PROJECT DEVELOPMENT AND ALTERNATIVES

CHAPTER FOUR

4 Project development and alternatives

This chapter describes the evaluation process undertaken to determine the preferred option. It includes an overview of the strategic alternatives, the alignment options, and station options. This chapter also identifies the consequences of not proceeding with the project.

4.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to project development and alternatives, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 4-1.

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

Ref.	Secretary's environmental assessment requirements	Where addressed
2. Environmental Impact Statement		
2.1 (e)	an analysis of any feasible alternatives to the project	Strategic alternatives to the project are identified and analysed in Section 4.3.
2.1 (f)	a description of feasible options within the project	Options within the project are described in Sections 4.4, 4.5, 4.6 and 4.7.
2.1 (h)	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	A description of the alternatives and options process is provided in Sections 4.3, 4.4, 4.5, 4.6 and 4.7.

4.2 Overview of the project development process

A large number of studies have identified and assessed potential transport solutions between northern Sydney and the Sydney CBD, including suburban rail and metro alignments. The potential transport solutions have influenced strategic rail planning in documents such as *Sydney's Rail Future – Modernising Sydney's Trains (Sydney's Rail Future)* (Transport for NSW 2012a) and the *NSW Long Term Transport Master Plan* (Transport for NSW 2012b). Therefore, they have also influenced the development process for the Chatswood to Sydenham project.

4.3 Strategic alternatives

A number of strategic alternatives relevant to a metro rail network were considered during the development of the *NSW Long Term Transport Master Plan and Sydney's Rail Future*. These options were:

- Regulatory, governance and better-use reforms
- Investment in road, bus and light rail
- Rail network options.

These options are discussed below, together with an assessment of their overall effectiveness in meeting Sydney's growing transport needs.

4.3.1 Regulatory, governance and better-use reforms

As an alternative to further investment in Sydney Metro, the NSW Government has considered a range of regulatory, governance and better-use reforms. The reforms could include:

- Regulatory reform (including review of passenger transport legislation to allow for more flexible transport services)
- Governance reform (including centralising transport planning and policy functions within Transport for NSW and integrating land use and transport planning, including for major growth corridors)
- Better-use reform (including continued implementation of the integrated electronic ticketing system; a bus priority system; interchange upgrades; and improvements, expansion and modernisation of train and bus fleets).

While these reforms are vital to meeting the government's policy objectives and are already being implemented, additional investment in transport infrastructure will also be required to ensure Sydney's transport network meets future demand.

4.3.2 Investment in road, bus and light rail

The NSW Government is currently delivering or has delivered a number of road, bus and light rail projects across Sydney as part of the *NSW Long Term Transport Master Plan* (Transport for NSW, 2012b) and the *Sydney City Centre Access Strategy* (Transport for NSW, 2013a). These projects include WestConnex, NorthConnex, the CBD and South East Light Rail, Inner West Light Rail and a number of bus priority projects including the Northern Beaches Bus Rapid Transit project.

However, while investments in road, bus and light rail projects will form part of the solution to Sydney's transport needs, these options are, by themselves, insufficient to address forecast growth in travel demand. This is because of the number of people travelling to the Sydney CBD each day is forecast to grow to 775,000 by 2031, which equates to 116,000 more cars or 2,685 more buses each day.

Sydney's mature road network has limited opportunity for additional capacity to connect in to the Sydney CBD. New roads where possible, e.g. a proposed 'Western Harbour Tunnel' to provide additional cross-regional links, cannot provide the mass transit capacity required to support Sydney's growth.

With respect to buses and light rail, these are complementary modes, bringing customers to and dispersing them from the major transport hubs served by suburban and metro rail services. However, buses and light rail cannot wholly support the large hourly commuter movements required in and out of the Sydney CBD. Buses can potentially provide a flexible response to local demand pressures and light rail offers medium capacity solutions for major transport corridors, replacing lower capacity bus services. However, both modes would not provide sufficient mass transit capacity to address Sydney's transport bottlenecks.

4.3.3 Rail network options

Broad rail network options

Based on projected population growth and transport demand, additional investment in rail is seen as a more efficient and effective solution than other strategic alternatives discussed in Sections 4.3.1 and 4.3.2. In developing *Sydney's Rail Future*, 15 alternative capital investment options for an expansion of the transit network were identified. The 15 options were grouped into four broad options (refer to Table 4-2):

- Rail Future A Use of the existing suburban rail network
- Rail Future B Rebuilding parts of the existing network in order to run single-deck metro trains
- Rail Future C A metro rail system that would integrate with the existing rail network
- Rail Future D An independent metro rail system that would not integrate with the existing rail network.

Each option was strategically assessed against a number of evaluation criteria. These criteria included their ability to meet customer requirements; network capacity requirements; ability to improve network resilience; delivery risk; and cost effectiveness. A two-step process was used to select the preferred strategic option.

The first step involved an assessment of whether existing rail operations should be expanded and improved to provide continued operation of a double-deck fleet with a two-tiered system of suburban and intercity services (Rail Future A) or whether a separate, independent 'differentiated' network should be constructed to provide metro 'turn-up-and-go' services (Rail Future B, C and D). An assessment of these two options found that a metro service is required to meet demand in both the short and long term. Rail Future B requires conversion of the T1 North Shore Line services across the Harbour Bridge and rebuilding of other parts of the existing network, resulting in major disruptions and inconvenience for customers would impact on network reliability and resilience. Accordingly, Rail Future A and Rail Future B were discarded and not further evaluated.

The second step involved an analysis of the differentiated service options that would best deliver against the assessment criteria. Criteria applied when assessing differentiated service options included delivery of capacity increases in key sections of Sydney's rail network; high-quality service levels and provision of significant improvements in operational reliability required to service Sydney's growth. The analysis found that Rail Future C would be superior to Rail Future D as it provides interchange potential with the existing network, so Rail Future D was discarded.

Table 4-2 The four rail network options considered in Sydney's Rail Future

Option	Key features
Rail Future A – suburban option	This option would involve the use of the existing double-deck rolling stock on the existing network, including for all future expansions (ie a second harbour crossing). This option would have a capacity of 20 trains per hour per direction (or 24,000 people per hour per direction). However, this option could not meet the long-term capacity and service improvements required by the *NSW The Long Term Transport Master Plan* and would not meet customer expectations for reliability, improved journey times and convenience.
Rail Future B – rebuild option	This option would involve rebuilding parts of the existing network in order to run single-deck metro trains. It would require conversion of the T1 North Shore Line services across the Harbour Bridge and major upgrading of the existing Sydney CBD infrastructure and stations. Although rebuilding the existing network would improve capacity in the medium term, it would not meet demand in the long term because capacity would be restricted to the current single train line across Sydney Harbour. Conversion of the existing line to accommodate a metro rail network would need to occur while maintaining existing services (to the extent possible), and would result in major disruptions and inconvenience for customers for a number of years. Further, the existing stations at Town Hall and Wynyard are already congested and an increase in the number of services using these stations would impact on network reliability and resilience and affect customer safety.
Rail Future C – Sydney's Rail Future (Sydney Metro network)	This option would involve construction of a metro rail network that would operate independently of the existing rail network; however, it would provide integration and interchange points with the existing rail network. New infrastructure would mainly be used; however, a section of Sydney Metro Northwest (historically referred to as the Epping to Chatswood Rail Line) and the existing rail line between Sydenham and Bankstown would be converted to metro and form part of the metro network. This option includes a second crossing of Sydney Harbour and a new underground line within the Sydney CBD. Interchanges would be provided at key stations (eg Chatswood and Central). Rolling stock would be designed to provide faster boarding and alighting, which would reduce dwell and journey times.
Rail Future D – an independent transit system	This option would operate independently and not integrate with the existing rail network. It would require construction of a harbour crossing and a Sydney CBD line. This option would only benefit customers along the new lines and would not adequately address the future requirements of the rail network. It would result in marginal benefits in terms of service enhancement, capacity improvements and improved operating efficiency on the existing rail network. It would also be the most expensive of the four options and would divert funding from service improvements on the rail network.

Why Sydney Metro was selected

Rail Future C (referred to from this point as Sydney Metro, and incorporating the whole proposed Sydney Metro network) was selected as the preferred rail network option because it would:

- Be more flexible and provide frequent services that would benefit customers
- Provide the required capacity and flexibility to respond to growing demand for rail in Sydney
- Create a more modern, resilient and faster service
- Deliver a seamless and less disruptive way of modernising Sydney's rail
- Deliver transport benefits more cost effectively.

Benefits of Sydney Metro

In terms of expanding capacity on the rail network, Sydney Metro would substantially expand capacity on Sydney's most constrained transport corridors and eliminate dependence on the Harbour Bridge as the only mass transit harbour crossing between the North Shore and the Sydney CBD.

The new cross-harbour rail capacity combined with new stations on the North Shore and in the Sydney CBD would also allow for a reduction in buses crossing the Harbour Bridge, offering the potential for substantial reductions in congestion at North Sydney, Wynyard and Town Hall stations and a reduction in road congestion in Sydney's CBD.

The introduction of a metro station at Waterloo would also be consistent with, and would further realise the benefits of Rail Future C.

South of Central Station conversion of the Bankstown line between Sydenham and Bankstown

The full delivery of Sydney Metro, including Sydney Metro Northwest from Cudgegong Road and Sydney Metro City & Southwest extending to Bankstown, was identified as a strategic option in *Sydney's Rail Future*.

Various options were considered for the southern and western component of the Sydney Metro network beyond Central Station.

Converting the T3 Bankstown Line between Sydenham and Bankstown into a dedicated metro line would improve rail network reliability by reducing the number of rail lines sharing the same existing tracks and would facilitate much needed capacity increase from the west and southwest. The Sydenham to Bankstown upgrade would unlock capacity at Central Station platforms and enable the relocation of train paths on the City Circle. It would also significantly reduce platform and train crowding.

The T3 Bankstown Line does not share operations with other lines or rail freight. It would therefore be less complex to convert and segregate from the existing rail network when compared with other lines. The T3 Bankstown line would require less infrastructure work to convert to a metro service when compared with other lines, such as the T2 South Line and T4 Illawarra Line, which would require additional tunnels and tracks, significant enabling works such as alternative freight routes and a new train stabling and maintenance facility for Sydney Trains.

The decision to proceed with a conversion of the T3 Bankstown Line to a metro service led to the alignment of the project from south of Central Station to just north of Sydenham Station.

The Sydenham to Bankstown upgrade, including work at Sydenham Station will be subject to a separate environmental assessment process.

4.4 Station location options

The station options evaluation process used to determine preferred station locations involved a number of stages, each with an increasing level of detailed analysis. The project objectives (refer to Section 3.9) underpinned the evaluation criteria used in the options evaluation process.

The evaluation of station location options has followed a three-phase process:

- Phase 1 – This involved the identification and assessment of a long list of 34 station options to ensure all possible metro station locations were considered. Some potential station options were grouped into station localities to reflect their close proximity to each other. This resulted in 20 station localities being subject to a preliminary station assessment. Of the 20 localities, 13 were shortlisted for further evaluation
- Phase 2 – This involved detailed evaluation of the 13 short-listed station localities and identified a preference for two North Shore station localities and three CBD station localities
- Phase 3 – This involved stakeholder and community consultation on the preferred station localities and the identification of additional station locations seen as having merit to enhance the project and increase project benefits.

The evaluation of station locations is described in more detail in the following sections.

4.4.1 Phase 1 – evaluation of long list station location options

Initially a long list of 34 station options was identified. The selection of preferred station locations on North Shore required a different approach to the selection of station locations in the Sydney CBD that were more heavily influenced by alignment constraints such as building basements. Station locations between Chatswood and Sydney Harbour were identified as 'North Shore' station locations and station locations between Sydney Harbour and Central were defined as Sydney CBD station locations.

Of the 34 options, some were grouped into station localities to reflect their close proximity to each other. This resulted in 20 station localities being subject to a preliminary station assessment. Of the 20 localities, 13 were shortlisted for further evaluation. These locations are shown in Figure 4-1. The evaluation resulted in the removal of seven station locations from further assessment, as discussed in Table 4-3.

Table 4-3 Preliminary station location options that were not shortlisted for further evaluation

Station option	Rationale for not being short-listed for further evaluation
Willoughby and Naremburn	These stations would be located in residential areas with small centres. While these locations would result in a new rail catchment area, they would not serve or stimulate development.
Wollstonecraft and Waverton	The existing suburban rail stations at these locations serve a small residential catchment (comprising detached housing and strata development and a metro station would not serve a new rail catchment.
North Sydney	The existing North Sydney Station is constrained and would not serve a new rail catchment.
Milsons Point	The existing suburban rail station at Milsons Point serves a small residential catchment (characterised by detached housing and strata development). There are a number of heritage constraints at this location (including the Harbour Bridge – an item of outstanding national heritage significance).
Hickson Road (Dawes Point)	Although a station in the north Hickson Road area (at Dawes Point) would introduce public transport to an area currently with limited access, there is only a small catchment (population and employees) that would use the station.

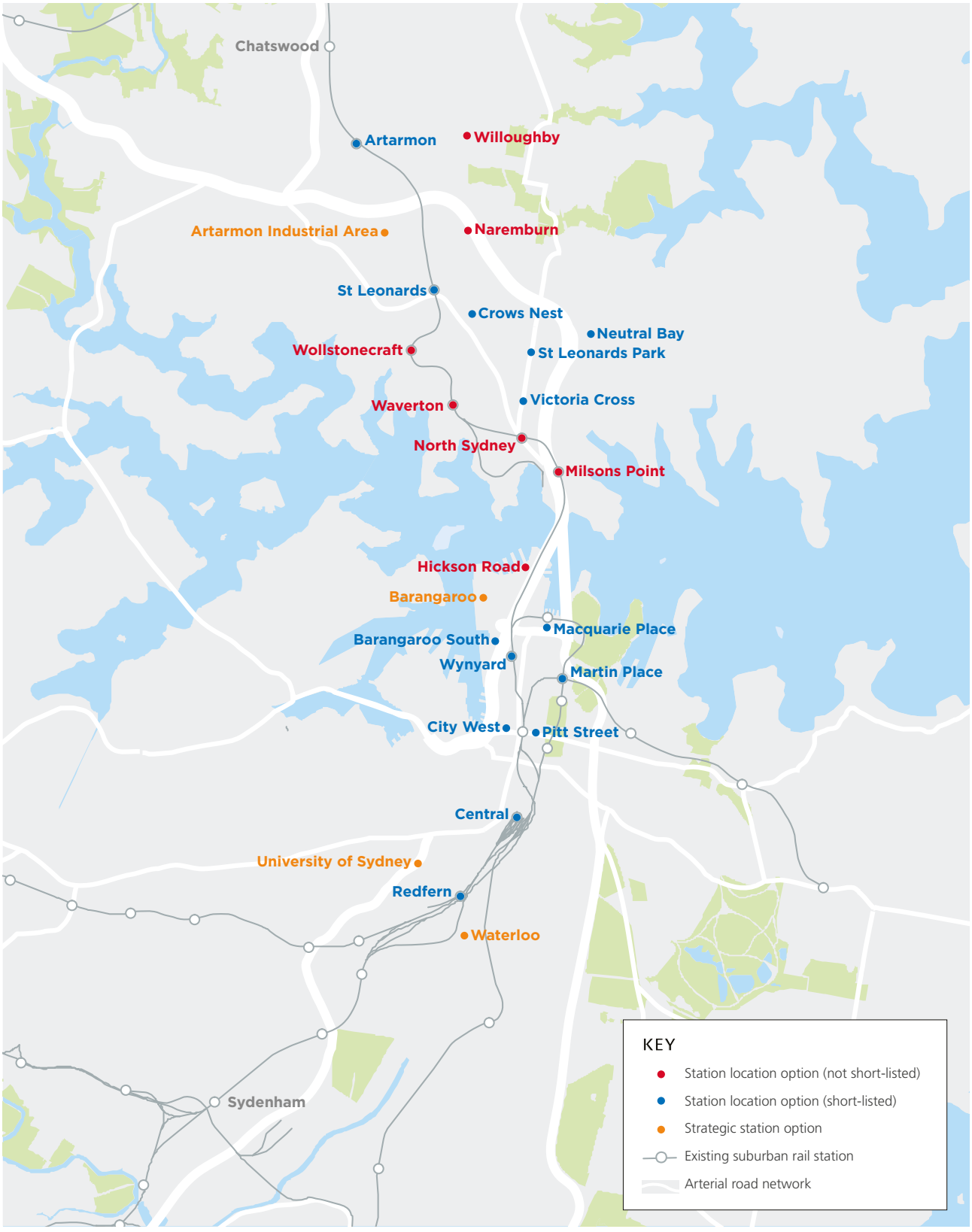

Figure 4-1 Preliminary station location options

4.4.2 Phase 2 – evaluation of short-listed station location options

Evaluation process

Phase two involved detailed analysis of the 13 short-listed station localities. Each of the remaining localities was evaluated against the project objectives using the process shown in Figure 4-2.

The process resulted in the selection of the preferred station location options ('base case' station locations).

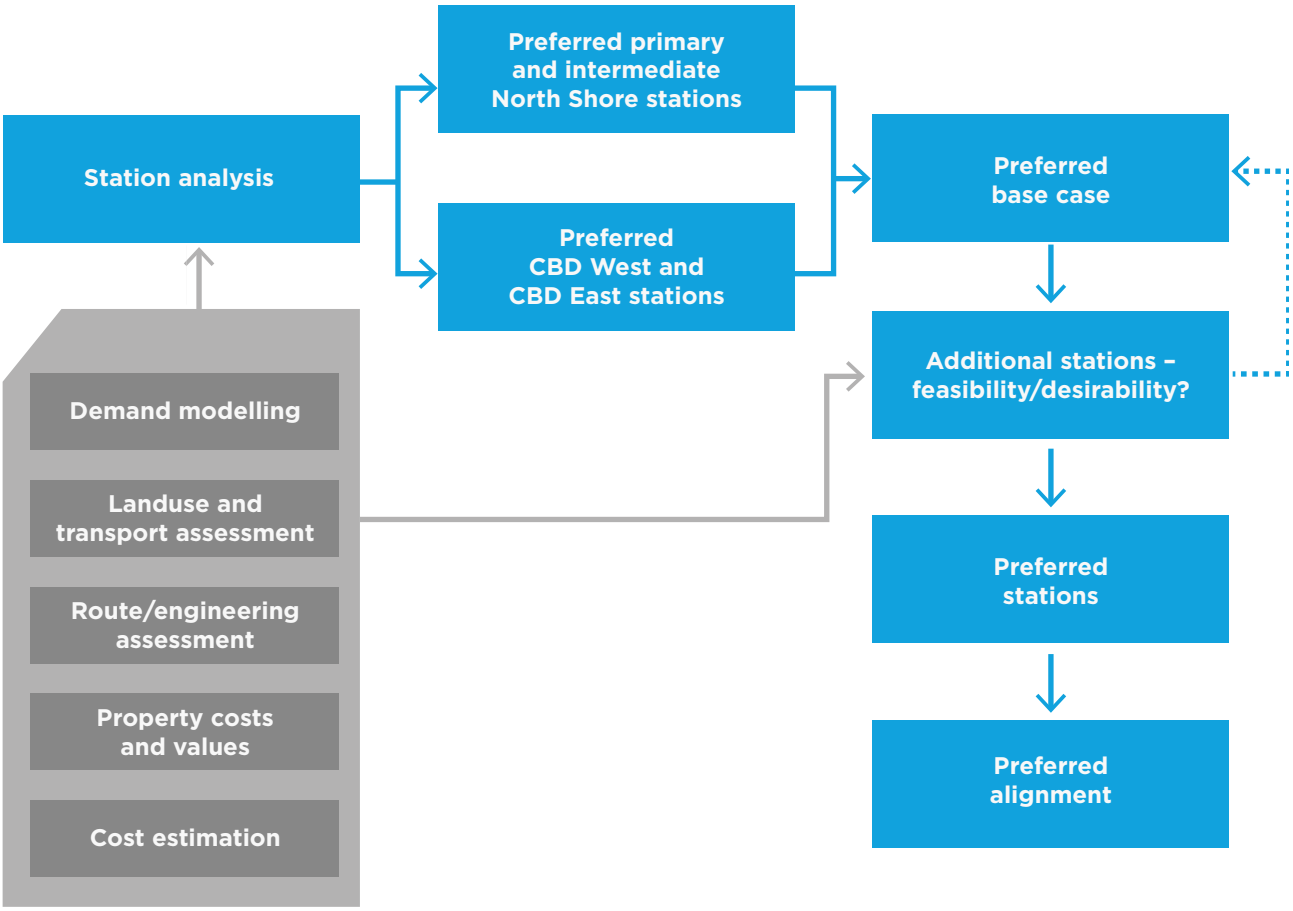

Figure 4-2 Process for evaluating the short-listed station locations

The performance of each of the remaining station locations was assessed against each of the objectives as either 'positive alignment' (green), 'some alignment, or neutral' (orange) or 'no alignment, or negative impacts' (red), as shown in Figure 4-3.

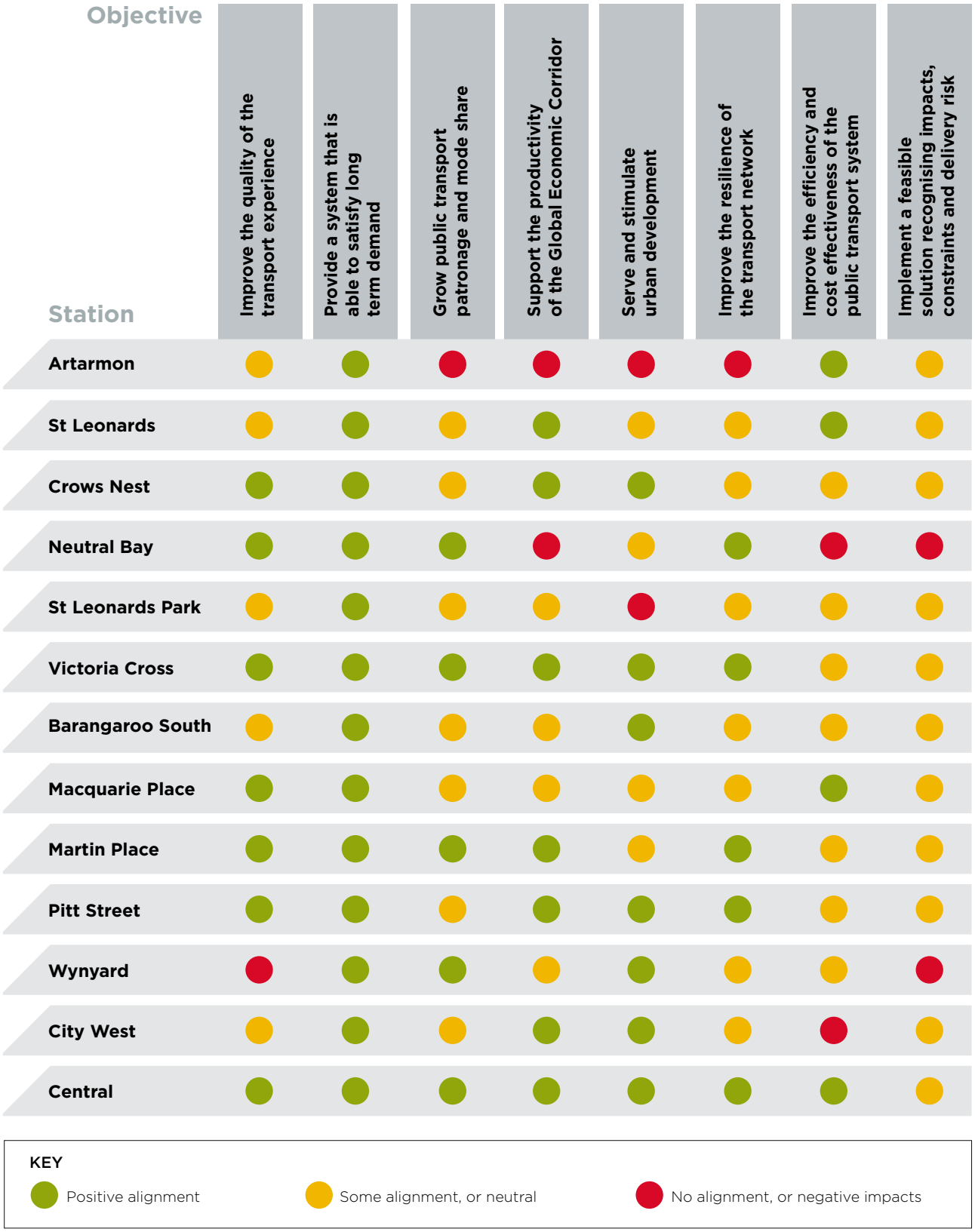

Figure 4-3 Performance of each short-listed station location against the project objectives

Findings of the short list evaluation process

The Artarmon, Neutral Bay and Wynyard station options were discarded as all performed poorly in the evaluation against more than one of the Sydney Metro project objectives. Artarmon is already served by a station on the Sydney Trains network and a metro station at Artarmon would not extend the rail catchment or provide significant travel times savings for customers. A station at Neutral Bay would not support the growth of the Global Economic Corridor and would not substantially improve public transport services for the Northern Beaches and Military Road corridor. Further, the locality was found to have a moderate ability to serve and stimulate development, particularly employment growth and only a moderate ability to serve major attractors.

Providing metro platforms at Wynyard Station would place further pressure on already constrained footpaths and underground connections around Wynyard Station, and would increase customer transfers at an already congested station.

St Leonards Park and City West also performed poorly on at least one of the objectives. St Leonards Park was subsequently compared with the alternative station at Victoria Cross. Victoria Cross was considered superior as it has a greater catchment area and a greater potential for residential, commercial and transit oriented development. St Leonards Park also has a number of heritage and environmental issues and was consequently discarded.

Further review of City West and Barangaroo South stations indicated that they would have a smaller current and potential future catchment than other Sydney CBD locations such as Martin Place. They would also have a number of physical constraints including the Cross City Tunnel alignment that would influence the location and depth of the stations, resulting in a material impact on the overall project cost. Given the relative advantages of alternative Sydney CBD stations (and a Sydney CBD eastern alignment) these stations were subsequently discarded.

A station at St Leonards would meet all the project objectives. However, further consideration indicated that, relative to a station at nearby Crows Nest, it would not extend the rail catchment and all future employment and dwelling growth would be within the existing rail catchment which is already well connected by public transport. In addition, construction of the station would cause disruption to existing customers during construction, and environmental and social issues associated with a tunnel boring machine launch site located close to sensitive receivers including the hospital. Sporting teams that utilise Gore Hill Oval would also need to be relocated. Accordingly St Leonards was not considered further as a preferred location for a metro station.

A station at Macquarie Place would meet all the project objectives. Compared to other Sydney CBD station locations Macquarie Place would have a smaller catchment and would overlap with the existing Circular Quay Station catchment, which already provides direct connections to Wynyard, Town Hall and Central stations and beyond. Accordingly Macquarie Place was not considered further as a preferred location for a metro station.

Crows Nest and St Leonards station options both performed well against the majority of the project objectives. These were carried forward for further investigation as part of Phase 3.

The preferred station locations are described in Chapter 7 (Project description – construction). During the development of preferred station designs a number of alternative station configurations may be considered. The station configurations may be reviewed for a number of reasons, including:

- Orientation of station buildings and associated infrastructure to provide effective and efficient access for customers, accessibility of station entry points, and integration with surrounding land uses
- The need to minimise environmental and property impacts
- Constructability
- The need to not preclude the potential for future over station development.

Preferred station locations

Based on the assessment of the short-listed stations, a decision was made to proceed with a project incorporating new metro stations at Crows Nest / St Leonards, Victoria Cross, Martin Place and Pitt Street, as well as new metro platforms at Central Station.

4.4.3 Phase 3 – additional station options

This phase involved stakeholder and community consultation on the preferred station localities and the identification of additional station location options, which were seen to have the potential to strategically enhance the project. This included further evaluation of a station location at either Crows Nest or St Leonards and the potential introduction of an additional metro station at the following locations:

- At Barangaroo
- In the Artarmon Industrial Area
- Between Central and Sydenham.

These additional station options, described below, were included because they would serve strategic transport needs.

Crows Nest or St Leonards

Based on further evaluation of both options and stakeholder and community feedback, the preferred station location is at Crows Nest. The Crows Nest Station location best meets the needs of this area by ensuring the new metro station is as close as possible to the St Leonards centre while also extending the rail catchment.

Barangaroo

A station at Central Barangaroo (as opposed to Barangaroo South, as discussed in Section 4.4.2) would serve the Barangaroo development and potentially some of the catchment area for Wynyard Station given connectivity improvements in the area associated with projects like Wynyard Walk.

Given the flexibility of the metro tunnel alignment, the provision of a metro station in the central to northern part of Barangaroo is possible while also providing a station at Martin Place.

The station would deliver a unique east west connection between Martin Place and Barangaroo, resulting in improved travel times between Barangaroo and other Global Economic Corridor centres, service special events and reduce future passenger demand on suburban rail platforms at Wynyard Station.

A station at Barangaroo would benefit from the high-quality public domain and amenity to be delivered as part of the broader Barangaroo development. It would connect the Central Barangaroo precinct to the metro network with cultural facilities, Barangaroo Reserve and entertainment within five minutes' walk and the Barangaroo South precinct within 10 minutes' walk. It would also provide a connection to the public domain and entertainment activities at East Darling Harbour. A station at Barangaroo would also service a residential catchment at Millers Point, Walsh Bay and future residents at Barangaroo.

A number of constraints have been considered during the development of sub-options and in the selection of the preferred location for a metro station at Barangaroo. The preferred location and station typology (cut-and-cover vs mined) of Barangaroo Station would have the following benefits:

- It would promote access to the Barangaroo precinct
- It would optimise the balance between station cost and customer outcomes (station depth, travel times, etc)
- It would minimise or avoid impacts on heritage items in the area including Millers Point Conservation Area, the Walsh Bay Wharves Precinct and the Millers Point / Dawes Point Village Precinct, although noting potential archaeological heritage significance as outlined in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).

A reference design for Barangaroo Station was assessed against the project objectives listed in Section 4.3.2. Considering that assessment (refer to Figure 4-4) and further consultation with key stakeholders, a station at Barangaroo has been included as part of the Sydney Metro project.

The preferred Barangaroo Station location and configuration has been selected to avoid conflicts with other Barangaroo developments; contain (as far as possible) the station entry and facilities building in the Barangaroo development site and allow for the efficient location of tunnel services and emergency facilities at the ends of the station.

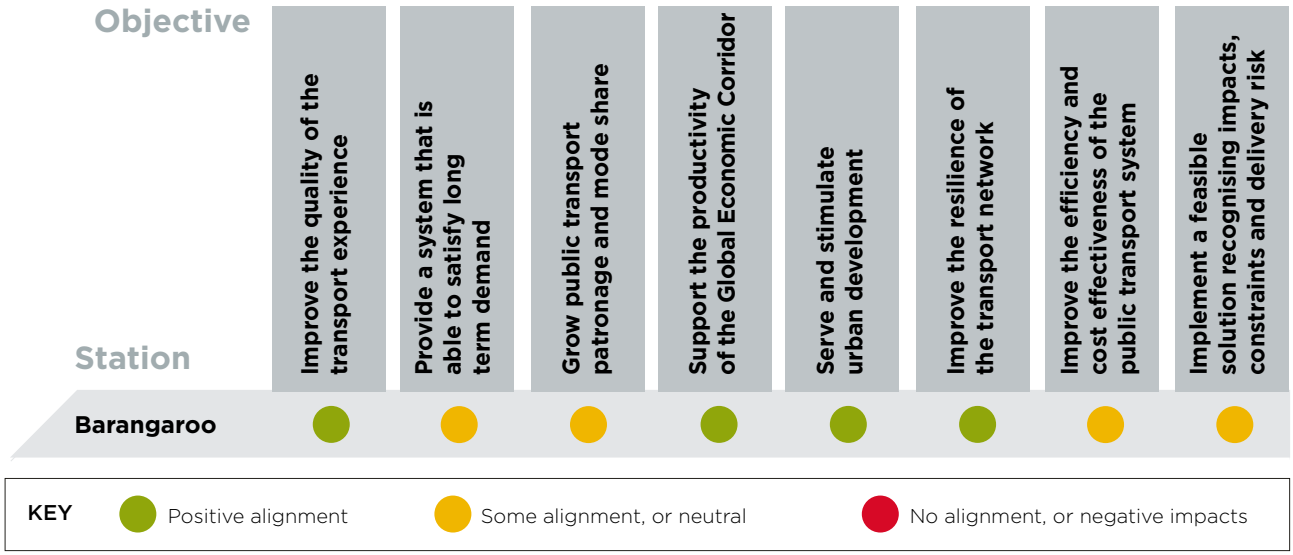

Figure 4-4 Performance of Barangaroo Station location against the project objectives

Artarmon Industrial Area

A station in the Artarmon Industrial Area would facilitate easier access to Artarmon employment areas and result in greater opportunities for commercial, mixed use and higher density residential dwellings.

There is a clustering of traditional light industrial activities, as well as specialist activities such as health and media. The Artarmon Industrial Area is uniquely located with high-quality access for medium and large vehicles, and with a substantial buffer between industry and residential uses. The area supports over 11,000 jobs, has low vacancy and high rents. It has an estimated contribution of $1.6 billion to the NSW economy each year.

The benefits of a station at this location are dependent on the realisation of urban renewal opportunities in the area. However, consultation with major stakeholders indicated that there was limited support for such a major land use change.

The importance of the wide range of industrial uses was recognised. The area would therefore retain its industrial uses, employment and services, resulting in a low demand for transport and a poor return on investment for a station in this area. The performance of an Artarmon Industrial Area Station was assessed against the project objectives (refer to Figure 4-5). Given the high cost of construction of an underground station, and limited ability to serve and stimulate urban development and relieve the existing transport network, an Artarmon Industrial Area Station was not considered further.

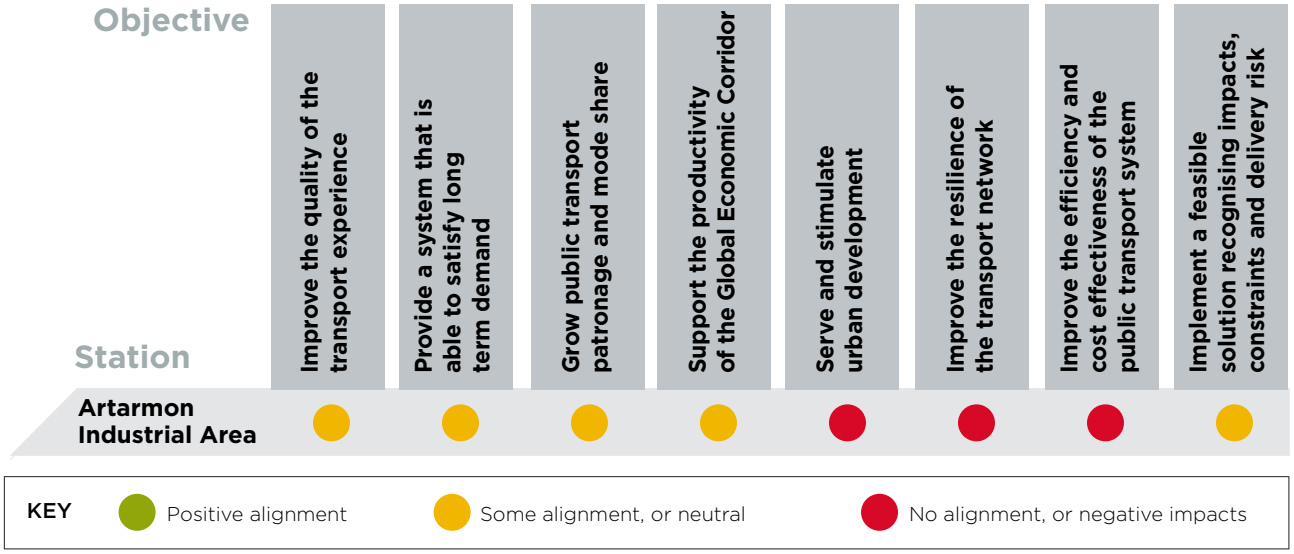

Figure 4-5 Performance of Artarmon Industrial Area Station against the project objectives

A station between Central and Sydenham

A long list of 12 station options was identified for the area between Central and Sydenham. An assessment of these station options against the project objectives was carried out (refer to Figure 4-6).

The assessment identified that new underground metro stations at Erskineville, Green Square, St Peters and Newtown would not serve a new rail catchment and would result in a limited shift to public transport services. Further, these locations would not serve or stimulate new development. As a result these stations were discarded.

Whilst a station at Doody Street would support a new rail catchment and would provide relief to existing bus services, a tunnel alignment associated with this station was considered unreasonable (due to its length and presence of tight curves) and this station was not considered further.

Due to their proximity to existing rail stations, the new rail catchment at Ashmore, Australian Technology Park and Wilson Street (Eveleigh) would be limited, resulting in a limited shift to public transport. Stations at Ashmore and Wilson Street (Eveleigh) would not provide any significant relief to existing public transport services. As such, these station options were also discarded.

Redfern was discarded as a metro station location because suburban rail connections already exist at Central and Redfern stations (that is, Central and Redfern also offers connections to intercity trains and other modes). Redfern also has some construction and technical issues including constraints with the existing station layout and heritage constraints.

McEvoy Street was also discarded as a metro station as is would not provide relief to the existing transport network, and the land use changes in the area would occur regardless of a metro station.

Based on the outcome of the assessment, it was decided to further consider two locations between Central and Sydenham (The University of Sydney and Waterloo).

Station	Improve the quality of the transport experience	Provide a system that is able to satisfy long term demand	Grow public transport patronage and mode share	Support the productivity of the Global Economic Corridor	Serve and stimulate urban development	Improve the resilience of the transport network	Improve the efficiency and cost effectiveness of the public transport system	Implement a feasible solution recognising impacts, constraints and delivery risk
Ashmore	🟡	🟡	🔴	🟡	🔴	🔴	🟡	🟡
Australian Technology Park	🟡	🟡	🟡	🟡	🟡	🟢	🟡	🟡
Doody Street	🟢	🟡	🟡	🟢	🟢	🟢	🟡	🟢
Erskineville	🔴	🟡	🔴	🔴	🔴	🟢	🟡	🔴
Green Square	🟢	🟡	🟡	🟢	🟡	🟢	🟡	🟡
McEvoy Street	🟢	🟡	🟢	🟢	🟢	🟢	🟡	🟡
Newtown	🟡	🟡	🔴	🔴	🟡	🟢	🟡	🔴
Redfern	🔴	🟡	🟡	🟡	🟡	🔴	🟡	🔴
St Peters	🔴	🟡	🔴	🔴	🔴	🟢	🟡	🔴
The University of Sydney	🟢	🟡	🟡	🟢	🟢	🟢	🟡	🟡
Waterloo	🟢	🟡	🟢	🟢	🟢	🟢	🟡	🟡
Wilson Street (Eveleigh)	🔴	🟡	🔴	🟡	🟡	🔴	🟡	🔴

KEY

🟢 Positive alignment

🟡 Some alignment or neutral

🔴 No alignment, or negative impacts

Figure 4-6 Performance of station options between Central and Sydenham against the project objectives

The University of Sydney or Waterloo

The University of Sydney is located between Parramatta Road and City Road and close to other arterial roads such as Cleveland Street and Glebe Point Road. The university is a key education precinct and is also close to health and retail precincts such as Royal Prince Alfred Hospital and the Broadway shopping area.

Waterloo is a centre for community and cultural activity and is a growing residential area, with business activity increasing in recent years. The NSW Government has earmarked Waterloo for greater residential development and urban renewal.

A station at Waterloo would take pressure off Redfern and Green Square stations and provide local residents with more public transport options, while encouraging the introduction of new homes, jobs, parks and community facilities to meet the needs of a growing Sydney.

A new metro station at Waterloo would help revitalise the Waterloo precinct and would also:

- Provide a high quality connection with bus services along Botany Road
- Provide additional connectivity to Australian Technology Park and Redfern Station
- Contribute to the NSW Government objective to transform Waterloo and Redfern.

The metro station would also allow further development and expansion of the Global Economic Corridor between the Sydney CBD and Green Square.

Outcomes of strategic options assessment

Based on the assessment of the strategic options against the project objectives, Sydney Metro decided to:

- Include a station at Crows Nest
- Include an additional station at Barangaroo
- Not include a station in the Artarmon Industrial Area
- Include a station at Waterloo.

4.5 Alignment options

4.5.1 Influences on the project alignment

The alignment of the Chatswood to Sydenham project has been influenced by:

- Previous investigations (refer to Section 4.2)
- Station locations
- Design criteria such as vertical and horizontal alignment requirements
- A decision on a Sydney CBD east or Sydney CBD west alignment
- Avoidance of underground constraints such as deep basements and major utilities.

More recent alignment options (based on possible station location combinations) are shown in Figure 4-7.

4.5.2 Sydney CBD east or Sydney CBD west alignment

A number of studies have focused on rail / metro alignments through the Sydney CBD. These have been separated into eastern and western options and hybrids of the two. As a result of these previous studies, two protected corridors have been previously created through the Sydney CBD – the CBD Rail Link corridor and the CBD Metro interim rail corridor.

Key issues considered in the selection of the alignment (in the context of metro rail network performance parameters) included the point of connection with the existing rail network in the north and south, and the preferred Sydney CBD station locations. As discussed in Section 4.4.3, given the flexibility of the metro tunnel alignment, the provision of a metro station in the central to northern part of Barangaroo was not an influencing factor in the selection of a Sydney CBD east or a Sydney CBD west metro alignment.

Both the CBD east and CBD west alignment options identified a combination of new and augmented existing stations:

- The eastern alignment included a new station at Martin Place and at Pitt Street (between Park and Bathurst streets) and an augmented Central Station
- The western alignment included an augmented Wynyard Station, a new City West Station (between Town Hall Station and Darling Harbour) and an augmented Central Station.

The evaluation process resulted in the eastern alignment being preferred based on a number of factors:

- The separation of the metro rail network from the existing rail network, especially at Wynyard Station (eastern alignment), means the project could accommodate long-term future demand (of up to 30 trains per hour in the morning peak period across Sydney Harbour)
- The inclusion of a Wynyard metro station (western alignment) would increase pedestrian numbers and congestion within the Wynyard precinct beyond what would otherwise be expected in 2036; and by about 13,000 additional passenger exits in the morning peak period
- Augmentation of existing operational stations (western alignment) would have substantial constructability issues and result in additional construction costs and an extended construction program (Central Station is the only station augmentation required for the Sydney CBD eastern alignment)
- New stations along the eastern alignment would provide better interchange opportunities (Martin Place Station with the T4 Eastern Suburbs Line, and Pitt Street Station with buses, light rail and Town Hall Station). These interchange opportunities would better relieve passenger demand at critical stations including Martin Place and Town Hall.

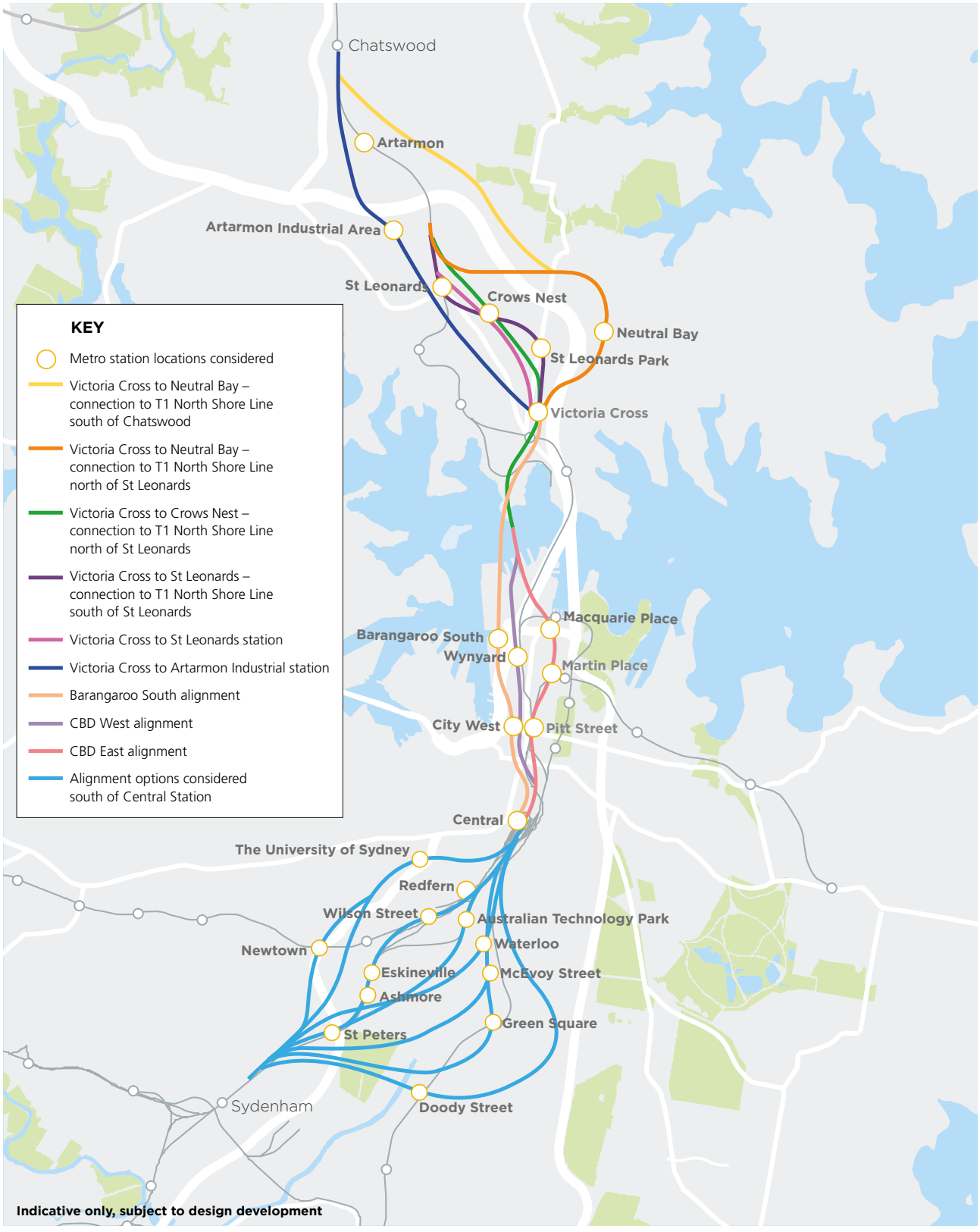

Figure 4-7 More recent alignment options considered based on possible station location combinations

4.6 Crossing of Sydney Harbour

Aboveground and underground options were considered for crossing Sydney Harbour. These included:

- A new carriageway beneath the Sydney Harbour Bridge
- A new rail viaduct above lanes seven and eight of the Sydney Harbour Bridge
- Conversion of lanes seven and eight of the Sydney Harbour Bridge to accommodate metro rail
- An immersed tube tunnel resting on the seabed
- Bored tunnels below the seabed through rock
- Bored tunnel below the seabed through rock and sediments.

4.6.1 Aboveground options

Options to install a new carriageway beneath the Sydney Harbour Bridge or to install a new viaduct above lanes seven and eight were found to have a number of constraints, such as impacts on (reductions to) shipping heights and / or substantial modification to the Sydney Harbour Bridge, which is a major landmark and a listed place on the National Heritage List. These options would also have broader network impacts during construction and operation (particularly in terms of access to the Sydney CBD for other transport modes). Consequently, these options were not progressed further.

The conversion of lanes seven and eight to accommodate the metro network would require connections to metro tunnel alignments to the north and south of the Harbour Bridge. Unlike the tunnel option (see below), use of the Sydney Harbour Bridge would require the use of existing suburban rail stations and platforms at North Sydney and Wynyard. The use of existing infrastructure for the project would largely result in replication of the existing T1 North Shore Line and would not provide additional rail services to new areas. Further, using existing infrastructure would have operational limitations; in particular, this option could not meet long-term capacity requirements (that is, there would be less than 30 trains per hour) and would result in longer journey times than a new tunnel. In addition, using the Sydney Harbour Bridge is estimated to cost substantially more than the preferred bored tunnel option (by over $400 million).

4.6.2 Underground options

Options investigated for underground crossing of Sydney Harbour included an immersed tube tunnel, bored tunnels through the bedrock and bored tunnel through a combination of bedrock and sediments. These options are shown on Figure 4-8.

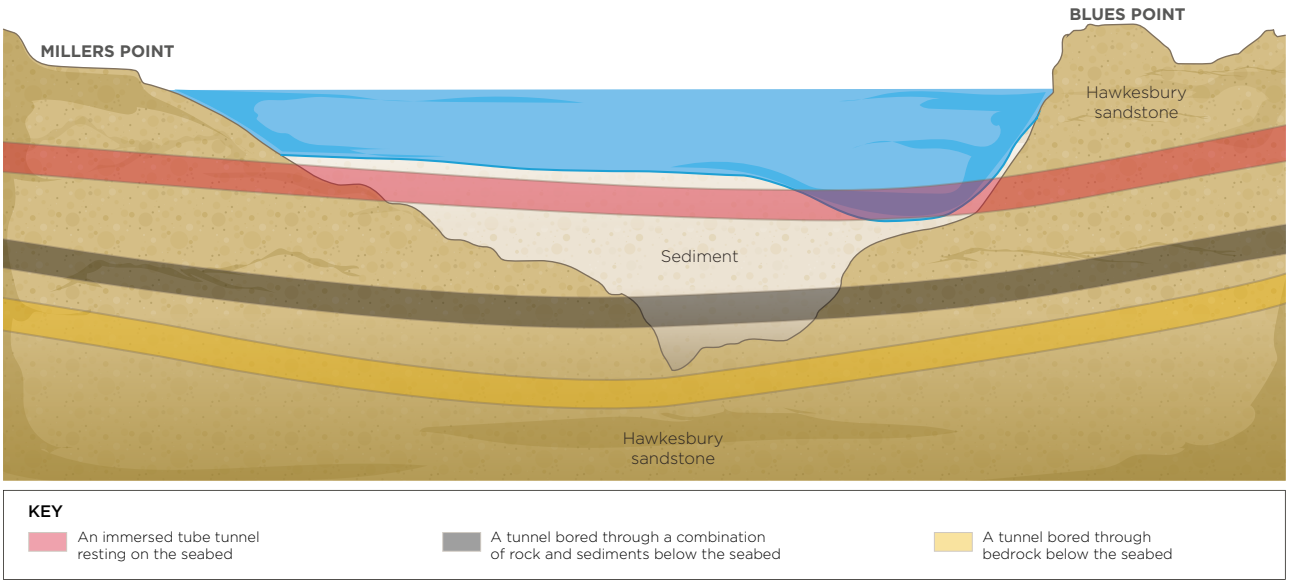

Figure 4-8 Sydney Harbour crossing vertical alignment options considered

A comparative assessment was carried out for these options. It found that:

- An immersed tube option is a favourable option in terms of station depth and tunnel gradient, but the likely environmental impacts associated with dredging and cofferdam construction in the harbour would be considerable, as compared with the tunnel boring machine options. Costs are also likely to be significantly higher than the bored tunnel options
- Given the depth to rock below the harbour, a tunnel bored entirely through rock would result in unacceptable station depths at Barangaroo and at Victoria Cross and / or unacceptable tunnel gradients
- Keeping the tunnel alignment wholly within rock would still likely require a specialised tunnel boring machine for the Harbour Crossing due to the anticipated poor rock quality and high water pressure
- A shallower tunnel involving tunnelling through rock and sediments would result in acceptable station depths. Whilst there would be some construction risks associated with tunnelling through sediments and transition zones from rock to sediment, they are considered to be manageable. The options for managing these transition zones from rock to sediment are discussed in Section 4.6.3.

Given these factors, a bored tunnel through a combination of bedrock and sediments was selected as the preferred option for crossing Sydney Harbour.

4.6.3 Sydney Harbour sediment ground improvement options

The need for ground improvement

Ground improvement (treatment to solidify sediments and other non-rock material), especially at rock-sediment transition zones has been considered for a number of construction-related reasons. Ground improvement would reduce construction risk to workers, prevent damage or excessive wear of cutter tools and allow for inspection of the tunnel boring machine cutter head prior to driving through the rock – sediment transition zones.

Specifically, ground improvement would:

- Reduce safety risks for construction workers by avoiding the need to undertake tunnelling in high pressure (up to 5 bar) environments
- Minimise risks associated with ground instability and / or air-loss issues of rock-sediment transition zones.

The feasibility of a tunnel below the harbour through rock and sediments was subject to detailed investigations including advice from a number of international tunnelling experts. Based on this advice it was concluded that it would be practical to tunnel below Sydney Harbour through rock and sediments using either a traditional slurry tunnel boring machine or a mix-shield tunnel boring machine.

Area targeted for ground improvement

Ground improvement would require the establishment of a grout zone (solid block of cementicious material about 35 metres wide by 20 metres long by 16 metres deep) at the two points where the tunnel alignment passes through a sediment-rock transition zone.

The proposed grout zone would need to extend from about six metres above the tunnel profile to about three metres below the tunnel profile and about six metres either side of both the tunnel profiles. The maximum depth of grouting is estimated at about 40 metres.

The feasibility of different types of ground treatment has been investigated as described below.

Ground treatment options considered

Ground improvement by jet grouting

Jet grouting would involve the injection of a cement grout and would need to be carried out from barges on the harbour. The grout would be delivered to the barges from an on-shore facility and would be injected from the barge via a crane and drilling lead. The use of barges would introduce a number of construction challenges, in addition to logistical issues associated with maintaining open shipping channels.

Jet grouting would result in a smaller physical footprint on the bed of the harbour compared with deep soil mixing (see below) and can better target the necessary treatment zone compared with deep soil mixing techniques.

Ground improvement by deep soil mixing

Deep soil mixing would involve the mechanical mixing of the harbour sediments with a cementitious slurry in order to form columns. Similar to the jet grouting approach, this method would need to be carried out from barges on the harbour, with deliveries of grout via barges.

Deep soil mixing would result in greater disturbance of the bed of the harbour compared to the jet grouting method and, potentially, result in the need to carry out ground improvement over a larger area than jet grouting.

Ground improvement by ground freezing

Ground improvement by ground freezing would involve installing about 24 drill pipes around the circumference of both tunnel alignments and circulating liquid nitrogen through the pipes to freeze all material present at the two rock-sediment transition zones. While this option would have less environmental impact on Sydney Harbour than jet grouting or deep soil mixing, this technique:

- Requires a large construction footprint at Blues Point and / or Barangaroo to support drilling operations and the laying out of drill pipes
- May not be a suitable solution where soft silty material needs to be treated or if the strength of the tunnel bedding material also requires improvement.

This option would also have the greatest construction costs.

Outcome of review of ground treatment options

Following review of the benefits and limitations of each ground improvement technique, jet grouting from barges or deep soil mixing were both considered feasible, however jet grouting would have less overall impact than deep soil mixing.

Based on the current understanding of the project, jet grouting is considered to be the most likely option for ground improvement works should they be required. As such, this approach has been assessed as part of this Environmental Impact Statement. Notwithstanding, ground freezing may be a feasible option depending on the future development of the project and construction techniques.

Further details regarding ground improvement construction methods are provided in Chapter 7 (Project description – construction).

4.7 Dive structures options

A dive structure is required where the surface track transitions to underground tunnel. These would be required near Chatswood (northern dive structure) and just north of Sydenham Station (southern dive structure), as discussed below.

4.7.1 Northern dive structure

Northern dive structure options

Due to a number of factors, including topography, proximity of adjacent infrastructure, engineering requirements, there are limited options for the northern dive structure location. The five options considered were:

- A dive commencing immediately south of St Leonards Station, transitioning into a tunnel north of River Road (St Leonards Option 1)
- A dive north of St Leonards Station, commencing about 100 metres north of the road bridge at Lambs Road, Artarmon (near the Francis Street / Station Street intersection), transitioning into a tunnel about 90 metres south of Lambs Road (near the Francis Street / Park Road intersection) (St Leonards Option 2)
- A dive commencing immediately south of Chatswood Station:
  - transitioning into a running tunnel located within the rail corridor, north of Mowbray Road (Chatswood Option 1)
  - transitioning into a tunnel portal located outside the rail corridor (eastern side), north of Mowbray Road (Chatswood Option 2)
  - transitioning into a tunnel portal located outside the rail corridor (western side), north of Mowbray Road (Chatswood Option 3).

Evaluation of northern dive structure options

The locations of these options are shown in Figure 4-9. Factors influencing the location of the northern dive and tunnel portal include:

- The length of new tunnel versus the extent of work required to accommodate metro tracks within the existing rail line, impacts on existing infrastructure and the extent of 'associated infrastructure' work required
- Interface with existing Sydney Trains and Sydney Metro Northwest operations
- Property impacts including the extent and type of property acquisition required
- Environmental constraints and potential community and business impacts
- Constructability considerations, including customer disruption associated with rail network impacts
- Preferred station locations, particularly in respect of whether a station would be located at Artarmon, St Leonards and / or Crows Nest (this is discussed further in Section 4.4).

Given that Crows Nest has been identified as the secondary North Shore station for Sydney Metro, a dive south of St Leonards Station was discarded based on a number of factors including journey time impacts, adverse environmental and community impacts (particularly during construction), and vertical and horizontal alignment limitations (that is, the tunnel alignment could not meet design requirements and access a Crows Nest station location).

Options to locate a dive structure immediately south of Chatswood Station were preferred over a dive north of St Leonards Station. These options would place a majority of the alignment below ground from Chatswood Station, delivering the following benefits:

- Minimise acquisition of non-government property
- Avoid a complex and prolonged construction interface around Artarmon Station, thereby avoiding substantial customer, community and business impacts in Artarmon
- Avoid direct impacts on the heritage listed Artarmon Station and Artarmon Heritage Conservation area
- Avoid impacts on Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges (a critically endangered ecological community listed on the NSW *Threatened Species Conservation Act and Commonwealth Environment Protection and Biodiversity Conservation Act*) that is located next to (and east) of the rail line between Artarmon Station and the Gore Hill Freeway
- Reduce construction complexity and risks and operational interfaces by, as much as possible, separating Sydney Metro assets and infrastructure from existing operational Sydney Trains assets
- Reduce the extent of noise walls required along the existing rail corridor by over one kilometre.

Given these benefits, a dive north of St Leonards Station was discarded in favour of a Chatswood dive option.

As shown in Figure 4-9, the three Chatswood dive options share a northern start point, with the primary difference between them relating to the tunnel alignment and portal orientation in the south. A tunnel portal located on the western side of the rail corridor (Chatswood Option 3) was identified to have a number of technical, operational and community benefits over the other two options. It would:

- Avoid acquisition of residential properties
- Avoid impacts on a heritage listed item and Chatswood Heritage Conservation Zone
- Reduce the extent, intensity and duration of construction work next to and impact upon operational Sydney Trains assets
- Avoid impacts to Mowbray Road Bridge during construction
- Provide for the establishment of a tunnel support site away from surrounding residential properties, which would reduce construction noise and other amenity impacts on adjacent receivers
- Substantially reduce construction costs compared to Chatswood Option 1 (Chatswood Option 2 would have a similar construction cost to Chatswood Option 3).

Notwithstanding these benefits, Chatswood Option 3 would have a number of impacts, including:

- The need to permanently close the road bridge at Nelson Street
- Acquisition of an Ausgrid property, containing one heritage listed property ('Mowbray House' located at 339 Mowbray Road) and a number of business properties along the eastern side of the Pacific Highway (571 585 Pacific Highway)
- Acquisition of up to five commercial premises
- The need to tunnel beneath a heritage listed water reservoir, a substation and a communications tower
- Impact on a major Telstra utility adjacent to the Ausgrid facility / rail corridor boundary.

On balance, Chatswood Option 3 was preferred over Chatswood Options 1 and 2 as this option represents the best balance between environmental, economic, social and engineering requirements.

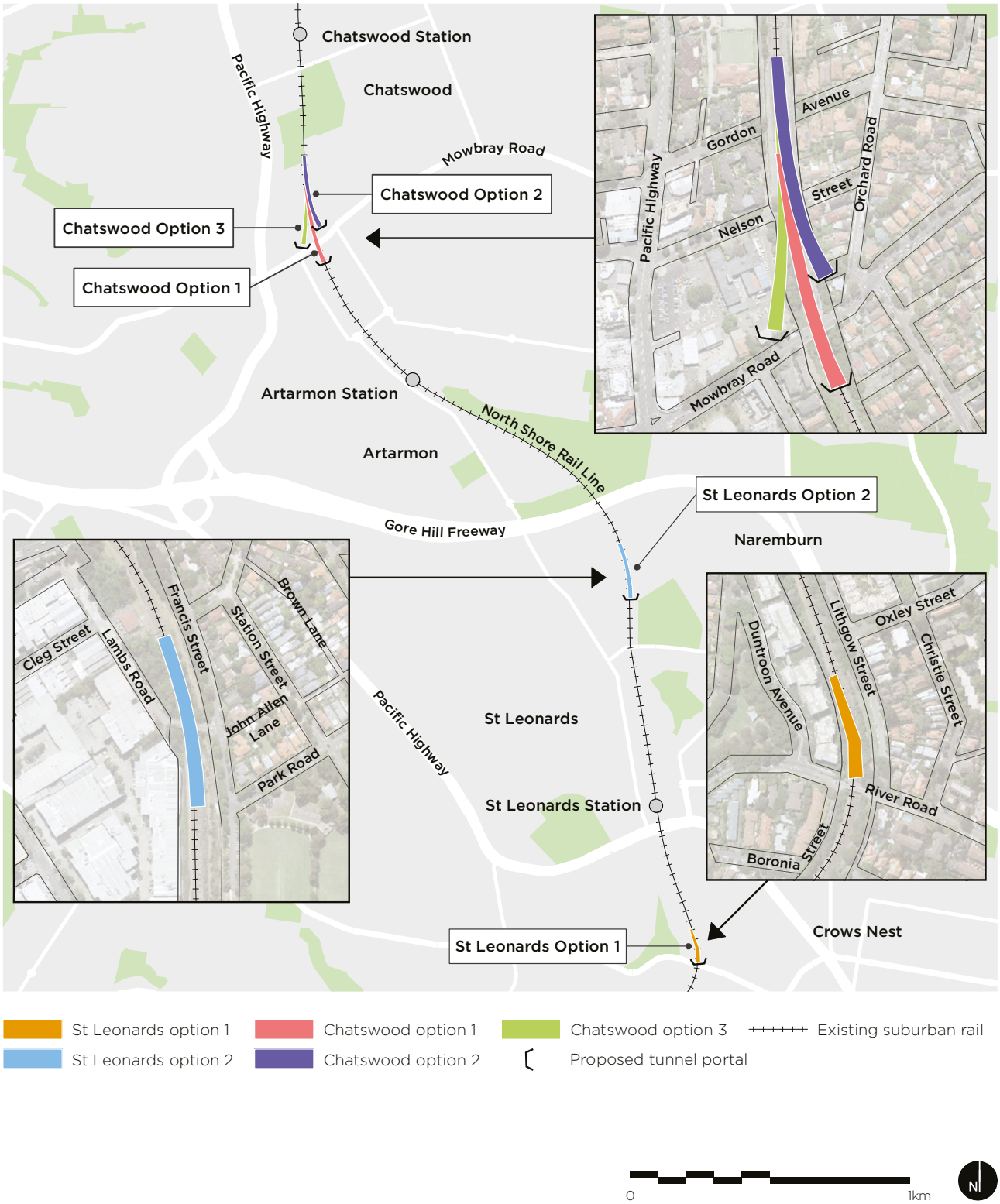

Figure 4-9 Northern dive structure options

4.7.2 Southern dive structure

Southern dive structure options and evaluation

In a broad sense the location of the southern dive structure is determined by the decision to convert the T3 Bankstown Line to Sydney Metro (refer to Section 4.3.4). This decision led the need to transition back to a surface level track in the area between Central Station and Sydenham Station.

Options for the location of a southern dive structure close to Central Station are limited by:

- Suitable available land within and adjacent the suburban rail corridor (between Central and Sydenham stations) to accommodate additional tracks
- Maximum allowable vertical track grades (which influence the length of transition of the tunnel from an underground station at Central to the surface).

Surface track options between Central and Sydenham stations would require widening of the rail corridor and significant property acquisition to accommodate the additional metro tracks and other infrastructure, including noise walls.

A tunnel option is preferred over a surface option as it would considerably reduce direct and indirect impacts on properties adjacent to the existing rail corridor (such as property acquisition, noise and vibration from surface rail operations and visual amenity impacts associated with new overhead wiring and rail infrastructure). The most suitable location for the dive structure between Central and Sydenham stations was identified as the Marrickville industrial area in order to avoid significant residential property acquisition, and avoid the potential noise impacts of a surface metro line within residential areas.

Locally around the Marrickville industrial area options to the west and east of the existing rail corridor were considered. A dive structure to the east of the rail corridor would:

- Be located closer to residential receivers on Unwins Bridge Road
- Require the metro tracks to cross the T4 Eastern Suburbs and Illawarra Line tracks to the south of Sydenham Station. This would result in unnecessary structures and impacts to rail track grades, or operational inefficiencies from tracks crossing at-grade.

Based on these factors, a dive structure to the west of the existing rail corridor was identified as the preferred option as it would:

- Allow for the desired alignment and future conversion of the T3 Bankstown Line to a metro service
- Minimise property acquisition
- Be located as far as practical from residential receivers
- Enable the efficient integration of the Metro network into the existing rail corridor whilst minimising potential impacts to other existing rail lines.

4.8 Consideration of alternatives during station design development

After the selection of metro stations was complete, the design development phase commenced. This involved the identification of the specific location of the stations and the above ground and below ground station footprints. Constructability issues were also considered in this phase. In the case of Martin Place and Central stations, the sensitivity and construction challenges associated with the proposed locations required a more detailed consideration of configuration options. These are discussed below.

4.8.1 Design development of Martin Place Station

The location of Martin Place Station

The station at Martin Place is intended to serve Sydney's financial district and the civic spaces and uses along Martin Place and Macquarie Street. Convenient interchange between the proposed metro station and the existing Martin Place Station is a key locational driver. Designing for Martin Place as a 'one station solution' that provides station-to-station interchange within the paid concourse areas of both stations places a geographical constraint on the station's location.

The specific location of the proposed Martin Place Station has also been influenced by a number of other key constraints. These include:

- Underground constraints such as basements and other services and infrastructure that influence the tunnel alignment and depth and therefore the location and orientation of the station itself
- Minimising impacts to heritage buildings and places, including direct and indirect impacts to the Commonwealth Bank building and the existing Martin Place Station, which are heritage items listed on the State Heritage Register
- Minimising impacts to, and optimising integration of the station with the public domain of Martin Place, a major civic spine that is a focus of the City of Sydney's *Martin Place Urban Design Study*.

The above constraints have resulted in the separation of the northbound and southbound tunnel alignments generally beneath Castlereagh and Pitt streets respectively; two station footprints (rather than one) that increase the offset distance from the Commonwealth Bank Building; and the provision of station entrances that avoid the direct use of Martin Place.

Design and layout of Martin Place Station

Secondary constraints and challenges that have influenced the design and layout of Martin Place Station include:

- Accommodating large pedestrian volumes and the need for convenient and safe connections into the broader precinct
- The provision of adequate pedestrian circulation spaces to accommodate increased pedestrian volumes
- The provision of adequate space for construction of the project
- Not precluding over station development at station sites.

Over 10 options were been developed for the design and layout of Martin Place Station that are located in the area bound by Bligh, King, Castlereagh and Pitt streets. These options differed in the following general ways:

- Single or multiple station entrances with corresponding street level footprints
- Station layouts to optimise station entry locations and street level footprint size, including within the public domain of Martin Place, at various locations along Castlereagh Street and Elizabeth Street, Hunter Street and Bligh Street
- The number of station entrances and their specific location and orientation within the various station footprint configurations.

The preferred option includes platforms south of Hunter Street between Castlereagh and Elizabeth streets with two street level footprint areas incorporating station entries: at the Hunter Street corners of Elizabeth and Castlereagh streets; and the Martin Place corners of Elizabeth and Castlereagh streets. Refer to Chapter 6 (Project description – operation) for more detail.

Discounted options did not perform as well as the preferred option for the following reasons or combination of reasons:

- Options that proposed one station footprint resulted in unacceptable customer outcomes and / or pedestrian level of service. Limited footpath widths on Castlereagh Street exacerbated this situation for many options. Some of these options also precluded provision for future over station development and resulted in poor urban design outcomes
- Some of the options that minimised the size of the street level footprint did not provide adequate station functionality and also resulted in unacceptable construction constraints, including poor construction efficiency based on limited space and challenges for construction site access
- Options that proposed direct access via Martin Place were not preferred because they did not meet pedestrian level of service requirements and would not be consistent with the objectives for Martin Place outlined City of Sydney's *Martin Place Urban Design Study*
- Some options did not provide suitable offset from the Commonwealth Bank building resulting in poor urban design outcomes and increased risk of impacts to this building
- Some options with predominantly northern street level footprints did not meet the 'one station solution' objective with regard to interchange functionality with the existing Martin Place Station.

The preferred option best optimises the number, size and location of street level footprints and station entries to:

- Respond to the major customer movement and desire lines to and from the station
- Relieve pedestrian congestion within Martin Place and complement objectives outlined in the Martin Place Master Plan
- Provide suitable space for potential future over station development while minimising the number of private properties required to ensure an adequate footprint for construction and operation of the station
- Provide a superior underground interchange with the existing Martin Place Station and although technically challenging, minimise direct impacts to the fabric of the existing State Heritage listed station.

4.8.2 Design development of Central Station

The development of Central Station over time has led to a configuration that makes day-to-day use of the station difficult, resulting in a number of sub-standard features such as difficult way-finding, and access and capacity constraints. These include changes in levels between different areas of the station and long customer routes. Consultation with Sydney Trains and other stakeholders has been undertaken in the development of the design for Central Station. This has influenced options developed for the design of the station; supporting infrastructure requirements and construction methodology.

Why metro platforms at Central?

Central Station is the busiest station in the Sydney transport network, providing key interchange for suburban and intercity rail services, light rail, bus, taxi and intercity coach services. Central Station has a large catchment comprising education, commercial and residential land uses. Having Sydney Metro services at Central Station reinforces the role of Central Station as the primary transport interchange for Sydney and also recognises the potential for the area around Central to be the civic, economic and community focus of the southern Sydney CBD.

Sydney Metro would build on the significant transport investments being made at Central, including the CBD and South East Light Rail project. The new metro platforms would support and enhance Central Station's historical role as the major interchange in the Sydney transport network and further build on the interchange functionality of the station.

As shown in Figure 4-3, compared with all other short-listed station locations, metro platforms at Central perform best against the identified project objectives. Metro platforms at Central Station would provide a number of benefits, including:

- Direct servicing of a large employment catchment with considerable growth forecast
- Efficient and direct connection to metropolitan-wide suburban rail services, inter-city services, light rail services and bus and coach services.

Based on the assessment of the short-listed stations, a decision was made to proceed with a project incorporating new metro platforms at Central Station.

Location of the metro platforms at Central Station

A number of locations were investigated for the provision of Sydney Metro platforms at Central Station. These included:

- Utilising existing disused platforms on the eastern side of the existing station
- Constructing the metro platforms on the eastern side of the existing station below Elizabeth Street
- Constructing the metro platforms on the western side of the existing station below the western forecourt
- Constructing new metro platforms in the centre of the station below existing platforms 13 to 15.

The introduction of underground metro platforms at Central Station would have material impacts to the station irrespective of the option chosen. Decision-making on the placement of the underground metro platforms seeks to balance the substantial benefits with the recognised constraints and challenges associated with its introduction.

Recognised constraints and challenges that required detailed consideration and management include:

- Maintaining acceptable customer accessibility and amenity during construction
- Ensuring acceptable customer outcomes during operations
- Ensuring the reliability of existing network operations while construction is occurring within an operational transport interchange
- The need for reliable ongoing access across operational rail for pedestrians and vehicles during construction and operation
- Minimising impacts to the State heritage significant Central station, including the curtilage which extends beyond existing building footprints.

Options to locate the metro platforms on the eastern side of Central Station below Elizabeth Street did not maximise the efficiency of interchange for customers between metro and suburban and intercity rail and other transport modes. Other concerns related to potential property impacts, heritage impacts and the required depth of the new platforms, which would affect the quality of the transport experience for customers.

Options that would utilise the existing disused platforms were discounted because of the inability to achieve a tunnel alignment that would not impact the T4 Eastern Suburbs and Illawarra rail line, and an Ausgrid cable tunnel. Although the platforms themselves could accommodate the metro trains, there would be sub-optimal customer outcomes with respect to the customer environment (light and space, comfort) and connectivity (distance to interchange). There would also be technical challenges for the provision of platform screen doors and other fire and life safety infrastructure (including provision of suitable ventilation systems and emergency egress).

Options to locate the new metro platforms below the western forecourt of Central Station were discounted because this location did not maximise the efficiency of interchange for customers between metro and suburban and intercity rail and other transport modes. Metro platforms at this location would also have potential impacts on known items of heritage and archaeological significance.

The proposed location for the new underground platforms below platforms 13 to 15 at Central Station has been selected for the following key reasons:

- It provides the most efficient interchange for customers between suburban and intercity platforms (and associated travel time benefits)
- The interchange and travel time benefits result in customer preference for interchange at Central Station rather than at Wynyard or Town Hall stations, providing congestion relief at these stations
- It best encourages the use of Sydney Metro as a service, resulting in a reduction in the use of crowded Central Station suburban platforms such as platforms 16 and 17.
- It allows for an efficient construction method (shallow cut-and-cover arrangement) that minimises construction duration and disruption to customers using Central Station.

Design development of the station services building

All metro stations include services infrastructure to support metro operations. A key design driver at Central Station has been to place the services infrastructure only at the southern end of the metro platforms to:

- Avoid conflicts between customers entering the metro and the services infrastructure (and its maintenance), which improves functionality and pedestrian circulation
- Minimise heritage and visual impacts of services infrastructure near the grand concourse and supports the integration of the station with the existing station (provides a better transport product through the provision of a clear and uncluttered access / exit point to the metro stations for customers)
- Allow for maintenance of the services building directly via the Sydney Yard Access Bridge from the south of Sydney Yard, minimising disruption to operation at Central Station.

Design for the provision of all station services at the southern end of the metro platforms is influenced by the length of the station. A shorter station requires a higher above-ground services building to accommodate all services infrastructure, whereas a longer station allows for a less visually intrusive above-ground services building (about a 50 per cent reduction in height).

The design of the station services building results in the removal of the heritage listed garden, the Rolling Stock Officers building and the Cleaners Amenities building in Sydney Yard. Options to avoid impacts to the Cleaners Amenities building were considered, however all options would result in:

- Sub-optimal operational outcomes for maintenance activities (a key restriction given the metro station at Central would be one of the busiest interchange stations on the metro network) and restricting space for emergency services access to the metro station
- Poor design outcomes that would result from a reduced services building footprint and retention of the Cleaners Amenities building immediately adjacent to the proposed infrastructure
- An unworkable construction arrangement for Central Station platforms that would overly restrict station excavation activities near the building, preclude over-size deliveries that would be required at the site (including ventilation fans and other large pre-cast station elements) and limit the functionality of the main construction access for the station.

Considering operational efficiency and the balance of impacts generated and those minimised or avoided, the design option for a longer station and reduced height services building is preferred.

Design considerations for the northern emergency egress and draught relief infrastructure

Design standards require emergency egress at the north and south of every station and require access be to a relatively open area. The proposed design includes provision for northern emergency egress in the location of the existing maintenance access ramp from Eddy Avenue. This is preferred because it best meets the design requirements while minimising direct infrastructure impacts within Central Station. It also minimises conflict with existing station operations (in both construction and operation phases).

Draught relief is required at the both ends of the station to support operational performance and efficiency, including to manage air pressure and temperatures within the station and tunnels and to minimise energy use in operation. Northern draught relief is proposed in the same location as the northern emergency egress. Provision of a single point for draught relief at the southern end of the station was considered, however was discounted because it would have greater impacts associated with a larger construction footprint, require substantial additional operational energy, and result in sub-standard performance.

Design considerations for access to Sydney Yard

Sydney Yard is the rail infrastructure staging area bounded by inter-city rail lines to the west, suburban rail lines to the east and Central Station and Sydney Terminal to the north. Access to Sydney Yard is currently limited to a primary access / exit via Eddy Avenue and the tracks adjacent to platform 15 (limited to medium-sized vehicles) and a secondary (infrequent) at-grade access over the inter-city rail lines for heavy vehicles during track possessions via the bus layover facility on the western side of Central Station. Access to Sydney Yard via Eddy Avenue would be removed as a result of the project.

Alternative permanent heavy vehicle access to Sydney Yard would be required to allow for ongoing operations and maintenance of the Sydney Trains and NSW Trains network and metro infrastructure.

A 'do nothing' option would not result in an acceptable outcome and a new access from Eddy Avenue would not be possible based on the constraints introduced by the location of the metro platforms and restrictions to access that will be created by the CBD and South East Light Rail that uses Eddy Avenue.

Other options considered for the provision of an alternative access to Sydney Yard included:

- Formalising the at-grade access via the bus layover facility. This option was not preferred as access would not be 'all hours' as is the case with the Eddy Avenue access (ie still be restricted to possession periods) and would result in conflict with buses using the layover facility
- Underground access via the bus layover facility on the western side of Central Station. This option was not preferred because:
  - the required horizontal geometry and vertical grades could not be achieved
  - it would likely require cut-and-cover construction with additional track possessions and disruption to the rail network
  - it has the potential to introduce additional constraints to the provision of future infrastructure at Central Station
  - it would result in conflict with buses using the layover facility.

- Underground access via Prince Alfred Park. This option was not preferred because:
  - the required horizontal geometry and vertical grades could not be achieved
  - it would likely require cut-and-cover construction with additional track possessions and disruption to the rail network
  - it has the potential to introduce additional constraints to the provision of future infrastructure at Central Station
  - it would be constrained by the alignment of the existing T4 Eastern Suburbs Line tunnel
  - it would require the use of a large area of Prince Alfred Park, permanently reducing the area of available public open space
- An access bridge from Regent Street to Sydney Yard. This option was preferred because:
  - it best accommodates the operational access requirements of Sydney Trains, NSW Trains and Sydney Metro
  - it minimises construction risk and disruption to the operational rail network during construction and does not affect the bus layover facility
  - can be introduced to support construction of the underground platforms at Central Station, thereby minimising the extent of long term track possessions and overall disruption at Central Station
  - improves customer safety by removing construction and operational access away from the main station entrance thereby separating activity from the heavily congested operational station environment.

Station excavation methodology

The metro platforms at Central Station are proposed to be excavated using a cut and cover technique (see Chapter 7 (Project description – construction) for more information). Some other metro stations would be constructed using a mined technique. While a station cavern could be constructed using a mined technique with a shaft located remotely, cut and cover construction would always be required at the station site to facilitate construction of the necessary vertical transport and services infrastructure.

Temporary pedestrian footbridge

Construction of the underground platforms at Central Station using a mined or cut-and-cover technique requires excavation through the existing underground pedestrian connections. A temporary pedestrian footbridge is therefore required to maintain pedestrian connections between above ground platforms (see Chapter 7 (Project description – construction) for more information). A temporary above-ground pedestrian footbridge is preferred because:

- A 'do nothing' option results in unacceptable outcomes for rail customers due to substantially increased interchange times and significant and unsafe levels of congestion at key circulation points around the existing station based on reduced options for transfer and access and exit from each platform
- Retention of the existing underground pedestrian connections 'in situ' would require staged construction of the metro platforms which would increase construction risks, substantially extend the duration of construction within Central Station and also be substantially more expensive to construct.

The above-ground temporary pedestrian footbridge extends between, and connects to each of platforms four to 23 because other connection options (such as above-ground connection only between platforms 12 and 16) would result in:

- Customers having to transfer over three vertical levels rather than two (resulting in associated increases to interchange times)
- Unacceptable safety outcomes for customers on heavily congested platforms and at key circulation points within the station.

As with other elements affecting Central Station, an above-ground temporary footbridge would be subject to further design development in order to minimise impacts to heritage fabric.

Minimising impacts at Central Station

As identified above, a new access for Sydney Yard would be required due to the removal of the existing access via Eddy Avenue. The Sydney Yard Access Bridge is the preferred solution for this new access. On balance, metro platforms below existing platforms 13 to 15 would have reduced heritage impacts compared with other metro station locations considered. The metro platforms at Central Station have been subject to ongoing design development to optimise the performance of the station while minimising impacts, including heritage impacts, to the existing station and adjacent heritage items.

The design has minimised the extent of metro station services and other infrastructure in the northern part of the station to reduce the footprint within the existing Central Station northern concourse and below the Bradfield Building (former Lost Property Office). The design of the station services building has also been refined to minimise the bulk and scale of above ground infrastructure that in turn, reduces visual impacts and changes within the setting of heritage items. The design of metro infrastructure at Central Station, including the Sydney Yard Access Bridge, is ongoing and would minimise direct impacts as well as impacts to the setting of adjoining and nearby heritage items. It would be developed in consultation with Sydney Trains and the Heritage Council of NSW and would be subject to review by the Sydney Metro Design Review Panel, including periodic independent review by an appropriately qualified and experienced heritage architect.

4.9 Consequences of not proceeding with the project (do nothing)

Demand on much of Sydney's rail network is nearing capacity during the morning and evening peak periods. In particular, demand on the T1 North Shore, Northern and Western Line experiences heavy train loads at peak times and is forecast to grow at 2.9 per cent a year over the next 10 years. Patronage will continue to grow as land is released or rezoned along the Sydney Metro Northwest corridor.

Changes in patronage growth will exacerbate crowding at Central, Town Hall, Wynyard and Chatswood stations and on the T1 North Shore, Northern and Western Line. When Sydney Metro Northwest opens in 2019, the T1 North Shore, Northern and Western Line will be operating almost at capacity during the morning peak period, with many customers on individual services experiencing crowded conditions.

By 2026, demand for rail transport will grow to a total of 237,000 trips in the morning peak (representing a 41 per cent increase in travel demand). The existing transport system cannot provide the capacity to accommodate this forecast growth as:

- The road and bus networks are already heavily constrained and cannot be effectively augmented to accommodate the additional capacity required
- Sydney's rail network is complex and becoming more crowded and less reliable (the growth in the demand for rail travel to the Sydney CBD alone is expected to increase by 31 per cent by 2026).

Even with the additional services provided by Rail Future A and Rail Future B of *Sydney's Rail Future* (refer to Section 4.3.3), the rail network will run out of capacity at some point during the mid to late 2020s.

To ensure continued growth in productivity, cater for forecast employment and population growth, and sustain the city's liveability, Sydney's transport capacity will need to substantially increase. This is particularly important given the leading role Sydney plays in the Australian economy.

The consequences of delaying the delivery of the project are as follows:

- Insufficient transport capacity will prevent Sydney from reaching its economic potential, leading to worse economic outcomes for the State and nation
- Sydney's transport network will not provide the minimum standard of service expected by rail customers and there will be major impacts on the operational efficiency, reliability and capacity of the suburban rail network in the medium to long term.

These consequences are outlined in Table 4-4.

Table 4-4 Consequences of not proceeding with the project

Problem	Impact per year
Broader challenges for Sydney	
• Constrained economic productivity and growth • Constrained employment and population growth • Reduced access to major employment and activity centres • Reduced connectivity between activity centres	• Lost economic benefits: $2.0 billion per year on average over 30 years • Lost economic value-add in the corridor by 2036: including $5.2 billion in the Sydney CBD • Jobs lost: 44,000 in the Global Economic Corridor by 2036 (3500 per year) • Reduced population growth in key areas. By 2036: 1950 less people in the Sydney CBD • Reduced competitiveness between Sydney and other Australian cities such as Melbourne and Brisbane.
Sydney's transport network problems	
• Increasing transport demand • Road network congestion • Bus network at capacity	• Additional public transport travel time: 12.7 million passenger hours per year (weighted) • Additional road users: 20,000 driver and passenger trips (2036 AM peak) • Cost of road congestion: 5.9 million vehicle hours per year (weighted).
Sydney's rail network problems	
• Network complexity • Capacity constraints • Increased train crowding • Increased platform crowding • Longer dwell times • Reduced reliability	• Increased rail demand to the Sydney CBD impacting existing Central, Town Hall, Martin Place and Wynyard stations: 6733 per year (2026 AM peak) • Increased train services required: six per year • Increased train crowding: 3.3 million passenger hours (weighted) in 2026, increasing in severity each year thereafter • Increased station crowding: 8.4 million hours by 2026 (weighted) • Reduced reliability: 5.1 million hours per year by 2026 (weighted).

Further details on the need and justification of the project taking into account all issues considered in this Environmental Impact Statement are provided in Chapter 29 (Justification and conclusion).