach their destination faster, safer and more reliably
- Increase the ability for the Harbour CBD road network to cope with traffic incidents
- Reduce travel times, delays and queuing on the Warringah Freeway by improving cross-harbour capacity and reducing merges and weaves, supporting long-term increased demand
- Improve streetscapes, sustainability and liveability across the Eastern City and North Districts by reducing congestion.

A summary of the project challenges, corresponding objectives and overall project benefits are shown in Figure 3-5 and discussed in more detail in Sections 3.4 and 3.5.

Transport challenges

High volumes of commuter traffic on roads around the Harbour CBD[1]

Congestion on key roads around the Harbour CBD[1], including Sydney Harbour Bridge, Sydney Harbour Tunnel and Anzac Bridge, add additional strain on capacity of the road network

The Harbour CBD[1] road network is unable to cope with traffic incidents – an incident can quickly cause long delays across the broader network and take a long time to clear afterwards

The performance of the Warringah Freeway is impacted by high traffic volumes, congestion on harbour crossings, and merges and weaves

Congestion impacting the streetscapes, sustainability and liveability across the Eastern City and North Districts[1]

Project objectives

Reduce congestion on key roads around the Harbour CBD[1], including the Sydney Harbour Bridge, Sydney Harbour Tunnel and Anzac Bridge

Create faster, safer and more reliable journeys across Sydney Harbour, particularly for traffic bypassing the Harbour CBD[1] to the west

Improve productivity by allowing commuters and freight to reach their destination faster, safer and more reliably

Increase the ability for the Harbour CBD[1] road network to cope with traffic incidents

Reduce travel times, delays and queuing on the Warringah Freeway by improving cross-harbour capacity and reducing merges and weaves, supporting long-term increased demand

Improve streetscapes, sustainability and liveability across the Eastern City and North Districts[1] by reducing congestion

Project benefits

A third harbour crossing to reduce congestion and pressure on Sydney Harbour Bridge, Sydney Harbour Tunnel and Anzac Bridge – leading to faster and more reliable journeys to, from and around the Harbour CBD[1]

Enable local businesses to have better and more efficient access to Greater Sydney, making it easier to move goods and provide services, as well as bringing employees and businesses closer together

Make journeys on the Warringah Freeway easier and safer by improving lane configuration and providing clear directions on the best way to cross the harbour and reach your destination

Contribute to an integrated transport network by enabling direct bus access to North Sydney and an efficient transfer to the new Metro

Return local streets to communities by moving traffic underground, freeing up local streets for local traffic, and supporting the sustainability of local town centres

Opportunities to enhance the local community by improving shared user connections and providing new public open space

Note 1: Refer to figure 3-1 for more information about the location of the Harbour CBD, Eastern City District and North District

Figure 3-5 Project challenges, objectives and benefits

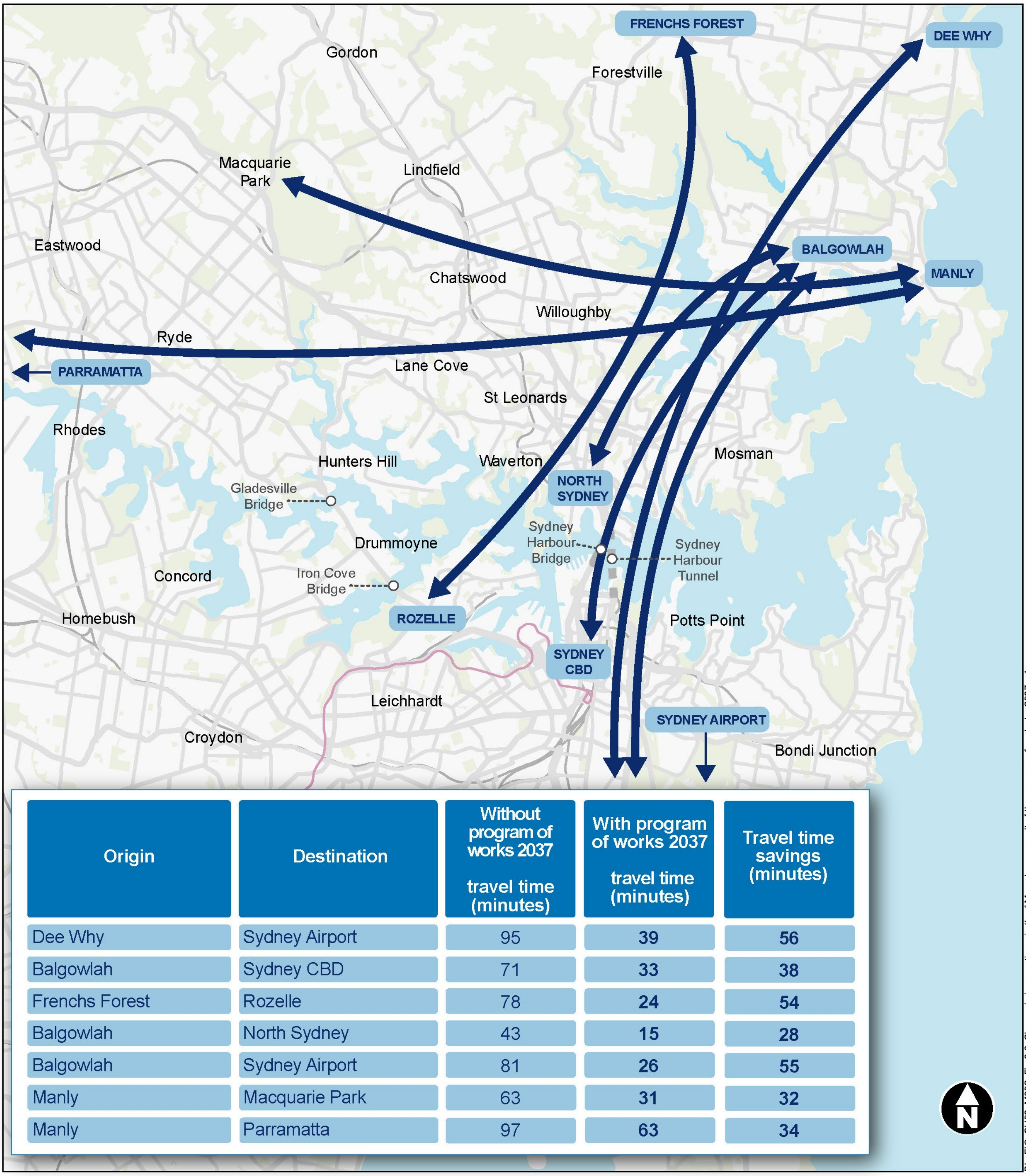
3.4 Key benefits of Western Harbour Tunnel and Beaches Link program of works

The Western Harbour Tunnel and Beaches Link program of works would deliver new strategic road links for Greater Sydney, improving journey times for freight, public transport and private vehicle customers and alleviating pressure on some of the city's most critical transport corridors. The program of works is designed to improve the capacity, reliability, and journey times on cross-harbour transport corridors near the Harbour CBD and improve connectivity to the Northern Beaches.

The program of works would support faster travel times for journeys between the Northern Beaches and south and west of Sydney Harbour. For example, journeys from Dee Why to Sydney Airport are expected to be 56 minutes faster (total travel time 39 minutes) in the AM peak by 2037 (via the proposed Beaches Link, Western Harbour Tunnel and WestConnex). Other key journey times in the AM peak as a result of the program of works are shown in Figure 3-6.

Delivering the program of works would also improve the resilience of the network, given that each project provides additional capacity and an alternative route to heavily congested harbour crossings.

In addition to the journey time and reliability benefits provided for service vehicles, freight and commuters, the program would enable significant improvements for public transport customers currently using some of Sydney's busiest road corridors.



Origin	Destination	Without program of works 2037 travel time (minutes)	With program of works 2037 travel time (minutes)	Travel time savings (minutes)
Dee Why	Sydney Airport	95	39	56
Balgowlah	Sydney CBD	71	33	38
Frenchs Forest	Rozelle	78	24	54
Balgowlah	North Sydney	43	15	28
Balgowlah	Sydney Airport	81	26	55
Manly	Macquarie Park	63	31	32
Manly	Parramatta	97	63	34

Figure 3-6 Change in journey times in the AM peak as a result of the program of works by 2037

Prior to completion of the B-Line works, the Northern Beaches experienced some of Sydney's longest and most unreliable peak-hour bus travel times. The B-Line project has already reduced travel times and increased bus patronage – with over 2000 weekly services providing enhanced services between Mona Vale and Wynyard. Refer to Figure 3-7 for B-Line express routes and integration with key project areas.

The proposed Western Harbour Tunnel and Beaches Link tunnels provide further opportunities for much quicker and more reliable express bus services between the Northern Beaches and strategic centres including North Sydney, the Harbour CBD, St Leonards and Macquarie Park via the motorway network. These bus services will provide links to strategic stations on the rail network to support longer distance public transport journeys. Expansion of B-Line services to take advantage of these opportunities would greatly improve the capacity, journey times and reliability for public transport to and from the Northern Beaches.

Figure 3-7 B-Line express routes and integration with key project areas

By reducing pressure on existing arterial corridors, the program would also provide benefits to users of surface bus services on Warringah Road and Military Road. Bus travel times along the Warringah Freeway would also generally improve as a result of the program of works. This is due to the reduction of traffic on Warringah Freeway caused by traffic demand transferring to the Beaches Link Tunnel and Western Harbour Tunnel, and improvements to the bus priority infrastructure.

By providing additional motorway capacity and bypassing communities underground, the program of works would reduce through traffic volumes through many areas. In addition to reducing pressure on key road corridors such as Military Road, Spit Road, Warringah Road, the Western Distributor and ANZAC Bridge, the program of works would also result in less through traffic through suburbs such as Naremburn, Mosman and Seaforth. This would result in reduced noise and improved amenity through these areas.

Key benefits related to the Western Harbour Tunnel and Warringah Freeway Upgrade project are discussed in detail in Section 3.5.

3.5 Key benefits of the Western Harbour Tunnel and Warringah Freeway Upgrade project

The Western Harbour Tunnel and Warringah Freeway Upgrade project is a vital part of the overall Western Harbour Tunnel and Beaches Link program of works. The project would provide much needed additional capacity on the busiest road corridor in Sydney, improving liveability and amenity for local communities that would benefit from reduced through traffic and improved connectivity, and deliver meaningful productivity benefits for NSW.

This project leverages off the underground WestConnex network to significantly increase the efficiency and capacity of the transport crossings of Sydney Harbour by delivering a new western bypass of the Harbour CBD. The additional core motorway capacity delivered by this project would significantly improve journey times and journey time reliability for approximately 2.5 million people who use the Sydney Harbour Bridge and Sydney Harbour Tunnel road crossings every week, as well as users of many arterial roads whose performance is affected by these crossings.

The Warringah Freeway Upgrade would allow for the new tunnel to connect with the existing road corridor and streamline traffic movements to optimise the use of the three harbour crossings into the future.

This new western bypass of the Sydney CBD would serve through journeys between the south and west of Sydney, including the international gateways of Sydney Airport and Port Botany, and strategic centres north of the harbour including North Sydney, St Leonards, Chatswood and Macquarie Park. Increased road network capacity and connectivity as a result of the project would also result in travel time savings for freight movements, further serving the growth of Sydney's Eastern Economic Corridor.

The increase in harbour crossing capacity and efficiency delivered by the project would also remove a major bottleneck that constrains the road transport capacity of areas north of the harbour, including the Northern Beaches area. The combined delivery of this project with future connections such as the Beaches Link and Gore Hill Freeway Connection project would deliver significant benefits for public transport, freight and other road users over an increased catchment.

Further detail on some of the key benefits of the project is provided in the following sections. Further information on alignment of the project outcomes with strategic State and Federal Government objectives is provided in Section 3.6.

3.5.1 Reduced pressure on distributor roads around the Harbour CBD

The roads around the Sydney and North Sydney CBDs perform a dual function, carrying traffic accessing these centres and their surrounds, while also serving as the primary through-routes for longer north–south journeys.

A key objective of the project is to provide a high quality western motorway bypass of the Harbour CBD. This would significantly improve journey times and reliability for through traffic and allow CBD collector-distributor roads to function more efficiently by removing the majority of through-traffic. This would benefit all users, including buses and freight, that rely on key corridors including Victoria Road, City West Link, the ANZAC Bridge, Western Distributor, the Sydney Harbour Bridge as well as numerous key road corridors that connect to the Warringah Freeway.

Figure 3-8 illustrates the forecast traffic distribution for the project, showing that large volumes of traffic would no longer need to use the Sydney Harbour Bridge to cross the harbour or the main distributor routes that connect to the Sydney Harbour Bridge. The Western Distributor and Sydney Harbour Tunnel in particular would experience large demand reductions of about 35 per cent and 20 per cent respectively.

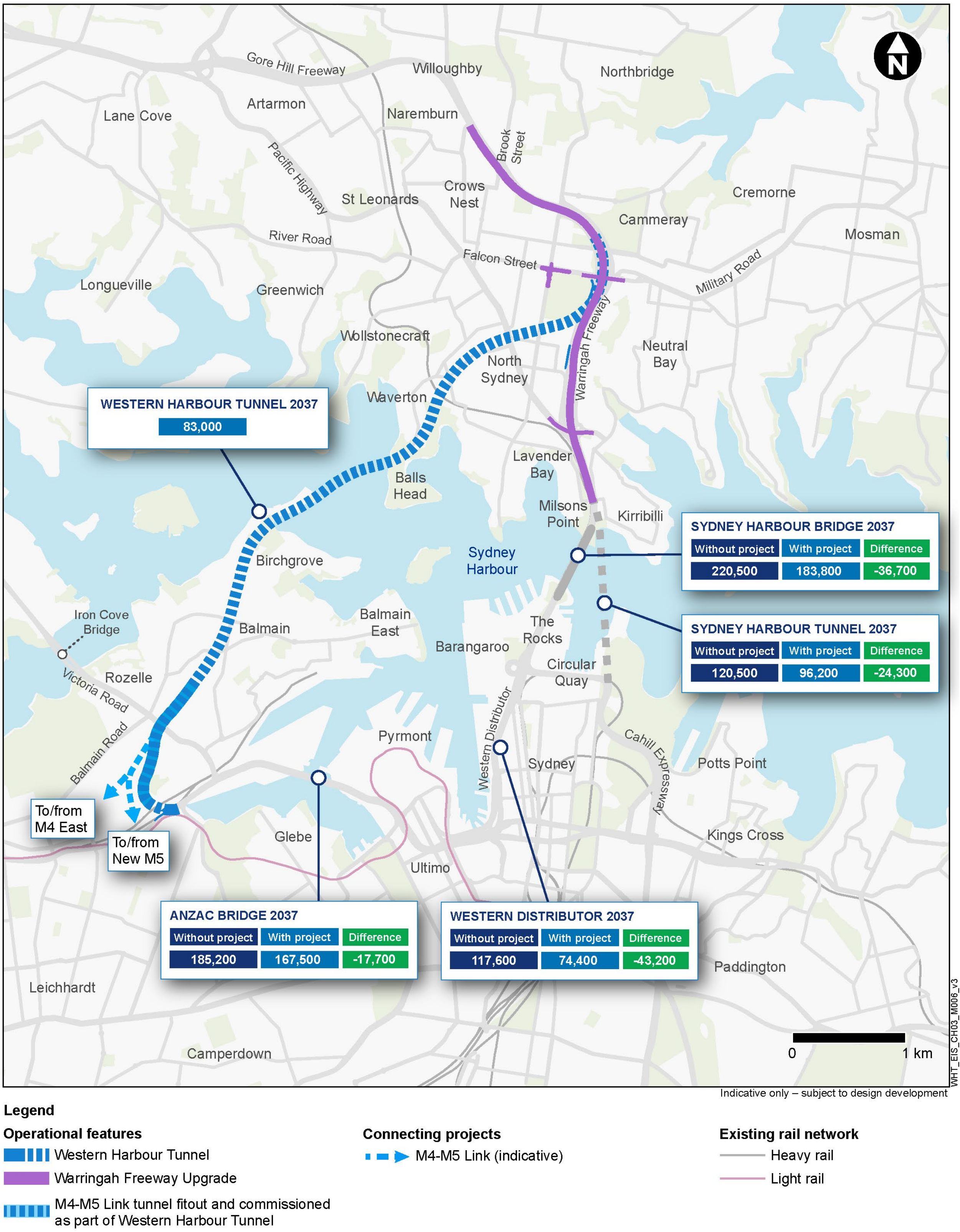


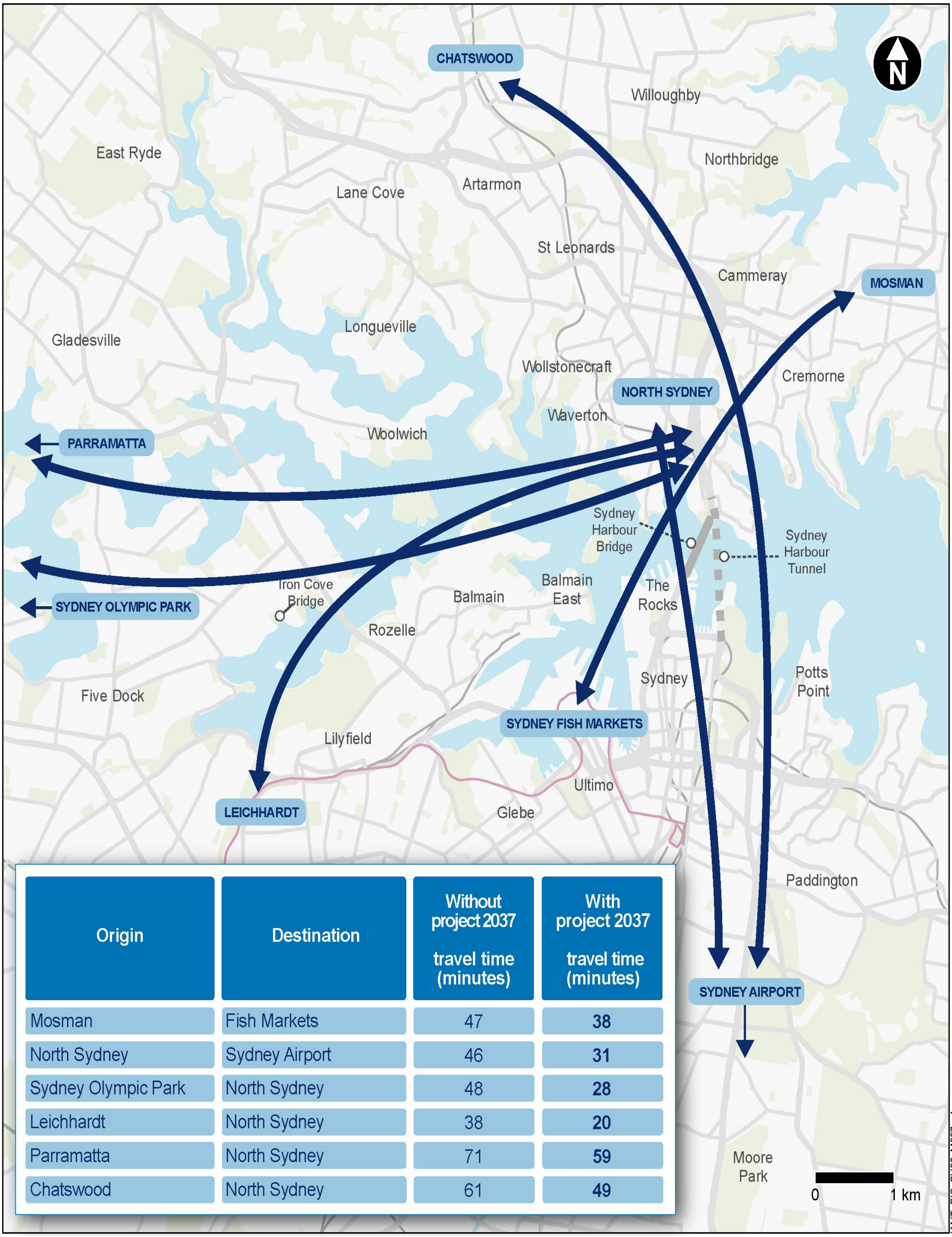
Figure 3-8 Change in average weekday traffic demands (two-way) on key road corridors by 2037

3.5.2 Faster, more reliable journeys on Sydney Harbour crossings

In addition to the fast and reliable journeys the proposed tunnels would offer to customers, the project would enable faster, more reliable journeys for all vehicles, including buses, on surface corridors by relieving pressure on these existing corridors. Relieving pressure on these road corridors would particularly benefit customers on northbound buses, since these buses are currently required to use the general traffic lanes and therefore experience the full impacts of congestion and any disruption to traffic flow.

The expected savings for specific journeys in the AM peak are shown in Figure 3-9, which points to shorter journey times when comparing the 2037 'with project' and 'without project' cases. For example, journeys from Sydney Olympic Park to North Sydney, and from Leichhardt to North Sydney, would both experience time savings of about 20 minutes. Journeys from North Sydney to Kingsford Smith Airport would experience time savings of about 15 minutes.

The impact on AM peak travel times to the Harbour CBD from across Greater Sydney is shown in Figure 3-10. The project would produce large travel time savings for commuters from the Northern Beaches and the Lower North Shore travelling to jobs in the CBD. In particular, travel time savings of up to 20 minutes would be achieved for commuters travelling from Chatswood, Roseville, Lindfield, Forestville, Belrose, Frenchs Forest, Cromer and North Narrabeen. By contrast, some slight increases in travel times would be observed for commutes starting in Rozelle due to an overall increase in travel demand through the Rozelle area (of up to 40 per cent by 2037). Travel time increases in Rozelle are likely to be less than one minute, which is considered to be negligible. The majority of traffic growth through the Rozelle area would be facilitated by the M4-M5 Link and the associated Rozelle Interchange, which would allow substantially more traffic to travel through the area via motorway tunnel.



Origin	Destination	Without project 2037 travel time (minutes)	With project 2037 travel time (minutes)
Mosman	Fish Markets	47	**38**
North Sydney	Sydney Airport	46	**31**
Sydney Olympic Park	North Sydney	48	**28**
Leichhardt	North Sydney	38	**20**
Parramatta	North Sydney	71	**59**
Chatswood	North Sydney	61	**49**

Figure 3-9 Change in journey times in the AM peak as a result of the project by 2037

Legend

Operational features

- Western Harbour Tunnel
- Warringah Freeway Upgrade

Travel time savings (minutes)

- -1 to 1
- 1 to 5
- 5 to 10
- 10 to 15

Figure 3-10 Travel time savings for journeys to the Harbour CBD in the AM peak as a result of the project by 2037

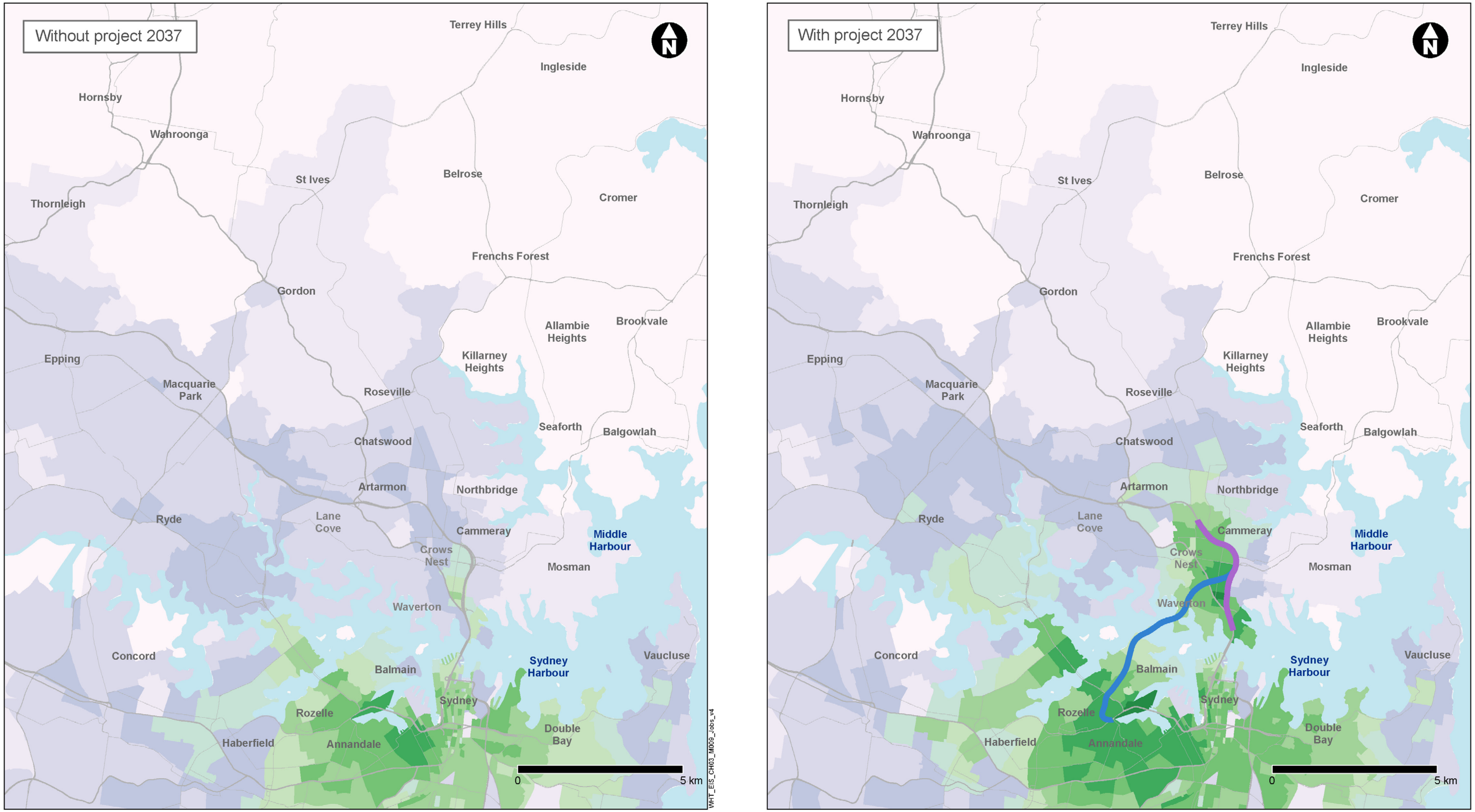
3.5.3 Improved productivity and access to the Harbour CBD

The major transport corridors around the Harbour CBD are critical links in Sydney's motorway network, with congestion on these corridors impacting the performance of the M1, M2, M5, A1, A4, A40 and A8 corridors. The current transport constraints on the major corridors around the Harbour CBD have broad reaching impacts on the productivity of the region.

The project would relieve pressure on the critical cross-harbour road network and thus reduce the cost of freight, provision of goods and services, and other business travel along and through the Eastern Economic Corridor and around the Harbour CBD. The combination of freight and business travel time savings as a result of the project would generate significant productivity benefits for the Harbour CBD and wider region.

Given the contribution of the Harbour CBD to New South Wales' gross state product, supporting the future growth and productivity of the corridor by enabling greater business-to-business connections is a large benefit for NSW and the national economy.

Figure 3-11 below shows the impact of the project on the number of jobs accessible by car within 30 minutes in the AM peak by 2037. As can be seen, residents in the Lower North Shore (particularly North Sydney and surrounding areas) and the Inner West would enjoy greater access to jobs as a result of the project.



Legend

Percentage of jobs within 30 minutes

- 0% to 5%
- 5% to10%
- 10% to 15%
- 15% to 20%
- 20% to 25%
- 25% to 30%
- 30% to 35%
- 35% to 40%
- 40% to 45%

Legend

Operational features

- Western Harbour Tunnel
- Warringah Freeway Upgrade

Percentage of jobs within 30 minutes

- 0% to 5%
- 5% to10%
- 10% to 15%
- 15% to 20%
- 20% to 25%
- 25% to 30%
- 30% to 35%
- 35% to 40%
- 40% to 45%
- 45% to 50%

Figure 3-11 Change in the percentage of jobs accessible within 30 minutes in the AM peak as a result of the project by 2037

3.5.4 Increased resilience of the Eastern Harbour City's road network

The major transport corridors around the Harbour CBD are critical links in Sydney's motorway network, with incidents on these corridors impacting the performance across the wider transport network. This heavy reliance on congested corridors with limited alternative routes creates a significant reliability risk for the motorway and arterial network.

The project would boost the resilience of the Eastern Harbour City road network by providing a vital additional road capacity to reduce the impact of incidents, and an alternate corridor to maintain the movement of people and goods through the heart of the Eastern Harbour City in the event of an incident on the Sydney Harbour Bridge, Sydney Harbour Tunnel or ANZAC Bridge corridors.

Resilience benefits reflect savings in travel time and vehicle operating costs that would be derived by providing an alternative route across the harbour, which would limit the impacts of an incident on alternative and connecting routes.

3.5.5 Improved traffic performance on Warringah Freeway to support long term increased demand

A further constraint on network capacity and performance around the Harbour CBD is the performance of the Warringah Freeway: a corridor of critical importance due to its role in providing access to both harbour crossings, as well as providing the primary bus corridor to and from the Sydney CBD.

The Warringah Freeway Upgrade component of the project is critical as it enables:

- The integration of the Western Harbour Tunnel and Beaches Link tunnels into the existing corridor
- Safe and efficient use of the three harbour crossings into the future by reconfiguring access arrangements, lane configurations and improving wayfinding where required
- The Warringah Freeway to accommodate the longer-term increase in demand along this corridor
- Improvements to bus priority infrastructure and integration of future express services via Beaches Link.

Once complete, the upgraded corridor would enable each of the three harbour crossings to perform their intended function:

- The Western Harbour Tunnel as the western bypass of the Harbour CBD
- Sydney Harbour Bridge as a primary Sydney CBD access and collector-distributor corridor
- Sydney Harbour Tunnel primarily providing access to the eastern suburbs and acting as the eastern bypass of the Harbour CBD.

3.5.6 Urban amenity improvements

The *Future Transport Strategy 2056* identifies 'Successful Places' as one of the six outcomes for NSW, and sets out a vision for better balancing 'movement and place' needs, particularly in major centres such as the Sydney CBD (NSW Government, 2018). Certain roads in and around the Harbour CBD perform important 'place' functions, meaning they are destinations in their own right, such as shopping or dining precincts. The amenity of some of these places suffer due to poor performance of the arterial road network.

The project would facilitate improvements to urban amenity by reducing through-traffic movements and relieving pressure on arterial roads connecting the broader Eastern City and North Districts to the Harbour CBD (see Figure 3-8). The project would deliver the opportunity to relocate a significant volume of through traffic on surface arterials underground. In addition to the direct benefit of moving bypass traffic underground, reduced congestion on the arterial network offers flow-on benefits to the adjoining local network, reducing the impact of queuing on local high streets and local roads. Reduced congestion on the arterial road network would result in further improvements in amenity related to physical safety, air quality and noise levels.

In addition to amenity benefits offered by the creation of an underground bypass for a significant number of vehicles, the project also allows for improvements to public spaces at Berrys Bay and Yurulbin Park to improve urban amenity.

The proposed Berrys Bay construction site would be located on Government owned land formally used as an industrial site. In addition to the construction efficiency and reduction in community impacts that use of this waterside site provides, the temporary construction support site at Berrys Bay provides a significant opportunity for Transport for NSW, North Sydney Council and other relevant stakeholders to rehabilitate this residual industrial site to create an area of high quality public space for the wider community.

The project has engaged Mr Bruce Mackenzie AM, a renowned Australian landscape architect who was responsible for creation of Yurulbin Park in the mid-1970s when the site was rehabilitated following its use as a shipyard. This work has informed the plan for establishment of the temporary construction support site to minimise long-term impacts to key features of the site. Mr Mackenzie has also provided the guiding principles for rehabilitation of the site post-construction. This work has identified a number of areas where the original landscape intent was not delivered due to budget constraints at the time (eg soil depths and subsurface drainage in many areas are not suitable to support certain species or larger trees long-term). The project intends to address these issues and revitalise certain areas of the park to improve the site and ensure its longevity as a high value community space.

The final form of these sites, and other areas to be rehabilitated post construction, would be subject to consultation with local councils, stakeholders and the local community.

3.6 Strategic planning and policy framework

The project has been developed to align with the objectives of a number of strategic plans for transport, freight, and city planning that have been prepared at a national and State level. Table 3-2 provides an overview of relevant strategic plans, policies and strategies and their relationship to the project.

Table 3-2 Strategic planning and policy framework

Policy	Description
Australian Infrastructure Plan	The *Australian Infrastructure Plan: Priorities and Reforms for Our Nation's Future* (Infrastructure Australia, 2016) identifies priority infrastructure investments that Australia needs over the next 15 years. The *Infrastructure Priority List* (Infrastructure Australia, 2018) is a reference point for Australia's most important infrastructure investment needs and currently identifies 100 major infrastructure projects and initiatives across Australia. The projects and initiatives have been assessed by Infrastructure Australia for their economic viability, deliverability and strategic compliance with the principles detailed in the *Australian Infrastructure Plan.* The list identifies the Western Harbour Tunnel and Beaches Link program of works as a priority initiative in recognition of its importance in addressing urban congestion on Sydney's arterial road network, augmenting critical cross-harbour capacity and Northern Beaches connectivity. This aligns with the Australian Infrastructure Audit's identification of road corridors to the Northern Beaches and across Sydney Harbour as among the top 30 most congested corridors in Australia.
NSW State Priorities	The NSW Government set out 18 State priorities and the Premier's 12 priorities to create a stronger, healthier and safer NSW (NSW Government, 2015). State priorities include improving road travel reliability, with a target of ensuring that 90 per cent of peak travel on key road routes is on time. The Premier's Priorities include building infrastructure, with a target of delivering key infrastructure projects on time and on budget across the State. The project would contribute to achieving a number of these priorities including: • **Encouraging business investment** – by improving east–west and north–south connectivity, and reducing congestion around the Eastern Harbour City, more people will be able to access Sydney CBD, North Sydney and other key employment centres in less time. Freight transport would also benefit from improved cross-harbour connectivity • **Improving road travel reliability** – by delivering travel time savings for freight, public transport and private vehicle users, and improving the resilience and efficiency of the existing road network • **Reducing road fatalities** – by providing a free-flowing cross-harbour alternative for through traffic, reducing traffic on surface roads and improving traffic flows is correlated with a lower number of road crashes.
State Infrastructure Strategy	The *State Infrastructure Strategy 2018-2038* (Infrastructure NSW, 2018) is a 20 year strategy which identifies and prioritises the delivery of critical public infrastructure to drive productivity and economic growth. The State Infrastructure Strategy recommends that: • Subject to completion of the business case, the NSW Government should invest in the Western Harbour Tunnel and Warringah Freeway Upgrade project to complete a Western CBD bypass and inner urban motorway network • Transport for NSW develops business cases to complete the deployment of smart motorway technology and digital infrastructure across the network in time for the expected opening of the Western Harbour Tunnel and Warringah Freeway Upgrade project. The NSW Government is committed to commencing work on a new crossing of Sydney Harbour to the west of the Sydney CBD. The Western Harbour Tunnel and Warringah Freeway Upgrade project, as part of the Western Harbour Tunnel and Beaches Link program of works, is the result of that commitment.

Policy	Description
	The *NSW Infrastructure Pipeline* (Infrastructure NSW, 2017) has also been prepared by Infrastructure NSW and outlines infrastructure proposals under development by the NSW Government. This includes the opportunities to develop the Western Harbour Tunnel and Warringah Freeway Upgrade project.
Future Transport Strategy 2056	The *Future Transport Strategy 2056* (NSW Government, 2018) builds on the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a) and sets the 40-year vision, strategic directions and outcomes for customer mobility in NSW. The plan identifies the transport challenges that will need to be addressed to support NSW's economic and social performance over the next 20 years and establishes a number of short, medium and long-term actions to address those challenges. These actions provide the overall framework for how the NSW transport system should develop, in terms of services and infrastructure. The Western Harbour Tunnel and Beaches Link program of works is identified in the strategy as a 'Committed' project (within the next 0–10 years, subject to final business case) forming part of the vision for the future strategic road network for Greater Sydney that will support key movements by road, including public transport, private vehicles and freight.
Greater Sydney Region Plan	The *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) is built on a vision of three cities where most residents live within a 30 minute journey of their jobs, education and health facilities, and services. To meet the needs of a growing and changing population, the vision seeks to transform Greater Sydney into a metropolis of three cities: the Western Parkland City, the Central River City and the Eastern Harbour City. This project is located in the Eastern Harbour City which contains Australia's global gateway (Sydney Airport and Port Botany) and financial capital, the Harbour CBD, as its metropolitan centre. One of the key roles of the Plan is to provide appropriate infrastructure in the right places to support the continued growth of Greater Sydney. The Plan also identifies the importance of investing in and delivering efficient and effective transport systems including road infrastructure that would improve business to business connections and support the 30 minute city vision. Objective 18 of the Plan references the Western Harbour Tunnel and Beaches Link program of works as infrastructure that would further improve accessibility from the Northern Beaches to the Harbour CBD and reduce through traffic in the Harbour CBD ensuring the economic strength and global competitiveness of the Harbour CBD. As part of the *Greater Sydney Region Plan,* the Greater Sydney Commission also prepared District Plans which provide a basis for strategic planning at a district level. District Plans relevant to the project are discussed below.
District Plans	The *North District Plan* (Greater Sydney Commission, 2018b) sets out priorities and actions for Greater Sydney's North District, which includes the project-based local government areas of the Northern Beaches, North Sydney and Willoughby. The *North District Plan* addresses issues influencing Greater Sydney to 2056 with one of the overarching priorities for a productive North District including improved access to local jobs, goods and services within 30 minutes. The *North District Plan* includes the Western Harbour Tunnel and Beaches Link program of works as a transport initiative that would provide improved connections and access. The *Eastern City District Plan* (Greater Sydney Commission, 2018c) sets out priorities and actions for Greater Sydney's Eastern City District, which includes the project-based local government areas of City of Sydney and Inner West. The *Eastern City District Plan*

Policy	Description
	addresses issues influencing Greater Sydney to 2056 with one of the overarching priorities for a productive Eastern City District including improved access to local jobs, goods and services within 30 minutes. The project complements this priority by providing improved connectivity and transport capacity across Sydney Harbour, which would enhance the 'Eastern City's' network resilience, improve access to services, and increase the proportion of people with good access to jobs via reliable bus services.
Directions for a Greater Sydney	*Directions for a Greater Sydney 2017-2056* (Greater Sydney Commission, 2017) aims to better integrate land use and infrastructure in Greater Sydney to accommodate a population that will grow from six to eight million people over the next 40 years. It builds upon the *Greater Sydney Regional Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) and *Towards our Greater Sydney 2056* (Greater Sydney Commission, 2016). The project would support this vision by improving road network performance, resilience and efficiency, enabling sustained growth and productivity across Greater Sydney. The project would also improve access to the strategic centres of the Sydney CBD, North Sydney and St Leonards, resulting in more people having access to jobs and services.
NSW Freight and Ports Plan	The *NSW Freight and Ports Plan* (Transport for NSW, 2018a) supports *Future Transport Strategy 2056* and provides direction to business and industry for managing and investing in freight into the future. The project in conjunction with WestConnex would benefit the freight industry by providing a western bypass of the Harbour CBD, significantly improving the quality of the freight connection through the Eastern Economic Corridor. The project would also provide direct access for freight to the Harbour CBD. The project would address key priority areas in the plan such as strengthening the freight industry, increasing access for freight across the road and rail network, protecting existing freight precincts and ensuring safe, efficient and suitable freight access would meet the needs of Greater Sydney.

Chapter 4

Chapter 4

Project development and alternatives

January 2020

4 Project development and alternatives

This chapter describes the alternatives that were considered as part of the project development process and explains the selection of the preferred alternative. The preferred alternatives presented in this chapter are based on technical, environmental and planning considerations. Stakeholder and community considerations which have been incorporated into the project development process are outlined in Chapter 7 (Stakeholder and community engagement). Design refinements for particular elements of the project are also outlined.

The Secretary's environmental assessment requirements as they relate to the project development and alternatives, and where in the environmental impact statement these have been addressed, are detailed in Table 4-1.

Table 4-1 Secretary's environmental assessment requirements - Project development and alternatives

Secretary's requirement	Where addressed in EIS
Environmental impact statement	
1. The EIS must include, but not necessarily be limited to, the following: e. an analysis of any feasible alternatives to the project	An analysis of strategic alternatives is provided in **Section 4.3**.
f. a description of feasible options within the project, including: - alternative methods considered for the construction of the project, including the tunnels; and - staging of the proposal	Alternative construction methods are detailed in **Section 4.5.1**. Further detail on staging is included in **Chapter 6** (Construction work)
g. a description of how alternatives to and options within the project were analysed to inform the selection of the preferred alternative/option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to, and options(s) within, the project were selected, including: - details of the short-listed route and tunnel options considered, and the criteria that was considered in the selection of the preferred route and tunnel design - details of the alternative construction methods that were considered for tunnel construction, particularly those areas spanning Sydney Harbour - the alternative tunnel design and ventilation options considered to meet the air quality criteria for the proposal - a justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979* (EP&A Act)	The assessment of alternatives is detailed in **Section 4.4** and **Section 4.5**. A description of the benefits of the overall program of works and the justification for the project is provided in **Chapter 3** (Strategic context and project need). Justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979* is presented in **Chapter 28** (Synthesis of the environmental impact statement).

Secretary’s requirement	Where addressed in EIS
i. a demonstration of how the project design has been developed to avoid or minimise likely adverse impacts.	Project design development is detailed in **Section 4.4** and **Section 4.5**, and **Chapter 5** (Project description).

4.1 Overview

The project has undergone extensive evaluation of alternatives from pre-feasibility and strategic investigations through to design development and refinement, as outlined in Figure 4-1.

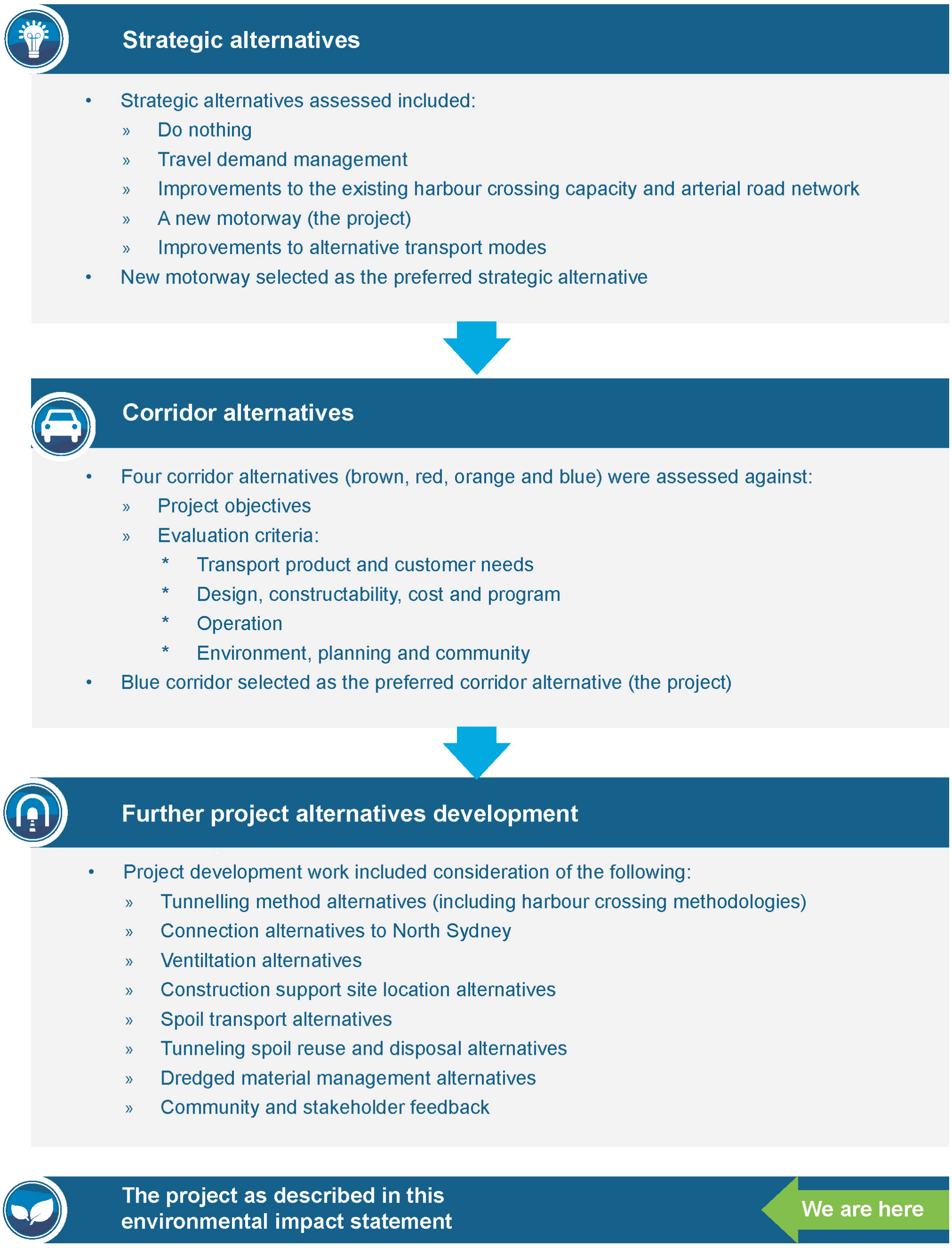


Figure 4-1 Alternatives development process

4.2 Historical context

The origins of the Western Harbour Tunnel and Beaches Link program of works extend back to the 1930s when the need for additional cross–Sydney Harbour transport capacity was identified as part of the development of the Warringah Transport Corridor.

A timeline for the historical development of the Warringah Transport Corridor and an additional harbour crossing as precursors to the Western Harbour Tunnel and Beaches Link program of works is provided in Figure 4-2.

1930s

Plans were developed for a new Warringah Transport Corridor, including an additional harbour crossing, to the Northern Beaches.

1951 - 1953

Planning for the Warringah Expressway (now Freeway) began in 1951. The Warringah Transport Corridor was adopted by the State Government as part of the *Main Road Development Plan 1953.*

1953

County of Cumberland Road Reservation prescribed. Included an inner ring-route, including a second crossing of Sydney Harbour (Greenwich-Birchgrove) and the Warringah Freeway crossing Middle Harbour between Sugarloaf Point and Pickering Point.

1959

Two tram tracks on Harbour Bridge converted to road lanes to improve road capacity.

1962

Cahill Expressway completed, helping to cope with traffic flows to/from the east.

1964

Opening of the Gladesville Bridge provided an additional harbour crossing to the west of the Harbour Bridge.

1968

The first stage of the Warringah Expressway opened in 1968. A review of the *Main Road Development Plan 1953* was carried out in the *Sydney Regional Outline Plan* (NSW State Planning Authority, 1968) and further studies were recommended.

1972

Western Distributor opened.

1974

The Sydney Area Transportation Study recommended that the Warringah Freeway be part of the long term road network in Sydney.

1978

Warringah Freeway extended.

Late 1970s

Government made formal call for suggestions to solve capacity issues at the crossing of Sydney Harbour. Submissions received included tunnels and bridges – most of which were west of the Sydney Harbour Bridge and required significant property acquisition for the approaches. Subsequently all formally rejected in 1982.

1981

The NSW Government established a Second Harbour Crossing Inquiry which presented alternative proposals for public comment including a route linking Greenwich to Birchgrove with a bridge or tunnel west of the Sydney Harbour Bridge. Due to strong community and stakeholder opposition the government abandoned the Second Harbour Crossing Inquiry without further analysis into the feasibility of the proposals.

1981

The Warringah Transport Corridor Inquiry starts, considering the proposal for the corridor to extend from the Warringah Freeway, across Middle Harbour at Castlecrag, to Seaforth and Balgowlah.

1983

The Commission of Inquiry into the Warringah Transport Corridor found that a new surface road to the Northern Beaches in the identified corridor would result in unacceptable levels of community and environmental impacts and would not deliver material transport benefits without addressing the constraint of the existing Sydney Harbour crossing, which was not part of the proposal. The Inquiry noted that the feasibility of the proposal would be improved by future tunnelling technology alleviating some of the potential environmental and community impacts.

1992

Opening of the Sydney Harbour Tunnel provided an additional harbour crossing.

1999

Eastern Distributor opens, providing an eastern bypass of the CBD.

2012

The NSW Government's *NSW Long Term Transport Master Plan* (Transport for NSW, 2012) proposed a new harbour crossing to the west of the CBD identifying it as a key 'missing link' in the Sydney motorway network. It also proposed a bus tunnel bypassing Military Road.

2014

Commitments were made in the *NSW State Infrastructure Strategy Update 2014* (Infrastructure NSW, 2014) that the Government would commence work on an additional harbour crossing and would further review and develop Beaches Link.

2015 - 2016

Transport for NSW carried out preliminary work to establish the viability and high level conceptual design for the Western Harbour Tunnel and Beaches Link program of work.

2015

Transport for NSW commence development of the B-Line program, to provide more frequent and reliable bus services between the Northern Beaches and Sydney CBD. Beaches Link and Western Harbour Tunnel would provide opportunity for express bus services into the CBD, and reduce pressure on Military Road for existing services.

2016

The draft *North District Plan* (Greater Sydney Commission, 2017b) and draft *Eastern City District Plan* (Greater Sydney Commission, 2017a) released by the Greater Sydney Commission identified the Western Harbour Tunnel and Beaches Link program of works as important initiatives to improve connections and access to and from northern Sydney.

2017

In March 2017, the NSW Government announced the commencement of a community engagement program to inform the development of designs for the Western Harbour Tunnel and Beaches Link program of works, including an additional harbour crossing. Transport for NSW commences community and stakeholder consultation, technical, environmental and heritage site investigations and more detailed design development for the Western Harbour Tunnel, Warringah Freeway and Beaches Link.

2018

The *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) references the Western Harbour Tunnel and Beaches Link program of works as infrastructure that would further improve accessibility from the Northern Beaches to the Harbour CBD and reduce through traffic in the Harbour CBD ensuring the economic strength and global competitiveness of the Harbour CBD.

2018

The *Future Transport Strategy 2056* (NSW Government, 2018), the *NSW State Infrastructure Strategy 2018-2038* (Infrastructure NSW, 2018), the *Greater Sydney Region Plan - A Metropolis of Three Cities* (Greater Sydney Commission, 2018a), the *North District Plan* (Greater Sydney Commission, 2018b) and the *Eastern City District Plan* (Greater Sydney Commission, 2018c) released. These strategies reference the Western Harbour Tunnel and Beaches Link projects as a transport initiative that will improve connections and accessibility across Sydney.

2018

The Infrastructure Priority List (Infrastructure Australia, 2018) identifies the Western Harbour Tunnel and Beaches Link program of works as a priority initiative in recognition of its importance in addressing urban congestion on Sydney's arterial road network, augmenting critical cross-harbour capacity and Northern Beaches connectivity.

Figure 4-2 Historical development of additional cross-harbour capacity

4.3 Strategic alternatives

The project aims to provide additional transport capacity, to relieve pressure on existing crossings and to improve the efficiency and reliability for journeys across Sydney Harbour. Further information on the strategic context for the project and the transport needs addressed are provided in Chapter 3 (Strategic context and project need).

The *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a) and subsequent *Future Transport Strategy 2056* (NSW Government, 2018) set the 40 year vision, strategic directions and outcomes for customer mobility in NSW. These plans identify the transport challenges that will need to be addressed to support NSW's economic and social performance and establish a number of short, medium and long-term actions to address those challenges.

Giving consideration to future land use, population density and transport requirements, both of these strategic plans identified road based transport, including improvements to bus services, as important modes to meet the needs of the Northern Beaches region. Furthermore, the need for additional core motorway capacity at the crossings of Middle and Sydney Harbour was identified as key to development of an appropriate multi-modal Sydney transport network – and specifically identified the Western Harbour Tunnel and Beaches Link program as transport projects required to support the plan.

Considering the identified requirements of the *NSW Long Term Transport Master Plan* and the *Future Transport Strategy 2056*, a number of strategic alternatives were considered for delivering the required road capacity, as follows:

- Do nothing
- Travel demand management
- Improvements to the existing harbour crossing capacities and road network
- A new motorway crossing of Sydney Harbour (the project)
- Improvements to alternative transport modes.

These strategic alternatives are described and evaluated in the following sections.

4.3.1 Do nothing

This alternative is to do nothing to the existing crossings of Sydney Harbour and adjoining motorway network and rely on the continued operation of existing transport networks and other transport projects currently proposed to meet future transport demands.

The Sydney Harbour Bridge and Warringah Freeway has been identified as one of Australia's 30 most congested road corridors, generating a congestion cost of $65,000 per day in 2016 (Infrastructure Australia, 2019). If no action is taken, this is forecast to rise to $98,000 per day by 2031. This congestion results in the existing road network being vulnerable to extensive network delays creating long and unreliable journey times.

The Sydney Harbour Bridge and Warringah Freeway corridor is integral to Sydney's Eastern Economic Corridor, which contributed two thirds of the NSW economic growth for the 2015/16 financial year (Greater Sydney Commission, 2018b). As Sydney's population and economy continue to grow, so will the pressure on access to this corridor. The network's vulnerability to congestion and significant delay will worsen with significant congestion incidents likely to become more frequent. Consequently, improvements to existing transport networks and creation of new transport connections will be essential for Sydney to continue to be a competitive global city.

The do nothing alternative has been rejected as an undesirable strategic alternative because it would not address the identified project need. For example, future traffic modelling (refer to Chapter 9 (Operational traffic and transport)) indicates that without the project, this alternative would be unable to accommodate forecast growth during the peak periods without unacceptable delays across the Sydney road network.

The do nothing alternative would adversely impact on:

- Future economy and opportunities for economic growth, particularly with regard to ongoing congestion costs and access to jobs and services
- Amenity and environment, including air quality, noise, visual and traffic related impacts resulting from traffic congestion.

These impacts would result in a reduction in Sydney's performance and desirability as a global city.

4.3.2 Travel demand management

Travel demand management is a measure that focuses on minimising or avoiding the need to invest in new motorway infrastructure, such as the project, by reducing individual trip lengths, reducing peak traffic volumes and making alternative transport mode options more viable. Demand management initiatives may include:

- Land use planning policies which promote urban consolidation and the establishment of town 'centres' to reduce the need for travel. For example, the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012a), *Future Transport Strategy 2056* (NSW Government, 2018) and *Greater Sydney Regional Plan: A Metropolis of Three Cities* (Greater Sydney Commission, 2018a) aim to bring jobs closer to homes and to areas of increasing population
- Augmenting existing public transport and integrating urban regeneration around transport nodes
- Implementing policies which restrict parking provisions in new developments to encourage alternative modes of transport
- Flexible working arrangements to reduce the number of trips during peak hours.

To have a major impact on road traffic, travel demand management measures would require considerable changes in social attitudes, travel behaviour and government policy and can take many years to achieve. Further, Sydney's population is forecast to grow from six million to eight million people over the next 40 years. An expanded road network would be required to accommodate this population growth, even with significantly reduced per-capita travel demand through demand management. Travel demand management changes alone are therefore not a viable strategic alternative to the project. They are, however, viewed as complementary initiatives, together with the project, to reduce the level of demand on Sydney's road network as population grows.

4.3.3 Improvements to the existing harbour crossing capacities and road network

To provide additional transport capacity across Sydney Harbour and increase the resilience of the road network in Sydney, improvements to the existing arterial road network, including the Sydney Harbour Bridge and Sydney Harbour Tunnel, have been considered.

Ways to increase road capacity across Sydney Harbour have been considered for many years (refer to Section 4.2). Options to provide additional capacity have included investigations into adding new lanes to the Sydney Harbour Bridge and developing new harbour crossing locations. Increases to road capacity of the Sydney Harbour Bridge have not proved to be feasible due to engineering and physical constraints limiting the additional load carrying capacity of the bridge, and the significant heritage, visual and tourist values of the Sydney Harbour Bridge limiting the feasibility of major modifications to increase capacity.

Improvements to the Sydney Harbour Tunnel to provide additional capacity along this strategic route are also not feasible due to engineering challenges and physical constraints.

Increasing capacity of the existing crossings would also have limited benefit due to the constraints imposed by existing roads on the southern side of the harbour, including the Western Distributor and ANZAC Bridge.

Transport for NSW has an extensive program of upgrades to existing roads across Sydney to address congestion and to improve travel times. Information on these projects can be found on the Transport for NSW website (https://roads-maritime.transport.nsw.gov.au). These projects are considered complementary because they would maximise the capacity of Sydney's existing motorway and arterial road network, but they would not relieve cross-harbour congestion or address the need to upgrade the Warringah Freeway to improve separation of through traffic and bypass functions (refer to Chapter 3 (Strategic context and project need) for additional details on these two functions).

Accordingly, substantial new improvements to the existing cross harbour capacities and road network have been rejected as a strategic alternative. It is not feasible to add additional lanes to the existing Sydney Harbour Bridge or Sydney Harbour Tunnel, and the impacts of substantial capacity increases to either connection are unlikely to be acceptable.

4.3.4 A new motorway crossing of Sydney Harbour

Options for new road crossings of Sydney Harbour have been considered for many decades. These have included concepts for new bridges and tunnels at several locations along the harbour. Since the release of the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012) and *State Infrastructure Strategy Update 2014* (Infrastructure NSW, 2014), investigations into alternative harbour motorway crossings have focused on tunnelled solutions to provide a western CBD bypass of the Sydney CBD.

A new tunnelled motorway west of the CBD would address the project need of providing additional transport capacity across Sydney Harbour to relieve congestion and improve reliability on existing crossings. Importantly, it would:

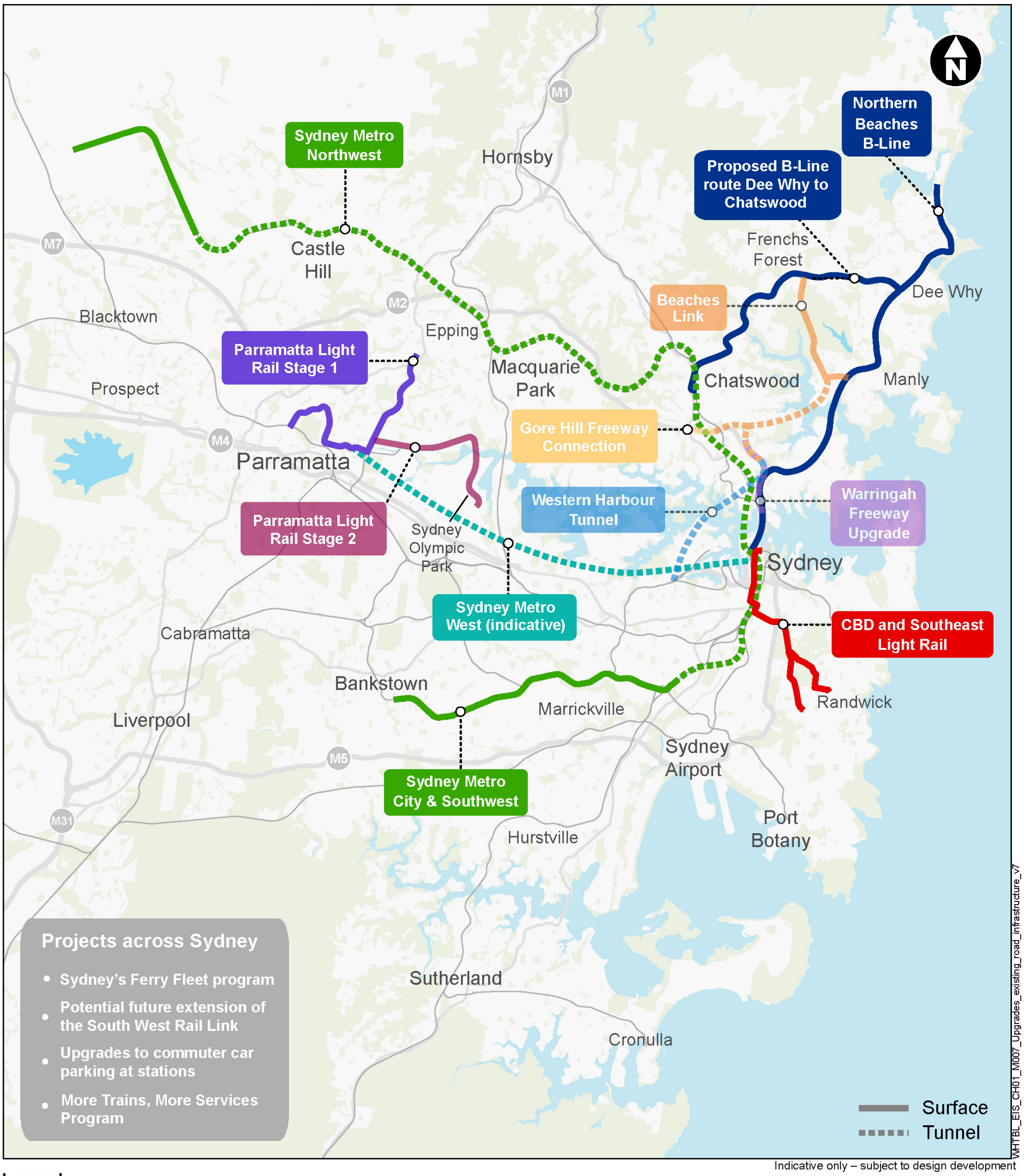
- Increase road capacity on the critical north–south harbour crossing by 50 per cent, providing journey time and reliability benefits to users of the new route, as well as users of the existing crossings
- Provide an alternative western bypass of the CBD, reducing pressure on the heavily congested ANZAC Bridge and Western Distributor corridor
- Improve performance, reliability and resilience of the adjoining arterial road network, which is heavily affecting performance of the existing harbour crossings
- Improve travel times between key centres for all road users, including a significant number of bus users, service vehicles and freight
- Re-establish road hierarchy for the harbour crossings (refer to Chapter 3 (Strategic context and project need) for additional information on the three crossings strategy).

4.3.5 Improvements to alternative transport modes

Alternative transport modes to the project, and their effectiveness in meeting the project need, are described in the following sections.

The NSW Government, through Transport for NSW, is currently planning and delivering a series of new and upgraded transport projects and initiatives, consistent with the *Future Transport Strategy 2056* (NSW Government, 2018). The key public transport projects in the Greater Sydney area are shown in Figure 4-3.

Information on these projects can be found on the Transport for NSW website (transport.nsw.gov.au/projects/current-projects).



Legend

Approved

- Sydney Metro
- CBD and Southeast Light Rail
- Northern Beaches B-Line
- Parramatta Light Rail Stage 1

Proposed

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Beaches Link
- Gore Hill Freeway Connection
- Indicative Sydney Metro West
- Parramatta Light Rail Stage 2

- Existing heavy and light rail

Figure 4-3 Improvements to public transport

Improvements to the Sydney bus network

Improvements to the Sydney bus network as a strategic alternative to the project include additional bus routes, additional buses on existing routes and bus priority measures.

Buses play a crucial role in Sydney's public transport system. They can be put into service more quickly, cheaply and to more places than any other type of public transport. Sydney's bus network currently includes more than 600 routes. For more than 90 per cent of residents within Sydney, local bus routes are within 400 metres of home and offer connections to neighbourhood shops and services, major centres and the wider public transport system. Figure 4-4 illustrates the number of bus passengers that rely on the Sydney CBD arterial road network in the AM peak.

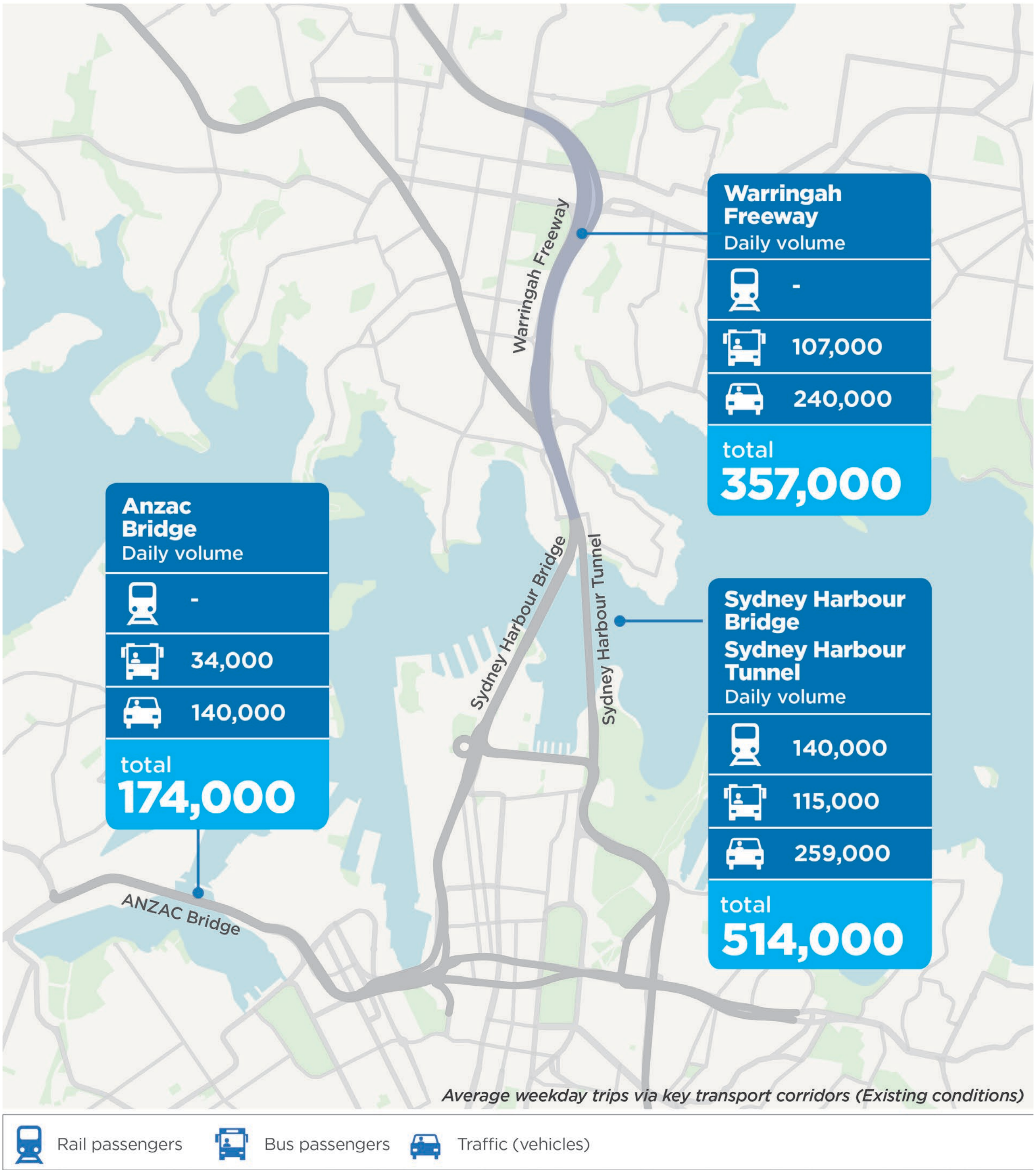


Figure 4-4 Average weekday trips via key transport corridors (existing conditions)

Sydney's Bus Future (Transport for NSW, 2013b) acknowledges that improvements to the bus network are essential to meet changing customer needs, including access to major centres outside the Sydney CBD. *Sydney's Bus Future* aims for seamless connection to other transport modes to deliver the right mix of services. In response to changing passenger needs and an increase in demand, additional services have already been added to the bus network. However, without measures to improve journey times by increasing the road efficiency or capacity, the addition of more buses to the network can contribute to congestion, making bus services less effective at meeting customer needs.

Sydney's Bus Future proposes major changes to the Sydney bus network to meet current and future demands by providing rapid service routes to connect major centres along transport routes with mass transit demand. Suburban and local service routes would build on the foundation of the rapid routes to improve access to local, neighbourhood destinations. Bus initiatives relevant to the project include the B-Line for the Northern Beaches (which commenced operation in 2017).

Despite the importance of the bus network in Sydney's transport future and the complementary nature of the aforementioned projects, improved bus services alone would not be sufficient to provide the level of additional cross-harbour capacity that is required. This is in part due to the wide range of purposes and destinations associated with cross harbour trips and the limited ability for buses to cater for these. The ability for the bus network to provide extra capacity is also strictly limited by the capacity of the road network itself.

Improvements to the rail network

The effect of proposed improvements to the Sydney rail network have been considered as strategic alternatives to the project. Rail initiatives relevant to the project include the Sydney Metro City & Southwest project; a 30 kilometre extension of metro rail from the end of Sydney Metro Northwest at Chatswood, under the Sydney Harbour, through new CBD stations and south west to Bankstown, which is currently under construction.

Sydney Harbour crossing capacity is a major transport constraint for all modes. The Sydney Metro City & Southwest project will deliver much needed cross harbour capacity for commuters, connect new nodes, and deliver faster and more reliable train journeys to and from the north-west of Sydney. Whilst this project will contribute to reducing congestion on the existing cross-harbour road connections it is only one part of an integrated transport network that is required to service the needs of a very diverse range of origins, destinations and journey purposes.

The array of journey patterns and trip purposes within Sydney, and the dispersed nature of origin and destination points for an individual journey mean that roads remain a critical element in the integrated transport network, servicing buses, freight, commercial and many other individual journey needs. Strategic transport modelling completed by Transport for NSW indicates that there will still be need for additional road transport capacity at the crossing of Sydney Harbour to cater for future demands post Sydney Metro City & Southwest.

Improvements to the freight rail network would assist with the efficient distribution of freight, particularly for freight travelling longer distances. However, a significant proportion of Sydney's freight, commercial, and services tasks require distribution of goods and services to customers within the Sydney basin. This requires a diverse and dispersed point-to-point transport system that is most efficiently provided by the road network.

Improvements to the ferry network

Additional ferry services were considered as a strategic alternative to the project. Additional ferry services would provide an improved cross-harbour public transportation link and would contribute to relieving congestion on existing cross-harbour road connections. While this would contribute to reducing congestion on the existing road network, it would not resolve the existing cross-harbour road congestion and capacity constraints. This is due to comparatively small number of journeys currently using these crossings that would be transferable to the ferry network.

Improvements to active transport

Improvements to active transport that could be considered as strategic alternatives to the project included additional cycling and pedestrian routes and facilities as identified in *Sydney's Cycling Future* (Transport for NSW, 2013c) and *Sydney's Walking Future* (Transport for NSW, 2013d).

Sydney's Cycling Future aims to make cycling a safe, convenient and enjoyable transport option for short trips by:

- Investing in separated cycleways and providing connected bicycle networks to major centres and transport interchanges
- Promoting better use of the existing network
- Engaging with stakeholders across government, councils, developers and bicycle users.

The strategy aims to increase the mode share of cycling in the Sydney metropolitan area for short trips that can be an easy 20 to 30 minute ride. The strategy aims to improve access to towns and centres, reduce congestion and increase capacity on the public transport system by investing in connected bike routes within five kilometres of major centres and public transport interchanges. The strategy commits to expanding bike route connectivity within 10 kilometres of major centres in the longer term. The 'Bike and Ride' initiative would make it convenient for customers to ride to transport hubs, leave their bikes securely locked up and transfer to public transport to continue their journey.

Sydney's Walking Future complements *Sydney's Cycling Future*. The actions set out in *Sydney's Walking Future* propose to make walking the transport choice for quick trips under two kilometres and help people access public transport. Encouraging and enabling more people to make walking trips would ease pressure on public transport, reduce congestion on roads and promote a healthier transport alternative.

As outlined in *Sydney's Cycling Future* and *Sydney's Walking Future*, journeys made by cycling and walking are generally for short trips only, which would not meet the project need of improving cross-harbour capacity or resilience. Improvements to cyclist and pedestrian infrastructure alone would not cater for the diverse travel demands within the project footprint that are best met by road infrastructure. Further improvements to cyclist and pedestrian infrastructure alone would not support long-term economic growth through improved motorway access or enhance the productivity of commercial and freight generating land uses. The active transport network is therefore complementary to other modes of transport as part of an integrated transport solution.

As part of an overarching integrated transport network, the project includes the development of new or improved active transport links in a number of locations, generally associated with surface works for the project. These links would improve connectivity between communities, open space areas, public transport modes and the existing active transport network. This is described in further detail in Chapter 5 (Project description) and Chapter 9 (Operational traffic and transport).

Summary

As outlined in the previous sections, alternative transport modes, including bus, rail, ferry and active transport, could be considered as strategic alternatives to the project. While many of these modes and upgrades are complementary to the project as part of a broader integrated transport network, none of the proposed initiatives negate the need to provide additional cross-harbour motorway capacity.

The array of journey patterns and trip purposes within Sydney, and the dispersed nature of origin and destination points for an individual journey mean that roads remain a critical element in the integrated transport network, servicing bus, freight, commercial and many other journey needs.

While improvements to the freight rail network would reduce pressure on the core motorway network, Sydney's freight, commercial and services tasks require distribution of goods and services within the Sydney basin, which relies on diverse and dispersed point-to-point transport network that is most efficiently provided by the road network. Providing high-quality motorway links to meet this need is key to growing Sydney's economic prosperity while reducing surface traffic through communities.

Extending the underground motorway network to address capacity, efficiency and reliability issues on critical road corridors would not only provide faster, more efficient and more reliable journeys for users who would use this network, but would also deliver much broader benefits through reduced congestion on existing surface networks.

The project would materially improve the functionality and performance of the bus network, in particular the reliability and optionality for both long distance and inner North Shore services, and efficiency of the Warringah Freeway and Sydney Harbour Bridge southbound bus lane, which services about 57,500 bus commuters each week.

The project would improve active transport links through the provision of a new dedicated bicycle path along the eastern side of the Warringah Freeway between Miller Street at Cammeray and Ernest Street, as well as a number of new and upgraded shared user bridges which would provide connectivity across the Warringah Freeway.

4.3.6 Preferred strategic alternative

When considering the strategic alternatives and complementary projects discussed in previous sections, it was concluded that the construction and operation of a new tunnelled motorway crossing of Sydney Harbour (the project) was the preferred solution. This would provide additional transport capacity across Sydney Harbour to relieve congestion on existing crossings and improve the efficiency and reliability for all non-rail journeys across Sydney Harbour.

The project is part of a suite of current and future transport initiatives outlined in *Future Transport 2056* that would work together to provide the cross-harbour transport capacity required to cater for a diverse array of journeys and future population growth. Further, as discussed in Chapter 3 (Strategic context and project need), a new harbour crossing would also provide capacity to deliver new strategic connections to the north, including new express bus routes, to be developed.

4.4 Corridor alternatives

Following identification of a new motorway tunnel as the preferred strategic alternative, a design development process was carried out to determine the most appropriate alignment and construction method to deliver the tunnel. The process for selection of the preferred tunnel alignment and construction method included consideration of 10 strategic corridors and over 15 different combinations of tunnelling methods.

Options were developed and assessed by a multidisciplinary team including design engineers, construction engineers, transport planners and environmental advisors with direct experience in delivering major transport infrastructure in NSW, Australia and internationally. Selection of the preferred corridor required consideration of various technical and environmental factors including:

- Strategic traffic demands and how they define the required connectivity to achieve transport outcomes
- Results of geotechnical, groundwater and contamination investigations
- Basements and foundations of major structures in North Sydney
- Marine heritage, biodiversity and marine ecology
- Turbidity and hydrodynamic monitoring and modelling for Sydney Harbour
- Opportunities for viable temporary intermediate tunnelling sites that minimise community, environmental and heritage impacts
- Physical and operational interfaces with other major infrastructure (eg Sydney Metro Tunnels, Rozelle Interchange, the Warringah Freeway)
- Integration with the proposed Beaches Link and Gore Hill Freeway Connection project in the future
- Horizontal alignments and waterway crossing methodologies that allow the tunnel to achieve acceptable vertical gradients to achieve the desired transport product, reduce whole of life emissions, operational costs, and improve safety outcomes
- Interfaces with commercial and recreational maritime traffic
- Construction and operational costs.

4.4.1 Description of shortlisted corridor alternatives

Following preliminary technical and environmental analysis, four corridor alternatives were shortlisted for a new tunnelled motorway connection between Rozelle and the northern side of Sydney Harbour (refer to Figure 4-5). The shortlisted corridor alternatives were termed the brown, red, orange and blue alternatives.

Brown corridor alternative

The brown corridor alternative included a crossing of Sydney Harbour between Rozelle and North Ryde, broadly under the Victoria Road and Gladesville Bridge corridor. The tunnel would provide connection to the M2 Hills Motorway/Lane Cove Tunnel corridor around East Ryde and would bypass the Lane Cove Tunnel and Warringah Freeway.

When compared to options that connect to the Warringah Freeway, this option would:

- Slightly reduce traffic volumes on the Lane Cove Tunnel, Gore Hill Freeway and a portion of the Warringah Freeway through to Cammeray
- Result in poorer traffic outcomes on the existing harbour crossings, ANZAC Bridge and Western Distributor corridor. This is because the connectivity provided would not be attractive for the high number of users with origins and destinations east of the Lane Cove Tunnel, including areas such as Chatswood, Lane Cove, North Sydney and the Northern Beaches catchment. This reduces the usage, and hence benefits, of the new tunnel
- Require construction of 50 per cent more tunnel, increasing the number of intermediate construction support sites, heavy haulage trips, construction cost and operational cost
- Expose the tunnel alignment to poor geology due to increased harbour and river crossings, increasing construction complexity and cost and requirements for intermediate construction support sites.

Red corridor alternative

The red corridor alternative included tunnels between the Rozelle Interchange and the Warringah Freeway near Cammeray, crossing Sydney Harbour between Balmain East and McMahons Point via Goat Island.

The alignment would include main tunnel connections to the Warringah Freeway and underground connections to the future Beaches Link and Gore Hill Freeway Connection project tunnels at Cammeray. Ramps would connect the Western Harbour Tunnel to North Sydney at Arthur Street (for vehicles travelling northbound via Western Harbour Tunnel) and from North Sydney at Berry Street (for vehicles travelling southbound via the Western Harbour Tunnel).

The alignment of this option, combined with the poor geology at the harbour crossing, force the main tunnels to pass under the Sydney Metro City & Southwest tunnels beneath North Sydney. Given the depth of the Metro tunnels, the Western Harbour Tunnel would need to adopt long spiral ramps to provide the required connectivity at North Sydney.

These ramps would significantly degrade the user experience, increasing the distance that users must travel via the tunnel to reach their destination, reducing speed, and impacting wayfinding. These long loop ramps would also significantly increase the amount of tunnelling, and hence heavy haulage trips, construction costs and operational costs for the Western Harbour Tunnel.

Furthermore, the red alignment would require temporary construction support sites at Goat Island and Sawmillers Reserve. The use of these two sites would be particularly challenging given their limited size combined with access and heritage constraints.

Orange corridor alternative

The orange corridor alternative was similar to the red corridor alternative at the Sydney Harbour crossing, with the key difference being the main tunnel connection was moved further to the north to connect to the Gore Hill Freeway near Naremburn rather than the Warringah Freeway at Cammeray. The intent of this alignment would be to extend the Western Harbour Tunnel to bypass the constrained section of the Gore Hill Freeway and Warringah Freeway through Naremburn.

Topography and constraints such as the Artarmon Reserve, the T1 North Shore and Northern rail line, flooding and existing traffic operations make connecting the Western Harbour Tunnel to the Gore Hill Freeway near Artarmon very challenging. This would result in significantly increased disruption, cost and property impacts.

Further to the challenges of integrating this alignment with the existing network, extending the Western Harbour Tunnel through to the Gore Hill Freeway would significantly increase tunnel lengths and costs. Providing the required connectivity for the future Beaches Link and Gore Hill Freeway Connection project would also be significantly more difficult and costly.

Blue corridor alternative

The blue corridor alternative included a tunnel connection across Sydney Harbour between Birchgrove and Waverton. The mainline tunnels would connect directly to the Warringah Freeway near the Cammeray Golf Course and the Beaches Link and Gore Hill Freeway Connection project (via underground ramps). Ramps would also connect the Western Harbour Tunnel with North Sydney at Falcon Street (northbound Western Harbour Tunnel traffic) and Berry Street (southbound Western Harbour Tunnel traffic).

This alignment would take advantage of a relatively shallow harbour crossing combined with the favourable geometry offered by the Waverton Peninsula and an alignment passing north-west of the major structures in the North Sydney CBD to allow the proposed tunnels to pass over the Sydney Metro City & Southwest tunnels north of the Victoria Cross station. This would in turn allow efficient direct connections to the Warringah Freeway near Cammeray and for the connections to and from North Sydney and the future Beaches Link and Gore Hill Freeway Connection project tunnels.

Widening at the Cammeray Golf Course would allow for construction of the Western Harbour Tunnel portals with minimal impacts to property and reduced disruption to the critical Warringah Freeway corridor.

This alignment would also result in the shortest harbour crossing, reducing exposure to poor geology, and presents the opportunity to establish viable construction support sites on Government-owned land, significantly reducing property impacts, and creating the opportunity to enhance the amenity of these spaces post construction.

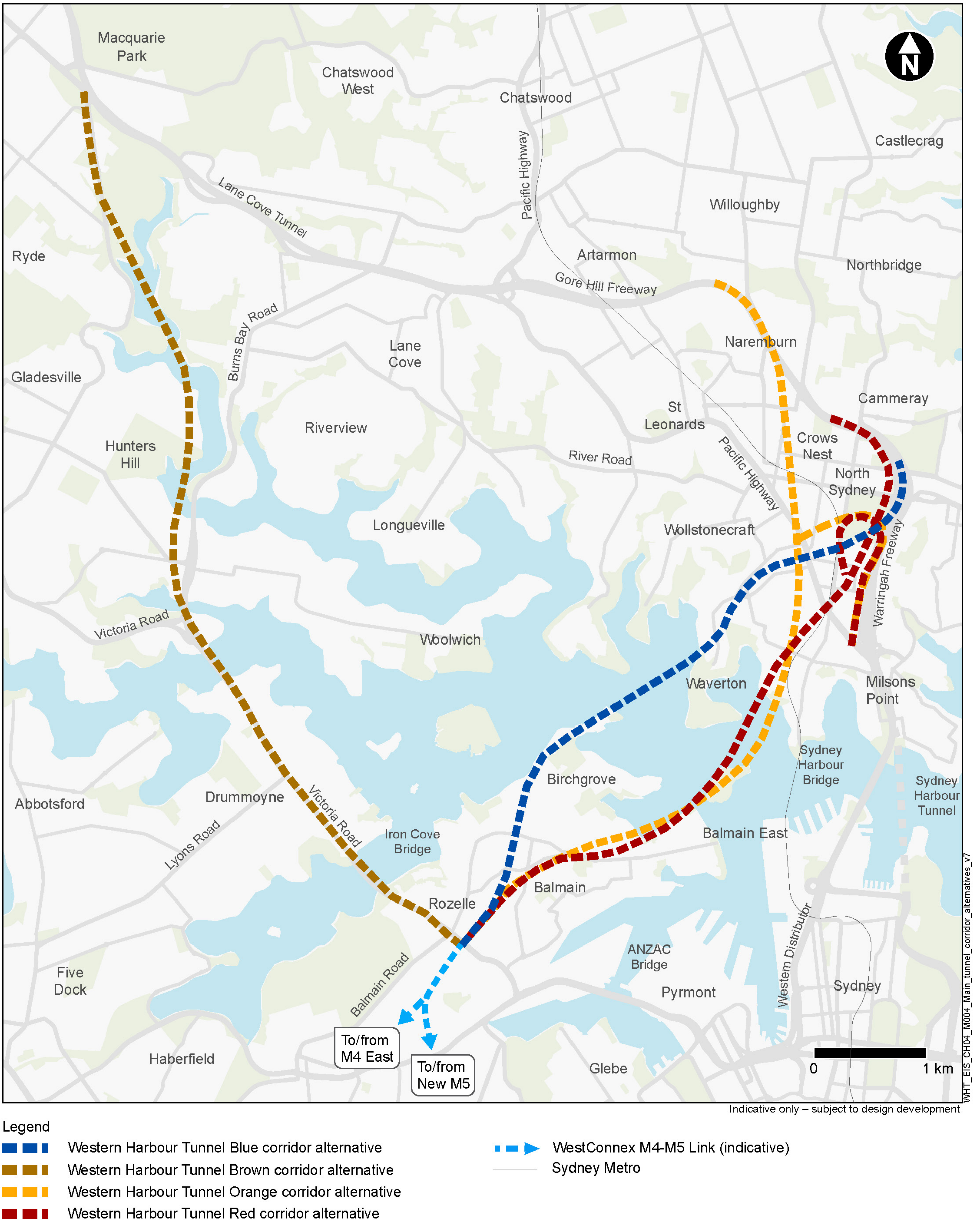


Figure 4-5 Main corridor alternatives

4.4.2 Evaluation of corridor alternatives

The four shortlisted corridor alternatives were evaluated to identify the solution that best balanced technical, social and environmental outcomes while meeting the transport objectives. The evaluation criteria used were an expansion of the project objectives with the addition of design and constructability criteria to reflect the more detailed comparison required (Figure 4-6).

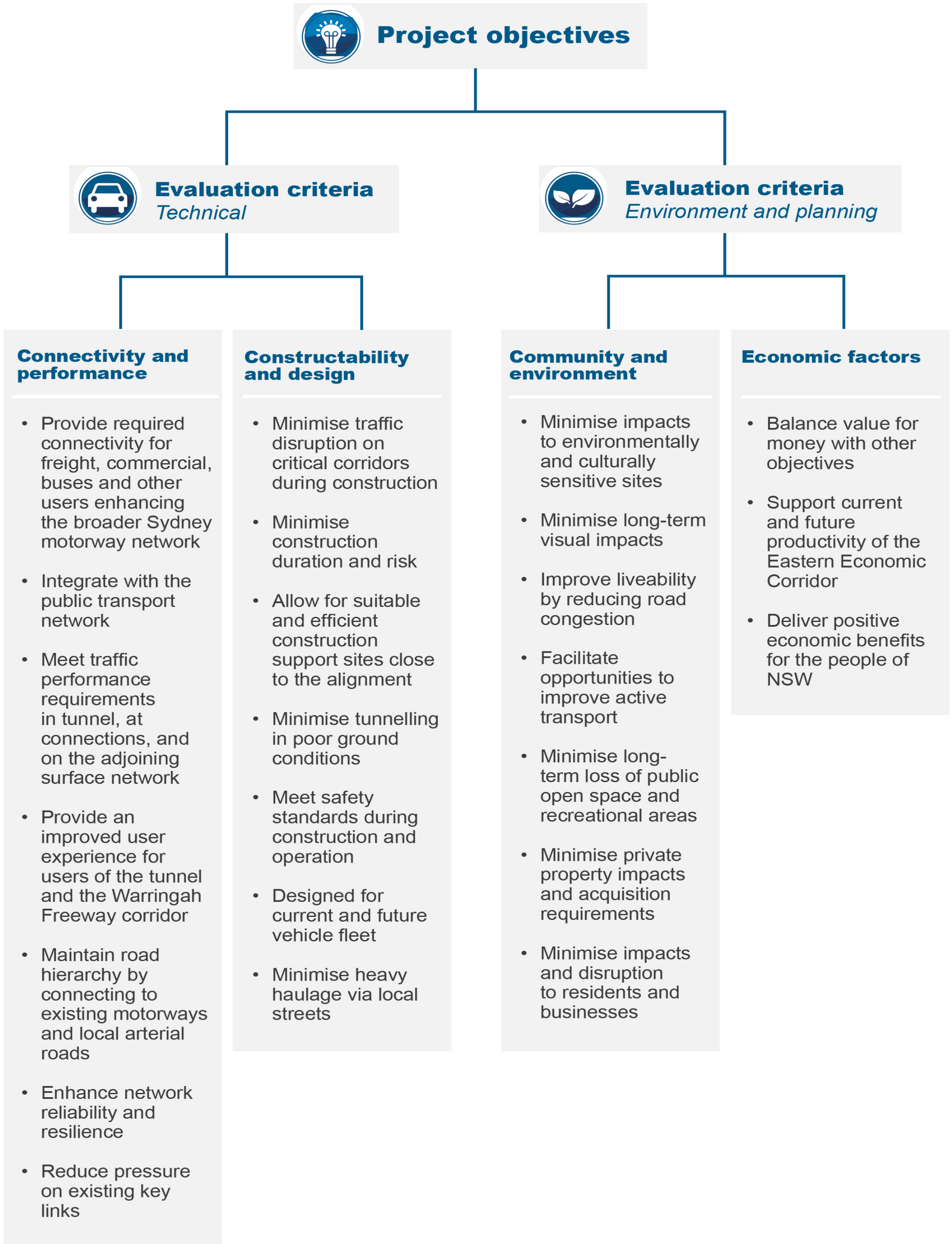
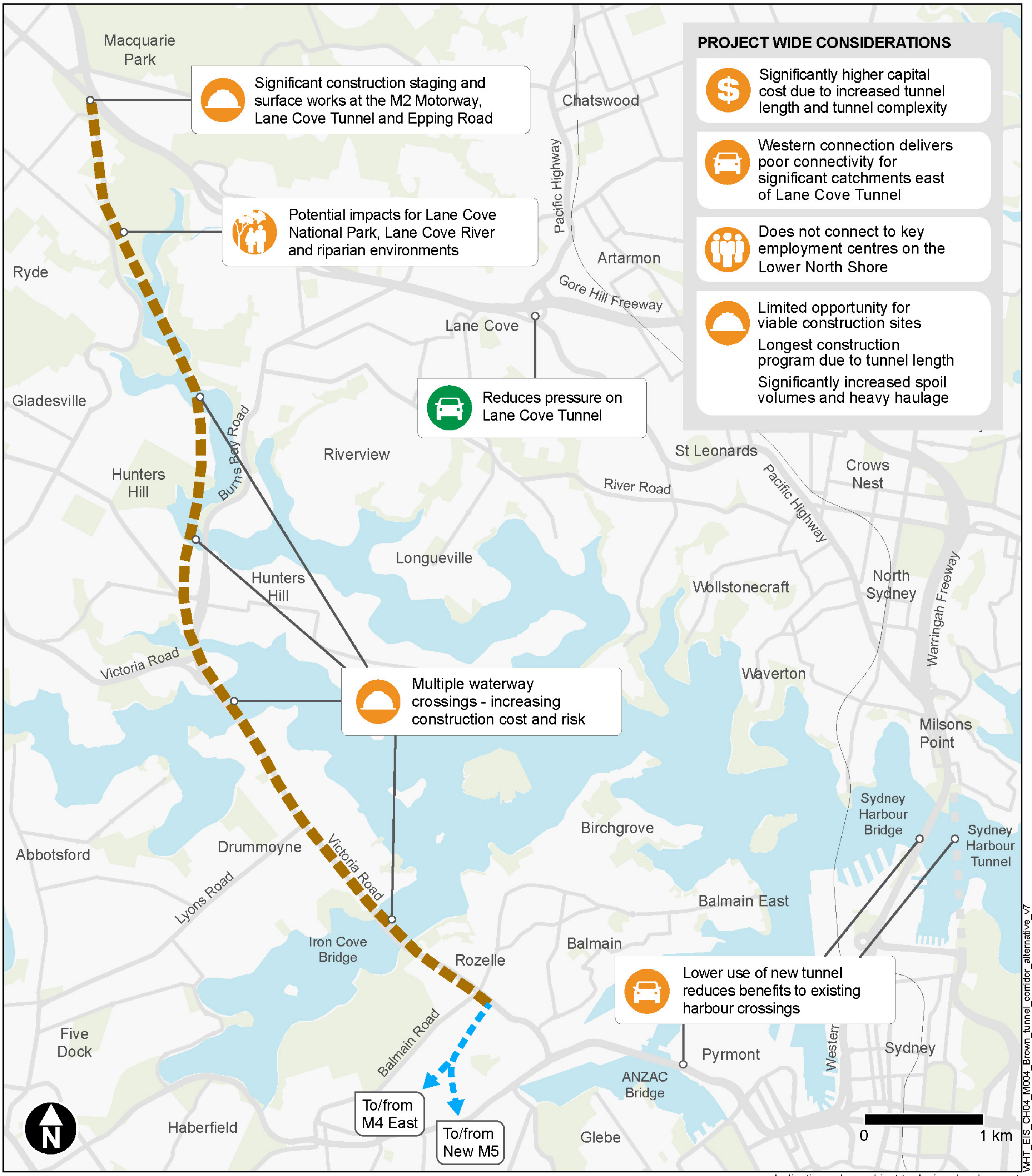


Figure 4-6 Evaluation criteria for corridor alternatives

A summary of the key strengths and weaknesses of each alignment with respect to the evaluation criteria, are shown in Figure 4-7 to Figure 4-10.

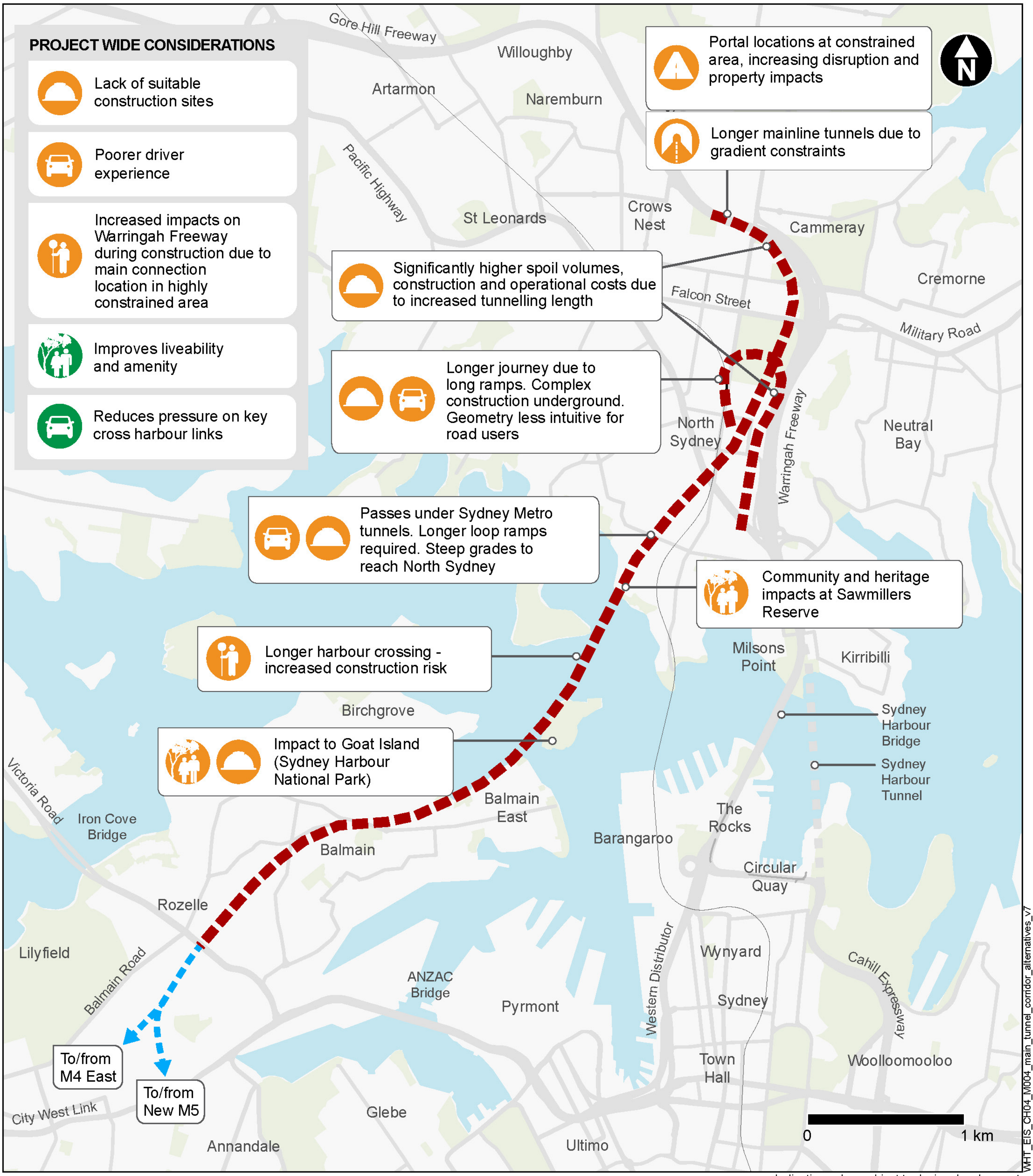


Indicative only – subject to design development

Legend

- Western Harbour Tunnel Brown corridor alternative
- WestConnex M4-M5 Link (indicative)
- Sydney Metro

Figure 4-7 Brown corridor alternative



Indicative only – subject to design development

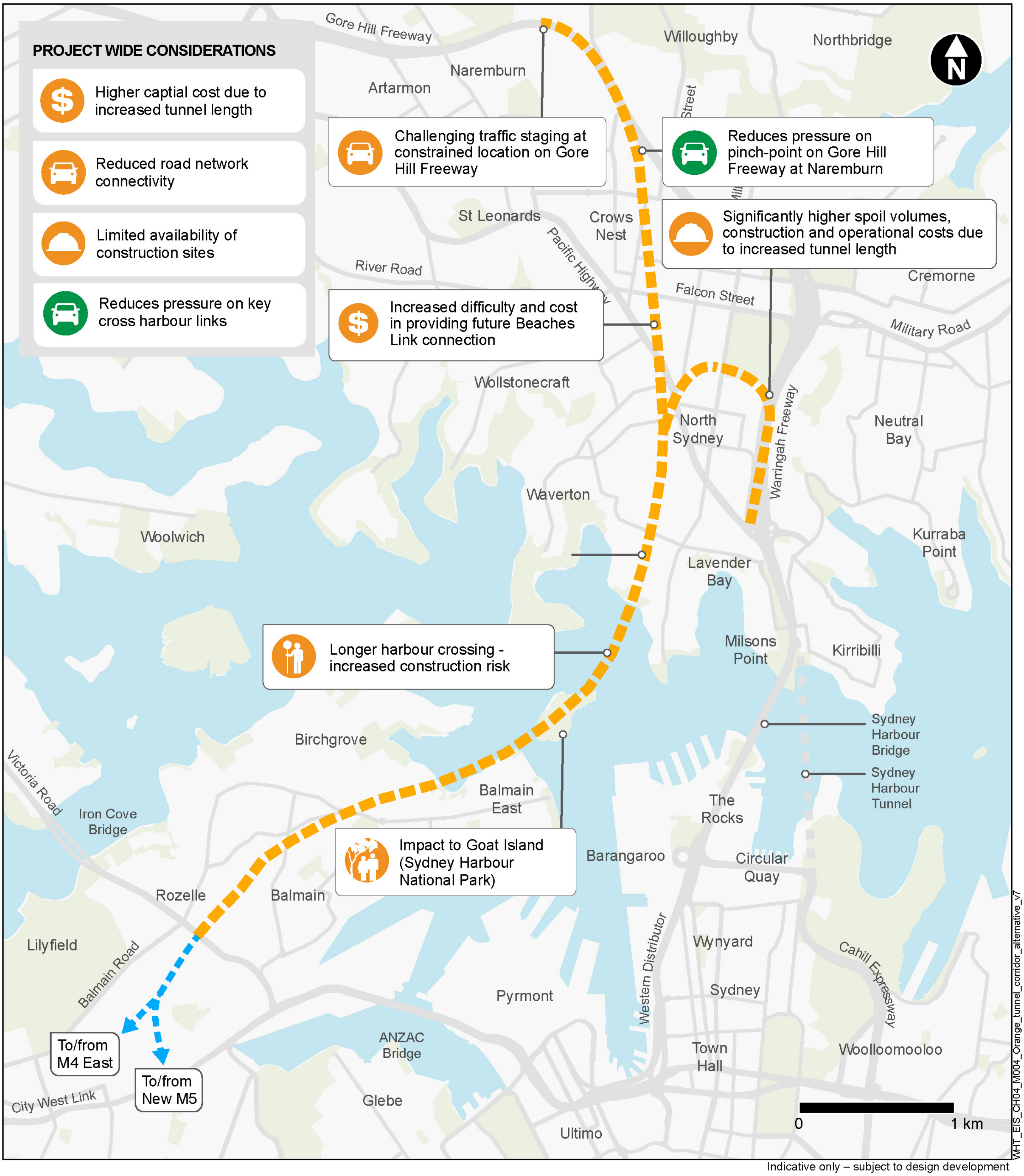
Legend

Western Harbour Tunnel red corridor alternative

WestConnex M4-M5 Link (indicative)

Sydney Metro

Figure 4-8 Red corridor alternative



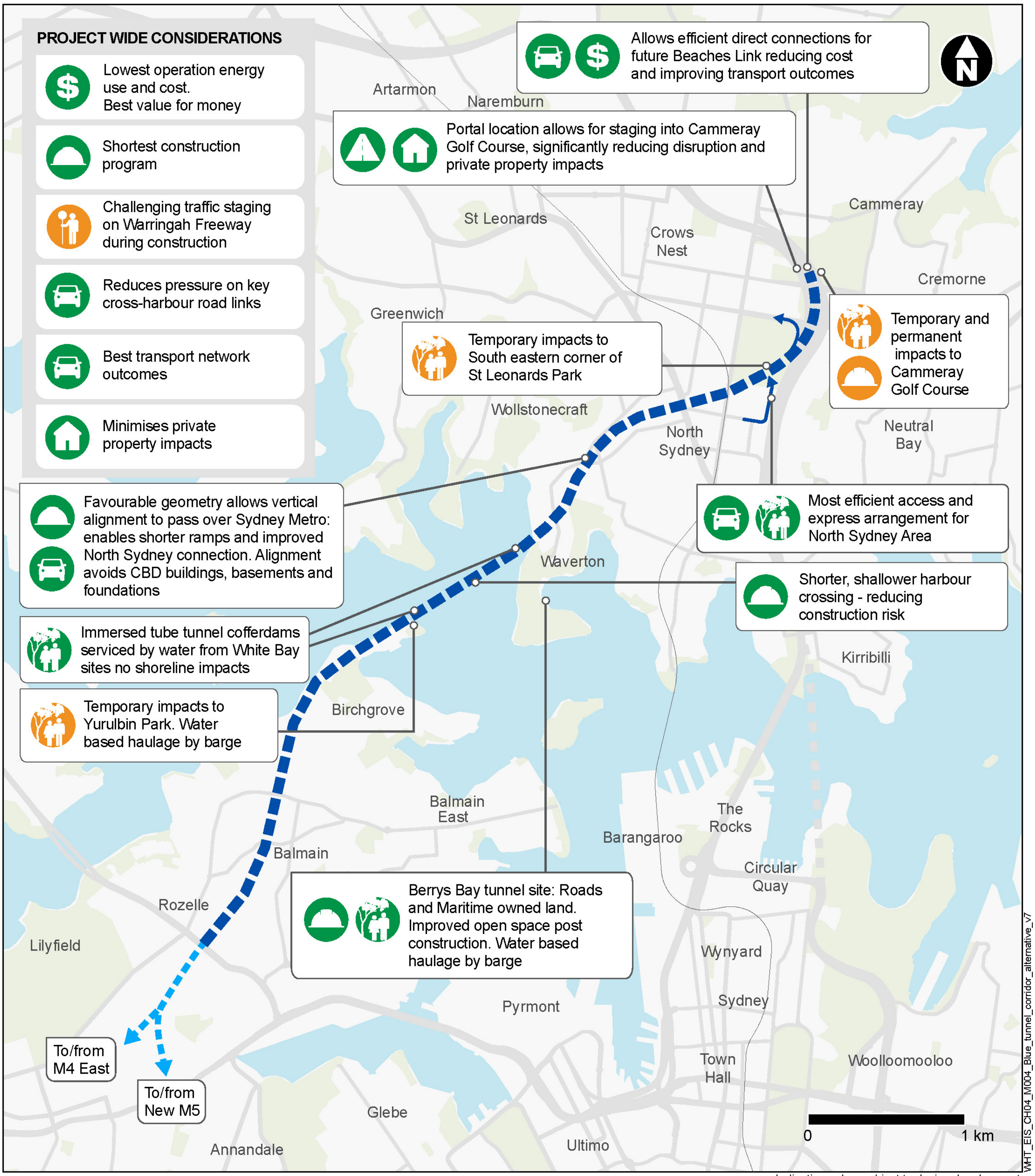
Legend

Western Harbour Tunnel orange corridor alternative

WestConnex M4-M5 Link (indicative)

Sydney Metro

Figure 4-9 Orange corridor alternative



Indicative only – subject to design development

Legend

- Western Harbour Tunnel Brown corridor alternative
- WestConnex M4-M5 Link (indicative)
- Sydney Metro

Figure 4-10 Blue corridor alternative

4.4.3 Preferred corridor

On the basis of its superior performance relative to other alternatives, the blue corridor alternative was identified as the preferred corridor to be carried forward for further design development (refer to Section 4.5).

Key advantages of the blue corridor alternative include:

- Improved experience, safety and efficiency for users:
  - The blue corridor alternative would enable the mainline tunnels to pass over the Sydney Metro tunnels at North Sydney, removing the requirement for two kilometre long loop ramps as per the red and orange corridor alternatives
  - The blue corridor alternative would enable shorter, more direct and more legible connectivity between the Western Harbour Tunnel and North Sydney, providing long-term benefits for users
  - The blue corridor alternative would provide a 4.5 per cent maximum gradient (compared to the six per cent maximum gradient for the red alternative), which is a result of removing the need to pass under the Sydney Metro tunnels at North Sydney. This would also improve the driver experience and support more efficient traffic movements and reduced emissions generation over time
- Viable construction support sites on Government-owned land:
  - The blue corridor provides the opportunity to establish temporary construction support sites suitable for delivery of the infrastructure. This improves the efficiency of construction, reducing cost and duration of construction impacts
- Shortest harbour crossing:
  - Significantly reducing exposure to poor geology, reducing construction risk, cost and program duration
- Reduced community and environmental impacts during construction:
  - The blue corridor reduces impacts on environmentally sensitive areas including Goat Island (Sydney Harbour National Park), the Lane Cove National Park, and Artarmon Reserve
  - The ability to establish viable construction support sites on Government-owned land improves efficiency, reduces construction duration, and significantly reduces the number of private properties directly impacted by the project
  - The construction support sites identified along the blue corridor allow for direct arterial road access or viable marine access, minimising heavy haulage trips through local communities
  - The blue corridor minimises the amount of tunnelling required to deliver the requisite transport product, significantly reducing the raw materials, heavy haulage trips and energy required to construct and operate the infrastructure
  - Temporary construction support site at Berrys Bay presents the opportunity for remediation of this site and subsequent use as a public space with improved amenity
  - Widening at the Cammeray Golf Course minimises impacts on the large number of users of the Warringah Freeway corridor during construction, and also minimises direct property impacts and construction duration.

4.5 Further project development

Following identification of the blue corridor alternative as the preferred corridor for the project, further detailed project development work has been carried out, including:

- Community and stakeholder engagement to identify key local issues to be taken into account in the development of the project (refer to Chapter 7 (Stakeholder and community engagement))
- Detailed environmental and other site investigations along the corridor, including desktop and field investigations to identify key environmental issues
- Design development and value engineering to ensure benefits are realised, while reducing costs, program, constructability risks and community and environmental impacts where possible. This process also included consideration of community and stakeholder feedback and the outcomes of environmental and other site investigations.

This project development work included detailed consideration of the following, with further detail on these key issues provided in Sections 4.5.1 to 4.5.7:

- Tunnelling methods, both land-based and the preferred harbour crossing methods
- Location and configuration of the North Sydney connections
- Ventilation alternatives, including the ventilation system design and outlet locations
- Construction support site locations, layouts and alternatives
- Spoil transport, reuse and disposal alternatives.

Other factors considered during design development included:

- Detailed construction staging within the Warringah Freeway corridor to minimise disruption and optimising the corridor for future operations
- Construction staging and work methodologies to reduce impacts on surrounding communities and the environment
- Integration with and enhancements to the existing public transport infrastructure, particularly along the Warringah Freeway corridor
- Opportunities to integrate with and enhance walking and cycling routes
- Utilities impacts and relocation requirements
- Minimising interfaces with heritage items.

The development and evaluation of detailed components of the preferred corridor included consideration of options against a localised set of criteria that was consistent with the project objectives. These included connectivity, transport network performance, constructability, design, community, environmental, and economic criteria specific to the scope item and area being considered.

4.5.1 Tunnelling method alternatives

The methods used to deliver tunnels at different locations around the world varies significantly, primarily in response to the geology encountered and the cross section that is required along the alignment. Roadheader, tunnel boring machines, immersed tube tunnels, cut and cover tunnels, and the drill and blast methods are all used to deliver tunnels in different conditions around the world.

The process for selection of the preferred tunnel alignment and tunnel construction method for the project included the development and evaluation of over 15 different combinations of tunnelling methods.

These options were developed and assessed by a multidisciplinary team of design, constructability, and environmental specialists with direct experience in delivering major tunnels in international, Australian and NSW contexts.

The assessment considered various technical and environmental factors including:

- Strategic traffic demands and how they define the required connectivity to achieve transport outcomes
- Results of geotechnical and groundwater investigations
- Marine heritage, biodiversity and marine ecology surveys
- Contamination testing
- Turbidity and hydrodynamic monitoring and modelling
- Opportunities for viable temporary intermediate tunnelling sites that minimise impacts on sensitive vegetation, heritage sites, private property, local communities and the functionality of public open space
- Implications for physical and operational interfaces with other major infrastructure (for example Sydney Metro & Southwest tunnels, M4-M5 Link tunnels, the Beaches Link and Gore Hill Freeway Connection project and building foundations in North Sydney and along the Warringah Freeway)
- Horizontal alignments and waterway crossing methods that allow the tunnel to achieve acceptable vertical gradients to achieve the desired transport product, reduce whole of life emissions, operational costs, and improve safety outcomes
- Consultation with commercial and recreational maritime stakeholders
- Market engagement, including technical engagement with 14 construction contractors
- Construction and operational costs.

Given the major change in geology beneath Sydney Harbour, the following sections discuss the methodologies for the harbour crossing and the tunnels north and south of Sydney Harbour separately.

Tunnelling south and north of Sydney Harbour

Favourable tunnelling conditions are expected north and south of Sydney Harbour, with the majority of the tunnel alignment expected to be constructed in high-quality Hawkesbury Sandstone. This has led to the consideration of roadheader and tunnel boring machine construction methods for these segments. Examples of roadheaders and tunnel boring machines are shown in Figure 4-11.

Roadheaders are made up of rotating cutting heads mounted on a boom or similar structure. They are typically used where the rock being tunnelled through is very sound without being too hard. In these conditions roadheaders can be used to cut away the rock to form a tailored cross-section to match the exact cross-sectional area of the tunnel.

When using the roadheader method, multiple roadheaders are typically deployed via intermediate construction support sites along the alignment. This allows the tunnel to be constructed from multiple fronts, typically providing significantly reduced construction durations when compared to tunnelling from a single site.

The roadheader tunnelling method has been the preferred construction technique for all major motorway tunnels in Sydney, with the exception being the existing Sydney Harbour Tunnel, which was delivered using the immersed tube tunnel technique. The favourable Hawkesbury

Sandstone geology combined with the requirement for a wide but short cross-section are the key variables that have combined to make roadheader the most efficient and cost effective method for delivering motorway tunnels in Sydney.

Tunnel boring machines are significantly larger than roadheaders, and use a circular rotating cutting head that houses many individual cutting tools. Due to the circular cutting head, tunnel boring machines excavate and produce a circular tunnel cross-sectional area.

To allow for tunnelling in many different types of geology, there are many different types of tunnel boring machines. With no one type of machine ideally suited to tunnelling through both rock and soft ground major changes in geology, soft sediments, such as sediments found beneath Sydney Harbour, would require a different type of tunnel boring machine to the landside tunnels being constructed through Hawkesbury Sandstone.

This is best demonstrated by the construction method adopted for construction of the new Sydney Metro crossing of Sydney Harbour, where the poor geology under Sydney Harbour requires a different type of tunnel boring machine to the landside tunnels. Accordingly, the Sydney Metro project is using five tunnel boring machines – two north and two south of the harbour to complete tunnelling through rock, with one specialised machine for the crossing of Sydney Harbour. This requires the establishment of large shafts at Barangaroo and Blues Point to change tunnel boring machines for the harbour crossing.

Figure 4-11 Examples of a roadheader (left) and tunnel boring machine (right)

The indicative cross-sections of the Western Harbour Tunnel if roadheaders or tunnel boring machines are used are shown in Figure 4-12. This diagram demonstrates that the cross-section required for a modern motorway does not fit efficiently within the circular cross-section provided by a tunnel boring machine, resulting in significantly increased excavation and backfill requirements.

Options to build multi-level roadways within the one cross-section were also considered (for example two lanes above two lanes), but these would require even larger machine diameters.

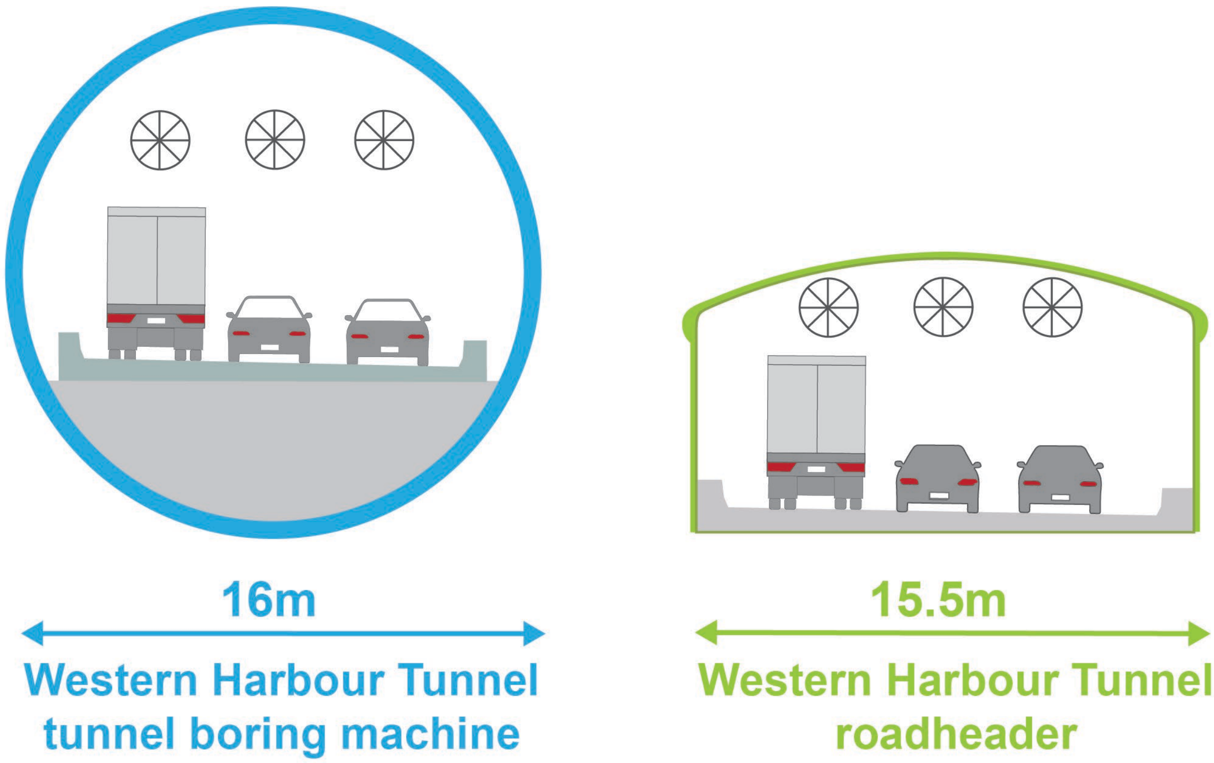


Figure 4-12 Comparison of tunnel cross-sections using a tunnel boring machine and a roadheader

A comparative evaluation of alternative tunnelling methods for tunnelling north and south of Sydney Harbour is summarised in Table 4-2.

Table 4-2 Alternative tunnelling methods

Method	Summary of evaluation
Roadheader (preferred method)	**Advantages:** • The technology required is well understood and has been proven to be most cost-effective for motorways in Sydney's geological conditions • All major road tunnels in Sydney to date have been built successfully by roadheader • Reduced construction risk relative to using a tunnel boring machine for a three lane road tunnel (further details below) • Ability to cut an exact cross-section reduces infrastructure or fill required within the tunnel to achieve desired road level • Significantly lower spoil volumes and heavy vehicle movements relative to using a tunnel boring machine • Machines are relatively inexpensive and readily available in the Sydney market • Roadheaders can generally be deployed much faster than tunnel boring machines, due to shorter procurement, establishment and commissioning times • Large trained workforce in Sydney, following recent major road tunnel projects. **Disadvantages:** • Tunnelling rate of roadheaders is less than tunnel boring machines when both reach peak production • Depending on the length of tunnel, roadheaders may require intermediate surface construction and access sites.

Method	Summary of evaluation
Tunnel boring machine	**Advantages:** • If the geology and cross-section are consistent, tunnel boring machines can usually construct much longer tunnels with fewer intermediate surface access points • Provides for faster excavation rates than roadheaders when the machine is ideally matched to the project geology and changes in cross-section along the tunnel are minimised • Provides safer tunnelling conditions in poor ground conditions when compared to roadheaders. **Disadvantages:** • Require larger tunnelling and access sites than roadheaders • Tunnel boring machines are significantly more expensive to procure and operate than roadheaders • The timeframe for procuring, commissioning and launching tunnel boring machines would be significantly longer than for roadheaders • A three lane motorway cross-section would require tunnel boring machines about 16 metres in diameter. These would be within the top five largest globally. Given that mega diameter machines are uncommon, machines of such size are likely to pose significantly more construction risk than a roadheader solution • Being a circular excavation, tunnel boring machines require significant over-excavation compared to roadheader construction. This results in significantly increased spoil volumes for the rock tunnelling and associated heavy vehicle hauling or barging and disposal, as well as a need to backfill within the tunnel to build the road level back up • Tunnel boring machines require long stretches of tunnel to outperform roadheaders on a cost and production basis. The maximum drive length for the Western Harbour Tunnel would be three kilometres; therefore, there would be minimal efficiencies from using tunnel boring machines • Roadheaders and intermediate sites would still be required to excavate interchanges and ramp connections ahead of tunnel boring machine arrival, as tunnel boring machines cannot accommodate these changes in cross-section • Major intermediate sites would be required at the northern and southern shorelines of Sydney Harbour to change machines if the project was to select tunnel boring machines that are matched to geology.

Sydney Harbour crossing

While the majority of the tunnelling for the project is expected to be constructed through high quality Hawkesbury Sandstone, the portion of tunnel crossing the Sydney Harbour presents particular challenges. These include:

- **Significant changes in elevation:** The project starts in Rozelle, at about three metres above the harbour water level, then travelling up to about 90 metres at the connections to North Sydney. In between, Sydney Harbour has a trench in the bedrock running along the northern side, with rock present at about 45 metres below the harbour bed level. This creates about a 145 metre elevation difference between rock level at the harbour and the surface level at North Sydney. Considering the elevation change between the rock level under the harbour and North Sydney it becomes apparent that there is significant pressure on the vertical grade of the proposed tunnel – with gradient having implications for long-term operations of the tunnel (safety and emissions)

- **Sydney Metro City & Southwest tunnels:** Adding to the challenge for the project are the new Sydney Metro tunnels. The project would need to be tunnelled either above or below the Sydney Metro City & Southwest tunnels at North Sydney (which are at a depth of more than 50 metres)
  - If the project were to tunnel under the Sydney Metro City & Southwest tunnels, connectivity at North Sydney would require steep, long, circular access ramps with adverse outcomes for traffic performance, emission generation, and project cost
  - If the project were to tunnel over the Sydney Metro City & Southwest tunnels, the ramps would become simple directional ramps, but with the increased challenge of achieving acceptable vertical grades under this design
- **Poor geology and rock fracturing at harbour crossings:** Geotechnical testing has been conducted for the proposed harbour crossing. At the northern side of the harbour, the top of the Hawkesbury Sandstone bedrock is approximately 45 metres below the harbour surface. Unlike the bedrock either side of the harbour, this rock is generally highly fractured. This fracture zone is likely to cause significant water ingress issues during construction using a mined or bored method as seen during the construction of the Northside Storage Tunnel and Greenwich to Woolwich Cable Tunnel. Above this fractured rock are layers ranging from stiff clay through to sand and sediment. Depending on the vertical alignment of the tunnels, they may need to be constructed through rock, through sediment, or a combination of these. Generally tunnelling through sediment is undesirable as it is prone to instability. However, high-quality Hawkesbury Sandstone is very deep beneath the harbour, giving rise to the need to balance between the preference to tunnel through rock and the gradient of the tunnels – with the gradient of the tunnels affecting traffic performance, emission generation, ventilation design, and long-term operational costs for the tunnel
- **Limited intermediate sites:** For most of its alignment, the proposed Western Harbour Tunnel would pass beneath harbourside suburbs like Balmain and Waverton, which are characterised by highly urbanised areas with very narrow streets. This presents as a significant challenge to the establishment of viable intermediate tunnelling sites as these would likely require acquisition of a significant number of private properties and/or unacceptable haulage routes via narrow streets. This is a particular challenge when considering the scale of sites required to support large diameter slurry shield or tunnel boring machines for the harbour crossing
- **Cross-section:** The cross-section required for a modern three lane motorway crossing of Sydney Harbour is about 16 metres wide. Given the poor geology (refer to Figure 4-13), this creates a significant challenge for tunnel boring machines or roadheader solutions. If using a tunnel boring machine, this would require one of the largest machines of its type ever used in the world – significantly increasing construction cost and risk.

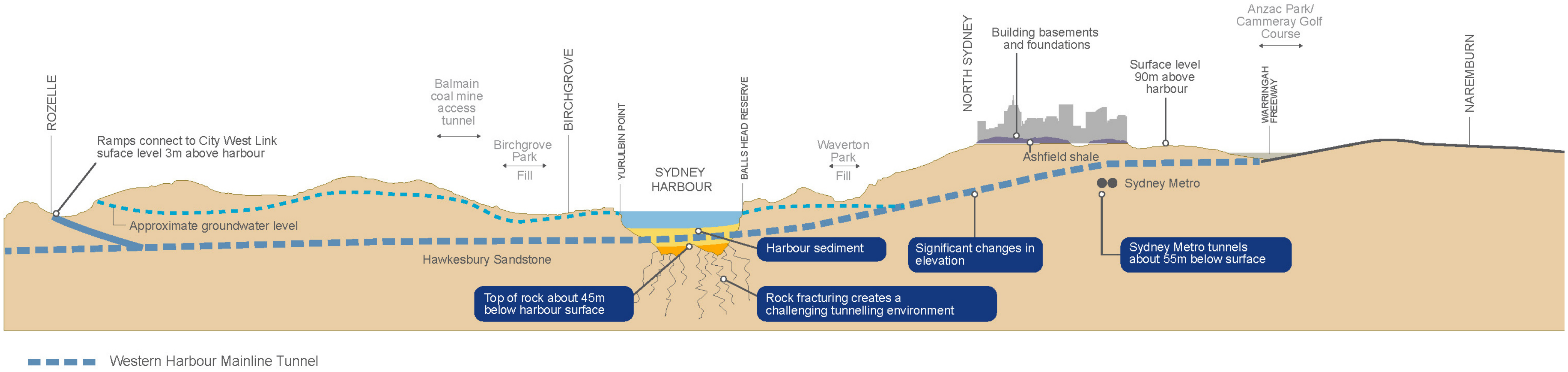


Figure 4-13 Indicative vertical alignment of the mainline tunnels

Design development for the project included a significant focus on evaluation of potential tunnelling methods for the crossing of Sydney Harbour. This analysis was carried out by a multidisciplinary team including design, construction, transport planning, and environmental specialists to ensure a comprehensive analysis. It included the consideration of the roadheader method, specialised slurry shield tunnel boring machines, and an immersed tube tunnel (similar to the existing Sydney Harbour Tunnel).

Roadheader options were discounted early in the process for the following reasons.

- The tunnel depth required to deliver this method beneath the harbour would significantly compromise the gradients of the mainline tunnel impacting the transport product, emissions generation, construction and operational cost
- The highly fractured geology beneath Sydney Harbour, which creates a risk of significant water ingress during construction if using the roadheader method.

Although tunnel boring machines are a viable alternative, the diameter and type of machines required for the crossing of Sydney Harbour cannot be considered a conventional solution. Depending on the depth of the alignment, the tunnel boring machines required to cross Sydney Harbour would need to be very large diameter slurry shield machines, as shown in Figure 4-14.

Slurry shield tunnel boring machines use clay slurry and compressed air to carefully control the pressure at the tunnelling face. This is required to maintain stability ahead of construction of the permanent concrete lining when tunnelling poor ground conditions, such as those expected beneath Sydney Harbour. The pressure at the face needs to be carefully controlled as the machine advances to respond to the ground conditions as they vary.

These are highly sophisticated and specialised machines, and have rarely been used for sub-sea tunnelling at the diameter that would be required for this project. These machines also require significant landside sites to accommodate:

- Segment production and storage
- Clay slurry production and processing
- High voltage power supply.

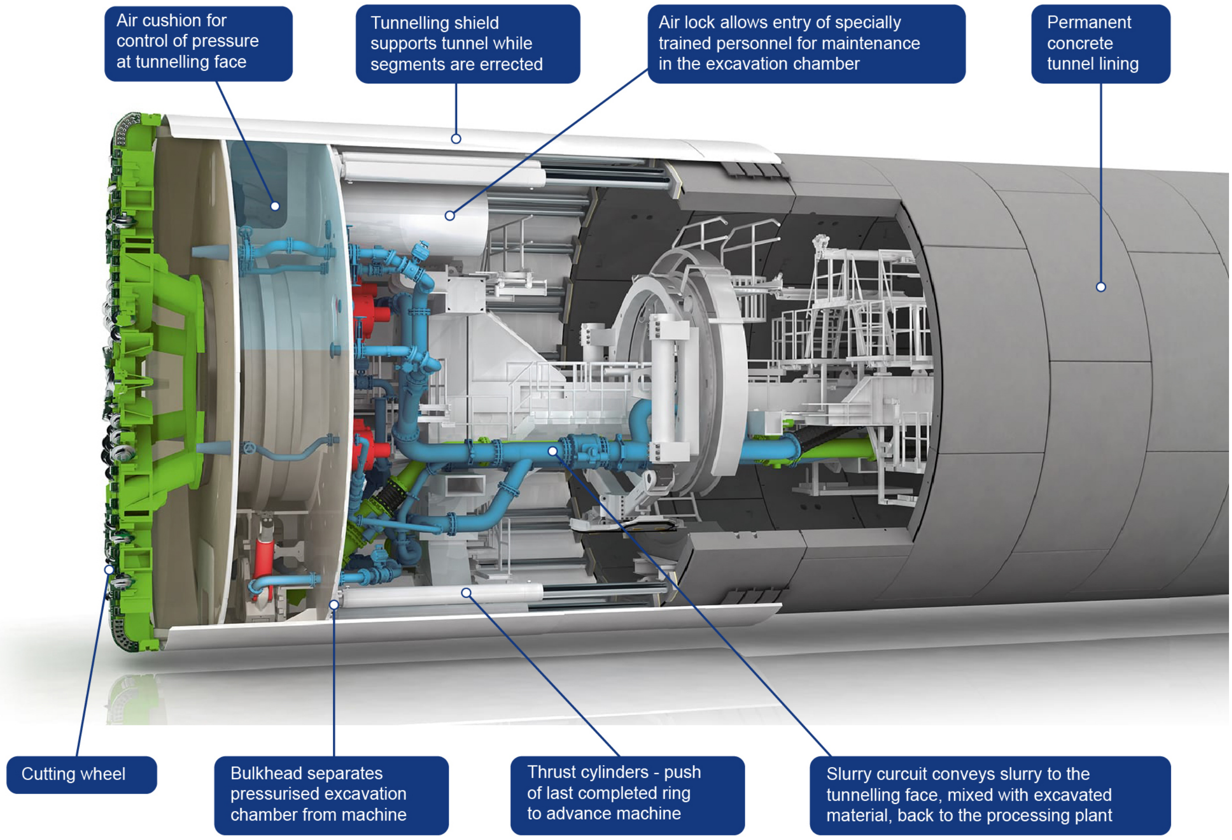


Figure 4-14 Example of a slurry shield tunnel boring machine

An alternative to tunnelling through rock or sediment using roadheaders or tunnel boring machines would be to place precast tunnel units on top, or within, the top layers of harbour rock and sediments. This method is known as an immersed tube tunnel and has been applied to over 150 major road and rail tunnels around the world to overcome similar combinations of geology, topography and cross-sectional challenges, including the existing Sydney Harbour Tunnel.

This alternative would involve excavation of the bed of the harbour and placement of immersed tube tunnel units within the excavated trench as shown in Figure 4-15.

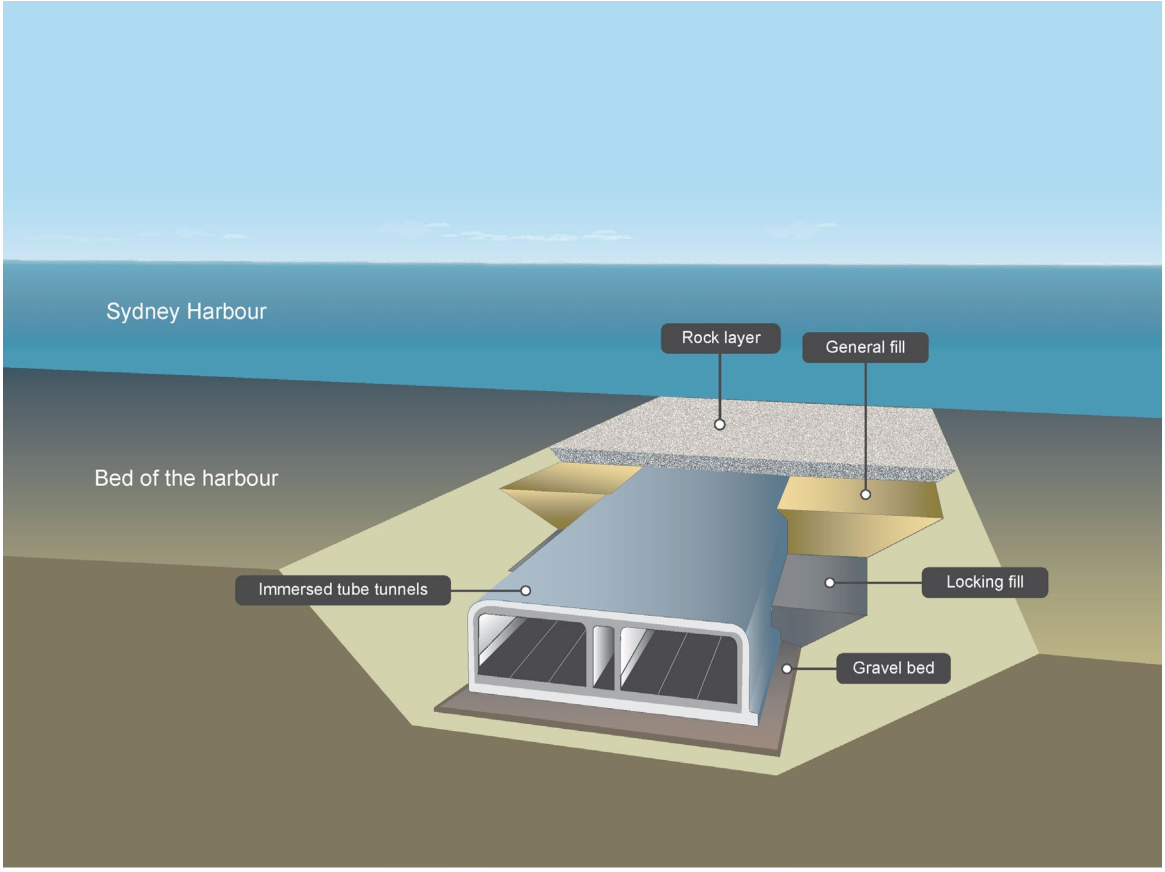


Figure 4-15 Example of an immersed tube tunnel

Figure 4-16 shows the four main options for the vertical alignment of the Sydney Harbour tunnels:

- A deep driven roadheader tunnel, completely within rock (grey)
- A shallower bored tunnel boring machine tunnel, with parts of the tunnel in softer, weathered rock or sediment (red and purple)
- An immersed tube tunnel lying on top, or within the top layers, of softer, weathered rock and sediments (green).

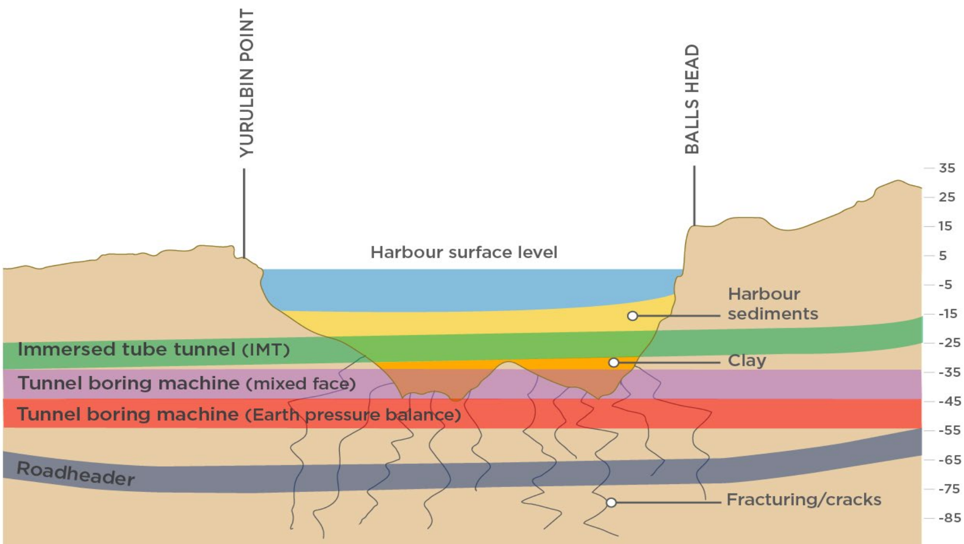


Figure 4-16 Main vertical alignment options for the harbour tunnels

When considering the performance of each of the potential methodologies against design, constructability, traffic performance, environmental and social criteria, the preferred method for crossing Sydney Harbour is via an immersed tube tunnel. The justification for selecting this alternative is summarised in Table 4-3.

Table 4-3 Preferred tunnelling method for the Sydney Harbour crossing

Preferred method	Summary of evaluation
Immersed tube tunnel	**Advantages:** • The technology required is proven, having been used on major contemporary infrastructure projects around the world, including the Sydney Harbour Tunnel • Provides the shallowest possible tunnel alignment at the Sydney Harbour crossing, enabling the best possible gradient and associated performance outcomes (eg safety, vehicle speeds, journey experience, long-term emissions) • Minimises tunnelling risks by reducing exposure to tunnelling through poor geology and reducing the time workers need to spend in high risk tunnelling environments • Lower construction and operational costs when compared to alternate methodologies • Minimises the size of waterside sites when compared to those required to launch large diameter tunnel boring machines • Significantly reduces haulage on land when compared to tunnel boring machine solutions • Takes advantage of marine logistics to minimise heavy haulage on roads • The preferred alignment avoids interfaces with sensitive marine ecology. **Disadvantages:** • Requires measures to be implemented to prevent migration of material during excavation of sediments, particularly areas with elevated levels of contaminants on the bed of Sydney Harbour • Interfaces with commercial and recreational maritime traffic during construction.

4.5.2 North Sydney connection alternatives

Connections to and from the North Sydney area that would link the North Sydney CBD and surrounding areas to the Western Harbour Tunnel service an important catchment area. Accordingly, these links were identified as critical connections for the project. The following key objectives were considered in the development of options for this connection:

- To service key origins and destinations around the North Sydney area, including the North Sydney CBD, Crows Nest and Waverton
- To ensure resilience of the North Sydney area transport network, including the ability to respond to changes to normal operating conditions
- To balance demands across established road corridors to avoid concentrating impacts in one area and diminishing network resilience and reliability
- To ensure the proposed connections integrate with the local arterial network, using established state road corridors where possible
- To provide accessibility of the ramps for the range of transport users including public transport, service vehicles, freight and private vehicles

- To minimise impacts on private property and public open space.

There were a number of challenges associated with the provision of a connection for the North Sydney area. The key challenges included high demands for traffic coming to/from North Sydney and the Crows Nest area, topography issues, and the limited number of parallel/alternate routes available in the area with connectivity to the motorway network.

Over 20 alternative arrangements have been considered for the Western Harbour Tunnel connections to and from the North Sydney area. Of the alternatives considered, three were shortlisted for further consideration, as shown in Figure 4-17:

- Connections to and from Pacific Highway (orange)
- Off ramp connecting to Arthur Street and an on ramp connecting from Berry Street (red)
- Off ramp connecting to Falcon Street and an on ramp connecting from Berry Street (blue).

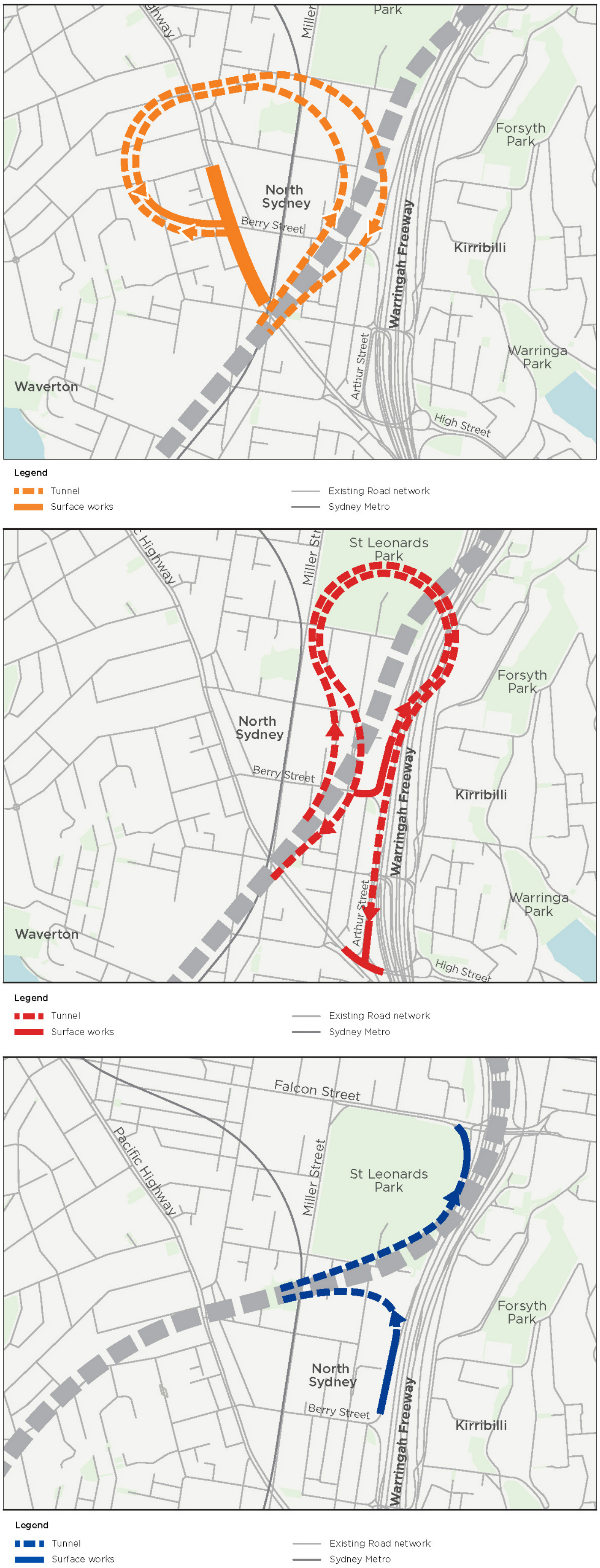


Figure 4-17 Connection alternatives at North Sydney

The preferred connection alternative for the North Sydney area includes an off ramp connecting to Falcon Street and an on ramp connecting from the existing Berry Street on ramp to the Warringah Freeway (Figure 4-17 (blue alternative)). These ramps would provide high-quality connectivity for the North Sydney area to accommodate current and future demands. Both ramps would connect to existing State Road corridors, which would result in good network performance outcomes and reduce impacts on local streets.

This option has minimal impacts on private property. Some impacts would occur to the south-eastern corner of St Leonards Park in the sloping area between the bowling greens and Warringah Freeway. However, this area is required during construction only, and would be reinstated following completion of the project.

This option also includes a new northbound ramp to the Warringah Freeway at High Street. This would enable better distribution of traffic across the North Sydney arterial network, with the primary northbound access to the Warringah Freeway and Gore Hill Freeway moved from the Berry Street ramp to the new High Street ramp. Berry Street would service a reduced number of destinations and would no longer provide access to Falcon Street or through to the Gore Hill Freeway.

An overview of the justification for selecting this alternative is summarised in Table 4-4.

Table 4-4 Summary of evaluation of North Sydney connection alternatives

Evaluation criteria	Reason for preferred alternative
Connectivity and network performance	• Provides the connectivity required to service key origins and destinations in the North Sydney area • Connectivity between North Sydney, surrounding areas and the Western Harbour Tunnel would be provided via existing State Road corridors (ie Berry Street and Falcon Street), which would provide appropriate capacity while minimising impacts on local streets • A new northbound on ramp to the Warringah Freeway from High Street would help to distribute trips across the existing surface arterial network, improving reliability and avoiding concentrating traffic flows into one area • Enables future connectivity for the Beaches Link and provides opportunities for integration of associated bus services with the Sydney Metro.
Constructability and design	• Both the Falcon Street off ramp and the Berry Street on ramp take advantage of local topography, geometry and geology to reduce tunnelling and minimise construction in poor ground conditions • Ramps would be located adjacent to the Warringah Freeway corridor, minimising impacts on operation of the freeway during project construction and enabling simpler integration • Suitable construction support sites are available on Government-owned land with direct arterial road access.
Community and environment	• The ramps are located on the western edge of the Warringah Freeway, avoiding major construction within the North Sydney CBD and minimising private property and business impacts • While there would be some impacts on St Leonards Park in the south-eastern corner between the bowling greens and the Warringah Freeway, the impacts would be temporary during construction. The construction support site would avoid significant vegetation and heritage items. Rehabilitation and landscaping works would also be undertaken following construction • Connections to existing State Road corridors would minimise impacts

Evaluation criteria	Reason for preferred alternative
	on local streets • Construction support site configurations minimise heavy haulage on local streets • No residential property acquisitions would be required for the construction of this connection option.
Economic factors	• Provides the required transport connectivity, which would improve the efficiency of freight, service vehicles, public transport and private trips • Significantly improves capacity, reliability and resilience of connectivity between the North Sydney area and other key business centres • Avoids major construction within the North Sydney CBD, minimising business impacts.

4.5.3 Ventilation alternatives

Ventilation system design

Tunnel ventilation systems must continuously, reliably and efficiently provide a safe environment for tunnel users and communities surrounding the infrastructure. The basic objectives of the tunnel ventilation systems are to:

- Maintain in-tunnel air quality
- Avoid portal emissions
- Manage smoke during fire incidents.

Most tunnels in NSW are unidirectional, meaning that traffic travels in one direction only within the tunnel. Usually two tunnels are constructed side by side (for example, the Lane Cove Tunnel), or one on top of the other (for example, the Eastern Distributor), to enable traffic to travel in both directions.

On an open roadway, vehicle emissions are diluted and dispersed by natural surface air flows. However, in a tunnel, mechanical ventilation can be required to ensure that air quality standards are maintained. This is achieved by providing fresh air to, and removing exhaust air from, the tunnel. The requirements for tunnel ventilation are determined by the vehicle emissions in the tunnel and the limits of pollutant levels set by regulatory authorities. Air quality is managed by ensuring that the volume of fresh air coming into the tunnel adequately dilutes emissions.

The movement of vehicles through a tunnel drives air flow, called the ‘piston-effect’, drawing fresh air in through the tunnel entrance, diluting the vehicle exhaust emissions. In short tunnels up to around one kilometre long, air flow resulting from the piston effect of the vehicles may be adequate to manage in-tunnel air quality.

In longer tunnels, the flow of fresh air can be supplemented by ventilation facilities which remove exhaust air and/or supply additional fresh air. The need for these features is dependent on tunnel size and length and the number and mix of vehicles using the tunnel. Fans may also be required when the piston effect is insufficient to maintain adequate air flow, such as during periods of low traffic or congested traffic conditions.

Elevated ventilation outlets are used for longer tunnels in urban areas in Australia to disperse tunnel air at a height that ensures compliance with ambient air quality criteria.

There are four broad types of road tunnel ventilation systems, and each of these was considered for application to the project:

- Natural ventilation
- Longitudinal ventilation
- Transverse ventilation
- Semi-transverse ventilation.

A number of alternatives for design of the ventilation system were considered. The advantages and disadvantages of the various systems are described below and shown in Figure 4-18.

Natural ventilation

Road tunnels with natural ventilation rely on vehicle movements, prevailing winds and differences in air pressure between the tunnel portals to move air through the tunnels without the assistance of mechanical ventilation (for example, through the use of fans). In the case of unidirectional naturally ventilated tunnels, the piston effect generated by traffic using the tunnels also assists in the movement of air. Because naturally ventilated tunnels do not have mechanical ventilation outlets, all air from within the tunnels is emitted via the tunnel portals.

Natural ventilation is only acceptable for use in relatively short tunnels (that is, less than one kilometre). This is because, without the assistance of mechanical ventilation, vehicle emissions can build up within the tunnels leading to unacceptable in-tunnel air quality under some traffic scenarios. Emergency smoke management considerations may also dictate a mechanical solution. Natural ventilation would not achieve acceptable in-tunnel air quality under low vehicle speed conditions or during emergencies and is therefore not a viable ventilation design for the project.

Longitudinal ventilation

The simplest form of ventilation for road tunnels is longitudinal ventilation, in which fresh air is drawn in at the entry portal and passes out through the exit portal with the flow of traffic. For longer tunnels, during normal operating conditions, most air would be forced through the tunnels by the movement of vehicles (the piston effect) and jet fans would be used to assist with the movement of tunnel air, to maintain acceptable in-tunnel air quality. The air pressure inside the exit portals would be maintained below atmospheric pressure to avoid the release of tunnel air from the portals. This air is then exhausted through an elevated ventilation outlet to maximise dispersion. All road tunnels longer than one kilometre built in Australia in the last 20 years have been designed and operated with longitudinal ventilation systems. This includes the NorthConnex, New M4, New M5 and M4-M5 Link tunnels, which are all under construction or complete.

Transverse ventilation

Another way to ensure adequate dilution of emissions is to provide fresh air inlets along the length of the tunnel along one side, with outlets on the opposite side. This system requires two ducts to be constructed along the length of the tunnel: one for the fresh air supply and one for the exhaust air. Transverse ventilation has been used in the past when vehicle emissions produced greater levels of pollutants than they do today. A transverse ventilation system is more expensive to construct because of the additional ducts that need to be excavated for each tunnel. This type of system is less effective than a longitudinal system for controlling smoke in the tunnel in case of a fire. It is also more energy intensive as more power is consumed to manage air flows.

Semi-transverse ventilation

Semi-transverse ventilation combines both longitudinal and transverse ventilation. Fresh air can be supplied through the portals and be continuously exhausted through a duct along the length of the tunnel. Alternatively, fresh air can be supplied through a duct and exhausted through the portals.

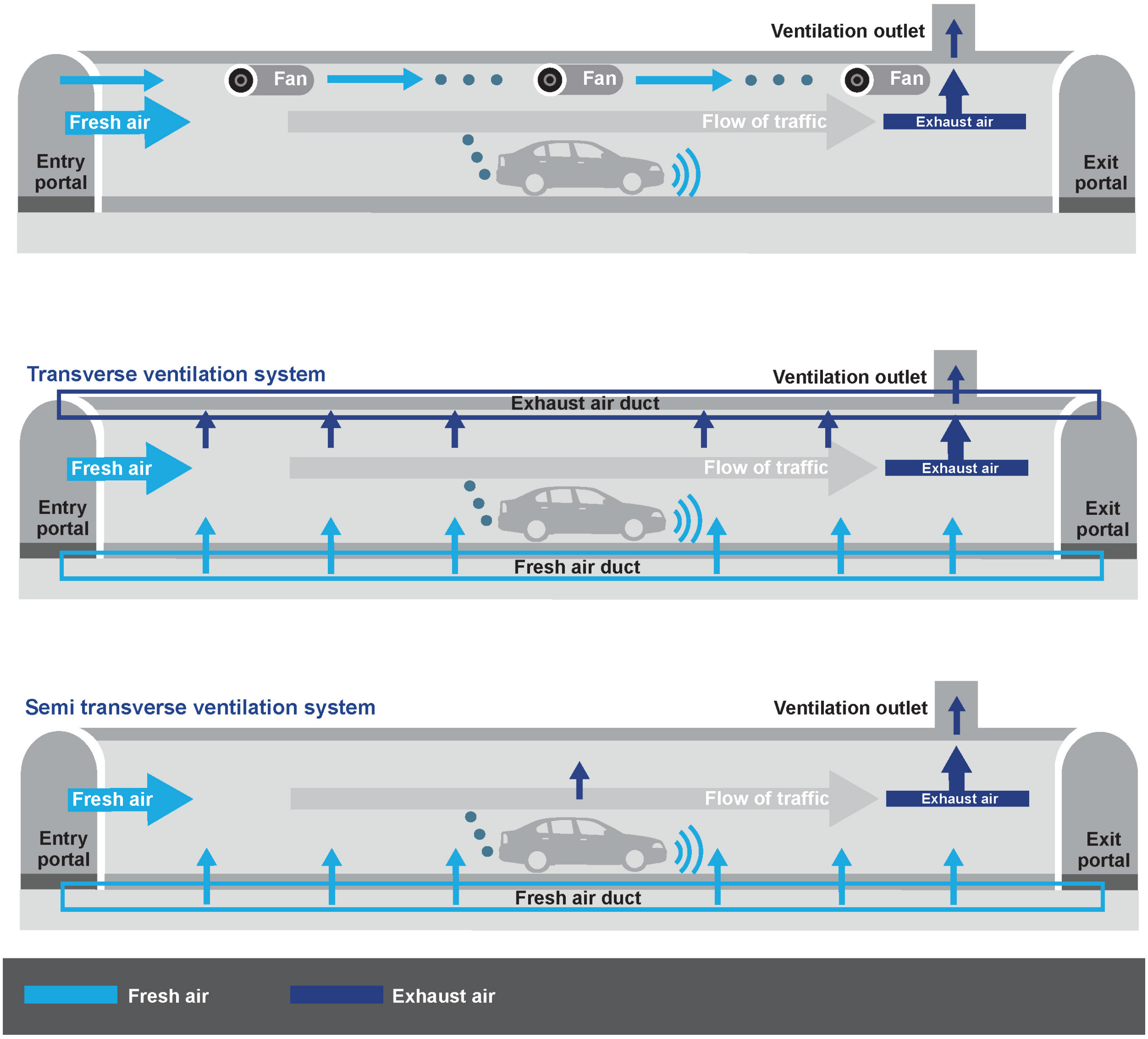


Figure 4-18 Ventilation system design alternatives

Preferred alternative

The development of cleaner vehicles in response to cleaner fuel and emissions standards has led to a significant reduction in vehicle emissions over the past 20 years. Where longitudinal ventilation was once not suitable for long tunnels, due to the need to supply large volumes of fresh air to dilute vehicle emissions, a well-designed longitudinal ventilation system can maintain acceptable air quality in long tunnels and is considered the most efficient and effective tunnel ventilation system (Advisory Committee on Tunnel Air Quality (ACTAQ), 2019).

Although all three mechanical ventilation systems described above could be designed to meet in-tunnel air quality criteria, a longitudinal system with elevated ventilation outlets has been selected as the preferred option for the project for the following reasons:

- It is less costly to construct and operate than transverse systems

- It is able to ensure emissions are dispersed and diluted so that there is minimal or no effect on ambient air quality
- It is considered to be more effective for the management of smoke in the tunnel in the event of a fire
- It is able to meet the requirement to avoid portal emissions.

The effectiveness of elevated ventilation outlets in dispersing emissions is well established. Chapter 12 (Air quality) presents the air quality assessments for both in-tunnel and external air quality. An overview of the ventilation system design and operation is provided in Chapter 5 (Project description).

Consideration of air filtration at the ventilation outlets

Only a small proportion of road tunnels around the world are fitted with air treatment systems. It has been shown that control of pollutants at the source is significantly more effective in improving local and regional air quality (ACTAQ, 2019; NHMRC, 2008a). Control measures include minimising road gradients, increasing tunnel height and providing a large tunnel cross-sectional area. The tunnel ventilation system for the project would be designed with appropriate levels of conservatism and redundancy to ensure compliance with air quality goals and limits.

No in-tunnel filtration system is proposed for the project because the modelling carried out demonstrates that the ventilation system would be effective in ensuring compliance with the in-tunnel air quality criteria. The inclusion of tunnel filtration was evaluated and found not to provide any material benefit to air quality or community health as discussed in Chapter 12 (Air quality).

The inclusion of filtration would result in no material change in air quality in the surrounding community when compared to the current project ventilation system and outlet design. Any predicted changes in the concentration of pollutants would be largely driven by changes in the surface road traffic.

Ventilation outlet locations

The contribution of the ventilation outlets is negligible for the expected traffic scenarios. This outcome can be achieved at nearly any location through appropriate outlet design. Therefore, the main factors when considering the location of the ventilation facilities and outlets were maintaining in-tunnel air quality, maximising operational efficiency and minimising surface disturbance.

Vehicles travelling through the tunnels create a piston effect which draws air in the direction of travel. As a result, the most efficient location for a ventilation outlet is above or adjacent to tunnel portal locations (that is, near the exit portal of the southbound tunnel in Rozelle and near the exit portal of the northbound tunnel in Cammeray). This minimises the length of tunnel where the air flow must be forced, by jet fans within the tunnels, against traffic flow back to the ventilation point. The reduced use of tunnel ventilation fans also increases the performance of the tunnels and reduces operational power consumption, thereby reducing the operational costs of the project and enhancing the sustainability outcomes.

The proposed ventilation outlet in Rozelle would be located within the Rozelle Interchange site alongside the M4-M5 Link ventilation building. The location of this facility was decided as part of the M4-M5 Link environmental impact statement assessment process.

For the ventilation outlet to the north of Sydney Harbour, the Warringah Freeway corridor was identified as the preferred location for the ventilation outlet. This location would provide the following key advantages:

- It would minimise the total project footprint, noting alternatives would require additional property acquisition external to the existing road corridor
- It would be immediately above the tunnel, with associated efficiencies.

4.5.4 Construction support site location alternatives

In addition to the surface disturbance areas required for the operation of the project, a number of construction support sites would be required along the project corridor. The construction support sites would be needed to support both tunnelling and surface works.

Construction support sites would include activities such as construction material and equipment storage and staging areas, spoil handling, component casting facilities, worker amenities and car parking.

Environmental investigations and community and stakeholder feedback were used to inform the identification of appropriate construction support sites. The primary driver for the location of these sites was the objective of minimising environmental and community impacts, while being suitably located to facilitate the construction activities of the project.

Key factors applied to identification of potential construction support sites included:

- Locating the construction support sites as close as possible to project construction areas
- Avoiding sensitive environmental and community locations where possible
- Avoiding material impacts on heritage sites or items
- Maximising opportunities for direct access to motorways and arterial roads or water transport opportunities for construction traffic, and avoiding the need to use local residential streets if possible
- Minimising direct and indirect property impacts and acquisition requirements, particularly in residential areas.

Where the identified construction support sites could not meet the criteria listed above, additional specific mitigation measures were identified to manage impacts associated with their use. Details of construction support sites are provided in Chapter 6 (Construction work) of this environmental impact statement.

4.5.5 Spoil transport alternatives

Most of the spoil generated by major transport infrastructure projects currently under delivery and development would be Virgin Excavated Natural Material (VENM). VENM is considered a desirable material for clean fill in development sites and major earthworks projects across Greater Sydney.

Securing spoil disposal sites to meet production throughout construction and during bad weather is critical to the delivery program of tunnelling projects. Most reuse arrangements are directly negotiated between construction contractors and councils or private developers – with major projects often using many sites to optimise haulage and cost.

Tunnel spoil generated from major projects in Sydney is generally transported via road due to the majority of reuse sites being within the Sydney basin and the desire to minimise double handling of material.

Options to reduce impacts of spoil haulage on the surface road network were considered during development of the project. The spoil transportation strategy for the project includes road haulage from all sites, with the exception of the construction support sites at Yurulbin

Point (WHT4) and Berrys Bay (WHT7), where water-based transportation has been adopted to minimise impacts on narrow streets through harbourside areas.

In addition to the mitigation measures adopted within the proposed construction strategy, additional options to reduce spoil haulage impacts have been considered, including rail or barge as outlined below.

Rail

Freight rail was considered as a mode of spoil transport that may offer the opportunity to move large volumes of material and reduce the number of heavy vehicle movements on the Sydney road network. However, when considering the location of the project and associated construction support sites, this method presents the following issues:

- The material would need to be at least double and, most likely, triple handled. Trucks would be required to move material from construction support sites to a suitable train loading facility, and from the rail terminus to the final disposal location. This would significantly undermine the benefits of any such arrangement, as heavy vehicles are typically on the motorway network shortly after leaving the proposed tunnelling construction support sites. Analysis of haulage to potential train loading facilities concluded that heavy haulage distances on non-motorways would actually increase if this option was adopted
- There are few spare timeslots for freight trains on the Sydney rail network, which presents a significant construction risk. If this material cannot be reliably moved, large spoil storage facilities would be required to ensure tunnelling operations are not interrupted
- Infrastructure upgrades would be necessary to develop an appropriate train loading facility to receive the material.

Barge

As with rail, the main benefit of barge transport is the potential to move large volumes of spoil, while reducing the number of heavy vehicle movements on sensitive areas of the Sydney road network. The benefits of this method are particularly pronounced on local roads near water-based construction support sites, which are generally not suitable for large numbers of heavy vehicle movements. This is the rationale for adopting this method for haulage from the proposed Yurulbin Point (WHT4) and Berrys Bay (WHT7) construction support sites.

However, beyond these two sites, this option presents a number of issues including:

- The material would need to be double (or possibly triple) handled, as trucks would be required to move material to a harbourside barge loading facility, and from the barge to its final disposal location
- Infrastructure upgrades would potentially be required to allow the barge loading facility to receive the material
- Given the final spoil disposal locations are likely to be within the Sydney Basin, this option is unlikely to increase heavy haulage impacts on local roads when considering that heavy vehicles are typically on the motorway network shortly after leaving the proposed tunnelling construction support sites.

Preferred alternative

A combination of trucks from most of the proposed construction support sites, and barging from the water-based construction support sites at Berrys Bay (WHT7) and Yurulbin Point (WHT4) is the preferred spoil transport method for the project. With major tunnelling construction support sites located near to the urban arterial network at Victoria Road and the

Warringah Freeway, or Sydney Harbour, this solution minimises impacts on the local road network, and would deliver a value for money solution.

Chapter 6 (Construction work) provides a summary of heavy vehicle movements, including spoil related haulage. Use of local roads would be avoided where possible, with the main haulage routes being via major arterial roads.

4.5.6 Tunnelling spoil reuse and disposal alternatives

As described in Chapter 24 (Resource use and waste management), spoil would be beneficially reused as part of the project before alternative spoil disposal options, such as other infrastructure or development projects, were pursued.

Most of the spoil generated by the project would be VENM, which is considered a desirable material for clean fill in development sites and major earthworks projects across Greater Sydney. Generally, VENM is not disposed of at licenced landfills, primarily due to the high cost of doing so in comparison to reuse at development sites.

Residual spoil waste which cannot be reused or recycled would be disposed of to a suitably licensed landfill or waste management facility. Potential opportunities for reuse of spoil within the project include use for the formation of embankments and earth mound noise barriers, site rehabilitation and landscaping, road upgrades and infill for temporary tunnel access shafts and declines.

Alternative and/or additional spoil reuse options may be identified by the construction contractor as the project progresses.

Determination of the final destination(s) for spoil from construction of the project would be made during further design development and may include more than one disposal site.

4.5.7 Dredged material management alternatives

The project would require material to be dredged from Sydney Harbour to allow for the construction of the immersed tube tunnel crossing between Birchgrove and Waverton. A number of options for the disposal and reuse of dredged material have been considered as part of the development of the project, including:

- Land disposal at a licensed waste management facility
- Offshore disposal.

A summary of the alternatives considered for the disposal and reuse of dredged material is provided below.

Land disposal at a licensed waste management facility

Disposal of all dredged material at a licensed waste management facility would require:

- Dewatering to a spadable condition prior to disposal, potentially requiring mixing of the material with additives to alter the consistency of the dredged material, enabling it to be transferred to land. Dewatering may require large areas of land, depending on the quantity of material, which may result in additional property acquisition, large and noisy machinery and potential impacts on nearby receivers
- Large volumes of marine vessel movements to transfer dredged material to land
- Potential odour impacts to nearby receivers

- Additional heavy vehicle movements to transfer material (once spadable) to a licensed waste management facility.

Disposal of this material at a licensed waste management facility would likely be at a landfill and would therefore require the use of landfill space. Given the potential environmental impacts associated with the disposal of all dredged material to a licensed waste management facility, this option was not considered feasible.

However, it is expected that the top 1.5 metres of material dredged from Sydney Harbour as part of the project may not be considered suitable for sea disposal. The reuse of this material is not an option and, given the smaller amount of material, disposal at a licensed waste management facility is considered an appropriate option.

Offshore disposal

An application for offshore disposal of suitable dredged material has been submitted to the Commonwealth Department of the Environment and Energy. Offshore disposal is regularly used by marine dredging projects in New South Wales, with licenced disposal grounds in operation off Sydney Harbour and Newcastle. These sites have been carefully selected by the Commonwealth to provide suitable disposal grounds for dredge material and minimise impacts on sensitive marine ecology. The designated offshore disposal site is over 20 square-kilometres in area and is a non-dispersive ground, meaning that material placed within the area generally does not migrate from that area.

Material disposed of at the designated offshore disposal site would comprise sediments removed from Sydney Harbour during the construction of cofferdams at Sydney Harbour south (WHT5) and Sydney Harbour north (WHT6), and dredged material removed from Sydney Harbour as part of the construction of the immersed tube tunnels.

Disposal of suitable dredged material at the designated offshore disposal site would:

- Avoid disposal of spoil to land based site
- Avoid additional heavy vehicle movements on the road network
- Minimise some environmental impacts such as noise, odour and dust at sensitive receivers, by avoiding the need to carry out treatment, dewatering and land-based transport of a large quantity of dredged material
- Avoid the creation of a significant waste stream on land.

Material would be required to satisfy the requirements of the *National Assessment Guidelines for Dredging* (Department of Environment, Water, Heritage and the Arts, 2009) before being considered suitable for disposal at the designated offshore disposal site.

Preferred dredged material management option

The preferred option for the disposal and/or reuse of dredged material is a combination of offshore disposal and disposal at a licensed waste facility. To minimise the potential environmental impacts associated with the disposal and reuse of dredged material, where dredged material complies with the *Environment Protection (Sea Dumping) Act 1981*, it would be disposed of at the designated offshore disposal site. Where material is not suitable for offshore disposal, treatment, dewatering and disposal on land to a licensed waste management facility would be carried out.

Chapter 6 (Construction work) provides a summary of heavy vehicle and vessel movements relating to the transport of dredged material to land for disposal at a licensed waste management facility. Chapter 24 (Resource use and waste management) details the indicative quantities of material requiring disposal at a licensed waste management facility and suitable for disposal at the designated offshore disposal site.

Offshore disposal of dredged material would be conducted outside NSW and is therefore not regulated under the *Environmental Planning and Assessment Act 1979*. Daily maximum construction maritime traffic volumes and routes to navigational channels that lead to Sydney Heads, including offshore barge movements for dredged spoil, are summarised in Chapter 6 (Construction work) and considered in Chapter 8 (Construction traffic and transport) and Appendix F (Technical working paper: Traffic and transport). Noise impacts related to the loading and unloading of barges at water-based construction support sites have been considered in Chapter 10 (Construction noise and vibration) and Appendix G (Technical working paper: Noise and vibration).

RMS 19.1441
ISBN 978-1-922338-08-2