Department of Transport and Main Roads

BaT project

Environmental Impact Statement

Executive Summary

August 2014

Great state. Great opportunity.

BRISBANE CITY

Queensland Government

JACOBS AECOM

JOINT VENTURE

Contents

1. Introduction

The Bus and Train project (the Project) is a proposed bus and rail tunnel extending from Dutton Park in the south to Spring Hill in the north, passing deep beneath the Brisbane River and Central Business District (CBD). There would be new integrated underground stations at Woolloongabba, George Street and Roma Street. The Project would combine rail and bus operations in a single, double-decked tunnel system, approximately 5.7km in length. Overall, the Project would be approximately 6.7km long, taking into account the surface connections.

The Project would address a number of capacity constraints facing the public transport system in Brisbane's inner city such as the Merivale Bridge (rail) and the Cultural Centre Busway Station. It would provide a new direct and unconstrained link to the Brisbane CBD from the southern and eastern growth areas, supported by new transport hubs with interchange capability across the inner city.

The Proponent for the Project is the Queensland Government represented by the Department of Transport and Main Roads (Transport and Main Roads). The Project investigations are being managed by Transport and Main Roads, in partnership with Queensland Rail, Projects Queensland and Brisbane City Council.

There are four phases to the Project. Phase A involved development of a concept design. This Phase, being Phase B, includes development of the reference design, preparation of this Environmental Impact Statement (EIS) and a business case. Phase C will involve procurement for construction, and Phase D will involve Project construction and subsequent delivery.

1.1 Environmental Impact Statement

The Project was declared by the Coordinator-General on 19 November 2013 to be a 'coordinated project for which an EIS is required'*, under Section 26(1) of the *State Development and Public Works Organisation Act 1971*. The EIS has been prepared in accordance with the Terms of Reference (ToR) issued by the Coordinator-General under the *State Development and Public Works Organisation Act 1971*.

The objective of the EIS is to ensure that potential environmental, social and economic impacts of the Project are identified so the benefits may be captured and the adverse impacts avoided or minimised and mitigated. Specifically, the EIS is to describe:

- the need for the Project, alternatives to it and options for its implementation
- the existing environment of the study corridor or other areas potentially affected by the Project
- the potential impacts of the Project on the natural, social and economic environment, including beneficial and adverse impacts, and direct, indirect and cumulative impacts
- measures for avoiding, managing or mitigating the adverse impacts and maximising or enhancing the beneficial impacts of the Project.

The EIS comprises:

- this **Executive Summary**, which provides an overview of the Project and summary of key issues identified through the EIS investigations
- **Volume 1 – EIS chapters and appendices**, which provides a detailed description of the Project, the existing environmental, social and economic conditions and values in the study corridor; an assessment of the impacts associated with the Project's construction and operation; and proposed environmental design requirements and management measures
- **Volume 2 – reference design drawings**, which provides detailed engineering drawings of the reference design, including the tunnel route and depth, station locations, extent of surface works and construction worksites, and property impacts
- **Volume 3 – technical reports**, which includes technical reports on matters such as traffic and transport, air quality and noise and vibration.

* The Project declared by the Coordinator-General to be a coordinated project is the Underground Bus and Train Project. The Bus and Train (BaT) project is the same project as referred to by the Coordinator-General, despite the difference in the nomenclature.

1.2 Community and Stakeholder Consultation

1.2.1 Purpose and scope of the consultation process

Development of the Project reference design and EIS have been informed by a program of stakeholder and community consultation. This has involved engagement with a broad range of stakeholders including the community, local government, Queensland Government, Australian Government, interest groups and industry.

The purpose of the community and stakeholder engagement program was to:

- raise awareness about the Project, including the need for the Project, its potential benefits and impacts, and the process to develop the reference design and EIS
- provide stakeholders with opportunities to inform investigations being undertaken for the reference design and EIS about local values and issues
- inform government agencies, stakeholders and the community about the progress of the Project and to seek their input into the development of the reference design and EIS
- understand stakeholder and community issues and where possible address any issues raised.

Consultation materials

The consultation program was designed to communicate and engage with individuals and groups directly affected by the Project, as well as provide general Project information to the wider community. The process was also organised to allow input from:

- key stakeholder groups with specific interests in the Project, such as Indigenous groups, industry associations, and business and advisory groups
- Queensland Government agencies and Brisbane City Council, particularly those agencies with a role in the design, construction or operation of the Project.

1.2.2 Consultation program and activities

In keeping with the scale and significance of the Project, an extensive information and engagement program was implemented to keep the community and other stakeholders informed and to provide opportunities for stakeholders to have input into the development of the reference design and EIS.

Engagement to date has involved two rounds of consultation coinciding with key project milestones.

Round 1 was undertaken between November 2013 and January 2014. The purpose of the Round 1 consultation was to inform the community and stakeholders about the Project, the concept design and project investigations, and how to make a submission on the draft terms of reference (ToR) for the EIS.

Round 2 coincided with the release of the draft reference design for comment on 19 March 2014. The purpose of this round was to provide greater detail about the Project, its possible alignment and station locations, as well as provide information on the construction works.

Round 3 consultation is proposed to coincide with the public notification of the EIS and confirmation of the reference design. This consultation will support the opportunity for people to make submissions about the EIS in accordance with the *State Development and Public Works Organisation Act 1971*.

Figure 1 shows the consultation program for the Project including the timing, purpose and focus of consultation, and feedback sought from stakeholders and the community.

The consultation program involved broad communication activities to raise general awareness of the Project and more targeted, local-area-based activities to assist residents and stakeholders in providing feedback.

A range of engagement activities were undertaken including open and accessible community information sessions, stakeholder briefings, public displays, online surveys, and technical briefings to agencies.

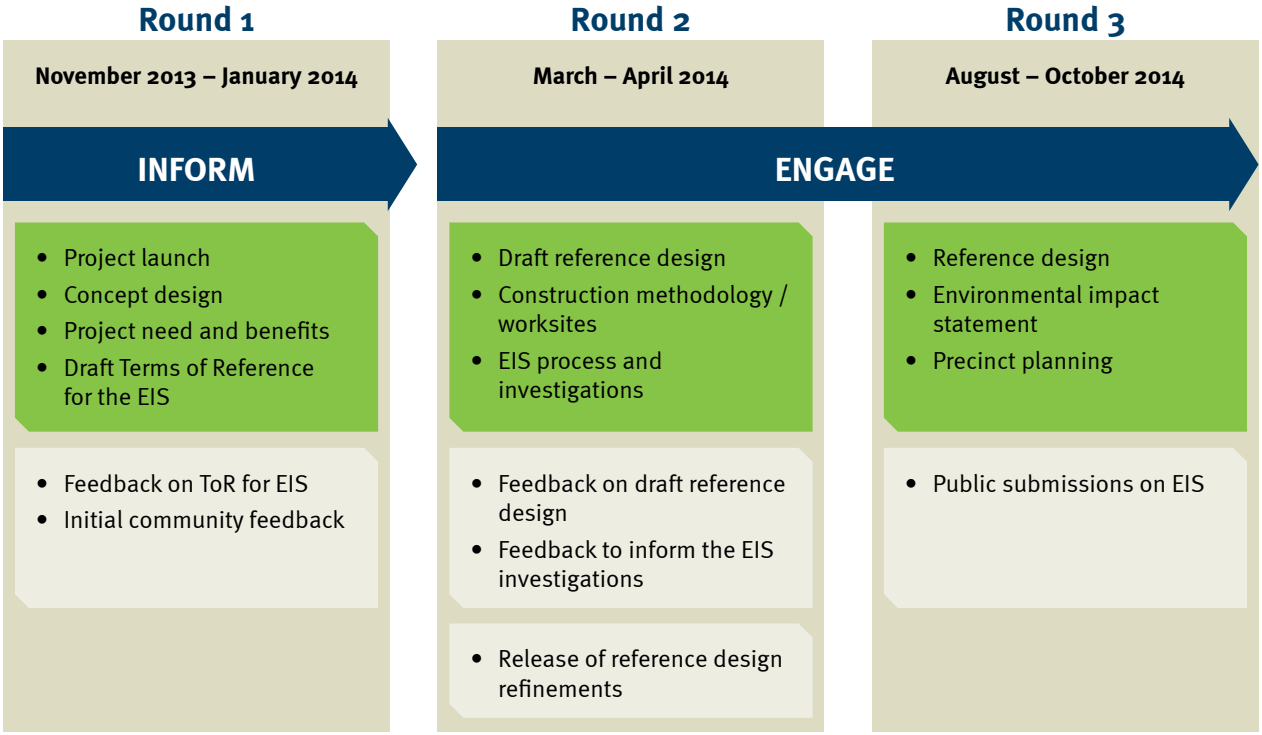
The Traditional Owners, represented by the Turrbal Association were consulted about Aboriginal cultural heritage values in the study corridor, and in turn, provided feedback about the Project and its potential benefits and impacts.

Two community advisory groups were also established, including one focussing on communities in the southern section of the study corridor and the other on businesses and special interest groups. Engagement was also undertaken with community groups in the northern section of the study corridor.

A project website was established and a newsletter was distributed to 350,000 households and businesses across Brisbane. Feedback and community enquiry channels established included a freecall project information line (1800 010 875), email address and postal address.

Cultural Centre Busway Station

Figure 1 Consultation program



1.2.3 Consultation outcomes

Between November 2013 and June 2014 approximately 4,000 people participated in the consultation program with more than 2,200 feedback responses received.

Consultation for the Project identified broad community support for the Project and recognition of the need to improve bus and rail services, including increased frequency of services, and integration between public transport modes.

Some people living close to the proposed works raised concerns about the location of the northern tunnel portal, impacts to Victoria Park, decommissioning Dutton Park Station and potential construction impacts, such as noise, dust, vibration, construction traffic, spoil extraction and haulage and construction worker parking and access. People raising such concerns generally acknowledged the likely Project benefits and many expressed support for the Project.

As a result of stakeholder and community feedback, and following further technical investigations, significant design refinements were made. The refined design addressed community concerns and included a significant reduction in the permanent impacts to Victoria Park at the northern portal, with much of the above-ground infrastructure to be contained within the existing transport corridor. Also, Dutton Park Station would remain open in the southern section of the Project, and be upgraded to improve disability and mobility impaired access.

Stakeholder and community feedback has informed development of the reference design and preparation of the EIS including:

- identification of community values and local conditions in the study corridor
- identification of issues about the Project alignment, station location, key infrastructure and proposed construction sites
- assessment of potential benefits and impacts of the Project's construction and operation
- identification of strategies to avoid or minimise and mitigate potential impacts and maximise or enhance potential Project benefits.

1.2.4 Submissions to the EIS

The EIS for the Project is now available for public comment as required by section 33 of the *State Development and Public Works Organisation Act 1971*.

A copy is available at
www.dsdip.qld.gov.au/underground

To the extent that the Project involves a material change of use, or requires impact assessment, under the *Sustainable Planning Act 2009*, a properly made submission is taken to be a properly made submission about the application under the integrated development assessment system (IDAS).

A properly made submission, defined in Schedule 2 - Dictionary of the *State Development and Public Works Organisation Act 1971*, means a submission that:

a) is made to the Coordinator-General in writing

b) is received on or before the last day of the submission period

c) is signed by each person who made the submission

d) states the name and address of each person who made the submission

e) states the grounds of the submission and the facts and circumstances relied on in support of the grounds.

Submissions to this EIS are to be addressed to:

The Coordinator-General
EIS Project Manager – Underground Bus and Train Project*
Office of the Coordinator-General
Department of State Development, Infrastructure and Planning

Post: PO Box 15517 City East Qld 4002
Fax: 07 3452 7486
Email: underground@coordinatorgeneral.qld.gov.au

Submissions can be made online or by post, fax or email.

* Note: the Project declared by the Coordinator-General to be a coordinated project is the Underground Bus and Train Project. The Bus and Train (BaT) project is the same project as referred to by the Coordinator-General, despite the difference in the nomenclature.

2. Rationale for the Project

In planning the transport network for South East Queensland, the Queensland Government has established a framework for integrated land use and transport planning, having regard for the existing and likely future conditions. The major public transport issues for the inner city are:

- sustained population growth in the South East Queensland region, particularly outside Brisbane, leading to increased demand for public transport services
- employment growth particularly in the Brisbane CBD and inner city requiring increased public transport in the peak periods
- sustained growth in public transport patronage
- capacity constraints on the rail and bus networks such as the Merivale Bridge (rail) and Victoria Bridge (bus)
- public transport service coverage requirements to meet the changing structure of the inner city such as improving access for the southern part of the Brisbane CBD
- increasing transport network congestion, contributing to declining travel time reliability and overcrowding on long-haul commuter services.

Without substantial investment in public transport infrastructure, the bus network in the Brisbane CBD would remain congested at critical river crossings, ramps and intersections. Similarly, the rail network would not be able to support additional train services into the CBD from 2020. Without the Project, the current congested conditions would deteriorate, impacting on the critical role of the Brisbane CBD as the economic and employment focus of Brisbane, South East Queensland and Queensland.

2.1 Strategic context

The Commonwealth, State and local policy frameworks support the continual development of the South East Queensland and Brisbane metropolitan transport networks to accommodate forecast future growth. A range of transport responses would be required to ensure that the region is able to operate efficiently.

Commonwealth policies such the National Infrastructure Plan 2013 and Infrastructure Australia: Urban Transport Strategy 2013, support investment in transport infrastructure to manage congestion, boost productivity and economic activity, and the integration of transport and land use outcomes in decision-making. The Project would be a critical component for achieving these Commonwealth polices in Brisbane and South East Queensland.

The Project is consistent with the major Queensland Government strategies for managing growth and guiding future development in South East Queensland. The Queensland Plan requires critical infrastructure being delivered efficiently and effectively with a focus on taking a long-term approach to realise economic, social and community benefits. The Project would result in significant improvements to public transport capacity, to bus and rail travel times and to regional accessibility supporting the needs of the community.

The Project would support the achievement of the Governing for Growth 2014 strategy by providing infrastructure for economic growth, by addressing key congestion bottlenecks in the urban transport network and by supporting accessibility to employment and labour. The Project would provide a more efficient, resilient and integrated passenger transport network that responds to the growing travel demand in the region. The Project would support a more robust economy by facilitating economic and social growth particularly in the Brisbane CBD, and at Woolloongabba, the Princess Alexandra Hospital (PA Hospital) and Boggo Road Urban Village.

The infrastructure reform strategy for Queensland, Infrastructure for Economic Development 2013, identifies that the Queensland Government is committed to deliver economic infrastructure to:

- drive development of a four pillar economy
- increase productivity
- reduce unemployment.

The Project is an integrated approach by State and local government to help drive economic growth by improving connectivity in the region and addressing capacity constraints on the existing rail and bus networks.

Ecosciences Precinct, Boggo Road Urban Village

The South East Queensland Regional Plan 2009-2031 (SEQ Regional Plan) provides direction for the management of growth in South East Queensland. The SEQ Regional Plan is planned to be replaced by late 2014. Generally, the Project would support the Desired Regional Outcomes of the SEQ Regional Plan by addressing capacity constraints in Brisbane's inner city rail and bus networks, improving public transport movement and accessibility to identified high growth areas. In particular it would:

- support sustainable growth by providing alternatives to private vehicle use
- support southern high growth areas and areas of increased urban density along the study corridor, including in the Brisbane CBD and Woolloongabba
- support economic development in regionally significant employment areas, such as the Brisbane CBD, PA Hospital, Mater Hospital, Royal Brisbane and Women's Hospital (RBWH), Queensland University of Technology (QUT), the Ecosciences Precinct and indirectly the University of Queensland (UQ).

Brisbane City Council has development strategies and plans to guide the growth and development of the Brisbane local government area (LGA). The overarching strategy is Brisbane Vision 2031 which identifies the aspirations for the City's future and ideas for achieving the vision. The first theme 'our accessible, connected city' includes:

- Brisbane is an accessible city for everyone.
- Road, public transport and active transport networks provide safe, efficient, fast and reliable travel options throughout the city.
- There is equitable access to high-quality, inter-connected public transport services that move throughout Brisbane.
- Brisbane has a modern, efficient and connected bus network with reliable services to work, schools and community activity centres.
- A variety of local services, businesses, community hubs and development will be located near public and active transport networks.

The Project would provide improved accessibility through increased cross river capacity for public transport and relieve the major bottlenecks in the rail and bus networks. The Project would also provide safe and efficient movement of people to and from the Brisbane CBD and Woolloongabba.

The Brisbane Economic Development Plan 2012-2031 guides the economic development of Brisbane with a focus on the forecast increase in economic output and inner city employment. Significant capacity building will be required across all sectors to meet these growth opportunities, including expanding transport infrastructure and improving public transport services. The Project would support the Economic Development Plan by increasing the public transport capacity in the inner city, benefiting commuters and inner city residents, and linking them with key economic activity areas such as the Brisbane CBD, the PA Hospital campus and Boggo Road Urban Village.

Transport actions for Brisbane are identified in the Transport Plan for Brisbane 2008-2026 which seeks to accommodate expected growth and provide sustainable travel choices. The Transport Plan sets a goal of achieving a public transport mode share of 13 per cent on weekdays before 2026. It provides strong recognition of the need for the Project as it identifies the need for 'a second CBD river crossing to increase cross-river capacity and rail catchment in the inner city beyond 2016'. In particular, the Project increases rail and bus capacity in the inner city through the delivery of the necessary extra river crossing and provides a new busway connection from Dutton Park through the CBD to link the Eastern Busway with the Northern Busway enhancing the regional busway network.

The Brisbane City Centre Master Plan 2014 sets the vision and strategic framework to guide growth within the Brisbane CBD and surrounds. The plan identifies the need for the Brisbane CBD to be well-connected with safe and efficient access between the various transport hubs and the health, knowledge, cultural and government hubs. It also identifies the need to deliver improvements to the inner-city bus network to improve bus access to the city centre. The Project addresses these needs through connecting the PA Hospital, Ecosciences Precinct, Mater Hospital, the Brisbane Cricket Ground (Gabba Stadium), the Brisbane CBD, Roma Street Station and the RBWH. This includes providing a significant increase in bus network capacity through the extra river crossing. The Project is identified as one of six priority projects to commence in the next five years.

The public transport capacity provided by the Project and its integration with existing and planned public transport infrastructure and land use in key locations, such as Woolloongabba, George Street and the Roma Street Station precinct, would improve accessibility and encourage public transport usage supporting Commonwealth, State and local planning intents.

2.2 Existing transport context

2.2.1 Existing transport use

In 2012, an average of 503,000 people used public transport on a daily basis in the Brisbane Statistical Division. Of this number, rail users accounted for approximately 214,500 people and bus users accounted for around 248,800 people. Private vehicle use was the dominant method of travelling within the Brisbane metropolitan area in 2012 with around 82 per cent of daily trips (over 5.8 million trips). In comparison, public transport trips were around 7 per cent of daily trips (over 0.5 million trips).

About 50 per cent of public transport trips occur during the morning and afternoon peak periods. Rail generally carries slightly more passengers than buses in the peak periods, although buses have a higher daily use. Bus trips are generally of a shorter distance and shorter duration compared to rail.

Cultural Centre Busway Station

2.2.2 Current rail network and passenger services

The existing rail network links the Brisbane CBD (Roma Street and Central stations) from the north, west and south. The lines from the west (Ipswich Line) and the south (Gold Coast Line) join north of the Brisbane River before Roma Street Station. The Cleveland Line joins the Gold Coast Line at Dutton Park, before Park Road Station.

The merging of rail lines close to the CBD imposes capacity and operational constraints on the rail network. The inner city rail network is at capacity over much of the peak commuter periods of travel.

Other existing constraints on capacity include:

- the capacity of the Merivale Bridge
- merging of rail lines at Park Road Station and to the west of Roma Street Station
- limited tracks and capacity between Roma Street Station and Bowen Hills Station
- speed restrictions and platform capacity at Central Station
- old signalling technology.

Rail capacity constraints in the inner city rail network are shown in **Figure 2**.

Figure 2 Rail capacity constraints

Rail level of service – on time reliability

The on-time operation of current rail services is reliable throughout the day including the commuter peak travel periods with over 95 per cent of trains recorded as operating on time (2013). However, there is a lack of resilience in the network with only one railway corridor through the CBD, contributing to incidents causing major disruptions. Rail services are predicted to become less reliable as the network becomes more congested.

Rail level of service – passenger crowding

The major passenger demands on the rail network occur in the morning and afternoon peak periods. Over half of the total daily volume (251,000 passengers) uses the rail system in just four hours over the two peak periods, resulting in overcrowding. This particularly occurs on the longer distance Gold Coast services, with utilisation of morning peak services in 2012 at 126 per cent of seated capacity. Overcrowding on the rail network impacts the time for loading and unloading of trains at all stations, exacerbating the limited capacity issues in the inner city.

Accessibility to rail stations from the whole CBD

The Brisbane CBD is currently served by two rail stations – Central Station and Roma Street Station. These are located on the northern side of the CBD, which means that the southern areas of the Brisbane CBD are more than a 15 minute walk from a rail station.

This results in high volumes of pedestrians walking across the CBD from both Central Station and Roma Street Station. During peak periods, pedestrian congestion is evident on a number of footpaths. This also results in use of other modes of transport.

2.2.3 Current bus network and passenger services

The Brisbane bus network is CBD centric with more than 500 bus services entering the CBD in the morning peak period. Some bus services provide access to suburbs that the rail network does not. Brisbane's south and inner north are serviced by grade-separated busways that provide access to the CBD. The busway network consists of:

- South East Busway, extending from the Brisbane CBD to Eight Mile Plains
- Northern Busway, including the Inner Northern Busway, extending from the Brisbane CBD to Kedron
- Eastern Busway, extending from the UQ to Langlands Park, Coorparoo.

The Brisbane CBD has three major bus stations at Queen Street, King George Square and Roma Street.

Merivale Bridge

The key routes into the Brisbane CBD for buses from the south are currently constrained by the two river crossings – the Captain Cook Bridge and Victoria Bridge. During the morning peak, the South East Busway system exceeds its design capacity at several locations on the approach to the CBD. This results in rocket services and all new bus service growth from the south predominantly being accommodated on the Captain Cook Bridge.

Other constraints on the bus network include CBD congestion and traffic arrangements. The key capacity constraints in the inner city bus network are shown in **Figure 3**.

Capacity constraints on the bus network have led to declining levels of reliability and increasing overcrowding. General traffic conditions and road congestion cause declining on-time reliability for bus services not using the busway network. As traffic congestion worsens, there would be a corresponding deterioration in reliability on these services.

Similarly, in 2012, about 45 per cent of bus routes that terminated in the Brisbane CBD in the morning peak had boardings that exceeded seat capacity. As this represents an average across the morning peak period, crowding on services in the shorter 'peak within the peak' would be more significant.

Figure 3 Bus capacity constraints

Congestion on the bus network

The bus network experiences difficulties feeding buses into and out of the CBD in some areas. Although the South East Busway provides buses with a dedicated right of way, this does not extend all the way to the CBD. Buses must mix with general traffic on congested major roads and city streets. Many of the capacity constraints on the South East Busway are highly visible during peak periods.

Queues of buses can be seen at gateways to the CBD such as the Victoria Bridge, the approach to the Melbourne Street busway portal, the Allen Street busway exit to the Captain Cook Bridge and at the Mater Hill Busway Station.

Bus congestion on CBD streets

Heavy traffic and bus-related congestion in some CBD streets impacts on-street stopping and layover space and the ability to accommodate growth in bus movements. Major congestion and operational constraints include:

- bus queues on Margaret Street and Elizabeth Street off-ramps from the Riverside Expressway
- the capacity of inner city bus stops for buses using the Captain Cook Bridge, with morning peak period buses often queuing in Elizabeth Street across its intersection with George Street and onto the Riverside Expressway off-ramp
- capacity constraints getting to the Captain Cook Bridge at Woolloongabba where they do not have an exclusive lane to access the Pacific Motorway via the Riverside Expressway
- access to the many bus stops and layover spaces in the CBD result in bus activity contributing to traffic congestion in the CBD.

Limited bus layover and bus stop space

Bus layover space in the Brisbane CBD is limited, with a range of dedicated on-street spaces in Alice Street, William Street, Queen's Wharf Road and Wickham Street. This is supplemented by off-street space at Woolloongabba (South East Busway), Countess Street (Inner Northern Busway) and at the Queen Street Bus Station. The provision of more terminating bus services in the Brisbane CBD is constrained.

Bus travel time reliability

The bus network is currently experiencing high levels of demand in commuter peak periods with congestion causing delays and reliability concerns. Bus capacity issues and resulting congestion on the busway and the CBD streets leads to unreliable bus travel times for bus journeys to and from the CBD during the commuter peaks.

2.2.4 Current road network and parking

The Brisbane regional road network is characterised by radial routes directing vehicles into and through the inner city and orbital arterial, and motorway routes taking traffic around the inner city. During the morning peak the road network approaching the CBD is constrained. Many of the key road corridors to the CBD have more than 90 per cent of available road capacity being used resulting in unstable flows, congestion, delays and poor level of service for inbound traffic.

Recent large road infrastructure projects have significantly improved the orbital network by providing alternatives for cross-city trips. These include the CLEM7, the Gateway Bridge duplication, Airport Link, the Go Between Bridge and the soon to be completed Legacy Way. However, this new road infrastructure will not overcome the increasing levels of congestion on the road network servicing the inner city and the CBD.

The capacity of the inner city major road network is essentially fixed with limited ability for further infrastructure capacity enhancement. The capacity in the regional and arterial network to satisfactorily cater for further growth in travel demand by private vehicles to Brisbane's CBD during the peak periods is constrained.

The majority of commercial car parks in and close to the CBD operate close to capacity on weekdays. All day on-street car parking is not available in the Brisbane CBD. Consequently, there is a lack of car parking spaces that could accommodate additional commuter trips by car to the CBD.

2.3 Future transport demand

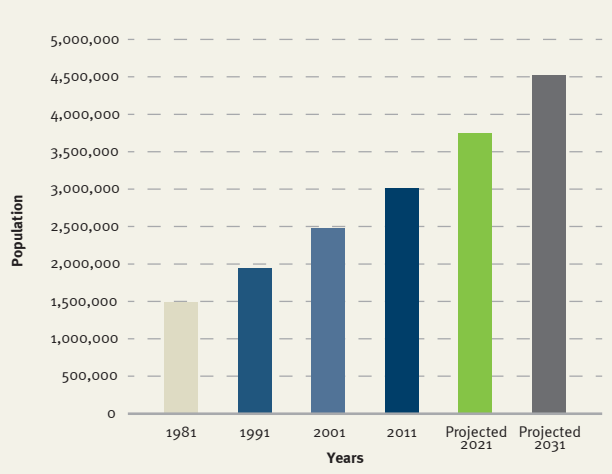
Travel demand is strongly influenced by population and employment growth. South East Queensland continues to experience significant growth in both.

2.3.1 Population growth

From 1981 to 2011, the population of South East Queensland doubled to over 3 million people. This trend is forecast to continue, where 3.7 million people are expected by 2021 and 4.5 million people by 2031 (refer to **Figure 4**).

Much of the region's population growth is expected to be in areas outside of Brisbane City in the Gold Coast, Ipswich, the Sunshine Coast, Moreton Bay and Logan LGAs. However, approximately 290,000 additional people are expected to settle within the Brisbane LGA by 2031 to bring the total population to around 1.4 million.

Figure 4 South East Queensland population growth



Source: Queensland Government population projections, 2013 edition

The residential population of the inner city is also expected to double in the next 20 years. Particular growth areas are expected in the inner city areas of the CBD, South Brisbane, Spring Hill, Milton, Woolloongabba, Bowen Hills and Fortitude Valley. Current planning intentions anticipate growth around the CBD with taller buildings in South Brisbane and increased intensity of development in the Woolloongabba, Roma Street and Fortitude Valley areas.

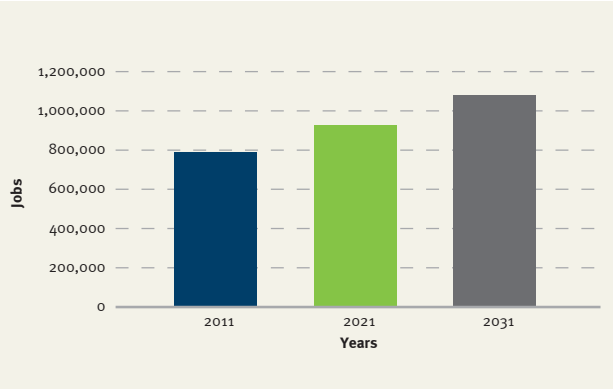
Population growth in LGAs surrounding Brisbane will place pressure on the regional transport network with a focus on peak period travel to the Brisbane CBD as a major employment destination. Similarly, the growth in inner city residents will also place pressure on inner Brisbane travel.

2.3.2 Employment growth

With the forecast increase in population in South East Queensland, employment will also grow. Brisbane City is the primary commercial and employment centre in South East Queensland. It is anticipated that about 44 per cent of the regional jobs growth will occur in Brisbane whereas population growth is mostly in outlying LGAs, giving rise to intra-regional travel demand.

Figure 5 shows the projected employment growth in Brisbane LGA with an extra 140,000 jobs by 2021 and a further 150,000 jobs by 2031. The Brisbane LGA will to reach a total employment of almost 1.1 million jobs by 2031 from just under 800,000 jobs in 2011.

Figure 5 Brisbane LGA employment growth



The importance of the Brisbane's inner city as a major employment node and travel generator for South East Queensland is illustrated in **Table 1**.

Much of the growth in jobs in Brisbane will be focussed in the CBD and adjacent fringe areas of Milton, South Brisbane, Fortitude Valley and Bowen Hills. Approximately 100,000 future jobs in Brisbane will be created in these locations. Overall, the CBD and fringe will host around 20 per cent of all jobs in South East Queensland through to 2031.

Table 1 Inner Brisbane population and employment forecasts

Year	Population	Employment
2012	57,900	270,600
2021	92,200	332,700
2031	119,800	397,000

2.3.3 Increased demand for travel

Forecast growth in weekday travel demand across Brisbane, without the Project, is shown in **Table 2**.

The highest growth is forecast to occur in public transport trips, with the number of trips forecast to double between 2012 and 2031. Private vehicle trips are anticipated to grow at a slower rate, increasing by 42 per cent between 2012 and 2031.

An increase in mode share for public transport is forecast from 7 per cent of all weekday trips in 2012 to 10.8 per cent in 2031.

This forecast change in mode share reflects the expected minimal changes in road capacity, as well as minimal increases in likely car parking availability in the CBD. As the Brisbane CBD continues to grow and provide more employment opportunities, public transport use will increase at a higher rate than private vehicles use. Growth of 122 per cent in public transport travel would occur from 2012 to 2031. Both peak period and daily rail and bus trips are forecast to double between 2012 and 2031.

In general, the scale and spatial distribution of travel demand across the region is primarily influenced by population and employment growth and location. The demographic and economic profile forecast indicates that strong growth will continue to drive demand for travel in South East Queensland.

Mater Hill Busway Station

Boggo Road Cycleway, Woolloongabba

Table 2 Growth in travel demand in the Brisbane Statistical Division (without the Project)

Parameter	2012	2021	2031
Total person trips by all modes	7,165,000	8,890,000	10,348,000
Total person trips by car	5,860,700	7,099,900	8,148,300
Percentage growth in person trips by car (on 2012)	-	21%	39%
Public transport person trips**	503,000	836,000	1,115,600
Percentage growth in public transport trips (on 2012)	-	66%	122%
Public transport mode share (of all motorised person trips)	7.0%	9.4%	10.8%
Total rail patronage (24 hour)	214,500	395,500	558,000
Percentage growth in rail patronage (on 2012)	-	84%	160%
Total bus patronage (24 hour)	248,800	381,300	496,600
Percentage growth in bus patronage (on 2012)		53%	100%

Source: BaT Project Model
** Total public transport trips include trips by ferry and intra-zonal trips

2.4 Performance of the transport network without the Project

The expected growth in population and employment in Brisbane's inner city would put increasing pressure on the existing public transport network to service this demand. Without the Project, there would be declining levels of service for rail and bus passengers as well as on the road network.

2.4.1 Passenger rail operations

Passenger numbers on rail services are expected to grow strongly between 2012 and 2021, and flatten somewhat between 2021 and 2031. Rail patronage growth in peak periods is likely to be higher than daily growth between 2021 and 2031 placing additional pressure on the periods of greatest congestion. Demand for other services, outside of peak period would also be strong across the rail network.

Expected growth in rail passengers and peak commuter demand to the Brisbane CBD would result in the inner city rail network approaching capacity by 2021. The capacity of the Merivale Bridge would be reached by 2020 meaning that any additional demand for rail travel from the south could be not be accommodated by the provision of extra trains post 2020. Rail commuters would be forced to take off-peak trains, use alternative transport or change trip making decisions.

Limited inner city passenger rail coverage

The existing rail network does not cover the whole CBD and inner city in terms of acceptable walking distances to stations. Central Station and Roma Street Station are located on the northern periphery of the CBD and are relatively remote from key destinations, such as the George Street precinct including Queen's Wharf Brisbane, and QUT Gardens Point.

Other major inner city areas that are less accessible by rail, being outside a walkable catchment of 800m, include:

- Woolloongabba/ Kangaroo Point
- Newstead/ New Farm
- RBWH
- City Botanic Gardens.

Without the Project, the reliance of the rail network on Roma Street and Central stations for accessing the CBD would continue, increasing congestion at these stations. These would be corresponding impacts to reliability and passenger comfort. The likely implications of this include:

- overcrowding
- higher numbers of boarding and alighting passengers, increasing congestion around train doorways due to people standing and increasing passenger congestion on platforms
- delays to boarding and alighting times
- reduction in on-time reliability of services and ability of the network to operate at capacity.

Reduced reliability of passenger rail services

As the services on the network increase over time and approach capacity, reliability can be expected to deteriorate across the whole network. For example the increased boarding and alighting times required in overcrowded conditions can compound and create significant impacts. For crowded stations like Central Station, delays may be exacerbated.

Overcrowding on trains

At present, passenger numbers on trains are most concentrated within the peak periods (the morning peak is greater than the afternoon peak) with the key destinations being the inner city stations of Roma Street, Central and Fortitude Valley. Central Station is the principal destination for CBD passengers, with 24,800 alighting there in the morning peak period in 2012. This is 72 per cent of all passengers alighting in the CBD. Overcrowding is being experienced currently on services in the morning peak period, particularly on the longer distance Gold Coast Line. Gold Coast Line morning peak services reached 126 per cent of seated passenger capacity in 2012.

Passengers from Central Station, Edward and Adelaide Streets

2.4.2 Bus operations

Similar to rail patronage, growth rates on bus services will be strong between 2012 and 2021, with continued growth but at a slower rate between 2021 and 2031. From 2012 to 2021, bus boardings would increase from 248,800 per day to 381,300 per day and to 496,600 per day by 2031. Peak period growth rates are expected to be greater than daily growth across the day between 2021 and 2031.

The congestion on the inner South East Busway network from the south would limit the provision of additional services. More buses would be diverted to the inner city road network, particularly the Captain Cook Bridge and be delayed due to congestion and mixing with general traffic.

There would be no scope to reduce bus volumes on the Victoria Bridge to ease the congestion that currently occurs. Interchanging would continue to be concentrated at the Cultural Centre Busway Station, contributing to ongoing queuing of buses over the Victoria Bridge.

Growth in buses into the CBD would require a large number of buses to be relocated to Margaret Street and Alice Street using additional scarce kerbside space for passenger pick-up and set-down. This would cause bus operations to be slower, reliability of bus services would further deteriorate, be more costly to operate, and less attractive to passengers. In the CBD, it would affect road congestion, footpath congestion, bus travel times and convenience.

Reliability of bus services

Bus movements relying on the road network are impacted by general traffic, road congestion and traffic incidents. This results in longer and more variable travel times affecting travel time reliability and service efficiency. From those suburbs where buses are required to use the road network, traffic conditions and congestion can affect bus services considerably. This can result in buses bunching (catching up to each other where one bus can be overcrowded and others empty) and being late for the start of their next service.

Bus overcrowding

In January to March 2012, 45 per cent of bus routes that terminated in the Brisbane CBD in the morning peak had boardings that exceeded seated capacity. This level of crowding along with the regular congestion, affects the passenger travelling experience.

Victoria Bridge, evening peak

2.4.3 Road network

Total trips by all modes on the region's transport network are forecast to increase by almost 40 per cent between 2012 and 2031 to around 10.3 million trips per day. Public transport is forecast to make up 1.1 million trips per day leaving the region's road network to cater for much of the remaining 9.2 million trips per day. Between 2012 and 2031, total private vehicle kilometres would increase by 60 per cent, resulting in increases in congestion and travel time and decreasing network efficiency.

There is very limited capacity on key roads to the inner city to support additional growth in peak period travel. The opportunity for further development of the road network in the inner city is constrained by the existing land use pattern and topography. Without the Project, inner city traffic congestion would further deteriorate.

2.4.4 Summary of transport network without the Project

Without the Project, the transport network in the inner city will not be able to accommodate the expected increase in commuter and personal travel demand to, from and through the CBD and inner city. The network will become further congested resulting in increased travel time and decreasing reliability and consequential impacts on the region's economy and liveability.

In particular, the rail and bus networks will not have the capacity to cater for the projected increase in demand for public transport travel in the future. The existing constraints in the transport network are pronounced at the Merivale Bridge for rail traffic, the Victoria Bridge for bus traffic and the Captain Cook Bridge for both bus and private car traffic. Each of these congestion points or constraints reduces the ability to service commuter trips from the south (between the Gold Coast and Park Road Station) and east (including bayside suburbs).

The current bus network into the Brisbane CBD from the south is operating beyond capacity at peak periods and the rail crossing at Merivale Bridge is forecast to reach capacity by 2020. The public transport network, which converges at the inner city and through the CBD, will not be able to meet future needs as forecast.

Roma Street Station

2.5 Benefits of proceeding with the Project

By providing an additional river crossing for both rail and bus and new inner city stations, the Project would provide a significant and necessary increase in public transport capacity, predominantly from the south. It addresses the following transport issues:

- travel demand from the projected population and employment growth in the inner city and region will increase public transport demand into the inner city beyond the existing capacity of the public transport network infrastructure
- constraints on increasing rail services from the south and east due to the capacity of the Merivale Bridge
- constraints on increasing bus services from the south due to the capacity constraints of Victoria Bridge and Captain Cook Bridge
- lack of rail coverage of the southern part of the Brisbane CBD and reliance on existing stations in the northern part of the Brisbane CBD
- lack of capacity to meet demand for additional bus services and facilities in the CBD and inner city more broadly
- the decrease in rail and bus reliability and increase in overcrowding and travel times.

The Project will strengthen the commercial role of the Brisbane CBD in South East Queensland and Queensland and contribute to the key transport policies and outcomes sought by the Commonwealth, State and local governments.

The critical benefits relate to the provision of greater public transport capacity, improved travel times, better accessibility to public transport and reduction of congestion and overcrowding.

2.5.1 Rail benefits with the Project

The Project would:

- provide additional rail capacity into the CBD to overcome the existing constraints and accommodate the forecast future need for additional train services into the CBD, particularly from the south
- provide improved travel times and comfort (less overcrowding)

- provide a more resilient rail network resulting in improved rail service reliability
- improve the effectiveness and efficient use of existing rail assets
- provide additional CBD and inner city rail stations (Woolloongabba, George Street and Roma Street) to increase accessibility to train services particularly around Woolloongabba and the southern part of the CBD as well as to avoid the predicted future congestion at the existing rail stations particularly Central Station
- link the high growth residential communities to the south of Brisbane with the CBD and inner city employment and tertiary services by a high capacity rail link.

2.5.2 Bus benefits with the Project

The Project would:

- provide additional bus capacity into and through the CBD to overcome the existing constraints and accommodate the forecast future need for bus services into the CBD, particularly from the south
- provide a grade separated connection between the South East Busway and the Inner Northern and Northern Busway through the CBD. This would also link the PA Hospital in the south with the RBWH in the north
- provide improved bus access to the southern part of the CBD and Woolloongabba from the north
- provide improved reliability, time savings and comfort (less overcrowding)
- remove buses from the congested road network in the CBD and connections into the CBD eg Captain Cook Bridge
- provide additional busway stations within the CBD and inner city to improve accessibility to the bus network
- provide improved accessibility to the CBD from parts of Brisbane not serviced by the rail network.

2.5.3 Combined public transport benefits

The Project would provide key benefits to public transport passengers and operators, including:

- wait time savings for passengers at stations
- greater CBD infrastructure capacity (passenger rail and bus) to operate improved services and timetables to match passenger demand
- reduced crowding and the delivery of more comfortable journeys as a result
- opportunities for improved rail and bus integration at rail stations served by the Project
- significantly enhanced accessibility to major trip generators, such as the southern area of the Brisbane CBD including QUT Gardens Point campus and the Queen's Wharf Brisbane project, the future development areas at Woolloongabba and Boggo Road, and the major events conducted at the Gabba Stadium
- higher fare revenues from higher patronage with the new and improved CBD services.

Corner of George and Alice Streets, Brisbane CBD

2.5.4 Benefits contributing to wider transport objectives

The Project would:

- deliver outcomes sought by Commonwealth, State and local transport strategies, policies and plans including National Infrastructure Plan 2013, Infrastructure Australia: Urban Transport Strategy 2013 and Transport Plan for Brisbane 2008-2026
- significantly contribute to delivering the transport objectives outlined within the State Planning Policy (SPP)
- contribute to improved regional accessibility, higher public transport mode share, reduced dependency on private motoring, lower growth in transport emissions and a lower regional carbon footprint.

2.5.5 Land use benefits

The Project would:

- support the future growth and development of South East Queensland proposed under the *South East Queensland Regional Plan 2009-2031* (SEQ Regional Plan), by providing improved public transport access to areas of future population and employment growth
- enhance the existing rail and bus networks, supporting the preferred land use patterns and efficient and sustainable development
- connect inner city development areas such as Boggo Road Urban Village and the Woolloongabba Priority Development Area (PDA) with the CBD
- provide rapid, high frequency connections between primary residential destinations and economic activity areas in inner Brisbane.

Princess Alexandra (PA) Hospital, Woolloongabba

2.5.6 Economic benefits of the Project

The Project would:

- deliver benefits of approximately $4.73 billion in present value terms (2014). This would be achieved primarily through crowding and reliability improvements to public transport users and travel time savings to public transport users and road users
- increase public transport services and connectivity for important economic centres within the inner city being Boggo Road Urban Village, PA Hospital campus, UQ, the Woolloongabba PDA, the CBD (QUT, the George Street government precinct) and the RBWH
- connect the high growth population areas to the south of Brisbane with the inner city areas forecast to experience future employment growth such as the CBD
- deliver economic development outcomes of Commonwealth, State and local strategies including Infrastructure for Economic Development 2013 and the Brisbane Economic Development Plan.

A more comprehensive discussion of the transport effects, including benefits of proceeding with the Project, is provided in **section 4** and Chapter 4 of the EIS.

A more comprehensive discussion of the land use effects is provided in **section 5.2.7** and Chapter 5 of the EIS, and the economic effects are discussed in **section 5.2.10** and Chapter 14 of the EIS.

2.6 Alternatives to the Project

Following a number of State and local public transport studies carried out since 2008, it was identified that substantial investment in Brisbane's rail and bus infrastructure would be required to meet the increasing capacity demands of the City's transport network.

The studies carried out preceding the development the Project reference design sought to address specific capacity issues within the transport network. These studies identified solutions that were to be delivered primarily in isolation to other transport network improvements and would have been delivered as alternatives to the Project.

These studies have led to the identification of the Project, a combined railway and busway in a single double-decked tunnel, as the preferred public transport outcome for the Brisbane area. The Project provides an affordable bus and rail solution that would address public transport capacity constraints at key inner-city destinations, including across the Merivale Bridge for rail and at the Cultural Centre Busway Station for bus. The Project would boost the capacity of the public transport network and reshape it to meet Brisbane's growing and changing travel demands.

2.6.1 Heavy rail options

The Inner City Rail Capacity Study (2008), and the Rail Assessment of Capacity Alternatives Study (2008), considered a range of upgrades to the heavy rail network to address capacity constraints. The possible upgrades included:

- two new inner city north-south heavy rail links to effectively double the inner city's heavy rail capacity
- a new north-west rail corridor to further expand on the inner city capacity
- a prioritised program of alternative capacity measures, including higher capacity trains, peak spreading, eliminating Mayne stabling issues, management of passenger loading / unloading, rescheduling the XPT service and fine-tuning service frequencies and spacings.

Central Station

2.6.2 Bus options

The Bus Access Capacity Inner City Study (2008), identified where the bus network was most heavily loaded and considered initiatives that would have the greatest potential for improving travel times and reliability.

Initiatives considered included policy intervention, network improvements to achieve operational efficiency and infrastructure solutions such as:

- providing a strategic mix of near-side termination and through running to minimise the impact of congestion while maximising connectivity
- developing a multi-nodal bus spine network to distribute passengers from terminus stations
- expanding the bus priority network to link other major inner city destinations
- improving inner city pedestrian and cycle connections to and from public transport nodes
- investigating an additional inner city distribution network.

2.6.3 Light rail and metro vehicle options

The Busway Conversion Report (2009) included a technical assessment of the potential to co-locate buses and light rail transit vehicles within the existing Brisbane busway network or to fully convert the existing busway into a dedicated metro rail operation utilising either light rail transit or metro vehicles.

The report found that it was not feasible to co-locate buses and light rail transit vehicles within the existing busway infrastructure. This was due to the considerable cost and significant disruption that the works would cause to the existing network when compared with the marginal increase in passenger capacity that would result from the conversion works.

2.6.4 Integrated transport and land use considerations

In 2009, the Queensland Government examined how the transport network overlaps and how gaps in the transport networks could be addressed in a coordinated way and aligned with preferred land use development patterns and current or committed investments.

The investigation supported the findings of the Inner City Rail Capacity Study, proposing a new north–south link via Park Road, Woolloongabba, the Brisbane CBD and initially via the Exhibition Line and ultimately extending to the north-west. This strategy was considered the most complementary to the preferred land use strategy by serving areas most in need of additional capacity and most likely to develop first.

Woolloongabba

2.6.5 Investigation of identified heavy rail and bus solutions

Following these studies, separate preferred options were identified for heavy rail and buses ie Cross River Rail and Suburbs 2 City. Both sought to provide additional river crossing capacity as well as new infrastructure in the inner city.

Cross River Rail detailed feasibility study

The Queensland Government undertook a comprehensive assessment of the impacts of the proposed Cross River Rail project through a business case, supported by a reference design and an EIS. The proposed Cross River Rail consisted of a 9.8km twin tunnels for heavy rail between Yeerongpilly in the south and Victoria Park in the north. Four new underground stations were proposed at Boggo Road, Woolloongabba, Albert Street and Roma Street, with new surface stations proposed at Yeerongpilly and the Exhibition. Minor upgrades at Moorooka and Rocklea stations were also proposed.

The Coordinator-General approved the project to proceed in December 2012 and indicated that, subject to the conditions being implemented, project impacts could be avoided or minimised to an acceptable degree. Infrastructure Australia's assessment process afforded the proposed project 'ready to proceed' status in mid-2012.

Due to the cost of the proposed project ($6.4 billion), the Cross River Rail project was held in abeyance while further investigations were undertaken.

Suburbs 2 City

In 2013, Brisbane City Council developed the Suburbs 2 City Buslink initiative to improve the performance of Brisbane's bus services through the busiest parts of the inner-city at the Cultural Centre Precinct and the Brisbane CBD. The project sought to:

- increase bus capacity across the river into the city centre
- develop further Brisbane's busway network by giving buses a congestion-free run through the CBD between the northern and southern busways
- alleviate bus capacity issues along Adelaide Street and free up city streets for people
- improve development opportunities along Adelaide Street.

Stage 1 proposed a segregated busway connecting the South East Busway to the Inner Northern Busway at King George Square comprising tunnels and a new busway bridge shared with pedestrians and cyclists. Following stages included: Stage 2 – Inner Northern Busway to Centenary Place, Fortitude Valley and Stage 3 – Centenary Place, Fortitude Valley to the Northern Busway at RBWH.

This study identified the benefits of improving busway capacity across the river and providing improved busway infrastructure in the Brisbane CBD. The prefeasibility study was provided to the Queensland Government for consideration as part of its investigations into the rail and bus networks.

2.6.6 Refinement of the preferred public transport strategies

A number of studies have been carried out following the completion of the Cross River Rail and Suburb 2 City investigations. These aimed to identify further opportunities in relation to affordability and integration of public transport outcomes.

Independent panel review of the proposed Cross River Rail project

In May 2012, the Queensland Government commissioned an Independent Panel to review the proposed Cross River Rail project. The Panel recommended:

- consideration of progressing with the core Cross River Rail project as part of a staged delivery
- implementation of priority short-to-medium term initiatives to increase rail capacity and optimise the use of existing infrastructure and services
- staging the Cross River Rail with an initial focus on the north-south core to enhance affordability
- the development of more accurate capital costings, confirmation of the extent of capacity enhancement by initiative and the development of a detailed implementation plan including funding arrangements.

Brisbane Inner Rail Solution

The Brisbane Inner Rail Solution (BIRS) is a program of works and initiatives to accommodate growth and address inner city capacity constraints in the existing rail system and was initiated in light of the findings of the 2012 Cross River Rail Independent Panel Review. The BIRS includes:

- delivery of an early capacity works program – a package of value-for-money, short to medium term solutions which includes capital works such as seat reconfiguration and routine operational improvements such as revisions to timetabling – to defer the need for Cross River Rail from 2016 to 2021
- delivery of the core Cross River Rail project between Yeerongpilly and Victoria Park.

The early capacity works program is currently in delivery with timetabling changes having taken effect from 20 January 2014.

Integrated heavy rail and bus infrastructure outcome

Both the Queensland Government and Brisbane City Council recognised the need to improve rail and bus capacity into and within the inner city. Constructing separate heavy rail and bus projects had significant costs and construction impacts that made separate projects unfeasible. It was recognised that significant savings could be realised by combining new inner city bus and train infrastructure into one project, while maintaining the significant benefits of both. This provided the direction for the development of the concept design and reference design for the Project.

3. Bus and Train project

3.1 Background

South East Queensland is one of Australia's fastest growing regions. Brisbane is the administrative, commercial and cultural centre of Queensland and is one of Australia's leading growth centres. Maintaining strong growth and economic competitiveness in a major city relies on an effective, safe and attractive transport system.

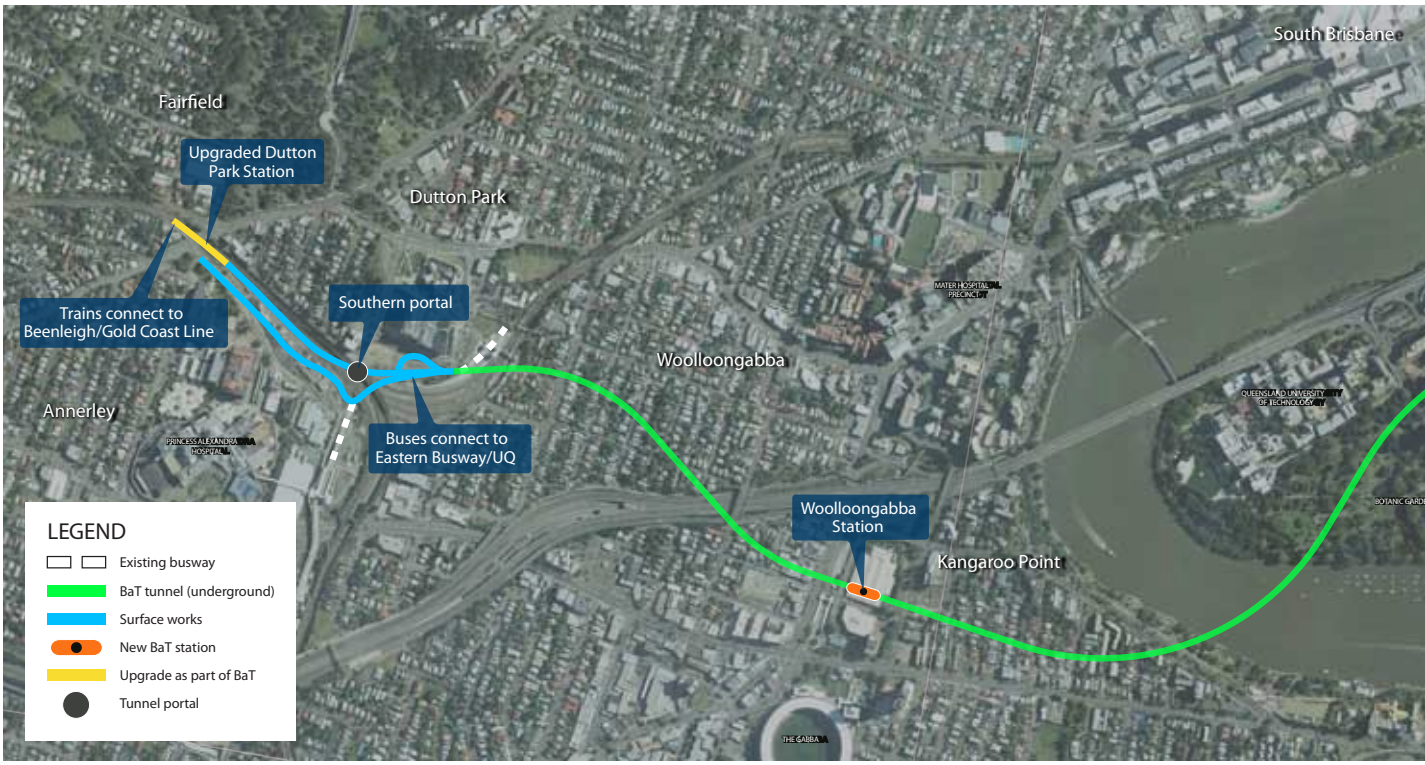
Brisbane and the inner city, including the CBD, will remain the primary employment centre in the growing South East Queensland region. Patronage studies indicate that the majority of workers entering the Brisbane CBD each day do so via public transport. Rail and bus services are similarly utilised for commuting, although rail tends to service longer haul, regional trips and buses the shorter, inner urban trips.

The preference for public transport in travel patterns is expected to be maintained as both the regional population and employment growth continues.

Brisbane's inner city is the hub of South East Queensland's rail network. By around the year 2020, the rail network is expected to reach capacity. Extensions and service increases to the broader rail network will depend on alleviating the capacity constraint at the heart of the network. The limited capacity of the Merivale Bridge and existing inner Brisbane rail tunnels significantly limit the number of additional trains that can be introduced to meet passenger demand.

Like the rail network, the bus network is centred on Brisbane's inner city. Constraints are already evident on parts of the bus network such as the Victoria Bridge and the Cultural Centre Busway Station, as well as on several streets in the CBD. Capacity in and through the inner city bus network is critical to the effective operation of the wider bus network and the ability to cater for future growth in services.

The Queensland Government and Brisbane City Council have undertaken a number of studies to examine solutions to the capacity constraints facing Brisbane's inner city public transport network.



These included:

- the Inner City Rail Capacity Study
- Cross River Rail
- Suburbs 2 City
- Underground Bus and Train Phase A – Concept Design.

On completion of Phase B studies for the BaT project, including the business case, reference design and EIS processes, an investment decision by government is required for the Project to proceed to procurement and construction, and ultimately delivery. Allowing for a five year construction program, the earliest time in which the Project could commence operations would be 2021.

3.2 Project overview

The Project would combine rail and bus operations in a single, double-decked tunnel system beneath the Brisbane River and Brisbane CBD. The Project would be about 6.7km in length in its entirety, with the tunnel system being about 5.7km in length. The Project would extend from Dutton Park Station in the south to Spring Hill in the north with integrated underground stations proposed at Woolloongabba, George Street and Roma Street.

The Project would connect to the existing bus network including the Eastern Busway at Dutton Park and the Northern Busway at Herston; and to the existing rail networks including the Gold Coast-Beenleigh Line at Dutton Park and the Exhibition Line at Spring Hill.

The Project reference design, upon which this EIS is based, provides for underground and surface infrastructure, including underground stations, tunnels, bridges, new and modified track, rail and bus signalling and fire life safety systems and associated services. The reference design has sought to meet technical design requirements as well as environmental and safety standards.

Construction of the Project would be undertaken simultaneously from a number of construction worksites, at the northern and southern connections and at each of the station sites.

This section provides an overview of the main elements of the Project's design and construction. More detailed information is provided in Chapter 3 of the EIS.

3.2.1 Busway

The busway would occupy the upper 'deck' within the proposed tunnel system, as well as the upper platforms in the multi-level, underground stations. It would comprise a dual lane, single carriageway with a posted design speed of up to 70km per hour, as well as:

- upgraded intersections with the Eastern Busway, Kent Street and Cornwall Street at Dutton Park and with the Northern Busway and Gilchrist Avenue at Herston
- a new busway bridge across the Inner City Bypass (ICB) and a new westbound on-ramp for buses to the ICB at Herston
- new bus layovers and associated accesses at Kent Street in Dutton Park, at Gilchrist Avenue, Herston and holding bays in the rail corridor at Spring Hill
- new bus access from the Northern Busway adjacent to Bowen Bridge Road to the ICB.

Appropriate design standards would accommodate operating systems to manage air quality, fire and life safety, security and network logistics.

The busway and stations would accommodate the existing bus fleet variants, including the standard length, long chassis and articulated buses.

3.2.2 Railway

The railway would occupy the lower deck and lower platform levels of the underground stations and would include two, narrow gauge rail tracks, separated by a structural partition.

The railway would connect the Gold Coast-Beenleigh Line in the south and the Exhibition Line in the north. Additional surface infrastructure would include new junctions with the Gold Coast-Beenleigh Line at Dutton Park and the Exhibition Line at Spring Hill.

The railway would have a maximum design speed of 80km per hour. Track infrastructure would be designed with a range of gradients and a maximum gradient of 3.25 per cent, to cater for fully loaded electric passenger trains (new generation rollingstock) and track maintenance vehicles. The new generation rollingstock (NGR) fleet are six car sets with capacity for up to 750 seated and standing passengers and two door carriage configuration. Traction power would be supplied through a fixed conductor suspended from the rail compartment roof.

3.3 Project development

The reference design has evolved from an early concept design completed in late 2013. The concept design sought to test the technical feasibility of extending rail and bus infrastructure in a shared tunnel and with shared underground stations as an affordable response to the existing and future capacity constraints in the public transport network.

The concept design was accepted by the Queensland Government in late 2013 as the basis for further investigations into the technical, transport planning, financial and environmental aspects to determine whether the Project should proceed.

A draft reference design was developed for the Project following further technical investigations and preliminary investigations of baseline conditions in the study corridor. The draft reference design was developed on the assumption that NGR rollingstock would operate at a maximum gradient of 3 per cent. This assumption, in combination with the available geotechnical information and built environment constraints, dictated the horizontal and vertical alignments from south to north.

The draft reference design was released for consultation on 19 March 2014. Feedback on the draft reference design, combined with further geotechnical information, building survey information and revised operating criteria for the rollingstock (increased maximum gradient to 3.25 per cent), were considered in further design development. As a consequence, refinements to the draft reference design were issued on 24 June 2014, in respect of the Southern Connection and Northern Connection.

If the Queensland Government decides to proceed with the Project, further refinement of the design would occur during the tendering process and the detailed design phase. Where such refinement would result in a change to the Project scope, possibly including its construction method, the Proponent would apply to the Coordinator-General for consideration of the project change. The Coordinator-General may seek further information in relation to the proposed change, if required, and determine whether such changes are to be the subject of further public notification including an opportunity for further written submissions.

3.3.1 Southern Connection

Features of the Southern Connection proposed by the draft reference design were:

- connections with the Gold Coast-Beenleigh Line at Dutton Park, requiring the decommissioning and demolition of the station
- connections to the Eastern Busway adjacent to the busway connection at Joe Baker Street, Dutton Park
- a pedestrian and cycle underpass of the rail corridor to provide a connection between Boggo Road Urban Village and the PA Hospital.

An overarching issue during consultation for residents, workers and stakeholders in the southern part of the study corridor were potential impacts relating to the closure of Dutton Park Station. This concern generally related to the loss of train services for local residents, and workers and users of nearby major facilities such as the PA Hospital campus and Ecosciences Precinct.

Community feedback was also received in regard to the proposed underground pedestrian link. Whilst a pedestrian link was generally supported, feedback suggested that people would not feel safe using the underpass and that alternatives should be considered.

The reference design was refined based on a combination of community feedback and further technical investigation. This included:

- realignment of the rail and busway connections in the south to allow Dutton Park Station to be retained
- upgrade of Dutton Park Station to incorporate lifts from the Annerley Road bridge
- a new pedestrian and cycle bridge on the northern edge of the existing Annerley Road bridge, rather than the underpass under the railway corridor
- the incorporation of a bus layover and turn-around facility at Kent Street, adjacent to Dutton Park Station and the PA Hospital.

3.3.2 Northern Connection

The draft reference design proposed a number features for the Northern Connection that if implemented, would have a permanent impact on Victoria Park south of the ICB. These included:

- rail connections with the existing Exhibition Line at Spring Hill, particularly the transition structure connecting with the existing surface rail network
- busway connections with the Northern Busway, including an above-grade connection across the Exhibition Line, the bus layover area and the bus turn-back facility.

Community concerns raised during consultation related to both the temporary construction impacts and permanent impacts of surface infrastructure on the visual, recreational, heritage and social values of Victoria Park. Feedback also highlighted concerns regarding the cumulative impacts on Victoria Park and the incremental loss of park land due to previous infrastructure projects (ie ICB, Inner Northern Busway, Legacy Way).

The reference design for the Project was refined to address community concerns and reduce the extent of permanent infrastructure within Victoria Park. This included:

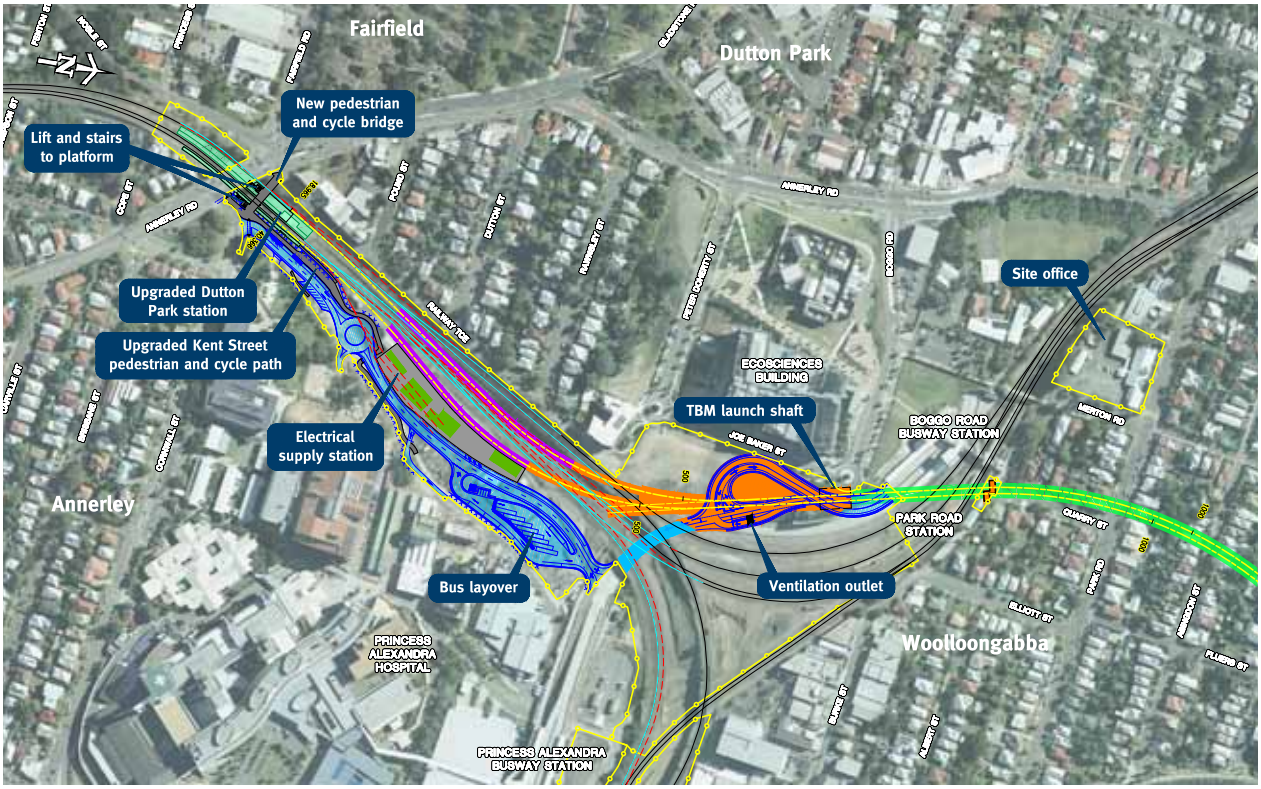
- realignment of the tunnel to allow both the rail and bus alignments to surface within the railway corridor rather than within Victoria Park
- stacking of the rail and busway alignments in the railway corridor to allow the busway crossing of the ICB
- use of Gilchrist Avenue for the bus layover.

Construction works would still be required within Victoria Park, although the area required for construction has been reduced significantly from that proposed by the draft reference design. Following construction, park areas disturbed by construction activities would be reinstated as park land and rehabilitated in consultation with Brisbane City Council, Traditional Owners, and the local community.

Draft reference design – southern connection

Draft reference design – northern connection

Reference design – southern connection



Reference design – northern connection

3.3.3 Ventilation outlets

The Project would require ventilation outlets at the connections to the existing surface network and each of the underground stations. A number of alternative locations were investigated for ventilation outlets at Dutton Park, Woolloongabba, the Brisbane CBD and Spring Hill. This considered factors such as accessibility, engineering, function, amenity, land availability, cost and proximity to sensitive receptors.

The ventilation systems at and above ground level would be enclosed or treated to retain the surrounding amenity. This would include the option to include ducts and vents within and on top of existing buildings or the stipulation of covenants that require their inclusion during subsequent redevelopment over the underground stations.

Station and tunnel ventilation equipment

3.4 Reference design

3.4.1 Tunnel

The tunnel would be a bored structure, lined with reinforced, concrete rings. Rubber gaskets and waterproofing membranes would seal the joints and overall structure. At the surface connections, separate tunnels for rail and bus alignments would be required to merge with the main tunnel. These single purpose tunnels would have smaller cross-sections and would be constructed by a combination of road header and cut and cover methods. These would be lined with pre-cast and cast in-situ concrete products.

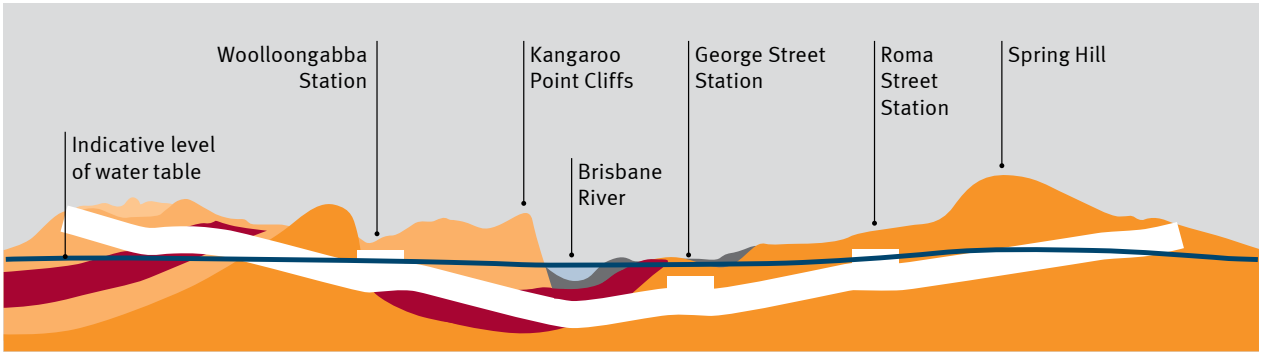
The tunnel long section is shown in **Figure 6**, while the depth of the tunnel along the alignment is shown in **Table 3**.

Table 3 Indicative tunnel depths

Section		Range of depth*
Start	End	
Dutton Park	Woolloongabba Station	11m – 46m
Woolloongabba Station	George Street Station	45m – 66m
George Street Station	Roma Street Station	35m – 48m
Roma Street Station	Spring Hill	12m – 58m

* Main tunnel, below ground level

Figure 6 Indicative tunnel alignment (underground)



The main tunnel would be divided into two sections, with the busway situated on the upper level. The lower railway level would be divided by a central, structural wall. This overall configuration provides sufficient area for two rail tracks and two bus lanes. An overhead duct would be provided in the crown of the tunnel for ventilation (refer to **section 3.4.5**).

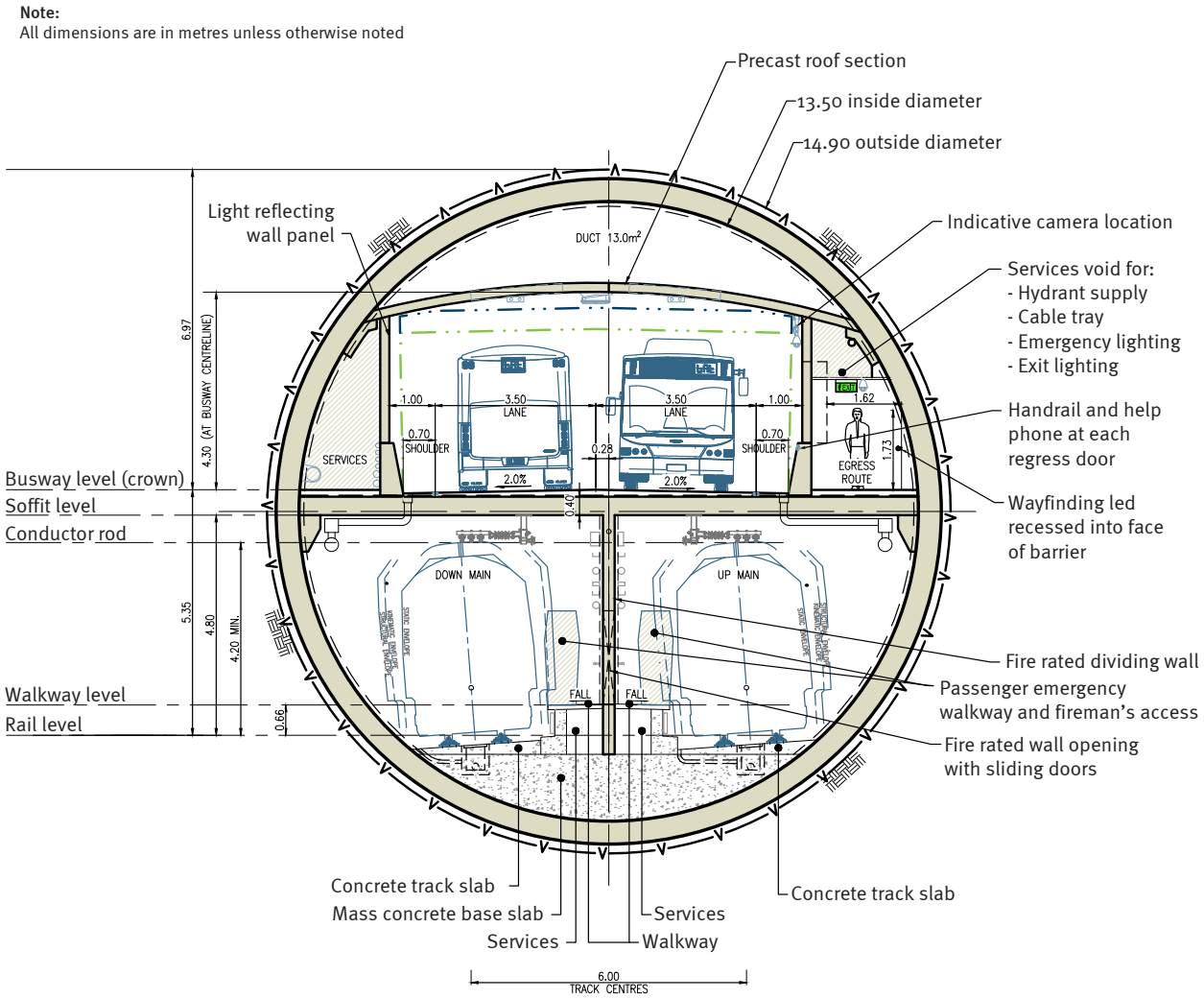
A cross section of the main tunnel is shown in **Figure 7**.

3.4.2 Dive structures

Dive structures would be required at the southern and northern connections, where the Project transitions from the surface to below ground. The dive structures would comprise concrete retaining walls to stabilise the dive structures, and base slabs to provide foundations for the railway and busway.

In the south, the dive structures would commence just north of Dutton Park Station and would be completely below ground when passing beneath the surface rail tracks near the elevated Port rail link. In the north, the dive structure would emerge just inside the Normanby Yard on the Exhibition Line adjacent to Victoria Park.

Figure 7 Main tunnel cross section



3.4.3 Stations

The Project would include three underground, combined bus and rail stations at Woolloongabba, George Street and Roma Street. The Project would also include the upgrade of the existing Dutton Park Station to improve disability access.

Stations have been designed to meet projected passenger loadings at each station, based on two-hour peak travel periods in both the morning and evening. The capacity and sizing of vertical transport (escalators, lifts) would be designed to meet the forecast station patronage with an additional allowance for future growth. Each underground station would include:

- surface entry and exit points at ground level
- a vertical access shaft, that accommodates escalators, lifts and stairs to provide public access to bus and rail platforms
- concourse areas from which passengers would have a choice of accessing either the bus or rail platform levels
- two levels of platforms – bus on the upper level and rail on the lower level – comprising side platforms with automatic platform screen doors for safety, climate control and air quality management
- passenger information systems, including electronic passenger information systems, public address systems, and passenger help points
- fire life safety measures, such as emergency fire stairs located at regular intervals along the platforms, fire detection and warning systems, and firefighting facilities and deluge systems
- safety and security measures, such as monitored closed circuit television (CCTV), intrusion detection and monitoring, lighting in and about the station entry points, and ability to close station entries during non-operational hours.

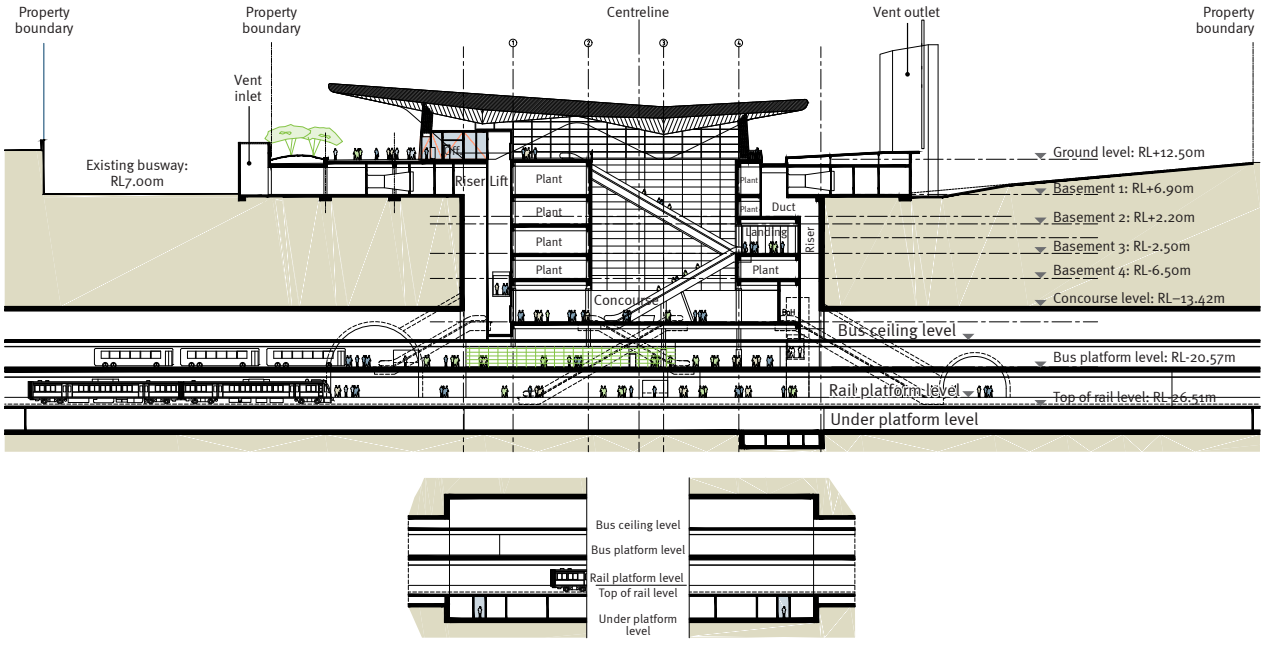
Rail platforms would be of sufficient size to accommodate six car NGR train sets[1], while busway platforms would accommodate six bus bays in each direction.

Woolloongabba Station

The Woolloongabba Station would be located within the area currently occupied by the GoPrint building (refer to **Figure 8**).

The station cavern would be about 229m in length, up to 24m wide and 16m high. The rail tracks would be situated about 39m below ground level. While the top of the station cavern would be about 23m below ground, the volumetric land requirement would be 11m below ground.

Figure 8 Cross section of Woolloongabba station



1 Details of the Queensland Government's NGR purchasing program can be found at www.tmr.qld.gov.au/Projects/Name/N/New-Generation-Rollingstock.aspx

Representation of Woolloongabba Station

The new station would include a full length canopy, and would be designed to allow natural light and ventilation into the station.

Street access to and from the new station would be through a single entry/ exit point. This would provide access for commuters as well as assist in managing passengers during events at the Gabba Stadium. Facilities for cyclists would also be included, with short term storage facilities located in public areas outside of the station. This integration of sustainable transport modes would occur at ground level with the Woolloongabba Busway Station and would service a wider catchment of commuters.

George Street Station

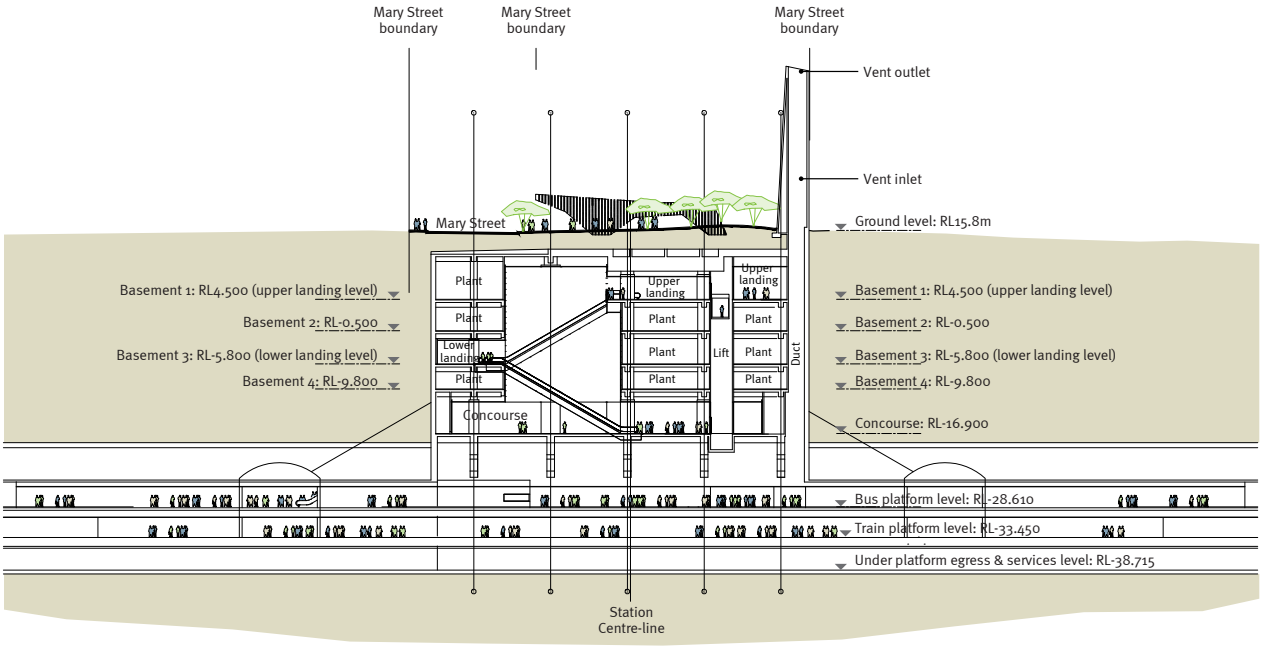
George Street Station would be located at 63 George Street, on the corner of George Street and Mary Street in the Brisbane CBD (shown on **Figure 9**).

The station would provide direct access to the southern part of the Brisbane CBD, including nearby government and education precincts. The station would also support the Queen's Wharf Brisbane development.

The station cavern would be about 229m in length, up to 27m wide and 17m high. The rail tracks would be situated about 49m below ground level, with the top of the cavern being about 33m below ground and the volumetric land requirement being about 21m below ground.

Entry and exit to the station would be available to both George Street and Mary Street. Access below ground may also be provided, allowing access to and from the nearby Queen's Wharf Brisbane development.

Figure 9 Cross section of George Street Station



Roma Street Station

The Roma Street Station would be located beneath the existing Roma Street Station in the northern part of the Brisbane CBD (shown in **Figure 10**).

The station extension would provide two access points to the new platforms – one to the north and a second to the south. The southern access would link with the existing underground subway, providing access to the surface bus and rail networks, the Brisbane Transit Centre and Roma Street. The northern access would provide improved access to Parkland Boulevard and Albert Street.

The station cavern would be about 229m in length, up to 24m wide and 16m high. The rail tracks would be situated about 37m below ground level*, with the top of the cavern being about 21m below ground level* and the volumetric land requirement being about 11m below ground.

Dutton Park Station

The Project would include an upgrade of the existing Dutton Park Station. This would include the creation of an island platform at the existing western platform, through the widening of the platform and provision of an additional platform face on the western side. The station would also be upgraded to improve disability and mobility impaired access.

A new pedestrian and cycle bridge is also proposed on the northern edge of the existing Annerley Road bridge. This would include a shared path up to 10m wide for pedestrians and cyclists. New lifts and stairs would provide direct access from the pedestrian and cycle bridge to the station platforms.

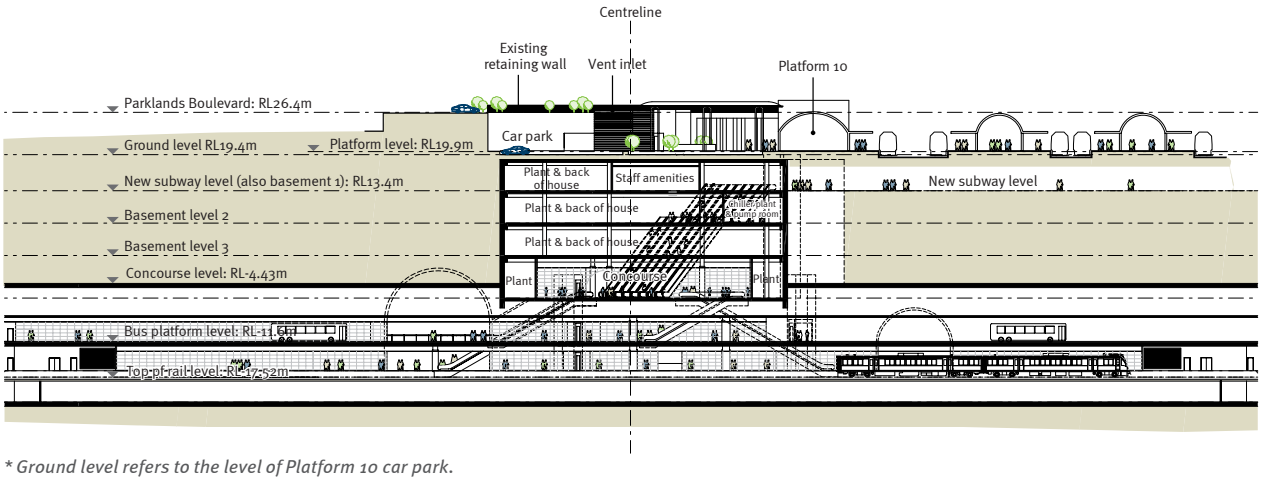
3.4.4 Busway bridge and Inner City Bypass connection

The Project would include a new busway bridge over the Exhibition Line and ICB connecting to the Inner Northern Busway and Gilchrist Avenue. The bridge would be up to 6.5m above ground and would be of sufficient width to provide two 3.5m bus lanes and associated shoulders.

An on-ramp connecting the Northern Busway and ICB westbound would also be provided as part of the Project. This would allow buses from the Project and the Northern Busway to connect to the ICB and Legacy Way, providing much needed improvements to network function and capacity.

Busway bridge – Eastern Busway, Woolloongabba

Figure 10 Cross section of Roma Street Station



** Ground level refers to the level of Platform 10 car park.*

3.4.5 Ventilation outlets

The tunnel and stations would be ventilated to manage heat and bus engine emissions. Much of the bus fleet would be operating high level emissions control systems. Consequently, the pollution load on the exhausted air flow from each of the ventilation outlets would be very low, particularly in comparison with a general use road tunnel ventilation system. The ventilation system would also be used to manage smoke in the rare event of a major fire.

The flow of air within the tunnel would be controlled by a series of ducts, fans and control systems. An overhead duct would be provided in the crown of the tunnel, avoiding the need for jet fans within the busway. In the railway sections of the tunnel, ventilation would be provided by a combination of the 'piston effect' where trains push air through the tunnel, and fans located in each of the underground stations drawing air from the tunnel.

Air would be drawn into the tunnel from the tunnel portals and at intakes positioned at each of the stations, and released through the ventilation outlets. Ventilation outlets would be required at each station and near to the southern and northern connections.

Ventilation equipment at and above ground level would be enclosed or treated to retain the surrounding amenity. This would include the option to include ducts and vents within and on top of existing buildings or the provision of development requirements for their inclusion during subsequent redevelopment over the underground stations.

Table 4 provides possible dimensions of each of the ventilation outlets, including the likely height and location.

Illustrative sketch of Roma Street Station ventilation outlet

Table 4 Proposed ventilation outlets

Area	Indicative cross section (m^2) (internal)	Indicative height (m)	Location
Dutton Park (Southern Connection)	15	11	Within Boggo Road Urban Village, adjacent to the railway corridor, east of the Ecosciences building
Woolloongabba Station	35	24	Located at the site of the station building. It is expected that this would be integrated within a future high rise building above the station.
George Street Station	35	25	Located at the site of the station building. It is expected that this would be integrated within a future high rise building above or adjacent to the station.
Roma Street Station	35	8	Located within the railway corridor near to the original Roma Street Station building.
Spring Hill (Northern Connection)	15	8	Located within the railway corridor adjacent to Victoria Park.

3.5 Construction

Construction of the Project would be a major, complex undertaking involving a number of discrete and integrated tasks at the various worksites. Construction would be undertaken using a range of recognised and proven methods. These works would be managed by a dedicated team of qualified and experienced professionals who in turn are supported by a large, modern construction fleet.

3.5.1 Construction phases

Pre-construction

Pre-construction works would include:

- site establishment, including preparation of worksites (ie fencing, establishment of site offices, amenities and services, hardstands and worksheds)
- relocation of existing services and utilities such as power, water, sewer and telecommunications
- demolition of existing buildings and structures
- realignment or removal of existing rail tracks at the southern and northern connections.

These works would progress at different rates for each worksite in accordance with an over-arching construction program.

Tunnel and station excavation

Excavation of the tunnel, dive structures and station cavities would be undertaken using a combination of methods including tunnel boring, mining and general excavation. Drilling and blasting may also be required in some areas with hard rock where other excavation methods are impractical or overly intrusive.

The main tunnel would be constructed by tunnel boring machine (TBM) commencing at Dutton Park. TBM operations would occur 24 hours per day, seven days per week. A maintenance period would generally extend up to four hours each day, during which time the TBM would not be working.

The anticipated rate of progress for the TBM would be about 100m per week, with a maximum rate of advance of about 140m per week, depending on ground conditions.

At this rate of progress, the TBM may affect properties above the alignment for about 5-7 days south of the river and for about 7-10 days between George Street Station and Roma Street Station. Spoil from TBM construction would be removed from the worksite at Dutton Park, and transported by road to the spoil placement sites.

Shallow sections of the tunnel and smaller areas of excavation (ie TBM launch box, cut and cover tunnel) would be constructed through mining and general excavation methods, including the use of roadheaders and possibly rock-breakers and drill and blast methods.

Handling and loading of spoil would occur within enclosed areas of excavation or ventilated, acoustic sheds. Station caverns and vertical shafts would be constructed using either a top down or bottom up approach. In a top down approach, excavators with rock-breakers would assist in the advance of excavations with subsequent material loaded within enclosed sheds. Below ground, station cavities would be excavated by road header. Where conventional methods of excavation would be intrusive or time-consuming due to hard or difficult ground conditions, drilling and blasting may also be implemented under carefully managed processes.

Excavation works – tunnel shaft
Photo courtesy of Brisbane City Council

Construction

Construction would encompass a wide variety of civil and building work. Components would include such things as superstructures of the tunnel, dive structures, stations and bridges as well as foundations for rail and busway. Construction would involve both pre-cast components (ie tunnel rings, bridge beams, retaining walls, etc) that are formed off-site and transported to construction worksites, as well as components that are constructed on-site or 'insitu' (ie smaller sections of tunnel, tunnel decks, bridge piers, etc). Building work would be generally confined to the stations. External structures for ventilation and power would also be established on sites indicated in the reference design.

Construction of the busway would involve the construction of road pavements, using a range of machinery including trucks, graders, excavators, rollers and specialised paving machines. Rail would involve the placement of ballast, sleepers and track. This would involve the use of specialised track laying machines.

Construction of the railway and busway would generally occur 'off-line'. However, works in a 'live' rail corridor would require temporary closures and possessions, many of which would be undertaken at night or weekends. In some locations, such as Dutton Park, rail possessions for an extended period of time, up to 80 hours, may be required to complete the construction task.

Construction, King George Square Busway

Fit-out

The fit-out phase would involve the provision of ancillary infrastructure and services to support general operation, such as systems for network function, fire and life safety, access, security, communication and general amenity. Communication and signalling systems for busway and rail would also be completed, with these works commencing from each worksite.

Rehabilitation and demobilisation

This phase would involve rehabilitation of areas affected by construction works and demobilisation or decommissioning of construction worksites.

Rehabilitation would include landscaping of station precincts and park areas such as Outlook Park, Emma Miller Place and Gallipoli Place and Victoria Park. Landscaping would be undertaken progressively and as construction and fit-out is completed.

Following the completion of construction works, construction infrastructure (plant and machinery, fencing and general facilities, etc) would be removed from the construction worksites. Areas disturbed by construction activities that are not required for permanent infrastructure would be reinstated to their original use and condition, or as agreed with the relevant landowner.

3.5.2 Construction worksites

Construction worksites would be required at the southern and northern connections and at each of the station locations. The worksites would be suitably sized to provide areas for surface works, loading, laydown and storage as well as general access. Facilities and services to support construction works (ie offices, amenities and parking) would also be provided.

Considerations in the selection of worksites included:

- safety
- size and proximity to permanent works to maximise efficiencies in time and cost
- land availability
- access to arterial roads
- need to avoid resumption of private property.

There are five precincts in which the worksites would be situated. These include:

(1) Dutton Park/ Boggo Road including:

- the principal site for spoil handling and segment laydown adjacent to the PA Hospital with access off both Ipswich Road and Kent Street
- the TBM launch site adjacent to the Ecosciences building with access off Joe Baker Street
- the rail reserve extending from just south of Annerley Road to Park Road Station and east to the Eastern Busway
- a small site on railway land off Quarry Street
- a worksite, offices and car parking area off Merton Road.

(2) Woolloongabba, with access off Main Street, Leopard Street and Vulture Street (light vehicles only)

(3) George Street, with access off George Street and Mary Street

(4) Roma Street, including:

- the main worksite adjacent to Platform 10 near Parkland Boulevard
- lay-down areas occupying Emma Miller Place and Gallipoli Park on Roma Street
- a workers' car parking site further to the west along Parkland Boulevard, with both gaining access off Roma Street

(5) Spring Hill/ Herston, including:

- the worksite in Victoria Park south of the Exhibition Line with access off Gregory Terrace
- the worksite in Victoria Park north of the ICB with access off Gilchrist Avenue.

Public access to worksites would be prohibited. Security fencing and screening would be provided for safety and to minimise visual impacts and nuisance (ie from noise and dust) on nearby communities.

Construction of Kangaroo Point workshed, CLEM7
Photo courtesy of Brisbane City Council

3.5.3 Construction spoil and transport

Construction of the Project would generate about 1.78 million cubic metres (in-situ) of spoil. Spoil would be generated by surface works such as excavation of the station shafts and the transition structures as well as underground works such as the driven tunnel and station caverns.

Spoil would be removed from each worksite. The largest quantity of spoil would be from the TBM tunnel construction. This would be removed from the Southern Connection worksite (PA Hospital site). **Table 5** summaries the expected spoil generation and transport requirements.

Table 5 Approximate spoil quantities

Worksite location	Spoil quantity	Spoil haulage*	
	Volume (m^3) (in-situ)	Average rate (truck loads/ day**)	Peak rate (truck loads/ day**)
Southern Connection			
- Boggo Road site	123,500	22	60
- PA Hospital site	922,600	84	194
Woolloongabba Station	217,900	14	41
George Street Station	263,900	25	40
Roma Street Station	185,300	12	44
Northern Connection	67,800	22	23

* estimated density of in-situ material is 2.42 tonnes/m3
** this relates to one way trips

Spoil from each of the worksites would be transported by road along designated haulage routes, to any of five placement sites. The purpose for designating these haulage routes is to facilitate construction in an efficient manner and with a minimum disruption and inconvenience to the public. The proposed spoil placement sites and haulage routes are outlined in **Table 6**.

Precast concrete segments, Legacy Way
Image courtesy of Rix Ryan Photography

3.5.4 Materials and equipment

Bulk quantities of materials would be required for temporary and permanent works, including concrete, steel, aggregate, bitumen, timber, soil, plants and water. This would include raw materials for fabrication and use on site as well as units that would be pre-formed off-site.

The reinforced concrete segments forming the structural rings and water-proofing for the tunnel would be fabricated off-site and transported to the southern worksite adjacent to the PA Hospital.

Materials and equipment would be delivered by road. **Table 7** provides a summary of the expected number of vehicles required for the delivery of materials and equipment.

Table 7 Material deliveries

Location	Vehicles per day (one-way)	
	Average	Peak
Southern Connection	31	67
Woolloongabba Station	12	14
George Street Station	10	10
Roma Street Station	12	14
Northern Connection	12	14

Table 6 Spoil placement sites and haulage routes

Spoil placement site	Spoil haulage route
Brisbane Airport (Lomandra Drive and Sugarmill Road)	Riverside Expressway and ICB, or via CLEM7, Airport Link and the East-West Arterial to access the Brisbane Airport precinct
Swanbank, Swanbank Road	Ipswich Road, or via Riverside Expressway, Legacy Way, Centenary Motorway and the motorway network to Swanbank
Pine Mountain (Mount Gravatt), Pine Mountain Road	O'Keefe Street, Old Cleveland Road, Creek Road, Pine Mountain Road, or via Ipswich Road, Riverside Expressway to Old Cleveland Road Note – not accessed from the Northern Connection worksites
Larapinta, Paradise Road	ICB, Legacy Way, Centenary Motorway, or via Riverside Expressway, Ipswich Road and the motorway network to Larapinta
Port of Brisbane, Port Drive.	Riverside Expressway, Vulture Street, Shaftson Avenue, Wynnum Road, Port of Brisbane Motorway Note – not accessed from the Northern Connection worksites

3.5.5 Hours of work

The Project is a major construction task extending from Dutton Park in the south, deep beneath the Brisbane River, under the CBD and onto Spring Hill in the north. The Project works would intersect with the most densely settled and used area in the city.

To minimise the disruption to the people living and working in the study corridor, works must progress continuously over the period of construction.

There needs to be a balance between Project construction program requirements and the community expectation of living and working in reasonable environmental amenity. The hours of work would vary depending on such factors as the type of activity, worksite or whether the works are undertaken above ground or below ground.

Table 8 provides an overview of construction hours proposed for the Project.

Table 8 Construction hours

Worksite	Surface works – standard hours*	Extended work hours**	Managed works#	Spoil haulage and materials/ equipment delivery*
Southern Connection (Boggo Road site)	Monday to Saturday: 6.30am – 6.30pm	For approved rail possession – periods of up to 80 hrs continuous work	24 hours, 7 days	Monday to Friday: 6.30am – 7.00am 9.00am – 2.00pm 4.30pm – 6.30pm Saturday: 6.30am – 6.30pm Sunday: None
Southern Connection (PA Hospital site)	Monday to Saturday: 6.30am – 6.30pm		24 hours, 7 days	24 hours, 7 days
Southern Connection (Dutton Park track connections)	Monday to Saturday: 6.30am – 6.30pm	For approved rail possession – periods of up to 80 hrs continuous work	n/a	24 hours, 7 days, except during peak traffic periods (Monday to Friday: 7.00am – 9.00am 4.30pm – 6.30pm)
Woolloongabba Station	Monday to Saturday: 6.30am – 6.30pm	Monday to Friday: 6:30pm – 10:00pm	24 hours, 7 days	24 hours, 7 days, except during peak traffic periods (Monday to Friday: 7.00am – 9.00am 4.30pm – 6.30pm)
Roma Street Station and George Street Station	Monday to Saturday: 6.30am – 6.30pm	Monday to Friday: 6:30pm – 10:00pm	24 hours, 7 days	Monday to Friday: 6.30am – 7.00am 9.30am – 4.30pm 6.30pm – 10.00pm Saturday: 6.30am – 6.30pm Sunday: None
Northern Connection and busway connections	Monday to Saturday: 6.30am – 6.30pm	For approved rail possession – periods of up to 80 hrs continuous work	24 hours, 7 days	Monday to Friday: 6.30am – 7.00am 9.00am – 4.30pm 6.30pm – 10.00pm Saturday: 6.30am – 6.30pm Sunday: None

* Note: works may be undertaken outside of these hours in the following special circumstances:

- Works undertaken within a rail corridor or road reserve that cannot be undertaken reasonably nor practicably during standard hours due to potential disruptions to rail operations or peak traffic flows.
- Works involving the transport, assembly or decommissioning of oversized plant, equipment, components or structures.
- Emergency works to avoid the loss of lives, damage to property or to prevent environmental harm.
- Materials and equipment deliveries including the delivery of 'in time' materials such as concrete, hazardous materials, large components and machinery.
- Works does not include the parking of vehicles or machinery.
- Environmental requirements to be achieved.

** Extended working hours: available for specific construction tasks and subject to specific management requirements including advance notice to near neighbours

#Managed works: works managed to achieve the performance criteria nominated in the Construction EMP

3.5.6 Construction workforce

Approximately 1,600 full-time equivalent (FTE) jobs would be involved in construction, infrastructure development and material supplies associated with the Project.

Up to 1,200 people would be required at the worksites during the peak workforce period (in year three). This would represent a maximum shift of 800 workers per 12 hour shift at the worksites.

Details of the construction workforce for each worksite is provided in **Table 9**.

3.5.7 Construction program

Construction of the Project would commence in 2015. Construction of the Project as a whole would be constructed over a period of about five years. Early construction works would be undertaken in advance, enabling longer term, more major work activities to be commenced on time, from multiple areas and with reduced risk of delays. Early works could include the relocation of public utilities, re-arranging rail signalling and possibly sections of rail track, and possibly some early demolitions.

Timing of key phases of construction is shown in **Table 10**. A number of activities within these stages are also interdependent and cannot commence until the preceding work is complete.

Table 9 Construction workforce per worksite

Precinct	Workforce		
	Average	Peak	Single shift (peak)
Southern Connection	200	300	200
Woolloongabba Station	150	200	150
George Street Station	150	200	150
Roma Street Station	150	200	150
Northern Connection	200	300	150
Total	**850**	**1,200**	**800**

Construction worksite, Legacy Way
Image courtesy of Rix Ryan Photography

Table 10 Indicative program of work

Activity	2015	2016	2017	2018	2019	2020
Pre-construction						
Site establishment and preparation						
Cadastral survey and set out						
Relocation of public utility plant						
Demolition of redundant infrastructure						
Track and road realignment						
Construction						
Southern Connection						
Excavation						
Construction						
Woolloongabba Station						
Excavation						
Construction						
Fit out						
George Street Station						
Excavation						
Construction						
Fit out						
Roma Street Station						
Excavation						
Construction						
Fit out						
Tunnel						
Excavation						
Construction						
Fit out (including connections)						
Northern Connection						
Excavation						
Construction						
Landscaping (all areas)						
Demobilisation (all areas)						

3.5.8 Construction options

In developing the reference design, and its related construction method, consideration was given to a number of alternatives, including:

- launching construction from the north, with the tunnel boring machine commencing its drive south from a worksite either in or adjacent to Victoria Park and the Exhibition Line rail corridor
- other methods of constructing the shafts and caverns for the underground stations to address anticipated impacts for sensitive receptors adjacent to the worksites
- progressing with a number of spoil placement sites to distribute potential impacts across the transport network and to optimise flexibility for the Proponent in managing its exposure to cost
- options for transporting spoil in addition to road transport (eg rail haulage, barging).

Other construction methods

During development of the proposed construction method, preliminary investigations indicated the potential for certain methods to lead to exceedances of the goals for noise and vibration. In part this was a combination of the effects of the construction method and the proximity of sensitive receptors (eg Roma Street Station, George Street Station).

Other methods investigated included the installation of 'cut-off walls' and the use of 'drill and blast' techniques. Cut-off walls would provide a gap or void between the working face and adjacent rock, arresting the transmission of vibration through the adjoining rock into building basements and structures above.

While the creation of the cut-off walls would lead to some exceedances of the goals, it would allow the Proponent to progress the works with significant reductions in impacts on the acoustic conditions.

Piling, Legacy Way Tunnel
Image courtesy of Rix Ryan Photography

Drilling
Photo courtesy of Brisbane City Council

Launching construction from the north

The option of launching the tunnel boring machine from the north has merit and would warrant further consideration if proposed during the procurement process for the Project. The worksite, if able to be established without undue disruption to the rail network and Victoria Park, is situated clear of immediate neighbours. Transport of spoil from the TBM may be achievable by rail. Road transport of spoil would involve few sensitive receptors.

Launching construction from the north would likely be of concern for Spring Hill residents. This alternative approach would require further assessment, through an application for project change, and further consultation.

Spoil placement sites

The initial advice statement and referral to the Australian Government indicated that, subject to the findings of the EIS, the preferred site for spoil placement was at Swanbank, involving a haulage task of approximately 75km (return trip). This would be costly and time-consuming, and would involve the consumption of a large quantity of fuel in transport.

Investigations identified four other sites that may be suitable and which all involve shorter return trips on the major road network. These sites include the Brisbane Airport land, a dis-used quarry now being rehabilitated at Pine Mountain, former sand pits at Larapinta and the reclamation area in the Port of Brisbane.

All five sites have been evaluated and have been found to be generally acceptable with regards a number of criteria including:

- accessibility from the arterial or major road network
- availability of land
- proximity of sensitive receptors and sensitivity of receiving environment
- environmental values, including cultural heritage
- functionality and capacity of the likely haul route, and the haulage distance.

Each site has the potential to receive spoil and allow for effective impact management. All sites are proposed for evaluation in the EIS. Any proposal to use any of these sites could require further approvals and detailed investigations into the potential environmental effects.

Options for spoil and materials transport

Spoil and materials transport is undertaken conventionally by road, due to the flexibility and low costs involved relative to other modes. Road transport does involve more direct interaction with other road users and the wider community, increasing the potential for adverse impacts.

Other forms of transport considered included rail transport and barging or river-based transport.

Rail transport requires extensive land bases at either terminus for the loading and unloading of spoil onto trains stored in sidings.

Apart from the Normanby Yard adjacent to Victoria Park, there is no other location in the inner urban rail network which has sufficient land accessible to the rail corridor for spoil loading and materials unloading. Only two of the nominated spoil sites (Swanbank, Port of Brisbane) have rail handling facilities. While there would be capacity at Swanbank, the Port facilities are heavily used for the handling of bulk commodities.

Rail transport also requires 'slots' in the operating rail network. At present the network is heavily committed during day-time hours. The movement of freight at night through the inner city is of concern to local residents. Rail transport would only service one worksite, namely that for the TBM due to reasons of efficiency and economy. Even if rail was to be engaged, nearly half of the spoil to be removed from the Project would need to be transported by road.

Transporting spoil and materials by barge would require wharf, loading and unloading facilities at both ends of the single route. Apart from the unavailability of suitable land, the loading facilities would need to avoid the risk for spills into the river. The unloading point would either be the end-point for spoil, or would involve further handling to transport spoil to the final placement site. This would be costly and inefficient.

Transport by barge would be slow and would lack the flexibility offered by road, and would be even less flexible than a rail-based option.

The road-based transport option has been adopted for the Project.

Freight train, Dutton Park

3.6 Commissioning

Inspections and testing would be undertaken on tunnel facilities and associated infrastructure prior to commissioning to ensure the Project's as-built infrastructure and operating systems, such as fire life safety, busway and train control, are complete and meet the required standards for operation. Integration with existing bus and rail networks would also be confirmed prior to opening. This work would be undertaken by accredited bodies within and external to the asset owner and operator. Activities to be undertaken during the commissioning phase would include:

- safety audits of bus and rail assets, including inspection of constructed infrastructure, and testing and trialling of operational systems (ie signals and signage)
- inspection, testing and trialling of station infrastructure and associated operating systems (ie fire life safety, security and CCTV cameras, ventilation, passenger control)
- testing of ventilation systems and smoke testing, to ensure adequate operation of the ventilation system
- testing of bus headway management, tracking and real time passenger information systems
- testing of signalling, control and train protection systems (European train control system or ETCS), including board tests and reviews of the interface with Queensland Rail's existing signaling system
- driver training and induction.

Upon satisfactory completion of commissioning tests, the Chief Executive of the Department of Transport and Main Roads would advise the Coordinator-General that the Project has been delivered in accordance with Project requirements, and is to commence operations for either bus or rail or both on a nominated date.

3.7 Operation

Assuming a continuation of the current operating paradigm, operation of the Project would be managed by Transport and Main Roads through Queensland Rail as the rail manager and TransLink as the busway operator. Existing operating systems are to be complemented with new procedures specific to the Project. Activities undertaken during the operations phase would include service delivery and maintenance.

3.7.1 Service delivery

Bus operations

A range of bus network design and planning principles, such as legibility, reliability and network efficiency, were used to underpin the development of bus service plans for 2021 and 2031. The bus service plans focus on routes that would optimise patronage growth and which would have good access to the Project, where necessary. The service plans were also devised to capitalise on opportunities on the existing network, created through the redistribution of services to the Project.

The Project bus tunnel would complement the South East Busway and Inner Northern Busway by offering a second, high standard path of travel for buses through the city centre. The Project provides a more direct route to the city centre and has fewer intersections and stations to be negotiated, compared with the South East Busway and the Inner Northern Busway. The Project offers fast, reliable and direct services to and through the city centre. In comparison, the existing busways offer a closer station spacing and wider coverage of non-CBD destinations.

Concourse gate

These complementary differences create the opportunity to use the Project, the South East Busway and Northern Busway in combination to provide two access paths through the city for services from high frequency corridors across the network. For many users of the existing high-frequency services, there would be the option of travelling either via the Project or the existing inner city busways serving established landmarks.

The proposed service plan for 2021 (refer to **Figure 11**) illustrates the key corridors for services using the Project. While the bus service plans may change in response to ongoing development of the network, infrastructure and operational strategies, the broad approach and underlying principles would remain unchanged.

Rail operations

The Project would create a new rail operating sector connecting the Gold Coast and Beenleigh lines through the new corridor to Roma Street Station.

This would allow the introduction of three-tier operations on the southern railway corridor including:

- Varsity Lakes express services via the Project – existing Gold Coast express services would stop at all-stations to Beenleigh, then at Loganlea, Altandi and Dutton Park. Services would then run via the Project, stopping at Woolloongabba, George Street and Roma Street stations
- Helensvale limited express services via the Project – Beenleigh all-stations services would be extended to Helensvale, operating express from Kuraby and stopping only at key interchange stations to the Project. Services would then run via the Project, stopping at Woolloongabba, George Street and Roma Street stations
- Kuraby all-stations services via South Brisbane – all-stations services would be introduced via the existing surface network, connecting the Gold Coast to the city via Dutton Park, Park Road, South Bank and South Brisbane.

Interchange stops at Altandi and Dutton Park would allow passengers to transfer between surface all-stops services and Project services. Bus connections at Roma Street Station and Woolloongabba Station would also provide additional transfer opportunities for the express services operating with the Project in place.

3.7.2 Maintenance

Provision would be made for asset management and maintenance activities such as cleaning and repair, delivery of supplies and provisions, inspection and certification. These activities would occur outside operational hours, where possible, to allow station operations to be maintained.

3.7.3 Management

Operation and management of the Project would involve entities, including:

- the State of Queensland would be the asset owner, with the Department of Transport and Main Roads being responsible for coordinating overall management
- Queensland Rail as the current railway manager of train services for the City Network
- TransLink as the current bus operations manager of the busway and responsible for the letting and managing of contracts with bus operators.

These roles and responsibilities would extend to the Project upon commissioning.

Trains operating through the Project would be controlled from Queensland Rail's centralised train control centre (Mayne control). Buses would be managed and controlled through the Project by the Busway Operations Centre.

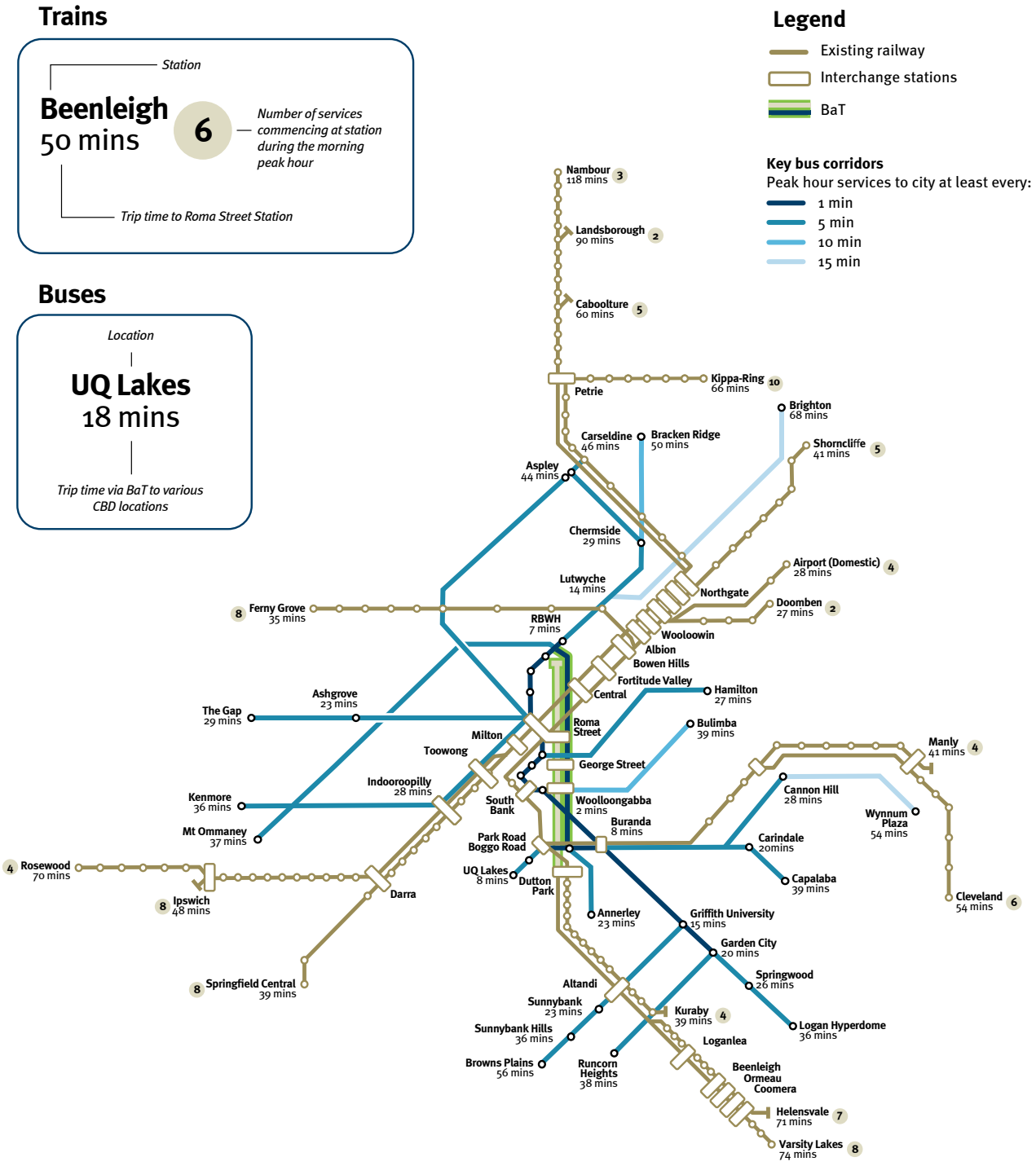
3.7.4 Workforce

The Project would require up to about 135 people to support new services facilitated by the Project. This would include staff for operation of the stations, rail rollingstock, and the bus fleet.

3.7.5 Design life

The intended design life of the Project is at least 100 years for structures and 40 years for buildings. Programmed maintenance and progressive upgrades during and beyond this time is anticipated to see the serviceability of the Project extended.

Figure 11 Proposed 2021 bus and rail network



4. Traffic and transport

This section summarises the findings from the traffic and transport assessment, including benefits and impacts for existing and future transport networks from the construction and operation of the Project. More detailed information about the Project's traffic and transport impacts is provided in Chapter 4 of the EIS.

4.1 Study approach

The public transport patronage forecasts and benefits of the Project were derived from a land use and transport network model specifically developed for the Project. The transport model provides average weekday travel demand forecasts for the Brisbane Statistical Division for both public transport and for private and commercial road traffic trips. Much of the analysis, including that relating to bus and rail patronage usage and crowding, travel times, road network congestion and user benefit forecasts, were derived from the model.

The model was used to provide patronage for 2012 (the base year for the assessment) and forecasts for 2021 (the year of opening of the Project) and 2031 (the final forecast year for which all key inputs were available).

Other transport models and analysis tools were developed to assess the Project:

- a dynamic rail operations simulation model was used for rail network service plan development
- a micro-simulation model was used to assess bus operations
- a pedestrian modelling tool was used to assess the forecast pedestrian demands at the station precincts
- traffic modelling was undertaken for key intersections.

4.2 Existing situation

4.2.1 Existing rail network

The Queensland Rail City network provides passenger services to communities across South East Queensland. The network extends from Brisbane City, south to Beenleigh and the Gold Coast, north to Ferny Grove, Shorncliffe, Caboolture and Gympie, east to Cleveland and west to Richlands, Springfield, Ipswich and Rosewood. Communities in the study area are mainly serviced by railway stations at Fairfield, Dutton Park and Park Road in the south and Roma Street and Central in Brisbane City.

4.2.2 Existing bus network

The study area is well serviced by the TransLink busway network, including:

- South East Busway, which extends from Eight Mile Plains to the Brisbane CBD
- Eastern Busway, which connects Coorparoo to UQ at St Lucia, via the Eleanor Schonell Bridge
- Inner Northern Busway, which extends from the RBWH at Herston to the Brisbane CBD
- Northern Busway, which connects from the RBWH to Kedron.

Communities in or adjacent to the study area are serviced by busway stations at PA Hospital, Boggo Road, Woolloongabba, Mater Hill, South Bank and Cultural Centre to the south; Queen Street, King George Square and Roma Street in the Brisbane CBD; and Royal Children's Hospital Herston and RBWH to the north. Busway stations at Boggo Road, South Bank, Cultural Centre and Roma Street provide opportunities for interchange with the passenger rail network.

Communities in the study corridor are also well serviced by on-road bus routes, many of which connect into the inner city busway network. In the south, bus routes follow Ipswich Road, Cornwall Street, Fairfield Road, and Annerley Road, providing both regular and high frequency services to the Brisbane CBD and other destinations within or near to the study area. A number of services also follow Gladstone Road to the CBD, via West End.

Within the Brisbane CBD, Adelaide Street and Elizabeth Street form bus routes, while other important routes include Margaret Street, Edward Street, Herschel Street and Roma Street.

4.3 Operational effects with the Project

4.3.1 Rail network with the Project

The key operating change with the Project in 2021 would be the creation of a new service for areas between the Gold Coast and Kuraby in the south connecting to the Brisbane CBD and terminating at Roma Street.

Increased rail capacity

The Project would create a significant improvement in rail capacity to and through the CBD. The changes in routing associated with the Project would help to alleviate congestion and crossing constraints including:

- at Park Road junction
- across the Merivale Bridge
- rail traffic levels on the inner city Suburban lines
- turn-back into stabling at Mayne Yard rather than travelling via Park Road junction.

Table 11 provides a summary of CBD station peak hour train volumes required to meet demand for the morning peak one hour without and with the Project. To meet demand, there would be a combined total of 97 trains per hour through the CBD in 2031.

With the Project in operation in 2031, an additional 12 trains per hour would be added to the Brisbane rail network during the morning peak compared to without the Project. This represents around a 14 per cent increase in capacity compared to the scenario without the Project.

Increased rail passenger use with the Project

The forecast change in rail patronage to the Brisbane CBD with the Project in the morning peak period and various system performance indicators across the Brisbane Statistical Division are presented in **Table 12**. With the Project, system wide average trip times and distance reductions would be realised.

Table 11 Forecast morning peak train movements (per hour) at CBD stations

Scenario	Trains to the CBD				Total two-way through CBD
	Trains from the south	Trains from the east	Trains from the west	Trains from the north	
2014 (base year)	11	8	16	37	72
2021 without Project	16	8	20	39	83
2021 with Project	19 (15 in BaT)	10	20	39	88 (15 in BaT)
2031 without Project	16	8	20	41	85
2031 with Project	26 (19 in BaT)	10	20	41	97 (19 in BaT)

Table 12 AM peak two hour rail performance indicators in the Brisbane Statistical Division

AM peak period	2021			2031		
	Without Project	With Project	Percentage change	Without Project	With Project	Percentage change
Total rail passenger kilometre	2,239,400	2,241,400	0.1	3,373,200	3,452,900	2.4
Total rail passenger hours	55,200	54,300	-1.6	81,200	81,600	0.5
Number of rail trips to the CBD	30,200	50,200	20.1	70,600	87,500	23.8
Average rail trip length (km)	21.3	21.3	-0.1	22.7	22.5	-0.9
Average rail trip time (min)	31.6	31.0	-1.9	32.8	31.9	-2.8

Source: BaT Project Model

The forecast increase in rail trips to the CBD during the morning peak period due to the Project would be significant, 20 per cent in 2021 rising to 24 per cent by 2031. The Project would allow rail passenger volumes to the CBD in the morning peak period to increase by more than double between 2012 and 2031 and allow rail to fulfil a larger role in CBD-based travel.

Table 13 provides a summary of forecast rail patronage, expressed as morning two-way line loadings of travel in each direction, between rail stations in the inner city with the Project.

In 2021, over 10,000 passengers would travel on Project rail services between Woolloongabba Station and George Street Station during the morning peak period rising to just under 15,000 passengers by 2031. Overall the busiest section of the Project would be between Dutton Park Station and Woolloongabba Station where over 17,000 rail passengers would use this section in the 2031 morning peak two hours.

Table 13 Forecast rail patronage with the Project – morning peak period (2 hours)

Section	2012	2021	Percentage growth	2031	Percentage growth
BaT project (rail)					
Dutton Park to Woolloongabba	-	12,800	-	17,300	-
Woolloongabba to George Street	-	10,300	-	14,900	-
George Street to Roma Street	-	4,100	-	6,500	-
Surface rail					
Roma Street to Central	15,300	17,700	16	25,000	64
South Brisbane to Roma Street	9,400	7,300	-23	10,000	6
South Bank to South Brisbane	12,100	8,900	-26	13,000	8
Park Road to South Bank	15,200	10,600	-31	17,100	12

Source: BaT Project Model

Figure 12 Connectivity of the Project to busway infrastructure

4.3.2 Bus network with the Project

Figure 12 illustrates how bus routes on major corridors such as the South East Busway, Eastern Busway (to UQ), Northern Busway, ICB and Bowen Bridge Road would access the Project. **Figure 11** (shown previously) illustrates the bus network in 2021.

Network design principles underpinning the bus operating strategies adopted for 2021 and 2031 with the Project include:

- accommodating much of the growth in bus demand on Project bus services
- reallocating services to the Project to provide sufficient capacity on the Victoria Bridge to respond to population and employment growth in South Brisbane and West End
- balancing the distribution of services between the Project and the surface networks to allow for the staged provision of future growth in service capacity
- spreading the passenger transfer opportunity across a larger number of stations, particularly away from the current overwhelming concentration at the Cultural Centre Busway Station.

Increased bus capacity to the CBD

Table 14 shows the bus volumes on the major routes across the Brisbane River in the morning (AM) peak (one hour). With the Project the pressure on bus carrying capacity of the Victoria Bridge and Captain Cook Bridge would be relieved. This would improve the reliability of bus services to and from the CBD and allow an increase in the number of bus services across the Brisbane River in 2031.

Table 14 Bus volumes on major river crossings with the Project in AM peak one hour

Link	Volume		
	2012	2021	2031
Victoria Bridge	225	179	199
Captain Cook Bridge	221	105	111
BaT Project	-	158	172
Total	446	442	482

Table note – bus volumes are in-service buses and does not include dead running buses

With the Project there would be a significant reduction of buses using CBD streets, leading to some improvements in the amenity and traffic operation. For example, reductions over 50 per cent in buses on Elizabeth Street compared to the base year in 2021 and 15 per cent on Adelaide Street would be achieved. This would reduce traffic congestion, improve pedestrian capacity, urban amenity, and would allow for rationalisation of CBD kerbside bus operations.

Increased bus passenger capacity

The Project would have a significant impact on the bus network capacity by:

- facilitating significant increases from the north to the Brisbane CBD from 5,200 passengers per hour up to between 11,000 passengers and 19,000 passengers per hour in 2021, using standard buses and articulated buses respectively
- doubling bus passenger capacity to 24,000 passengers by 2021 from the south to the CBD
- providing potential for an ultimate corridor capacity (with fleet optimisation) of 35,000 passengers per hour.

Inner Northern Busway

Impacts on bus patronage

Changes in overall modelled bus patronage and performance across the Brisbane Statistical Division are shown in **Table 15**. This shows a forecast increase of between 5-6 per cent in overall bus passenger kilometres travelled with the Project in both 2021 and 2031 compared to without the Project. An increase in overall bus patronage (over 8 per cent) in 2031 with the Project is forecast compared to the scenario without the Project.

By 2031 with the Project, forecast average trip lengths by bus would be shorter (-2.7 per cent), and average bus trip times would be less (-7.6 per cent). The change to shorter bus journeys is likely to be the result of a combination of factors such as greater levels of bus-rail interchange. Average trip times would be reduced due to a reduction in congestion, greater reliability and a more direct busway alignment to the CBD.

4.3.3 Public transport mode share with the Project

Table 16 presents the forecast average weekday travel and total trip growth without and with the Project from 2012 to 2031.

The forecast total number of trips made by all motorised modes (ie car and public transport) across the Brisbane Statistical Division would be similar for both with and without the Project.

However, the proportion of trips by public transport (or mode share) is higher with the Project in both 2021 and 2031. By 2031 with the Project, 11 per cent of motorised trips would be by public transport on an average weekday across the region, compared to 10.8 per cent without the Project.

By 2031, with the Project, over 45 per cent of CBD trips made by motorised modes are forecast to use rail. With the Project, bus travel would also increase in significance as a mode of access to the CBD in the morning peak, catering for over 25 per cent of CBD travel by 2031.

Analysis of cross river trips in the morning peak is illustrated in **Figure 13**, which shows a trend towards more rail and bus trips and less car trips with the Project.

Figure 13 Forecast AM peak period travel demand (trips) across the Brisbane River

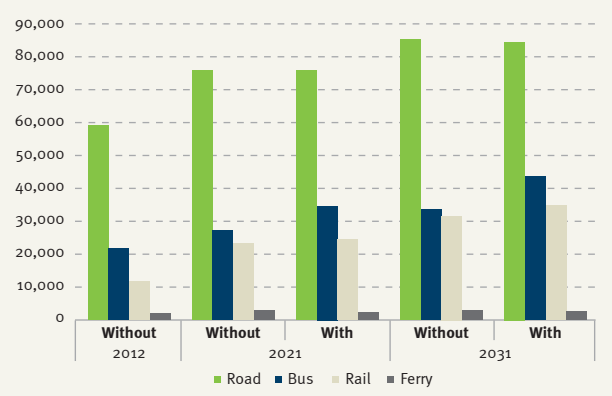


Table 15 Forecast daily trips by bus in the Brisbane Statistical Division

24 hours	2021			2031		
	Without Project	With Project	Percentage change	Without Project	With Project	Percentage change
Total bus patronage	381,300	408,300	7.1	496,600	539,500	8.6
Total bus passenger (km)	3,790,200	4,002,400	5.6	4,882,400	5,159,600	5.7
Total bus passenger hours	146,300	147,600	0.9	196,600	197,400	0.4
Average bus trip length (km)	9.9	9.8	-1.4	9.8	9.6	-2.7
Average bus trip time (min)	23.0	21.7	-5.7	23.7	22.0	-7.6

Source: BaT Project Model

Table 16 Average change in weekday trips in the Brisbane Statistical Division

Parameter	2012	2021		2031	
		Without Project	With Project	Without Project	With Project
Total trips by all modes	7,163,100	8,890,000	8,890,000	10,348,000	10,348,000
Total vehicle trips (24hr)	4,695,000	5,755,800	5,740,000	6,680,100	6,665,200
Public transport mode share (per cent)	7.0	9.4	9.5	10.8	11.0

Source: BaT Project Model.

4.3.4 Public transport use with the Project

The number of peak period and daily public transport trips is forecast to increase by more than double from 2012 to 2031. By 2031, there are forecast to be more than one million daily public transport trips in the region.

Across the Brisbane Statistical Division, total bus patronage in 2031 would be 42,900 more daily trips and rail patronage would be 10,900 more trips than without the Project (refer to **Table 17**).

4.3.5 Project station activity

Table 18 shows forecast Project station daily passenger activity for 2021 and 2031. This data presents forecast passenger movements on both bus and rail as boarding, alighting and transfer passengers.

It shows the key interchange role played by the BaT project stations at Woolloongabba and Roma Street. The new station at George Street would provide a destination function, attracting approximately 23,400 passengers during the morning peak in 2021. George Street Station is forecast to have 93,500 passengers using it per weekday in 2021, which is comparable to the current daily use of Central Station.

Table 17 Public transport users by mode across the Brisbane Statistical Division

Period	2012	2021				2031			
		Users		Growth (from 2012) (per cent)		Users		Growth (from 2012) (per cent)	
		Without Project	With Project	Without Project	With Project	Without Project	With Project	Without Project	With Project
Rail Users									
AM 2hr peak	59,500	104,900	105,100	76	77	148,600	153,400	150	158
PM 2hr peak	54,300	98,800	98,800	82	82	143,600	146,600	165	170
Daily	214,500	395,500	397,000	84	85	558,000	568,900	160	165
Bus users									
AM 2hr peak	58,000	88,800	97,200	53	68	114,400	128,400	97	121
PM 2hr peak	49,500	70,800	78,000	43	58	91,300	103,900	84	110
Daily	248,700	381,300	408,200	53	64	496,600	539,500	100	117

Source: BaT Project Model Note: The number of rail and bus users include those whom may use more than one mode for a complete journey.

Table 18 Project station daily passenger activity, 2021 and 2031

Year	Station	Boarding	Alighting	Transfer (boarding and alighting)	Total
2021	Roma Street	10,200	10,000	44,800	65,000
	Woolloongabba	6,000	5,800	12,900	24,600
	George Street	47,700	44,400	1,400	93,500
	Total	**63,900**	**60,200**	**59,100**	**183,100**
2031	Roma Street	15,500	14,000	72,800	102,300
	Woolloongabba	13,200	13,300	16,000	42,500
	George Street	68,200	63,700	2,500	134,400
	Total	**96,900**	**91,000**	**91,300**	**279,200**

Source: BaT Project Model

Impact on Brisbane CBD stations

The morning peak period bus and rail patronage at Brisbane CBD stations with the Project is forecast to increase. There would also be a distributional change where bus and train boardings and alightings occur. **Table 19** provides a summary of the forecast change in total passenger activity (boarding, alighting and transfers) during the morning peak period.

In 2021 with the Project, there is forecast to be 132,000 passengers boarding and alighting the bus and rail services in the CBD in the morning (AM) peak period. This would be 20 per cent higher compared to without the Project. By 2031 this is forecast to increase to over 180,000 passengers – some 30 per cent greater than without the Project.

The Project stations provide more opportunities for boarding, alighting and transfer between bus and rail modes. A reduction in passenger activity at the existing Brisbane CBD stations is forecast with the Project as passengers take the opportunity to use the improved accessibility offered by the George Street Station and the greatly increased number of bus and rail services at Roma Street Station. Characteristics of the patronage changes at stations are:

- a more even distribution of passenger usage across Brisbane CBD stations is anticipated. This would significantly decrease cross town pedestrian movements and total trip times for passengers
- a high number of rail to rail transfers and between bus and rail services at Roma Street Station are expected to occur between the BaT project platforms and surface platforms in both 2021 and 2031
- a significant reduction of the number of passengers using CBD street bus stops on Adelaide Street, George Street, Elizabeth Street, Edward Street, Queen Street, Ann Street, Creek Street and Alice Street during the 2031 morning peak period is expected. This would bring amenity benefits
- the reduction in passenger activity at the existing stations and stops would lead to an easing of footpath congestion and improved level of service at stations and stops.

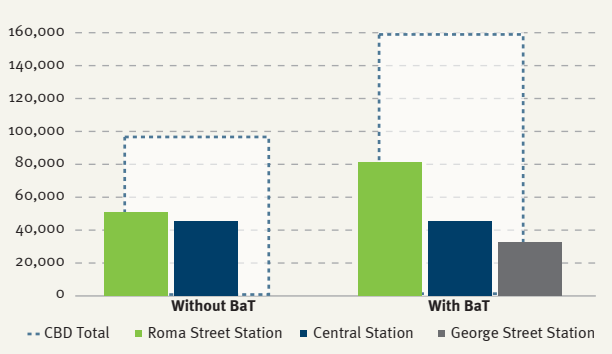
Table 19 CBD Station forecast passenger activity (AM peak two hour period)

Station	2012	2021				2031			
		Without Project	With Project	Change	Percentage change	Without Project	With Project	Change	Percentage change
Roma Street									
Surface rail	12,600	23,100	26,100	3,000	13	42,500	45,200	2,700	6
Surface bus	5,300	6,500	5,900	-600	-9	8,900	7,600	-1,300	-15
BaT project (rail)	-	-	4,100	-	-	-	6,400	-	-
BaT project (bus)	-	-	13,600	-	-	-	22,400	-	-
Roma Street total	**17,900**	**29,600**	**49,700**	**20,100**	**68**	**51,400**	**81,600**	**30,200**	**59**
George Street									
BaT project (rail)	-	-	7,700	-	-	-	11,300	-	-
BaT project (bus)	-	-	15,700	-	-	-	21,800	-	-
George Street total	-	-	**23,400**	-	-	-	**33,100**	-	-
Central - rail	27,400	46,100	39,700	-6,400	-14	45,700	44,600	-1,100	-2
QSBS - bus	4,300	3,000	2,900	-100	-3	4,300	2,700	-1,600	-37
King George Square - bus	10,300	7,300	4,400	-2,900	-40	8,100	4,100	-4,000	-49
CBD streets - bus	16,900	23,800	12,100	-11,700	-49	29,600	15,600	-14,000	-47
CBD Total Rail	40,000	69,200	77,600	8,400	12	88,200	107,500	19,300	22
CBD Total Bus	36,800	40,600	54,600	14,000	34	50,900	74,200	23,300	46
CBD Total	**76,800**	**109,800**	**132,200**	**22,400**	**20**	**139,100**	**181,700**	**42,600**	**31**

Source: BaT Project model. Note: Passenger movement is the total of boarding, alighting and transfers.

Figure 14 illustrates the significant forecast increase in patronage at the three stations (Roma Street, Central and George Street) by 2031 during the morning two hour peak period. This shows that compared to without the Project there is no growth in patronage activity at Central Station during peak periods whilst activity at Roma Street Station almost doubles. George Street Station is forecast to cater for over 33,000 passenger movements.

Figure 14 CBD major station patronage: 2031 morning peak period (all movements)



CBD fringe stations

A reduction in passenger activity is forecast at each of the CBD fringe stations of Mater Hill, South Bank, South Brisbane, Cultural Centre and Fortitude Valley due to the Project. This would generally be due to the improved attractiveness of bus and train services in the Brisbane CBD provided by the George Street Station.

Public transport passengers that currently access the CBD by alighting at Mater Hill, South Bank, South Brisbane and Cultural Centre stations and walking across the river to the CBD would find that the George Street Station offers improved accessibility and improved travel times for the southern area of the Brisbane CBD.

4.3.6 Summary of transport benefits of the Project

Table 20 summarises the key transport benefits that are attributable to the Project.

Underground station concourse

Table 20 Transport benefits of the Project

Benefit	Explanation
Additional bus and rail capacity and growth in patronage	• Provides the additional cross-river and public transport network capacity to accommodate passenger growth to 2031 and beyond. • Increased ability to provide more buses and trains on the network to 2031 and beyond, with timetables that better meet increasing travel demand to Brisbane's inner city and CBD.
Improved modal integration	• Opportunities for the development of greater rail/ bus integration. • A range of interchange opportunities to an enhanced city distributive bus network and surface rail. • More effective transfers and less wait time would be provided by the Project. • The Project would reduce total network-wide wait times by about 2 per cent (2021 and 2031).
Improved rail and bus travel time and reliability	• Opportunities to simplify rail operations and improve service reliability. • More trains at higher frequencies would access the CBD. • Reduction in morning (AM) peak average rail trip time across network of 1.9 per cent in 2021 and 2.8 per cent in 2031 compared to without the Project. • Significant increase in peak period bus passenger capacity to the Brisbane CBD from the north and south. • Reduced bus congestion on the South East Busway, Captain Cook Bridge and Victoria Bridge. • Travel time savings of around four minutes for buses using the Project compared to existing travel times on inner city busways. • Less variability in bus travel times for BaT project services due to the ability of buses to travel on a grade separated route through the CBD.
Reduced crowding	• Significant crowding relief on trains in the Gold Coast/ Beenleigh corridor. • Reduction in crowding on bus routes across the Brisbane River. • The Project would provide capacity relief to passenger activity at Central Station.
Improved CBD accessibility	• The George Street Station would improve access to CBD destinations by bus and rail with the vast majority of the CBD within a 10 minute walk. • The Project would significantly enhance accessibility to the southern area of the CBD with travel time savings of around 15 minutes. • Better and more effective passenger distribution between CBD rail stations, with the new centrally-located George Street Station expected to provide convenient accessibility for 93,500 passengers daily in 2021. • Reduced CBD station interchange delays and station access times.
Facilitated growth of the region and inner city	• Provides the capacity to cater for efficient, reliable, safe and sustainable means to cater for transport demand associated with the economic growth of the inner city. • Supports growth of future development areas at Woolloongabba and Boggo Road (through more rail services to Dutton Park Station) by providing new bus and train stations at these growth precincts • Supports residential growth throughout the region by improving access to job opportunities in the inner city.
Improved mode share to public transport	• Assists in increasing public transport mode share to 11.0 per cent by 2031, compared with 10.8 per cent without the Project.
Reduced dependence on private transport	• The Project would avoid 80 million private vehicle kilometres in 2031 and reduce the need for car travel in the CBD.
Reduced road congestion	• The BaT project would attract car drivers to public transport and generate less road traffic, less vehicle kilometres travelled resulting in a reduction of around 1 per cent of vehicles on the road cordon around the inner city. • Bus volumes on several CBD streets would decline so reducing traffic congestion and improving pedestrian capacity and urban amenity.
Rail freight unaffected	• Rail freight paths can be maintained.

4.4 Construction traffic

In its construction phase the Project would require five main construction worksites within the study corridor, with worksites at the southern and northern connections comprising several sites. The Southern Connection worksites at Boggo Road and PA Hospital, are proposed to support the launching and operation of the TBM to construct the tunnel.

Each worksite has the potential to impact on local roads and traffic operation. The potential traffic impacts of the construction works at some of the worksites would be complicated by other development projects that may commence in the vicinity (eg Queen's Wharf Brisbane) or as major events take place (ie at the Gabba Stadium or in the Brisbane CBD).

Construction activities, including construction traffic, would be managed through implementation of an Environmental Management Plan (EMP), developed in consultation with stakeholders. The approach to environmental management is summarised in **section 6**.

Anticipated construction traffic impacts would be addressed through the preparation of specific Construction Traffic Management Plans prior to the commencement of works. For traffic management, general hours of work for construction works on or above the surface would typically be consistent with those established in the Construction EMP. Works within the busway and rail corridor generally would have to be conducted outside standard hours, and particularly peak bus and rail operating periods and peak traffic periods. This would include works during night time, weekends and holiday periods.

Spoil haulage on arterial roads is proposed to occur 24 hours, seven days per week from the TBM site adjacent to the PA Hospital. Spoil haulage relying on local roads would occur during day-time and evening hours only Monday to Friday, day-time hours on Saturdays and no haulage on Sundays. Haulage for special circumstances could occur as determined by a specific construction traffic management plan.

There would be haulage of major construction equipment, materials and components outside these hours to avoid the impacts on day-time traffic flows.

4.4.1 Busway and rail services – assessment of construction effects

Surface works would interface with the existing busway and rail network requiring works to be conducted in or close to areas where bus and rail services operate. The detailed construction method would include measures to maximise the works undertaken in isolation from rail traffic and overhead energy by closing of tracks and locking of points.

Underground works would be planned to have minimal impact on bus and rail operations, although impacts would be associated with works at Dutton Park, Roma Street Station and Spring Hill. Generally all bus, passenger rail and freight rail services would continue to operate except when the Project takes possession of the existing busway and rail through targeted night-time (outside of passenger operations), weekend and other longer period rail shutdowns.

Construction activities requiring a busway or rail shutdown would be planned well in advance to minimise disruption to the network as a whole by, for example coordinating construction with already scheduled rail maintenance activities and not when major events are being held.

Airport Link–Northern Busway worksite

4.4.2 Construction impact on the road network

Construction activities would have potential impacts on the major road network (eg haulage routes) and the local road network in the vicinity of worksites. The construction traffic expected to be generated from each of the worksites for total and peak daily and hourly flows is presented in **Table 21**.

Each worksite would have specific construction traffic management plans to mitigate the effects of construction traffic. Such plans would address safety aspects, the movement of pedestrians and cyclists around worksites, the relocation of bus stops and taxi ranks where required and measures to mitigate the effects of lane closures if and when they might be required.

Haulage vehicles, Cross City Tunnel, Sydney

Table 22 provides a summary of the construction impacts and proposed mitigation measures at each worksite.

Spoil haulage routes

Construction haulage routes have been determined to minimise the impact of truck operations resulting from the proposed routes. The proposed worksite access arrangement takes account of possible alternative spoil placement sites and the key access roads. Proposed spoil haulage routes are described in **section 3.5.3**.

The impact of construction traffic including spoil haulage and deliveries of plant, equipment and material has been assessed. Critical intersections on the haul road routes have also been assessed to determine changes resulting from the proposed construction traffic. The peak hour intersection modelling for both the worksite precincts and the wider extent of the cumulative routes to the spoil placement locations revealed minor increases in queuing and delay at most of the critical network intersections modelled.

Hours of spoil haulage operations for each worksite are provided in **section 3.5.5**.

Table 21 Summary of truck generation at each worksite – one way

Worksite	Total trucks		Peak total (daily)		Estimated duration of main spoil haulage task (months)
	Spoil	Delivery	Spoil	Delivery	
Southern Connection					
- Boggo Road	10,100	2,300	60	12	3-6
- PA Hospital	76,200	22,600	194	55	~18
Woolloongabba Station	18,000	10,000	41	14	12-18
George Street Station	21,800	8,800	40	10	15-18
Roma Street Station	15,300	9,900	44	14	9-12
Northern Connection					
- Busway and rail connections	600	1,100	3	3	9-12
- Northern Connection	5,000	3,200	20	11	9-12

Table 22 Summary of construction traffic impacts and proposed mitigation at the worksites

Impacts	Proposed mitigation measures
Southern Connection	
Short term temporary closure of Eastern Busway	• Manage closure through consultation with TransLink. • Shutdowns carried out on weekends, at night or during holiday periods, where practicable. • Provision of alternative routes.
Short term temporary shutdown of passenger rail operations	• Manage shutdowns through consultation with Queensland Rail and TransLink. • Shutdowns should be carried out on weekends or at night, where practicable.
Reduce noise from spoil trucks on Peter Doherty Street	• Provide a right turn from Annerley Road into Peter Doherty Street as an entry route with the exit route via a left turn from Boggo Road to Annerley Road. • This facility is required so that fully laden spoil trucks would not travel up-hill on Peter Doherty Street close to residential land uses.
Use of local roads for haulage from Boggo Road worksite	• Designated haulage routes limit use to Annerley Road and Cornwall Street, in accordance with a Construction Traffic Management Plan.
Provision of workforce parking	• To provide workforce car parks with sufficient space and with efficient access to Ipswich Road.
Woolloongabba Station	
Potential demand from construction workforce on on-street parking	• Provide workforce shuttle to car parking at the Southern Connection worksite.
George Street Station	
Traffic changes as a result of staged lane closures of George Street and Mary Street in the vicinity of the worksite and short term full closure	• Alternative routes would be available within the Brisbane CBD. • The closure would only be required for a short duration during the construction period. • Closure should be carried out during holiday periods and/ or weekend and night times, where practicable.
Introduction of a construction traffic lane on George Street between Elizabeth Street and Mary Street. Removal of two traffic lanes on both George Street and Mary Street in the vicinity of the worksite	• Alternative routes are available for the removal of turning movements at the intersection of George Street and Mary Street. • Presence of the construction traffic lane would not to generate a significant worsening of traffic operational performance. • A construction traffic management plan would be prepared in consultation with the Brisbane City Council.
Removal of some turning movements at the intersection of George Street and Mary Street	• Use of traffic management measures such as traffic control officers so that construction traffic does not block the intersection of George Street and Mary Street or access to the Marque Hotel.
Impacts to pedestrian movements along George Street and Mary Street and pedestrian safety	• Provision of a kerbside pedestrian barrier between Elizabeth Street and Charlotte Street to prevent pedestrian from entering the construction traffic lane. • Pedestrian access would be diverted (and actively encouraged from Elizabeth Street) along the southern footpath of George Street and the western footpath of Mary Street. This footpath has sufficient capacity for the change in pedestrian demand.
Some closure of kerbside activity along George Street	• Reassigning some metered car parking on Charlotte Street, Mary Street and Margaret Street to loading activities.
Relocation of one bus stop located between Margaret Street and Mary Street	• Relocate bus stop to existing bus zone between Mary Street and Charlotte Street.

Impacts	Proposed mitigation measures
Roma Street Station	
Access to Platform 10 and associated vehicle parking, pedestrian and cycle access through Roma Street Parkland	• Access to Platform 10 would be relocated to the west of its existing location. Parking would be provided within the Roma Street Parkland public car park. • Provision of new pedestrian access from Roma Street Station up to the Parkland Boulevard pedestrian concourse. • Access for vehicles, pedestrians and cyclists would be maintained through the Parkland. Traffic management measures would be implemented where there is potential for conflict with construction traffic.
Loss of car parking and passenger drop off and pick up adjacent to Platform 10	• Suitable alternative car parking arrangement exists through using the commercial car park associated with the Roma Street Apartments accessed from Parklands Crescent. A number of these car parks would be reserved for use by Queensland Rail staff and customers. • Use of an area of vacant land within the Roma Street Parkland, north of the Central Apartments, is proposed to be established as a car park. It is anticipated that this car park would be used by Queensland Rail employees and for other operational purposes such coach set-down and pick-up activities.
Loss of car parking in Roma Street Parkland	• Existing staff car park (close to College Road) made available for public use.
In the event of there being a need to close other roads in Roma Street Parkland such as Parklands Boulevard for a period of time	• Vehicular, pedestrian and cycle access must be maintained to Roma Street Parkland such that: • residents and their visitors can access the car parking associated with the Roma Street Parkland apartments • the public can continue to access and visit the Roma Street Parkland • long distance rail services can be accessed from platform 10 • pedestrian and cyclists can continue to access the off-road bicycle facilities that connect Roma Street Parkland (and hence Roma Street) to the northern suburbs via off-road shared bicycle and pedestrian paths.
Northern Connection	
Pedestrian and cycle access at Victoria Park – closure of existing shared cycle and pedestrian path	• Realignment of shared paths around the worksites to enabled continued access during construction. • Where required, implementation of traffic controllers at locations where there is potential conflict between cyclists, pedestrians and construction traffic.
Construction traffic right turn from Gregory Terrace into the worksite access road	• Suspension of parking in worksite access driveway adjacent to Substation. • Temporary removal of four on-street parking spaces adjacent to worksite driveway on Gregory Terrace will mean that right turning construction traffic would not block straight ahead traffic. • Provision of 'keep clear' markings for northbound Gregory Terrace at worksite driveway entrance.
Construction traffic using Gregory Terrace, Bowen Bridge Road and Herston Road. Temporary impacts to busway operations during construction	• Use of the Project busway infrastructure constructed at the start of the construction program as connection between the Northern Connection worksites, removing some construction traffic activity from Herston Road, Gregory Terrace and Bowen Bridge Road.
Construction traffic to use a short section of the Northern Busway to access the ICB	• Consultation with TransLink on busway operations to develop a coordinated approach to the delivery of the busway infrastructure and to manage the mixing of haulage trucks with bus operations.

4.4.3 Construction workforce parking

The identified construction workforce is expected to generate a peak parking demand of approximately 690 vehicles across all construction worksites based on a conservative assumption that each member of the workforce would drive. A total of 700 parking spaces are to be provided across the construction worksites catering for the majority of the peak workforce. Car parking numbers are summarised in **Table 23**.

Overall the level of car parking provided is expected to be sufficient to cater for overall workforce parking demands across the construction program with additional certainty to be provided through mitigation measures including:

- no provision of car parking for construction workforce at Roma Street and George Street worksites due to public transport and commercial car park accessibility in the CBD
- encourage the workforce to carpool or catch public transport where possible
- workforce parking and associated management for surrounding residential or commercial areas, addressing issues such as safety, access and amenity, would be fully addressed in the Construction Traffic Management Plans prepared by the Proponent.

Kalinga Park worksite, Airport Link

Table 23 Construction workforce parking

Site	Peak workforce	Proposed workforce car parking	Surplus/ deficit
Southern Connection	180	310	130 surplus. Workforce parking provision well in excess of peak demands. Site would cater for overspill as required. On-street car parking discouraged due to Dutton Park traffic area (Monday to Friday).
Woolloongabba Station	135	130	Five deficit. Excess workforce at peak times could carpool or use public transport. On-street car parking discouraged due to Gabba traffic area (Monday to Friday and on game days).
George Street Station	115	0	115 deficit. Workforce to use off-street public car parks, carpool or use public transport. On street car parking discouraged through Brisbane Central traffic area (Monday to Saturday).
Roma Street Station	140	140	No deficit. Workforce would use off-street public car parks, carpool or public transport.
Northern Connection	120	120	Sufficient. Workforce parking provision matches demand.
Total	**690**	**700**	

Note: 1. Assumes all workforce drives.

4.4.4 Pavement assessment

The impact of construction traffic has been assessed to measure the likely contribution towards the reduction of road pavement life spans. The contribution of Project construction traffic is generally predicted to be less than a 5 per cent increase in the equivalent axle loadings, to the existing loadings for most of the construction routes proposed. For some roads, including the immediate access points to worksites and spoil placements sites, the increase in equivalent axle loadings is higher.

With the exception of those links, only minor deterioration in pavement condition could be expected for all other road links, and given the relatively short duration of construction in the context of pavement design lifespans, this level of impact is considered acceptable.

Due allowance would need to be made by the contractor to repair any road surface impact due to wear and tear during construction, such as in the immediate vicinity of major worksite entrances where heavy vehicle turning is likely to deteriorate pavements.

4.5 Transport conclusions

Without the Project the rail and bus networks would not be able to accommodate the expected increase in demand for public transport trips due to growth in population and employment. Bus connections to the CBD are already at capacity and Merivale Bridge would reach its train capacity in 2020. Once capacity is reached, the networks would be unable to add additional services and the current services will deteriorate in terms of reliability, travel time and crowding.

The CBD and inner city would benefit from this increase in public transport capacity in terms of support for ongoing economic development and the efficiencies created by linking key economic and social land uses within the inner city as well as the linkages to further away population growth areas.

The Project would deliver the required capacity increases for the bus and rail networks to provide high quality and reliable public transport into the CBD and inner city.

While the construction of the Project over five years would result in a number of impacts to the transport network, particularly around worksites, mitigation measures have been identified to minimise these impacts. The short term construction transport impacts relatively to the 100 year life of the Project, are outweighed by the significant long-term benefits provided by the Project.

5. Environmental assessment

The EIS assesses the environmental, social and economic benefits and impacts associated with the construction and operation of the Project. This section summarises the key findings from the assessment of impacts associated with the design, construction and operation of the Project.

Further details about the Project's potential environmental impacts are provided in **Chapter 5** to **Chapter 17** of the EIS.

5.1 Methodology

Impact assessment involved studying the bio-physical and socio-economic values and conditions in the study corridor and other areas potentially impacted by the Project in order to:

- describe the existing conditions and values to provide a baseline from which the Project's impacts could be assessed
- identify and assess potential impacts, both positive and negative, and direct and indirect, of the Project's construction and operation on these biophysical and socio-economic conditions
- identify measures to avoid, or mitigate or manage adverse impacts and maximise or enhance beneficial impacts.

Environmental aspects relevant to the environmental assessment for the Project include:

- biophysical matters, including: climate; soils, topography, geology and geomorphology, land contamination; ecology; hydrology, including surface water quality, flooding and groundwater; air quality and noise and vibration
- socio-economic matters, including land use and tenure; cultural heritage; landscape and visual amenity; and social and economic
- Other matters such as waste; hazard and risk; and cumulative impacts.

5.2 Impact assessment

5.2.1 Overview

The Project would be delivered into a highly modified, densely settled, inner city environment. Much of the Project works would take place underground, minimising the construction and operational impacts for people living and working on the surface. Surface works would be confined to the three station sites and the connections with the existing transport network in the south and in the north.

The Project would provide high quality public transport services in highly accessible and convenient locations to people living and working in the inner city, the inner suburbs and the South East Queensland region. Consequently, there is a likelihood that the Project would disrupt daily life to some extent around the worksites during construction. With careful design, the potential for similar disruptions during operation of the Project would be avoided, or minimised.

Roma Street Parkland

Ecological values in the study corridor are generally low due to European settlement and long-term urbanisation. While there are no natural areas in the study corridor, there are a number of topographical features which provide reminders of the natural setting. These features include the Brisbane River and the undulating landform it has created. There are places of landscape and recreational value which enhance community attachment including the Kangaroo Point cliffs which were formed by early quarrying of hard rock, the City Botanic Gardens, Roma Street Parkland and Victoria Park.

Socio-economic values in the study corridor arise with reminders of early Aboriginal life across the study corridor, and patterns of daily life and movement around activity centres, service centres, places of cultural or entertainment value, and the physical arrangement of land use, buildings and plantings of ceremonial or recreational gardens.

Once constructed, much of the Project infrastructure would be located underground with surface infrastructure limited to connections to the existing surface rail and busway networks at Dutton Park and Spring Hill, station buildings at Woolloongabba, George Street and Roma Street and associated infrastructure such as feeder stations and ventilation outlets.

Potential adverse impacts associated with the construction phase of the Project would be relatively short term (less than five years), with the most intense activities close to the surface likely to be completed in about 18 months. On-going surface activities would tend to be less intense and less intrusive.

In the context of the 100 year design life of the Project, the benefits would be enduring, wide-spread and equitably distributed, even if overtaken by sustained population growth and economic development.

5.2.2 Soils and topography

Existing values

The topography of the study corridor is generally characterised by undulating terrain with a number of prominent high and low points. The highest point within the study corridor is on Wickham Terrace in Spring Hill at 55m Australian Height Datum (AHD), and the lowest point is within the Brisbane River channel at less than om AHD.

The geology is dominated by the Palaeozoic 'Brisbane Metamorphics', which consists of Neranleigh-Fernvale Beds and the Triassic sediments of the Aspley formation. All dominant geological formations are overlain by Quaternary Alluvium within low-lying and floodplain areas associated with the Brisbane River and its tributaries.

Soil types in the study corridor include Rudosols, Hydrosols, Podosols, Sodosols and Dermosols. The highest risk of erosion would occur where surface and sub-surface soils would be disturbed on steep slopes (greater than 10 per cent gradient). Although low, there is potential for acid sulphate soils (ASS) to be present north of the Brisbane River channel extending beneath the Brisbane CBD and within the southern bank of the Brisbane River near Woolloongabba. ASS are not likely to be present at the sites of the Woolloongabba Station, Roma Street Station or the southern or northern connections.

The study area contains a number of sites that are known or have the potential for contamination due to current or past land use activities, such as railway yards, petroleum or oil storage, or waste disposal. Searches of the Environmental Management Register (EMR) and Contaminated Land Register (CLR) identified 1,987 land parcels listed on the EMR. This included 1,067 land parcels considered to be listed for higher risk land uses, of which 126 land parcels are located within the study corridor. An additional 73 potentially contaminated land parcels were also identified within the study corridor, through the review of current and historical photography and other searches. There are no properties listed on the CLR within or adjacent to the study corridor.

Geotechnical drilling, Brisbane River

Impact assessment

Topography and soils

Changes to topography would be minor and primarily confined to negligible to minor ground level changes through the possibility of settlement from tunnelling activities. Settlement in tunnelling projects may arise due to many factors including groundwater drawdown and local ground relaxation effects around excavations and underground openings. The study corridor intercepts areas of shallow groundwater in the vicinity of Woolloongabba Station, the river crossing and the George Street Station, resulting in consolidation settlement of the soft alluvial material. As there are no properties or other structures vulnerable to the effects of settlement overlying this soft alluvium, the impact of settlement along the river crossing, if it occurs, would be negligible.

Subsidence may also occur north of the Southern Connection between the TBM launch shaft and Quarry Street. The tunnelling methodology through this section of the alignment would need to be tailored to manage the risk of subsidence in overlying material above the tunnel and strengthened via such methods as micro tunnels filled with reinforced concrete. A pre-condition survey of structures predicted to be affected by settlement, including rail infrastructure, would be undertaken to enable any damage to be made good. Preliminary settlement mapping for the Project is provided in Appendix E of the EIS.

Areas with slopes steeper than 10 per cent are identified at construction worksites at Dutton Park, Woolloongabba and Spring Hill. A review of gradient differences and soil type erosion risk indicates standard sediment control measures would be appropriate for mitigating this risk.

Detailed soil investigations would be undertaken during the detailed design to quantify the likely erosion risks. Soil erosion prevention techniques and on-site erosion and sediment control plans would be developed to manage the erosion risks. Sediment control and mitigation measures to address the risk of accelerated erosion would be developed during detailed design and incorporated into the construction EMP.

The potential for wide-spread disturbance of ASS as a consequence of construction works is considered to be low and manageable. Field investigations would be undertaken as part of the detailed design to confirm the presence or otherwise of ASS and to manage potential impacts on surface and ground water resources. There are well established protocols for the identification and management of construction works where ASS would be encountered.

Land contamination

Potential impacts relating to land contamination from the construction and operation of the Project include:

- disturbance of potentially contaminated soils and areas of unexpected contamination
- contamination from potentially contaminated sites adjacent to project works
- migration of potential groundwater contamination and ground gas accumulation in subsurface structures
- disturbance of asbestos containing materials.

Goprint Building and Land Centre, Woolloongabba

The potential for land contamination within the study corridor was investigated to identify sites that may require further investigation or management. A total of 20 sites were identified within or adjacent to the Project works as containing potential soil or groundwater contamination.

These included:

- land within the railway corridor at the southern and northern connections, which is likely to be contaminated from past management practices
- Roma Street Station – a known containment cell is situated on land adjacent to the worksite, while the Roma Street Parkland may contain residual soil and groundwater contamination, from the former use as the Roma Street goods and freight yards
- Woolloongabba Station, which may contain residual soil and groundwater contamination due to the former use as a railway yard.

In accordance with the *Environmental Protection Act 1994* and subordinate legislation, a disposal permit would be required for the removal or disposal of contaminated soil from land that is recorded on the EMR or CLR. Where contaminated soil or materials are encountered, specific mitigation measures would be developed and implemented prior to the commencement of construction activities. These would relate to such things as dust and odour management, erosion and sediment control, haulage of contaminated materials and workplace health and safety. Off-site disposal of contaminated material would be to a licensed landfill facility under a Department of Environment and Heritage Protection issued Disposal Permit.

Contamination associated with rail yards, including areas within or adjacent to the Roma Street Parkland and the Woolloongabba worksite, may have the potential to produce noxious or harmful gases. If encountered and left unmanaged, such ground gas has the potential to pose a risk to human health or result in explosive atmospheres. The potential for ground gas intrusion into subsurface structures would require investigation during the detailed design to ensure that suitable mitigation measures are integrated into Project design.

Asbestos may be present in buildings, structures and fill materials in some areas impacted by surface works, including the GoPrint building at Woolloongabba, some Queensland Rail buildings or structures and possibly in residential pockets in the building at 63 George Street. An audit would be undertaken by a licensed asbestos contractor prior to demolition. Asbestos discovered during the audit would be removed prior to commencing demolition.

Detailed investigations would be carried out as part of construction planning and prior to commencement of Project works in accordance with the Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland and National Environment Protection (Assessment of Site Contamination) Measure.

5.2.3 Climate and Greenhouse Gas

Existing values

The Project would be located within a sub-tropical climate that experiences irregular but often extreme weather events that result in floods and droughts. The mean maximum temperature ranges from about 21°C in July to 28°C in January. The driest months on average are in the spring season, while February is the wettest month on average. The strongest winds often occur in January associated with the storm season.

Impact assessment

With a design life of 100 years, the Project would be likely to experience a range of weather and climactic conditions. Adverse weather has the potential to cause natural hazards such as floods, landslides, bushfires, coastal erosion and storm-tide inundation. In Queensland, the planning for these events is coordinated through instruments such as the State Planning Policy (SPP). The principles of the SPP have been applied to the Project.

Measures to manage the effects of weather have been included in the Project's design, material selection and emergency management systems, and would provide the required level of service and immunity over the Project life. The Project reference design would accommodate changes in sea level due to climate change, in the range of 0.5 – 1.0m through to the year 2100.

An assessment of Greenhouse Gas (GHG) emissions was undertaken for the most significant emissions sources associated with the construction and operation of the Project, in accordance with the Greenhouse Gas Protocol (WBCSD & WRI, 2004), Intergovernmental Panel on Climate Change and Australian Government GHG accounting/ classification systems.

The most significant sources of GHG emissions identified for the construction and operation of the Project relate to:

- diesel consumption of plant, equipment and construction vehicles (direct emissions)
- electricity consumption associated with tunnel construction and other construction electricity requirements (indirect emissions)
- electricity consumption for operation of the tunnel and underground stations, including tunnel ventilation (indirect emissions).

The outcomes of the assessment are presented in **Table 24**. The potential reduction in GHG emissions associated with a shift in mode choice from private vehicles to bus and train use as part of the Project is estimated to be in excess of 2,500,000t CO_2-e over the 100 year design life of the Project. This reduction in GHG is likely to increase further as the effects of road congestion, and the subsequent further mode shift away from private vehicles, are also considered.

5.2.4 Ecology

Existing values

Native vegetation generally has been removed from within the study corridor. There are several isolated patches of regrowth mangroves along the Brisbane River and some remnant trees within urban parklands and private properties.

The fauna and flora communities of the study corridor are typical of inner city urban areas, and are characterised by common and widespread species.

The only threatened species known or likely to occur within the study corridor is the Commonwealth-listed Grey-headed flying-fox, which is known to forage throughout the study corridor and the wider urban area. No threatened flora species were identified during field surveys undertaken for the EIS.

Impact assessment

Impacts to flora would be confined mostly to the loss of trees within the construction worksites at Woolloongabba and Victoria Park, including mature fig trees, as well as the loss of several street trees (ie Leopard trees) at George Street and Mary Street. From an ecological perspective, the significance of this impact would be negligible.

It is recognised that the trees within Victoria Park in particular, are highly valued by the community for their landscape values and that the loss of these trees would be a concern for local residents. This concern needs to be balanced against the long-term benefits provided by the Project to the regional community and the inevitable evolution of the landscape over time, with or without the Project.

Victoria Park, Spring Hill

Table 24 Estimate of GHG emissions

Phase	Estimated GHG emissions	Proportion of GHG inventory for Year 2010-2011 (per cent)	
		Australia	Queensland
Construction	530,249 t CO_2-e	0.09	0.30
Operation (per year)	44,474 t CO_2-e	0.01	0.03

Where practical, the layout of the construction worksites, including at Victoria Park, would be designed to minimise the requirement to clear vegetation. Following construction, areas of vegetation affected by construction activities would be rehabilitated. In particular, land within Victoria Park disturbed by construction activities, would be rehabilitated and reinstated in accordance with a master planning process to be undertaken by Brisbane City Council in consultation with Traditional Owners and local residents. This would provide the opportunity to improve the functionality of the park and its landscape and recreational values for local residents.

The extent of groundwater drawdown (greater than 1m) is not predicted to extend to most locations where Groundwater Dependent Ecosystems (GDEs) are present. Groundwater drawdown may occur within small areas of the City Botanic Gardens, near Alice Street, and along the banks of the Brisbane River, although the level of groundwater dependency in these areas is likely to be relatively low.

The establishment of construction worksites may cause minor, localised temporary displacement of common and widespread fauna species that occur in urban environments. As the faunal community of the study corridor consists largely of species common within the existing urban landscape, the magnitude of this impact is likely to be negligible. The Grey-headed flying-fox is unlikely to be affected as the Project would not impact on important, mature trees of the *Myrtaceae*, *Proteaceae* or *Moraceae* families of plants. The Project is not expected to impact on the availability of these resources.

The introduction or spread of invasive species is a potential risk at each worksite. Measures would be incorporated in to the Construction EMP providing for ongoing monitoring and management of these areas. Measures would include such things as provision of appropriate soil hygiene procedures, and preparation and implementation of a risk management plan for Red Imported Fire Ants.

5.2.5 Hydrology

Existing values

The Project is located within the lower Brisbane River catchment. The Brisbane River is the most prominent waterway that passes through the study corridor. Other watercourses near to the study corridor include Norman Creek and Breakfast Creek. Artificial water bodies such as ponds and lakes are also found at the City Botanic Gardens, Roma Street Parkland lake and York's Hollow in Victoria Park.

The Lower Brisbane River Catchment is a highly modified, urbanised catchment, with extensive clearing of riparian vegetation. Most of the inflows to the river and its tributaries enter via stormwater infrastructure in urban zones (EHMP, 2013b). Ecosystem health of the lower Brisbane River catchment is generally characterised as 'poor' due to poor nutrient cycling, aquatic macro-invertebrate and fish indictors, and high turbidity, low dissolved oxygen, elevated levels of nutrients and poor riparian vegetation. Estuarine water quality in Norman Creek and Breakfast Creek is also characterised as 'poor' due to high nutrient levels and dissolved oxygen below Water Quality Objectives.

The study corridor also includes numerous overland flow paths or drainage lines that are not part of a creek, river or waterway. These are usually dry except in rainfall events. They are typically activated in short duration, high intensity rainfall events.

The hydrogeological regime of the study corridor and surrounding area comprises two broad aquifer types (from oldest/deepest to youngest/shallowest):

- fractured rock (secondary porosity) aquifer systems comprising Neranleigh-Fernvale Beds, Brisbane Tuff, Aspley and Tingalpa Formations, Woogaroo Sub-Group
- alluvial (primary porosity) aquifer systems overlying bedrock aquifers.

The groundwater resource in the study corridor is variable and influenced by the Brisbane River and the local drainage system, as much of it is by the geological conditions. In some locations, there is likely to be a hydraulic connection between the River and the local streams and shallow aquifers.

In fractured rock aquifers, groundwater is typically stored in geological structural features (ie fractures). The availability of water in these systems is largely dependent of the nature of the fractures and their degree of interconnection. Groundwater in primary porosity systems exists within pores between grains of the sedimentary rock.

Recharge to the alluvial aquifers is controlled by weather and geology, with direct vertical recharge likely to occur from rainfall or overland flows. As most of the streams in the study corridor are tidal, both recharge and discharge processes are likely to occur during high and low tides respectively, where hydraulic connections exist.

Potential also exists for localised recharge from leaking water mains, stormwater systems and sewage pipes. Basement dewatering is a potential source of discharge for the surrounding aquifers within the Brisbane CBD.

Groundwater levels in the study corridor as depicted in **Figure 6** are variable and are generally a subdued reflection of topography, apart from those areas where the water table has been impacted by existing infrastructure (eg basement dewatering). As a generalisation, regional groundwater flow is towards the Brisbane River.

Groundwater quality in the fractured rock is generally poor. Groundwater quality within the alluvial aquifer is fresh to brackish, with the pH ranging from acidic to slightly alkaline. Groundwater quality in the alluvial aquifers is influenced by the proximity of creeks or rivers and associated tidal influences, including saline intrusion.

The contaminated land investigation identified a number of known or potentially contaminated sites within the study corridor. It is highly likely that groundwater is contaminated within the vicinity of these sites.

Areas of localised groundwater contamination, particularly of petroleum hydrocarbons, are also likely to be located in the rock mass along the study corridor. Hydrocarbon and nutrient contaminants have been identified in Norman Creek, Brisbane River and Breakfast Creek. It is likely that groundwater connectivity occurs at creeks and rivers, having the potential for contaminants to enter groundwater aquifers.

GDEs are likely to be present within shallow alluvial sequences associated with drainage lines. In these areas, the water table is likely to be permanently shallow and above the maximum rooting depth of established vegetation. Most of the drainage lines within the study corridor saline to brackish, and tidal in nature. It is anticipated that groundwater in these areas is also of a saline nature. Groundwater levels in these areas are likely to be tidally influenced with the water table fluctuating accordingly. Groundwater dependency in these areas is likely to be relatively low and opportunistic at best, with mostly salt-tolerant species potentially utilising groundwater in these saturated zones.

Impact assessment

Flood management

The Project has been designed to provide flood immunity for the tunnel and underground stations from the 1 in 10,000 Annual Exceedance Probability (AEP) event in regional flooding (riverine and creek events) and from the 1 in 100 AEP event in local (overland flow) events. The aim of this design approach is to minimise the risks of flood damage to the Project to as low as reasonably practicable.

The Project may be at risk to drainage issues from overland flow at the Southern Connection, Roma Street Station and the Northern Connection. Suitable design of the onsite stormwater network, such as retaining walls, kerbing and channelling, would be undertaken during detailed design to manage impacts of overland flow.

Surface water

The Project could impact on downstream waterways through such things as:

- use of water, including recycling water, for environmental management and construction activities
- changes to surface water flow at construction worksites
- sedimentation and surface water run-off
- disturbance of ASS or contaminated land
- introduction of litter or toxicants from spills or the accidental release of pollutants.

Erosion and sedimentation of waterways is a naturally occurring catchment process, although vegetation clearing, earthworks and spoil stockpiling associated with the Project's surface works have the potential to cause detrimental concentrations of sediments if managed poorly.

The aggregate area of the Project worksites would be approximately 25 ha, compared with a total catchment area for the Brisbane River of approximately 15,000 km^2. Considering the range of rural, industrial and urban development activities underway at any time in the catchment, the potential impact of Project works due to sedimentation would be negligible to imperceptible.

To address local concerns and potential impacts, adequate sediment and erosion control measures at worksites would be implemented to reduce discharges of sediment into the receiving environment.

Oils, fuels, chemicals, hazardous substances and litter have the potential to enter surface waters through run-off from worksites. Water quality treatment control devices would be designed and implemented at the Project's worksites to avoid the potential release of contaminants to surface waters.

During construction, water would be used for activities such as dust suppression, compaction, vehicle and wheel wash down, production of grout, and firefighting supply. Water discharged from construction areas and worksites has the potential to contaminate surface waters if not managed and treated appropriately prior to discharge.

A Soil Erosion and Sediment Control Management Plan would be prepared and implemented for each worksite as part of the Construction EMP. The planning objective would be to avoid or minimise the transfer of sediment or other pollutants from construction activities to waterways or drainage lines.

A range of mitigation measures would be used, including:

- the use of effective erosion, sediment, dust and stormwater controls
- considering flood affected areas, drainage lines and waterways during stockpiling and placement of spoil and other bulk materials
- implementing Water Sensitive Urban Design measures at construction worksites for mitigating erosion, controlling sediment and site drainage
- implementing appropriate practices and procedures for handling, storing and management of hazardous substances
- minimising vegetation clearing, where reasonable and practicable
- rehabilitation and restoration of cleared areas as soon as practicable upon completion of the works.

Groundwater

Groundwater drawdown associated with the Project would be caused from dewatering portions of the tunnel and at station locations, potentially resulting in:

- reductions in groundwater availability for existing groundwater users
- impacts to GDEs
- inflow of contaminated groundwater to the tunnel and station caverns
- exposure of potential acid sulphate soils through oxidation, resulting in the acidification of groundwater.

The Project has undrained sections (ie waterproof) and drained sections (ie allows groundwater to inflow). The undrained sections are limited to the sections of tunnel constructed by TBM and fitted with reinforced concrete segments with gaskets and grouting to provide a waterproofed, structural lining. The undrained sections extend generally from portal to portal, excluding the underground stations. The underground stations would be drained, and would be designed with groundwater cut-off walls and drainage systems to capture any groundwater that might enter the station shafts and caverns. Most of the groundwater inflows would emanate from the shallow aquifers, rather than through the fresh competent rock in which the caverns would be constructed.

The rate of groundwater inflow into the drained sections of the Project (ie station caverns and cut and cover sections) would decrease over time after an initial high peak in the first year. The average groundwater inflow post-construction is estimated to be approximately 11ML/ year. This is significantly less than inflows estimated for the CLEM7 and Legacy Way projects.

The existing beneficial use of groundwater within the study corridor is considered to be low, given the existing groundwater quality is brackish to saline. The RNA Showgrounds are known to contain registered bores, but modelling indicates negligible impacts to pumping rates of the bores.

Contaminated groundwater may exist in the vicinity of contaminated sites within the study corridor. Any mobile groundwater contaminants within the study corridor may ultimately drain to the proposed station caverns. However, groundwater inflow to the stations is expected to be low with any contaminant fluxes correspondingly low. All groundwater entering the underground elements of the Project would be treated prior to disposal.

The extent of groundwater drawdown is predicted to extend out to the Brisbane River in some areas. It is likely that groundwater has drained to deep basements associated with tall buildings in the CBD, causing the oxidation of potential acid sulphate soils as a result of this drawdown. Further drawdown, associated with the Project, could contribute to the formation of acidic conditions in these areas resulting in the acidification of groundwater, potentially impacting on concrete and steel structures. While the overall risk is considered to be low, further quantification and characterisation would be undertaken in drawdown zones where areas of acid sulphate soils may exist. Once the occurrence of these sites has been confirmed, remediation measures would be put in place prior to construction of the tunnel.

Groundwater inflows to the Project would be monitored for quality to determine and manage the requisite treatment, prior to release to surface waters. The Environmental Protection Policy (Water) and Queensland Water Quality Guidelines will apply to groundwater releases to receiving waters.

Image courtesy of Rix Ryan Photography

5.2.6 Air quality

Existing values

The meteorology of the study corridor is generally characterised by winds north-east during summer and spring and south-west during autumn and winter.

Existing air quality in the study corridor has been collected from data recorded by the Department of Environment and Heritage Protection at Brisbane CBD (QUT Gardens Point), South Brisbane, Woolloongabba and Rocklea. The data indicates that air quality in the study corridor is generally good with concentrations of most pollutants well below the ambient air quality goals. Regional sources such as controlled burns or dust storms, contribute to exceedances from time to time of the air quality objectives specified in the Queensland Environmental Protection Policy (EPP (Air)) for PM_{10} and $PM_{2.5}$. Locally, the main contributors to air emissions in the study corridor include motor vehicle emissions from major roads; transport infrastructure such as rail yards and localised building construction activities.

Ventilated acoustic shed, Legacy Way
Image courtesy of Rix Ryan Photography

Impact assessment

Construction

During construction, potential impacts on air quality would most likely be from dust emissions from construction worksites and possibly from the haulage of spoil. Construction activities most likely to cause dust related impacts would include:

- worksite establishment and demolition activities
- tunnelling activities and associated excavation
- shaft excavation
- spoil handling and haulage.

As a result, the pollutants of interest from the construction phase of the Project are:

- Total Suspended Particulate (TSP)
- Particulate Matter 10 (PM_{10})
- deposited dust.

Deposited dust and TSP have the potential to cause nuisance impacts, rather than impacts on human health. Dust emissions from construction vary with the intensity of construction activity. The air quality parameters of interest during construction address particulates and dust. The EPP (Air) establishes objectives for human health and well-being as indicated in **Table 25**.

Table 25 Predicted particle concentrations and dust deposition

Worksite	Cumulative model predictions (range)*				
	TSP (µg/m³)	24 hour PM10 (µg/m³)		Monthly dust (mg/m²/day)	
	Annual	Max	5th percentile	Max	Average
Objectives	90	n/a	50	130	n/a
Southern Connection	36.4 – 39.4	22.1 – 30.8	21.2 – 30.9	64 - 128	62 – 83
Woolloongabba Station	36.8 – 38.7	24.4 – 29.2	22.9 – 29.0	68 - 105	65 – 75
George Street Station	26.6 – 39.1	21.4 – 29.6	20.9 – 25.6	67 - 109	64 – 81
Roma Street Station	36.0 – 38.3	20.1 – 24.4	20.1 – 23.3	60.1 - 91	60 – 76
Northern Connection	36.3 – 38.0	24.8 – 33.4	22.1 – 30.3	64 - 85	62 – 71

Modelled at the closest sensitive receptors to each worksite

Dust emissions from large construction projects are typically greatest during periods of significant earth moving activities conducted during dry weather. The construction worksites with potential for the highest dust emissions are at the Southern Connection worksite due to its size and proximity to sensitive receptors, George Street and Roma Street worksites due to their proximity to sensitive receptors, and the Northern Connection worksite due to its size and proximity to Victoria Park.

During construction, with appropriate dust mitigation measures in place, total suspended particulates and PM10 concentrations are predicted to remain below the ambient air quality goals in the EPP (Air) (refer to **Table 25**).

The scenarios modelled for the EIS considered the maximum construction activity levels (including blasting) and focussed on the nearest sensitive receptors to construction worksites. This approach represents a conservative 'worst case' assessment. More typical construction activity levels would result in lower impacts.

The loading of spoil to trucks from the TBM operation at the Southern Connection would be approximately 40m from the metropolitan linen services, general energy services and general support services buildings within the PA Hospital campus. The loading of spoil would occur within a ventilated acoustic shed, which would provide significant dust mitigation. With controls, dust deposition is estimated to be close to, but below, the air quality objectives at these buildings. Due to the proximity of these receptors potential management measures would require ongoing dust monitoring to support adaptive management and application of additional controls.

In addition to ongoing monitoring, effective mitigation measures would be required throughout the construction period at all worksites to minimise the potential for dust nuisance. A construction dust monitoring plan would be required as part of the Construction EMP. The Construction EMP would also specify measures for avoiding and managing nuisance dust from fixed and stationary plant and equipment with diesel motors.

A potential mitigation regime was developed for each site to meet air quality objectives (refer to **Table 26**).

The mitigation options modelled included a selection of:

- acoustic enclosures or sheds at worksites with higher intensity activities (load out areas/ shaft excavations)
- hoardings around general work areas
- hardstand on internal roads
- standard controls.

The level of dust control could be managed depending on the specific activity and prevailing weather (temperature, wind and precipitation) conditions.

Table 26 Modelled mitigation options

Potential mitigation and control factors (per cent reduction)	Work sites/areas						
	Dutton Park (PA Hospital site)	Dutton Park (Boggo Road site)	Woolloongabba Station	George Street Station	Roma Street Station	Spring Hill (south of ICB)	Spring Hill (north of ICB)
Enclosure (70 per cent)	Yes	Yes	Yes	-	-	-	-
Enclosure equipped with fabric filters (99 per cent)	-	-	-	Yes	Yes	-	-
Sealed/ hardstand roads (100 per cent)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hoardings (30 per cent)	-	-	-	-	-	Yes	Yes
Base standard dust controls (eg water spraying, wheel wash-down)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Operation

As all rail traffic through the Project would be electric powered, and would not include freight, there would be no engine emissions released into the tunnel or the underground stations. Air quality within the Project and in the atmosphere would be impacted by exhaust emissions from buses, including combustion related gases and particulate matter. Emission concentrations at sensitive receptors would be below the health-based goals. Atmospheric conditions in the vicinity of ventilation outlets may experience warm air flows. Features of the ventilation outlets are outlined in **Table 27**.

Impacts from a range of ventilation outlet heights and locations were modelled for the air quality assessment. This was to inform the design process of any risks or opportunities associated with the location of the ventilation outlets relevant to air quality outcomes. A summary of the results is shown in **Table 28**.

The Project's exhausted air would provide a very small contribution to existing air pollution levels in the receiving environment. The selection of outlet locations was based primarily on creating separation distance sufficient to avoid exhausted air being drawn back into the tunnel system via the air intakes and to allow ventilated air to return to ambient temperature.

Modelled predictions of cumulative air quality impacts from the operational emissions from each ventilation outlet are well below air quality objectives for 24 hour average of $PM_{2.5}$, the one hour average for NO_2 and the eight hour average for CO. As the cumulative impacts from the Project are predicted to be below the relevant air objectives, the health risk due to the operation of the Project is considered to be low.

Table 27 Modelled ventilation outlet characteristics

Site	Height (metres above ground level)	Indicative dimensions (external)	Aperture (internal) (m^2)
Southern Connection	11	4m x 6m	15
Woolloongabba Station	24	6m x 8m	35
George Street Station	25	4.5m x 11m	35
Roma Street Station	8	4.5m x 11m	35
Northern Connection	11	4m x 6m	15

Table 28 Predicted range of particle and gas concentrations at the closest sensitive receptors

Sensitive receptors	Cumulative model predictions (range)				
	PM2.5 (µg/m³)		NO2 (µg/m³)		CO (µg/m³)
	24 hour	Annual	1 hour	Annual	8 hour
Objectives	25	8	250	62	11,000
Adopted background concentrations	9	7.8	19	15	260
Southern Connection	9.1 – 9.6	7.80 – 7.82	20.6 – 23.2	15.00 – 15.04	265.3 – 271.3
Woolloongabba Station	9.21 – 9.96	7.83 – 7.90	21.07 – 26.42	15.07 – 15.25	263.8 – 275.7
George Street Station	9.8 – 11.3	7.83 – 7.93	25.5 – 73.9	15.07 – 15.31	274.1 – 315.6
Roma Street Station	9.1 – 10.0	7.80 – 7.85	20.2 – 25.1	15.00 – 15.12	262.6 – 277.8
Northern Connection	9.03 – 9.31	7.80 – 7.82	19.3 – 20.7	15.01 – 15.05	260.7 – 265.3

5.2.7 Noise and vibration

Existing values

Existing noise levels in the study corridor are generally influenced by railway noise or road traffic noise during the daytime and evening periods, and distant road traffic noise at night-time.

Noise monitoring conducted for this EIS found that a number of locations within the study corridor experience existing high noise levels (refer to **Table 29**). These include locations such as Brisbane Girls Grammar School, the PA Hospital and St Andrew's War Memorial Hospital; residential apartments at Parkland Boulevard, 21 Mary Street and 191 George Street, and 803 Stanley Street; and commercial uses at 40 George Street.

These high background noise levels are typical of their inner city locations with high density of road and rail traffic, pedestrian activity and nearby mechanical noise. Existing noise levels at 21 Mary Street were dominated by rooftop mechanical plant from surrounding buildings.

With the exception of the PA Hospital, existing noise levels near the Southern Connection are generally lower, and representative of more suburban locations with larger distances from dominant noise sources. Road and rail traffic continues to dominate background noise levels for most locations in this area, including those away from major roads.

Table 29 Measured rating background noise levels

Monitoring location		Rating background levels (RBL), LA90 (dBA)		
		Day (7.00am-6.00pm)	Evening (6.00pm-10.00pm)	Night (10.00pm-7.00am)
1	St Joseph's College	50	48	40
2	Brisbane Girls Grammar School	61	60	46
3	St Andrew's War Memorial Hospital	55	53	51
4	Parkland Crescent	54	50	47
5	191 George Street	58	57	54
6	40 George Street (The Mansions)	59	55	51
7	QUT Gardens Point	49	48	46
8	58 Leopard Street	53	50	46
9	803 Stanley Street[1]	58	57	51
10	143 Park Road	43	39	34
11	Dutton Park State School	44	40	35
12	26 Elliot Street	46	44	40
13	68 Railway Terrace (Leukemia Foundation ESA Village)	47	45	41
14	19 Dutton Street	43	42	37
15	PA Hospital	54	54	53
16	4 Fenton Street	39	38	34
17	Building 3 Parkland Boulevard (Level 3 conference room)[2]	RBL: 53 (30) LA_{eq}: 61 (37)	RBL: 50 (27) LA_{eq}: 58 (35)	RBL: 44 (<24)3 LA_{eq}: 55 (31)
18	21 Mary Street (Level 27 unit 1)[2]	RBL: 56 (33 – living room) LA_{eq}: 58 (34)	RBL: 55 [4] LA_{eq}: 56 [4]	RBL: 53 (27 - Bedroom) LA_{eq}: 56 (30)

Note 1: RBL based on only one (1) full day of data due to logger malfunction and access restrictions.
Note 2: Levels in brackets were measured inside the building.
Note 3: Actual noise level was below the instrument noise floor of 24 dBA.
Note 4: Evening period data not available due to logger malfunction at 21 Mary Street.

Existing vibration levels were also measured at 10 locations within the study corridor, including for residential uses and special uses such as educational, research or health care facilities. The background vibration levels (V_{90}) for all sites varied between 0.01 mm/s and 0.13 mm/s during daytime and evening and between 0.01 mm/s and 0.11 mm/s at night-time.

Maximum vibration levels (V_1) for residential monitoring locations ranged from 0.11 mm/s to 2.69 mm/s during daytime and evening and 0.04 mm/s to 0.71 at night-time. High vibration levels were monitored at some residential uses. This shows that normal activities such as closing doors, drawers and cupboards, walking, moving and sitting on furniture generate high vibration levels.

At locations with vibration sensitive equipment, such as hospitals and education uses, background vibration levels (V_{90}) ranged from 0.02 mm/s to 0.06 mm/s. Maximum vibration levels (V_1) ranged from 0.03 mm/s to 2.50 mm/s, with the PA Hospital particularly measuring high vibration levels.

Impact assessment

At each of the construction worksites, a range of activities would be undertaken that may result in noise or vibration. The activities typical of noise emissions during construction include:

- demolition of existing buildings and site establishment, including construction of spoil handling facilities
- installation of perimeter retaining walls using piling or precast concrete segments
- assembly of TBM and associated facilities for tunnel construction
- excavation, using excavators, rock-breakers, drill and blast techniques, TBM and other construction plant
- spoil removal by heavy vehicle
- TBM assembly, retrieval and disassembly
- station construction, fit out and commissioning.

Tunnel construction

TBM and roadheaders would operate underground on a 24 hour, seven days per week basis, including a daily maintenance period when operations would cease temporarily. The noise and vibration modelling undertaken for tunnel construction predicts that:

- groundborne vibration levels would result in no exceedances of the cosmetic damage vibration goal or the stricter cosmetic damage goal to heritage buildings
- the night-time residential vibration goal would be exceeded, although these exceedances would occur during a relatively short period (less than one week for the TBM passby)
- the ground-borne noise goal for residential sensitive receivers would be exceeded for about seven days during the TBM passby. There are also five hotels in the CBD where levels may exceed the night-time ground-borne noise goal for up to ten days.

The following management strategies are proposed to minimise the impact of the TBM tunnelling works:

- comprehensive advance notice would be implemented for communities in the localities near the tunnel alignment. Part of the consultation process would include information regarding the monitoring program, which may require involvement from residences located above the tunnel alignment
- building condition surveys would be conducted in locations where there may be potential risk for cosmetic (superficial) building damage
- if required, other measures agreed with residents particularly impacted by ground-borne noise from TBM tunnelling.

Roadheader construction

Portal and station construction

During construction, activities likely to generate noise impacts at each of the portals and stations include the demolition of existing buildings, excavation using rock-breakers or drill and blast techniques, and other construction plant, earthworks and removal of spoil. The noise and vibration modelling undertaken for portal and station construction predicts the following impacts at each worksite, mostly as a consequence of rock-breaking operations:

- Southern Connection – minor exceedances of the daytime noise goal and the night-time sleep disturbance goal for residential receivers adjacent to Railway Terrace.

  More significant exceedances of the night-time noise goals are predicted for the Leukaemia Foundation ESA Village (ESA Village) due to rock-breaking works. Vibration is predicted to exceed the night-time, human comfort, vibration goal at the ESA Village and marginally exceed the floor vibration tolerance for the transition electron microscope (TEM) located within the basement of the Ecosciences building.
- Woolloongabba Station – minor exceedances of the daytime noise goal are predicted at the nearest residential receivers along Vulture Street and more significant noise goal exceedances are predicted for St Nicholas Russian Orthodox Cathedral due to its quiet land use status. Construction activities (ie rock-breaking) are also predicted to exceed the night-time residential noise goal at the nearest receivers.
- George Street Station – significant exceedances of the daytime and night-time noise goals due to rock-breaking are predicted for the residential and accommodation receivers adjacent to the worksite.

Portal construction, Legacy Way
Image courtesy of Rix Ryan Photography

- Vibration due to rock-breaking is also predicted to exceed the night-time human comfort vibration goal for residential receivers. A marginal exceedance of the 2mm/s vibration goal for heritage structures is predicted for Harris Terrace during the initial stages of heavy rock-breaking of the station shaft.
- Roma Street Station – significant exceedances of the daytime and night-time noise goals due to piling and rock-breaking are predicted for the Parkland Boulevard residential receivers. Vibration levels at the Parkland Boulevard building is also predicted to exceed the night-time human comfort vibration goal should rock-breaking continue into the night.
- Northern Connection – minor exceedances of the daytime noise goal are predicted for residential receivers adjacent to Gregory Terrace.

Suitable ventilated acoustic sheds would be erected at each of the worksites at Woolloongabba, George Street and Roma Street to minimise airborne noise impacts. It is likely predictive modelling would indicate the need for a workshed also during construction of the TBM launch box at Dutton Park, whereas an acoustic enclosure may be sufficient for Victoria Park. The erection of noise barriers close to particularly surface-based noisy equipment or the temporary relocation of residents from affected premises would also provide effective mitigation if required.

Other mitigation measures responding to ground-borne noise and vibration impacts may include the construction of cut-off walls around station shaft worksites, the modification of work methods possibly including the selective use of drill and blast methods, and variable working hours.

The extent of any construction noise and vibration impact would depend on the construction method ultimately adopted. Construction planning and worksite management strategies, developed in consultation with stakeholders and affected parties, would serve to minimise potential construction noise and vibration impacts.

Some specific mitigation measures required to achieve a reasonable environmental amenity where noisy construction works are required near sensitive receivers would include:

- advance notice to the affected parties and the local community of the works program and the nature and duration of the proposed works
- constant review of alternative construction methods and working hours aimed at balancing the extent of potential impacts with the need to deliver the Project without unreasonable delay
- use localised acoustic barriers, or install a ventilated acoustic workshed as necessary for particularly noisy works activities conducted on or near the surface, such as piling, rock-breaking, and possibly drilling and blasting as an alternative method, and spoil handling and loading
- pre- and postconstruction building condition surveys where predictive modelling indicates a potential for construction vibration to cause cosmetic building damage from the Project construction activities
- selection of the quietest plant and equipment that can economically undertake the work, wherever possible, and regular maintenance of equipment to resolve noisy operations
- where possible, avoid the coincidence of plant and equipment working simultaneously close together near sensitive receivers
- on-going noise and vibration monitoring during the works, having regard to the implementation of agreed mitigation measures
- minimise intrusive or high impact night-time construction activities where possible.

Construction traffic

Spoil haulage would be restricted to major roads, in keeping with their function and capacity. Modelling indicates that the introduction of spoil haulage traffic would not change the overall noise profile for those roads with road traffic noise due to the Project spoil traffic predicted to increase less than 2 dBA.

Changes in noise levels of 2 dBA or less are considered to be undetectable to the human ear and are therefore negligible. The absolute maximum noise levels associated with vehicle passbys would not be altered by Project construction vehicles, although the frequency of such events would increase.

Operational noise and vibration

Ground borne noise and vibration

Modelling of ground-borne noise for the operational phase of the Project indicates that the selection of appropriate trackforms would achieve compliance with the ground borne noise goals at all sensitive receivers along the alignment.

Resilient track fastening would be required in a number of places to achieve compliance. For example, resilient track fastening would be required for approximately 790m on the Down or north-bound track, mostly in locations between Park Road Station and the proposed Woolloongabba Station, and for some sections of track under Spring Hill, owing to the undulating terrain there. Resilient track fastening would be required for approximately 665m on the Up, or south-bound track, in similar locations.

The modelling also indicates the vibration goals would be complied with at all sensitive receivers. This includes vibration levels for the TEM at the Ecosciences Precinct and all research and medical facilities within the study corridor, including the PA Hospital, QUT Gardens Point and St Andrew's War Memorial Hospital.

Airborne noise

Noise levels from rail operations at the Northern Connection are predicted to comply with Queensland Rail's operational planning levels in 2031 for rail operations at all sensitive locations. No mitigation measures are required in this section. At the Southern Connection, operational noise levels are predicted to exceed Queensland Rail's planning levels in 2031 at several places. While an additional noise barrier would reduce operational noise levels to achieve compliance with Queensland Rail's planning levels, constraints on the location and height of barriers constrains the ability to achieve compliance at all receivers.

Operational noise levels from bus operations at the Northern Connection are predicted to exceed the TMR Code of Practice 65 dBA L_{A10} (1 hour) noise criterion for three educational buildings at St Joseph's College Gregory Terrace and two health buildings. Exceedance to the TMR Code of Practice 69 dBA L_{Amax} noise criteria is also predicted at one health building. At the Southern Connection, operational noise is predicted to meet the relevant noise criteria at all noise sensitive receivers.

Noise mitigation has not been recommended at any of the noise sensitive receivers in the north as exceedances are attributable to the existing road networks and not the Project. Noise levels at all sensitive locations, attributable to only the Project, would be at least 15 dBA below the relevant criteria.

5.2.8 Land use and tenure

Existing values

The study corridor comprises a mix of land uses including residential, major commercial developments, small scale industrial uses and local and regional level community facilities.

Land use and development in the study corridor is guided by both State and local government planning frameworks. At a State level, land use and development is governed by the *Sustainable Planning Act 2009* and guided by State planning instruments such as the State Planning Policy, Queensland Plan and South East Queensland Regional Plan 2009-2031. Locally, land use and planning is guided by the Brisbane City Plan 2014, including neighbourhood plans. These planning frameworks provide an overarching view that transport networks in South East Queensland and Brisbane need to be improved in order to accommodate future population growth and economic development.

The Brisbane CBD is the primary commercial centre in South East Queensland. It accommodates the largest and most diverse mix of land uses and is the primary location for government administration, retail, commercial and professional services. Woolloongabba and Spring Hill are also a focus for commercial development within the study corridor.

Specialist activity centres are also located within or near to the study corridor at Boggo Road/ Buranda and Herston/ Kelvin Grove. These locations are intended to be a primary focus for specialised economic activity, employment and education. They incorporate office and research uses within the Ecosciences Precinct at Boggo Road Urban Village, and health, education and research uses within the PA Hospital campus at Woolloongabba and RBWH campus at Herston.

A broad range of services and facilities are located within the study corridor, including primary, secondary and tertiary level education facilities, major medical and health facilities, community support services, shopping, entertainment, recreation and open space areas. These include services and facilities that cater for communities in or near to the study corridor as well as communities across greater Brisbane and South East Queensland.

Ecosciences Precinct, Boggo Road Urban Village

Major community facilities near the Project include:

- the PA Hospital at Woolloongabba, Mater Hospital and Queensland (Lady Cilento) Children's Hospital at South Brisbane, Brisbane Private Hospital and St Andrew's War Memorial Hospital at Spring Hill, and RBWH at Herston
- community support services, such as the ESA Village at Dutton Park, and Sunshine Welfare and Remedial Association (SWARA) at Woolloongabba
- Dutton Park State School, UQ Pharmacy Australia Centre of Excellence (PACE) at Woolloongabba, Queensland University of Technology (QUT) in Brisbane City and Brisbane Girls Grammar School, Brisbane Grammar School and St Joseph's College Gregory Terrace at Spring Hill
- open space, parkland and sporting facilities, including the Gabba Stadium at Woolloongabba, City Botanic Gardens and Roma Street Parkland in Brisbane City, and Victoria Park at Spring Hill.

Residential uses within the study corridor are varied and include medium to high density residential development within the Brisbane CBD, Spring Hill and Kangaroo Point and lower density, character housing at Dutton Park, Woolloongabba and Spring Hill.

University of Queensland PACE, Woolloongabba

Impact assessment

The Project supports and is consistent with the strategic planning intent of State, regional and local planning frameworks. At a regional level, the Project would enhance the viability of rail and bus transport within South East Queensland, including access to the region's Primary Activity Centre (ie Brisbane CBD) and facilitating the continued growth and development of the region, with a focus on the southern corridor.

The Project would also improve the frequency and reliability of public transport services between living and working areas in South East Queensland, including main activity and specialist centres.

Locally, the Project would provide more frequent public transport services between residential and employment growth areas such as the Woolloongabba PDA and the Brisbane CBD. The establishment of new stations in these areas would create a more efficient and functional public transport network, characterised by stronger integration of high intensity land uses with transport nodes.

The Project would directly impact a total of 297 properties, either in total or in part. This includes 21 properties impacted by surface works and 276 properties impacted by sub-surface volumetric acquisition, where the Project passes beneath the property. Volumetric acquisition requires the resumption of part of the land below the surface of the property, without changing the tenure, ownership and generally the existing use and occupation of the land at surface.

Properties required for surface works are owned by either the State or a Government Owned Corporation. All but one property, being commercial use at 63 George Street, comprise transport infrastructure or community uses. Private properties would be affected by volumetric acquisition where the Project passes beneath.

Properties impacted by volumetric acquisition include 208 private properties and one property owned by Brisbane City Council. The majority of properties impacted by volumetric acquisition (148) comprise residential uses or mixed use developments.

The Project would result in land use changes within the footprint of the Project's surface infrastructure. This includes temporary land use changes due to construction worksites and permanent land use change to transport infrastructure at sites accommodating Project infrastructure at the southern and northern connections and station locations.

Construction of the Project's underground infrastructure may also influence future development at some locations. This includes development of Lot 2 at the Boggo Road Urban Village, which has been identified for future development up to six storeys in height. The Project's underground infrastructure would restrict development of the northern portion of Lot 2 to about 2-3 storeys. However, the southern portion of the site would be capable of accommodating a development consistent with the development approval. Elsewhere along the alignment, new high density developments would need to consider the position of the volumetric lot and right of support for the Project infrastructure.

Indirect changes to land uses may be experienced at locations near to the Project stations at Woolloongabba, George Street and Roma Street. Improved public transport accessibility provided by the Project at these locations may bring forward development and support intensification of land uses, consistent with the aims of the various planning strategies. The Project may require a limited change to the existing City Plan zoning classification over a small area of Victoria Park impacted by permanent surface infrastructure. Elsewhere, the Project is consistent with the existing zoning classifications.

Following construction, having regard for agreements reached between the Proponent and affected property owners, land used for construction and not required for operations would either be rehabilitated, or where appropriate, would become available for redevelopment (not part of the Project). In particular, open space areas affected by construction worksites and not required for permanent infrastructure at Boggo Road Urban Village, Emma Miller Place and Gallipoli Place and Victoria Park, would be reinstated to open space.

The air space above the George Street Station, Roma Street Station and possibly Woolloongabba would become available for possible development following construction. Any development of the air space would be undertaken as a separate planning process to the Project.

5.2.9 Cultural heritage

Existing values

The Project would pass deep beneath a number of areas of significance to Aboriginal people and incorporates a number of important Aboriginal living, resource extraction and ceremonial sites. It contains physical or tangible cultural heritage values as well as intangible Indigenous cultural heritage values through a system of Dreaming Tracks and pathways that incorporate a number of culturally significant places. A number of recorded Indigenous cultural heritage places are located within the study corridor, including:

- an earthen arrangement at Woolloongabba
- a cultural site and a resource area at Roma Street
- a contact site and cultural site at Spring Hill.

Old Woolloongabba Post Office

The Project would also pass beneath or nearby a number of places of historic heritage value. Some of the surface works have the potential to intercept archaeological places. A total of 104 places of Commonwealth, State or local heritage significance are also located within the study corridor, particularly in the Brisbane CBD. These include:

- Hefferan Park Air Raid Shelter at Dutton Park
- the old Woolloongabba Post Office and St Nicholas Russian Orthodox Church at Woolloongabba
- The Mansions, Harris Terrace, Brisbane Synagogue, Government Printing Office and Early Streets of Brisbane near George Street Station
- the original Roma Street Station building
- Victoria Park at Spring Hill.

The study corridor's heritage and history associated with the area's Indigenous culture and early European settlement of Brisbane is important to the character and identity of the study corridor and is highly valued by local and regional communities.

Impact assessment

Indigenous heritage

The Project would not impact directly any recorded Indigenous cultural heritage places at Dutton Park, Woolloongabba, George Street, Roma Street or Spring Hill.

The Project works are either deep underground or generally occur within existing road or railway corridors or in areas that have been subject to significant ground disturbance. The design and construction of the Project has the potential to impact on residual Indigenous cultural heritage items in the form of subsurface material, or intangible cultural heritage values, particularly at Woolloongabba, Roma Street and Spring Hill due to their proximity to nearby Indigenous cultural heritage places.

The Turrbal Association, being representative of the Traditional Owners for the area were consulted during development of the reference design. They raised concerns about the potential visual impacts of surface infrastructure in Victoria Park at Spring Hill. In particular, concerns related to the busway bridge across the ICB in the context of the cumulative impacts with other projects in this area on the cultural vistas associated with Barrambin[2].

Aboriginal cultural heritage would be managed through a Cultural Heritage Management Plan negotiated with the Aboriginal Party(s) and Cultural Heritage Body(s) prior to construction.

The implementation of cultural heritage management measures during construction would assist in minimising potential impacts on residual Indigenous cultural heritage items. The recognition of intangible cultural heritage values through the design of Project infrastructure would also assist in managing potential impacts, including visual impacts, on these values.

York's Hollow, Victoria Park

Non-Indigenous heritage

The Project would be undertaken as development by the State, in accordance with the Queensland Heritage Act. The Project would be referred to the Queensland Heritage Council for consideration and advice on how best to reflect and protect the values of State heritage places nearby the alignment.

There are a number of State and local heritage places that are located either within 50m of the tunnel alignment or within 50m of surface works. Potential impacts of the Project on these heritage places could mainly result from:

- possible differential settlement effects on buildings near to the tunnel alignment
- continuous vibration from construction of the tunnel or station caverns.

Preliminary modelling undertaken for the Project predicts that absolute settlement at heritage places along the tunnel alignment would be 10mm or less, while differential settlement would be less than 1:1000. This would result in a negligible magnitude of change to these structures, and neutral or slight significance of impact. Continuous vibration levels from tunnel construction at heritage listed properties near to the tunnel alignment are generally predicted to be below 2mm/s and are not expected to cause damage to these properties. However, there is potential for some marginal exceedance of the 2mm/s vibration goal due to works associated with the construction of the station shaft at George Street, potentially impacting on Harris Terraces. There are no exceedances predicted to impact on The Mansions.

2 Barrambin: name given by the Turrbal to the area, used for as an important camp site by Aboriginal people, as well as for ceremonial purposes, meetings and gatherings

The preparation of building condition surveys for heritage places potentially affected by settlement effects or vibration prior to construction works, as well as ongoing monitoring during construction would assist in managing potential impacts on heritage places close to the Project. Any damage resulting from the tunnelling would be repaired by a suitably qualified professional, and in accordance with the requirements of the Burra Charter.

Construction activities involving ground disturbance (ie excavation or temporary pavement works) also have the potential to impact subsurface archaeological deposits, particularly near surface works at George Street and within Victoria Park at Spring Hill. The implementation of management measures such as 'test pitting' prior to construction and monitoring during construction would assist in managing potential impacts of any possible archaeological deposits. Any archaeological deposits discovered during construction would be managed in accordance with the requirements of the *Queensland Heritage Act 1992*.

Surface infrastructure associated with the Project has potential to disrupt the setting of some heritage places, particularly at George Street and Victoria Park. Ensuring the design of surface infrastructure is sympathetic to, and recognises the heritage values in these areas, would assist in minimising potential impacts on these heritage places.

Clearing of vegetation within Victoria Park for construction may also disrupt the heritage setting of the Park. In particular, the Project would require the removal of some trees identified as part of the original Harry Oakman design for the Park. The Project would not require the removal of trees planted within the Gundoo Memorial Grove or the fig trees planted prior to World War II located north of the tennis courts. Following construction, areas of Victoria Park disturbed by construction activities would be rehabilitated, including with new tree plantings in accordance with a master planning exercise to be undertaken in consultation with the local community, Traditional Owners and Brisbane City Council. Over time, this would assist in minimising the potential effects on the Park's heritage setting.

The tunnel design and construction method means that potential impacts on heritage values associated with groundwater drawdown effects on mature vegetation such as in the City Botanic Gardens, are unlikely.

The implementation of dust management measures for surface works and spoil haulage would also assist in minimising potential impacts on heritage places associated with the deposition of dust.

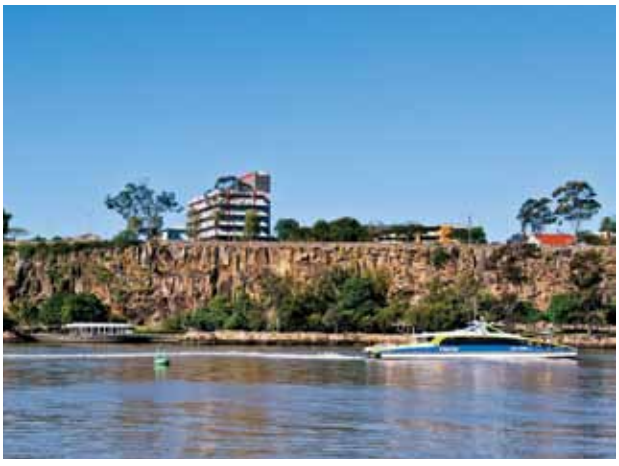
Where predictive modelling and assessment indicates Project works would impact on heritage listed places, a full photographic and descriptive report would be prepared prior to construction. Works would be conducted in accordance with cultural heritage management plans.

5.2.10 Visual and landscape amenity

Existing values

The study corridor also includes some of Brisbane's most well-known and recognisable urban and natural areas and features, such as the Kangaroo Point Cliffs, City Botanic Gardens, George Street heritage buildings, Roma Street Parkland and Victoria Park.

A number of landscape character types occur throughout the study corridor including parkland areas, residential areas, institutional areas (eg hospitals, education uses and government administration), commercial areas, city centre, transport corridors (eg road, rail and busway corridors), sports and entertainment and waterway areas (eg Brisbane River). These areas offer variation and diversity in visual amenity and landscape character, including topography, land use, vegetation and built character.



Kangaroo Point Cliffs

Impact assessment

Once constructed, impacts on landscape character and visual amenity are generally expected to be minor, with much of the Project infrastructure located underground. Potential changes to landscape character and visual amenity (both positive and negative) would generally be confined to those areas near to surface infrastructure.

Positive impacts on landscape character and visual amenity would generally relate to the development of new station buildings and enhancement of public realm and civic spaces at station locations.

The establishment of construction worksites would require demolition of existing buildings and structures and clearing of trees and other vegetation. Following construction, having regard for agreements reached between the Proponent and affected property owners, construction worksites would be rehabilitated suitable for a similar use. In particular, open space areas affected by construction worksites and not required for permanent infrastructure would be reinstated. This would include Outlook Park at Boggo Road Urban Village, Emma Miller Place and Gallipoli Place at Roma Street, and Victoria Park at Spring Hill. This would provide opportunities to enhance the public realm and landscape character of these areas and mitigate any long-term impacts on these areas.

The main impacts on landscape character and visual amenity generally would be associated with surface infrastructure at Spring Hill. These impacts would relate to:

- the encroachment of infrastructure into Victoria Park north of the ICB, resulting in the permanent loss of a small area of playing fields
- the presence of new transport infrastructure within the railway corridor, including the feeder station and ventilation outlet
- the presence of a new busway bridge over the ICB, which is likely to have a long-term visual impact
- the clearing of mature trees and vegetation.

The significance of these impacts is lessened on account of the siting of the Project in the lowest and most contained part of Victoria Park adjacent to the existing infrastructure. Over time, the significance of these impacts would diminish as the tree plantings from reinstatement works mature, providing screening to Project infrastructure.

Ventilation outlets at Woolloongabba Station and George Street Station are expected to be integrated within new high rise developments above these stations, which would mitigate potential visual impacts for nearby sensitive receptors. While ventilation outlets at Dutton Park, Roma Street and Victoria Park would be noticeable, it is anticipated that over time these structures would assimilate into the existing transport corridor environments in these areas.

Without mitigation, night-time construction works, particularly associated with works within the railway corridor, and security and safety lighting at construction worksites, may result in temporary impacts associated with night lighting, such as possible light spill onto surrounding areas. This impact would be temporary and of minor to moderate adverse impact, and is not considered to be significant.

Albert Street pedestrian link, Roma Street Parkland

5.2.11 Socio-economic assessment

Existing values

In 2012, there were about 44,532 people living in suburbs within or adjacent to the study corridor. This is expected to grow to about 64,831 people by 2036, an average of about 1.6 per cent annually (Queensland Treasury and Trade, 2014). Woolloongabba is projected to have the highest rate of population growth in the study area, reflecting the presence of the Woolloongabba PDA and the planned development of this area as a mixed use precinct, with high density residential development.

The study corridor comprises diverse social environments and communities, and offers a range of housing choice including medium to high density apartments in the Brisbane CBD, Spring Hill and Kangaroo Point and lower density character housing at Dutton Park, and Woolloongabba.

Overall, the population in the study corridor is characterised by a relatively young population, with low levels of socio-economic disadvantage. Communities in the study corridor are also culturally diverse, with high proportions of people born overseas, people who speak a language other than English and who do not speak English well, or at all. The study corridor's population is also relatively mobile with proportions of people who lived at a different address both 12 months and five years prior to the 2011 Census above the averages for both the Brisbane LGA and Queensland. The study corridor has relatively high proportions of people who use public transport, walk or cycle to work, reflecting the study corridor's high level of access to public transport, pedestrian and cycle networks and proximity to the Brisbane CBD and other major employment and activity centres.

There were approximately 150,377 people working in or near to the study corridor in 2011, of which about three quarters worked in Brisbane CBD. There were about 16,700 registered businesses in suburbs within or near to the study corridor in 2012. The majority of businesses were located in the Brisbane CBD (11,412 businesses), with Spring Hill and Woolloongabba also having large concentrations (Queensland Treasury and Trade, 2014).

Overall, amenity in the study corridor is high with good access to community facilities and services of state and regional significance, the full range of transport services and facilities, and residential neighbourhoods within easy reach of local services, employment and the Brisbane CBD.

The study area also includes a number of open space areas that contribute to the amenity of the study corridor and that are highly valued by local and regional communities due to their landscape, scenic amenity, heritage and recreational values. These include the Brisbane River, City Botanic Gardens, Roma Street Parkland, Victoria Park including Victoria Park Golf Course. Outlook Park at Boggo Road Urban Village is a local park valued by local residents and workers of the Ecosciences Precinct for its informal recreational values.

Roma Street Parkland provides a range of formal and informal recreation and leisure opportunities, and is an important location for major community events as well as smaller private events. The Parkland is valued for its historic, landscape and recreational values. The Parkland attracts between 500,000 and 900,000 visitors each year, including visitors from intrastate, interstate or overseas.

Victoria Park is highly valued by residents in Spring Hill and Brisbane's inner northern suburbs for its landscape, aesthetic, recreational and heritage values. It provides formal sport and recreation facilities as well as informal recreational and leisure facilities such as the dog off-leash area, playground, areas of open space, and picnic areas. Victoria Park is listed on the State heritage register, for both its Indigenous and non-Indigenous heritage values. The area is an important gathering place and ceremonial area for Aboriginal people, which is recognised by the area known as York's Hollow, located north of the ICB. Victoria Park includes landscape spaces and trees of community importance, including some landscaped areas recognised on the State heritage listing.

Victoria Park, Spring Hill

Local amenity in the study area is currently affected by increased travel times and congestion on major transport routes as well as increased noise from road traffic and rail operations. Major transport corridors also act as a barrier to movement within and between communities. Air quality in the study area is also affected by motor vehicle emissions from major roads and local construction activities.

Residents in the study area have good access to a diverse range of community facilities that provide local meeting places and support local social cohesion. Communities in the study area are relatively mobile, although amongst longer term residents, there is a strong sense of belonging, connections and shared networks, which enhance community cohesion. The need to maintain or improve safety and security is also important to communities in the study area, particularly in relation to pedestrians and cyclists access near the Project, and personal and property safety and security near bus and rail stations.

Impact assessment

The Project would provide long-term benefits for communities within the study corridor as well as across South East Queensland, through improved public transport access and connections to services, facilities and employment within the Brisbane CBD and Brisbane's inner city. The Project would also support growing populations and changing social environments, such as at Woolloongabba and Queen's Wharf Brisbane redevelopment.

Permanent changes to the social environment would include the loss of a small area of playing fields at Victoria Park north of the ICB, and changes to streetscapes and urban environments near Project stations.

The main impacts of the Project on socio-economic conditions and values in the study corridor would relate to the construction phase. These impacts would mainly be limited to areas closest to the southern and northern connections as well as at each of the station locations and would be relatively short-term (ie up to, but likely less than five years) compared to the life of the Project (ie 100 years). Following construction, these communities would benefit from the operation of the Project through improved bus and train access from new or existing stations to destinations within the inner city and across South East Queensland.

Social impacts

Surface works for the Project would not impact on any privately owned properties, with properties impacted by surface works owned by the State or a Government Owned Corporation. However, private properties would be affected by volumetric acquisition, where the Project passes beneath the property.

Volumetric acquisition requires the resumption of land below the surface of the property and would not require the relocation of occupants. Volumetric acquisition of private properties would be undertaken in accordance with the *Acquisition of Land Act 1967*. This allows compensation for those properties in which there is a direct requirement by the Project.

A total of 208 properties would be impacted by volumetric acquisition. Most of these properties (about 148 properties) comprise residential uses, with many being for rented. Volumetric acquisition would impact six properties comprising State-owned housing. The Queensland Government has notified potentially affected property owners about volumetric acquisition requirements and will continue to liaise with them as the Project progresses.

The Project would not impact directly on the supply or demand for housing and accommodation in the study area, as the construction workforce would generally be sourced from across Brisbane and South East Queensland.

Without mitigation, residents, businesses and users of community facilities closest to construction works may experience temporary impacts or disruptions due to:

- changes in local amenity associated with noise, dust, vibration and light spill from construction activities, particularly at the ESA Village at Dutton Park, and residential apartments next to construction worksites at George Street Station and Roma Street Station
- increased construction traffic near to construction worksites
- changes in local access, including temporary changes to pedestrian and cycle access near construction worksites and short-term disruptions to some bus and rail services at Dutton Park Station, George Street and Roma Street Station

Leukaemia Foundation ESA Village, Dutton Park

- disruption to open space, including at Outlook Park, Emma Miller Place and Gallipoli Place and Victoria Park
- changes to visual amenity from the presence of construction infrastructure and removal of established vegetation, particularly at Emma Miller Place, Gallipoli Place and Victoria Park.

Some occupants of buildings above the tunnel alignment may also experience impacts from regenerated noise or vibration for short periods as the TBM passes or works occur beneath the property.

The implementation of mitigation measures would assist in managing potential impacts on communities closest to the Project works. Early and on-going consultation and communication with local residents, businesses and managers of community facilities close to the construction works would also assist in managing impacts. This would be particularly important where night-time works are proposed to occur near residential uses or where activities are likely to generate particularly high levels of noise and vibration.

During construction, the use of Victoria Park for construction activities and the removal of established trees and vegetation would impact community values associated with the Park's landscape, recreation and visual amenity. Following construction, land within Victoria Park disturbed by construction activities would be rehabilitated and reinstated, which would help to mitigate potential impacts. This would be undertaken in accordance with a master planning process to be undertaken by Brisbane City Council in consultation with the Turrbal Association, local communities and stakeholder groups. In the longer term, the Project would impact positively on community values in the study corridor by enhancing public transport access, including for people with mobility difficulties and vision impairment, and improving urban environments and streetscapes near new stations.

Economic impacts

The Project would return a positive net present value (NPV) ($641 million) and a benefit cost ratio (BCR) of 1.16. This indicates that the Project would provide societal benefits in excess of the Project costs. Consistent with other public transport projects, the Project costs are dominated by capital expenditures while the Project benefits are more broadly distributed across different benefit categories. Improvements in public and private transport travel times and private vehicle operating costs are the largest contributing factors (Deloitte, 2014).

The Project will also impact positively on employment. Construction of the Project would generate employment for construction workers, skilled tradespeople, professional and administration staff, plant and machinery operators and labourers. The Project will create an average of 425 full time equivalent (FTE) positions during the construction phase (2014-2021) in South East Queensland. In addition, an average of 698 FTE positions will be created during the operations phase (2022-2031) in South East Queensland (Deloitte, 2014).

In the rest of Queensland, an average of 351 full time equivalent (FTE) positions will be created during the construction phase (2014-2021) and an average of 698 FTE positions will be created during the operations phase (2022-2031).

Surface works for the Project would impact directly on one commercial property located at 63 George Street. Businesses in this building would need to relocate prior to construction. Volumetric acquisition would not impact on the operation of businesses above the tunnel alignment. The Project would improve public transport access for workers and customers to commercial and employment centres would have positive impacts on businesses. The Project would also support local business development, including through opportunities for small scale commercial development within stations; stimulating revitalisation around stations; and increasing pedestrian traffic near stations.

During construction, the main positive effect on business would result from increased demand for local goods and services. Businesses supplying goods and services to construction (ie manufacturing, construction, trade, transport, financial and businesses services), are likely to experience benefits from increased construction activity. Local shops and food outlets near construction works are also likely to benefit from increased business due to the day-to-day needs of construction workers.

Temporary changes to local roads, increases in construction vehicles and loss or disruption to loading zones or on-street parking areas could potentially disrupt access to some local businesses for workers, customers and service vehicles, particularly in the Brisbane CBD.

Temporary changes would also be required to pedestrian access near to construction worksites. This may impact on customer access to some businesses, particularly near construction worksites at George Street and Roma Street. This would have the greatest effect on those businesses that rely on passing pedestrian trade (ie small scale retail uses, cafés, restaurants and takeaway outlets). Changes to amenity from increased noise, dust and construction traffic, may also impact some businesses near to construction worksites. The effects of this impact would depend on the nature and type of business, but could impact on employee productivity, ability to interact with customers, or changes to general ambience. This would have the greatest impact on businesses that include outdoor areas, such as cafés and restaurants with outdoor dining.

5.2.12 Waste

There is the potential for a variety of solid and liquid wastes, both regulated and inert, to be generated during the construction and operation of the Project. The type of construction and demolition waste would primarily be used building materials and activity related consumable. The quantity and composition of the construction waste stream would be site-specific and largely dependent on existing land use, design features and construction methodologies. Wastes generated during operation of the Project would include recyclable wastes such as paper, plastic and glass and small quantities of waste oils and cleaning agents.

A waste management strategy would be prepared for the Project which would align with the Queensland Government's waste management hierarchy of avoid, reuse, recycle, recover, treat and dispose. Implementation of this strategy would ensure that:

- opportunities to minimise waste disposal to landfill are identified and realised during design, construction and operation of the Project
- all materials suspected of containing asbestos would be removed by a certified asbestos waste contractor and disposed to an appropriately licensed landfill
- contaminated soils, if encountered, are managed and disposed of in accordance with the EP Act
- acid sulphate soils, if encountered, are managed in accordance with the Queensland Acid Sulphate Soil Technical Manual – Soil Management Guidelines (version 3.8) (2002)
- storage, transportation and disposal of hazardous waste materials occurs in accordance with relevant Australian Standards
- sulphur hexafluoride filled electrical equipment is disposed of in accordance with the requirements of the Energy Networks Association Industry Guideline
- groundwater inflows through all phases of the Project are captured, treated and released to an approved point of discharge.

Waste and resource recovery activities associated with the Project are not anticipated to pose a significant risk to the environment or public health with the implementation of effective waste management and resource recovery control measures.

5.2.13 Hazards

An assessment of Project related hazard and risks was undertaken in accordance with Australia/New Zealand Standard (AS/NZS) ISO 31000:2009 Risk Management – Principles and Guidelines. A number of potential risks were identified, analysed and subsequently evaluated.

The assessment identified a number of potential construction phase scenarios with a post-mitigation risk ranking of 'high' with 'rare' or 'unlikely' probabilities of occurrence. The high risk attribution would be derived from the consequences should the particular scenario be realised. These scenarios are as follows:

- tunnel collapse or ground subsidence during tunnel excavation/ construction activities (rare)
- fire or explosion in tunnel during excavation activities (rare)
- rollingstock accident on existing rail lines due to communication failure, signal failure or changed conditions during construction leading to injury or potential fatality to Queensland Rail staff, passengers, public and/ or construction workers on track or adjacent construction worksites (rare)
- work within a live rail environment leading to potential injury or fatality to construction workers (unlikely)
- inadequate emergency response resulting in increased impact to people in an emergency situation during the construction of the Project (unlikely)
- storage, handling, use and transportation of Hazardous Substances or Dangerous Goods leading to injury or illness to construction personnel or the public (unlikely)
- release of hazardous chemicals as a result of a natural hazard event, (eg a flood event leading to adverse health and safety effects to construction personnel or the public) (rare).

The assessment identified a number of potential operation phase scenarios with a post-mitigation risk ranking of 'high', albeit with 'rare' or 'unlikely' probabilities of occurrence. These scenarios are as follows:

- inadequate emergency response resulting in increased impact to people and property in a potential emergency situation during the operation of the Project (unlikely)
- fires leading to injury/ possible fatality and/or damage to property/ environment (unlikely)
- exposure to noxious or toxic atmospheres to users of the tunnel due to fire leading to adverse health and safety impacts (rare)
- train accident/ collisions within the tunnel or portal (rare)
- bus accident/ collisions within the tunnel or portal (rare).

The most significant risks identified for the Project are associated with the need to evacuate the tunnel and stations in the event of an emergency situation during both construction and operation of the Project, such as tunnel collapse or tunnel fire.

Following the application of mitigation measures, through design and operating controls, the likelihood ratings for the 'high' risk scenarios listed above can be reduced to 'rare' or 'unlikely'. However, the consequence rating of any event may remain unaffected by mitigation. Overall, the residual risk ranking of any hazard with a 'rare' or 'unlikely' likelihood, but a 'severe' consequence is still considered to be a 'high' risk. Further management measures would be implemented to reduce these risks to as low as reasonably practicable and would be subject to continual refinement during construction and operation of the Project.

Integrated management planning procedures, including evacuation plans, would be developed for the range of emergency situations identified throughout the risk assessments conducted for the Project. Emergency management plans for the Project would integrate the responses of the owners and operators of the rail and bus infrastructure, rollingstock, rail track and passenger services, with those of the station managers and local emergency response agencies.

Emergency planning and response procedures are to be further developed during detailed design in consultation with State and regional emergency service providers for both the construction and operation phases of the Project.

5.2.14 Cumulative impacts

Cumulative impacts across the Project

During construction of the Project, local communities surrounding each of the construction worksites would experience impacts as a result of construction activities if mitigation measures are not implemented. The combined effects of construction (eg noise, vibration, dust, traffic) would be likely to cause disruption, nuisance and loss of amenity within these local communities. These impacts would be localised in extent and limited in duration to the construction phase.

The wider community is not likely to experience any discernible impacts during construction, other than minor disruption for commuters during possessions of the railway corridor and 'tie in' works for the new busway. Cumulative economic benefits experienced during construction of the Project would include increased employment opportunities for multiple construction related sectors supplying materials and labour to the Project, heightened economic activity around construction worksites due to increased demand for goods and services, and industry innovation through enhanced construction techniques.

Overall, the cumulative impacts of the Project during operation are predicted to be beneficial at the local, neighbourhood, metropolitan and regional levels over the long-term. Short-term impacts to local communities during construction of the Project would be offset by the long-term city-wide benefits the Project offers to communities during its operation. The Project would provide long-term city-wide benefits, including more equitable public transport access for commuters and improved connections to where people live, work and play, reductions in traffic congestion on main roads, and reductions in air and noise emissions due to increased public transport usage.

Cumulative impacts with other projects

Table 30 provides an overview of urban development and transport infrastructure projects that would overlap in construction timeframes with the Project.

Construction of multiple major projects at the same time and within similar geographic areas has the potential to increase cumulative impacts relating to disruption, nuisance and loss of amenity. However, construction of multiple major projects within proximity to each other is not uncommon, particularly within the Brisbane CBD.

Table 30 Construction timeframes for projects and potential for cumulative impacts

Project	2015				2016				2017				2018				2019				2020			
Bus and Train project																								
Urban development projects																								
One William Street																								
Queen's Wharf Brisbane																								
Woolloongabba PDA																								
BRUV developments																								
Albert Street Master Plan																								
Transport infrastructure projects																								
North Brisbane Bikeway																								
Kangaroo Point Pedestrian Bridge																								
Kingsford Smith Drive Upgrade																								
Gateway Upgrade North																								

Notes:

Projects located within the study corridor and therefore likely to have direct interaction with the Project.

Projects not located within the study corridor but potentially having indirect interaction with the Project due to proximity and overlapping construction periods.

The George Street Station would interface with the Queen's Wharf Brisbane development. In the longer-term, the projects would be complementary, creating a highly accessible CBD destination. Concurrent construction of both projects would have potential for cumulative construction impacts relating to the combined effects on amenity due to construction traffic and parking, noise, vibration and dust. Pedestrian and cycle movements and traffic flows in George Street, including buses, would be constrained by the combined construction of the projects. Coordinated management of pedestrian, cycle and traffic flows would be required to achieve safety requirements and to reduce disruptions to the functioning of the CBD.

During detailed design, the Proponent would consult various entities responsible for these projects in order to better integrate connectivity and functionality between these developments so as to fully realise their significant economic and social benefits. During construction of the Project, the Proponent would engage in early and ongoing consultation with entities responsible for other projects having overlapping construction periods in order to coordinate construction activities as far as practicable to reduce cumulative impacts. This would include consideration of construction programmes, traffic management measures and environmental management plans for other nearby projects as part of construction planning for the Project.

George Street, Brisbane CBD

5.3 Summary of benefits and impacts

A summary of the key beneficial and adverse impacts across the Project are provided in **Table 31** to **Table 35**.

Level of impact significance

Positive	Adverse
Negligible	
Low	
Medium	
High	

Duration

‹1	less than 1 year
2	1 to 2 years
5	2 to 5 years
›10	greater than 10 years

Activity

Intermittent

Continuous

Table 31 Summary of impacts – Dutton Park (Southern Connection)

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
DESIGN					
Land use and tenure					
Constraints of underground infrastructure on future development of Lot 2 (Boggo Road Urban Village)		›10		• Project design to minimise affected area in Lot 2, consultation with DPWH	
Support development of Boggo Road Urban Village		›10		• Project design optimises access to Dutton Park Station from the north	
Cultural heritage					
Potential impact on the State heritage listed air raid shelter (Hefferan Park)		›10		• Detailed design of the Kent Street bus turn-around to avoid Hefferan Park	
Landscape and visual amenity					
Visual impact of ventilation outlet and feeder station for near neighbours		›10		• Design of ventilation outlet to minimise visual impacts, provision of screening or integration in future development of Lot 2	
CONSTRUCTION					
Traffic and transport					
Construction traffic – spoil haulage and materials delivery (TBM construction) to O'Keefe Street, pedestrian safety, worker parking		2		• Construction traffic management plan, use of agreed haulage and access routes, provision of on-site worker parking	
Construction traffic – spoil haulage and materials delivery to Peter Doherty Street/ Boggo Road, pedestrian safety, worker parking		2		• Construction traffic management plan, use of agreed haulage and access routes, provision of on-site worker parking • Early and on-going consultation with near neighbours	
Temporary public transport disruptions (Dutton Park Station, Eastern Busway)		‹1		• Planning of shut-downs to avoid peak periods, provision of alternative public transport services	

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
Soils and topography					
Differential settlement from shallow tunnelling, cut and cover and dive structures (up to 1:200 at dive structure; 1:600 TBM)		<1		• Tunnelling method to address settlement, predictive settlement modelling, building condition surveys, site management	
Disturbance of contaminated soil within railway corridor, possible asbestos contamination of Queensland Rail structures		<1		• Soil testing, management planning, preparation of Asbestos Management Plan prior to demolition, use of licenced disposal to registered facilities	
Hydrology					
Overland flow drainage Erosion and sedimentation, including possible hazardous substances		5		• Capture and treatment of surface water run-off • Construction EMP (sediment and erosion control plan)	
Air quality					
Dust from construction activities (ie site establishment, excavation, spoil handling and transport)		2		• Construction EMP (dust management). loading of TBM spoil in ventilated enclosure or workshed, covered loads, sealing access roads, wheel wash or similar • Ongoing monitoring	
Noise and vibration					
Noise from surface works (excavation of dive/ transition structure, TBM launch shaft) Noise from night-time surface works within railway corridor Noise from night-time spoil haulage Vibration from excavation works, TBM tunnelling		2		• Construction EMP (noise and vibration) • Spoil loading within ventilated acoustic shed • Use of acoustic screens, enclosures for excavation works • Managing continuous night-time works in railway corridor • Early and ongoing consultation with affected communities • Testing of vibration isolation system for TEM (Ecosciences building) • Ongoing monitoring	
Landscape and visual amenity					
Impact on Outlook Park (impacts on landscape character)		5		• Reinstatement and rehabilitation of park as soon as practicable	
Socio-economic assessment					
Amenity impacts on ESA Village, nearby residents and local businesses (dust, noise, traffic) Safety for students at Dutton Park State School and childcare at O'Keefe Street (construction traffic) Pedestrian/ cycle safety near construction works, staff/ visitors to PA Hospital (Kent Street)		5		• Construction EMP (noise and vibration, dust management, traffic management) • Limiting haulage during school drop off/ pick up • Ongoing consultation and communication • Active pedestrian and cyclist traffic management near worksites • Worker induction • Develop and implement a strategy to enhance training and employment of local people, including Aboriginal people on Project works	

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
Cumulative					
Interaction with concurrent construction of development with Boggo Road Urban Village (if any)		<1		• Ongoing consultation with DPWH, DSITIA, CSIRO and Developer about construction planning	
OPERATION					
Traffic and transport					
Improved bus and rail access at Dutton Park Station (increased frequency of services)		>10		• Changes to rail operating plan to optimise accessibility and inter-changing	
Reduced interchange opportunities at Park Road Station		>10		• Interchange opportunities provided at Dutton Park Station • Maintain interchange opportunities at Park Road Station	
Air quality					
Emissions from ventilation outlet		>10		• Design of ventilation outlets, siting away from sensitive receptors	
Noise and vibration					
Noise from surface rail noise Regenerated noise and vibration from underground rail		>10		• Establishment of noise barriers (if required under the QR Noise Code) • Design measures installed, if required, to comply with QR Noise Code	
Socio-economic					
Enhanced public transport access to community services, facilities and employment (PA Hospital campus, Ecosciences Precinct, UQ)		>10		• Change to rail operating plan to optimise accessibility • Develop and implement a strategy to enhance training and employment of local people, including Aboriginal people on Project works	

Table 32 Summary of impacts – Woolloongabba Station

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
DESIGN					
Traffic and transport					
Improved bus and rail access (interchange with South East Busway)		>10		• Siting of station to maximise interchange opportunities with existing South East Busway	
Land use and tenure					
Support development of Woolloongabba PDA		>10		• Design of Project (ie station, underground infrastructure) to support future development in accordance with the Woolloongabba PDA development scheme	
Support functionality of Gabba Stadium during major events		>10		• Detailed design of proposed station to accommodate pedestrian flows during major events at Gabba • Develop and implement a major event transport management procedure	
Landscape and visual amenity					
Visual impact of ventilation outlet		>10		• Integration of ventilation outlet within building above or adjacent to the station • Implement design measures aimed at mitigating the height and mass of the outlet structure	
CONSTRUCTION					
Traffic and transport					
Construction traffic – spoil haulage from station excavation, materials haulage (Ipswich Road, Stanley Street, Allen Street, Vulture Street), pedestrian safety		2		• Prepare and implement a construction traffic management plan, use of agreed haulage and access routes • Manage worksite traffic to minimise interaction with AM and PM peak traffic flows on arterial roads	
Soils and topography					
Differential settlement from excavation of station cavern (1:2000 to 1:5000)		<1		• Tunnelling and station construction methods to address settlement, predictive settlement modelling, building condition surveys	
Disturbance of contaminated soil (former rail corridor), asbestos within GoPrint building		2		• Soil testing, management planning, preparation of Asbestos Management Plan prior to demolition, use of licenced disposal to registered facilities	
Air quality					
Dust from construction activities (ie demolition of GoPrint building, site establishment, excavation, spoil handling and transport)		2		• Construction EMP (dust management), loading of spoil from station excavation in a ventilated, acoustic shed, use of water sprays, covered loads, sealing access roads • Ongoing monitoring	

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
Noise and vibration					
Noise from daytime surface works (demolition of GoPrint building, site establishment, initial shaft excavation) Noise from night-time excavation and spoil removal (outside of acoustic shed) Possible ground-borne noise from TBM tunnelling (residential, St Nicholas Russian Orthodox Cathedral)		2		• Construction EMP (noise and vibration), spoil loading within a ventilated, acoustic shed and use of acoustic screens/ enclosures for initial excavation works, pre-construction building condition surveys • Through EMP, manage work hours for excessively noisy activities • Early and ongoing consultation with affected communities • Ongoing monitoring	
Cultural heritage					
Possible impact on residual or intangible Indigenous heritage values from excavation works Possible vibration and settlement effects on Old Woolloongabba Post Office and St Nicholas Russian Orthodox Cathedral		‹1		• Works to be undertaken in accordance with agreed CHMP, ongoing monitoring • Consider on-site Aboriginal heritage monitor during early work, site preparation and surface works	
Socio-economic assessment					
Increased demand by workforce for local goods and services		5		• Develop and implement project work placement and training program to provide employment opportunities to Aboriginal and other local people	
Impacts on local businesses at Stanley Road, Vulture Street and Main Street (ie due to changes in amenity, worker parking, construction traffic) Amenity impacts for South Brisbane Dental Hospital and St Nicholas Russian Orthodox Cathedral		5		• Construction EMP (noise, dust, vibration, traffic management), provision of on-site parking for Project work force • Early and ongoing consultation with residents, businesses and community facility managers	
Cumulative					
Interaction with concurrent development of nearby urban developments		5		• Ongoing consultation with DSDIP and other project proponents about construction planning	
OPERATION					
Transport					
Balanced accessibility and connectivity		›10		• Integrated land use and transport planning	
Air quality					
Emissions from ventilation outlet		›10		• Design and siting of ventilation outlets, (at height) away from sensitive receptors • Liaison with assessment manager for developments in Woolloongabba PDA about ventilation outlet requirements	

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
Noise and vibration					
Regenerated noise and vibration		>10		• If required, design measures (track fastening) to comply with QR Noise Code	
Socio-economic					
Enhanced public transport access to community services, facilities and employment (Gabba Stadium, Mater Hospital, Royal Children's Hospital)		>10		• Develop and implement station operating procedures to accommodate major event crowds and to optimise accessibility to nearby employment centres	

Table 33 Summary of impacts – George Street Station

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
DESIGN					
Land use and tenure					
Support development of Queen's Wharf Brisbane and future urban development		>10		• Maintain ongoing liaison with QWB project to provide opportunities for design integration between the Project and QWB • Allowance for future underground pedestrian connection from station to QWB development	
Influence of tunnel on deep basements and footings of high rise development		>10		• Consult with Brisbane City Council about Project 'envelope' around tunnel and station structures, to inform development assessment • Design to allow for future high rise development above the tunnel, compensation to property owners for volumetric acquisition	
Landscape and visual amenity					
Visual impact of ventilation outlet		>10		• Integration of ventilation outlet within building above the station	
CONSTRUCTION					
Traffic and transport					
Changes to local access and traffic disruptions – temporary loss of traffic lanes (George Street and Mary Street), construction traffic use of George Street Construction traffic – spoil haulage via Elizabeth Street and George Street to Riverside Expressway Changes to pedestrian, cycle, public transport access		5		• Construction traffic management plan for Project works in George Street and Mary Street • Consultation with Brisbane City Council about changes to local streets and traffic flows	

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
Soils and topography					
Differential settlement from excavation of station cavern (1:2000 to 1:5000)		<1		• Tunnelling and station construction method to address settlement, predictive settlement modelling, building condition surveys particularly at nearby heritage places (Harris Terrace, The Mansions)	
Disturbance of possible asbestos within office building at 63 George Street		<1		• Preparation of Asbestos Management Plan prior to demolition, use of licenced disposal to registered facilities	
Air quality					
Dust from construction activities (ie demolition of office building, site establishment, excavation, spoil handling and transport)		2		• Construction EMP (dust management), loading of spoil from station excavation in a ventilated, acoustic shed, use of water sprays, covered loads, sealing access roads • Ongoing monitoring	
Noise and vibration					
Noise from daytime surface works (demolition of office building, site establishment, piling and initial shaft excavation)		5		• Undertake predictive modelling to inform design and planning of construction method, plant and equipment, hours of work for particularly activities to minimise noise and vibration	
Ground-borne noise from rock-breaking at residential, and commercial uses		<1		• Prepare and implement a site-specific Construction EMP (noise and vibration) based on predictive modelling of potential impacts, to manage intrusive construction works through hours of work, site specific work methods (eg cut-off walls, drill and blast) and advance consultation with affected parties	
Noise from roadheading of station cavern at residential uses (George Street)		2		• Early and ongoing consultation with affected residents and building occupants • Ongoing monitoring	
Potential for vibration effects on heritage buildings and sensitive equipment from initial rock-breaking of station shaft		2		• Prepare site-specific Construction EMP, based on predictive modelling of potential impacts • Pre-construction building condition surveys • Consultation with affected building occupants to identify sensitive equipment • Ongoing monitoring	
Cultural heritage					
Potential vibration and settlement effects on heritage places (ie The Mansions, Harris Terraces, Queensland Club, Brisbane Synagogue) Potential disturbance of archaeological deposits and residual Indigenous heritage		<1		• Preparation of CHMP for George Street heritage precinct (ie Harris Terrace, The Mansions, the Queensland Club) and management of Indigenous heritage values • Construction EMP (vibration and settlement)	

Benefits/ impacts	Significance	Duration (yrs)	Activity	Proposed mitigation	Residual
Socio-economic assessment					
Increased demand by workforce for local goods and services		5		• Develop and implement a strategy to enhance training and employment of local people, including Aboriginal people on Project works	
Local business impacts (ie changes to on-street parking and loading zones, amenity disruptions, changes in pedestrian access) Amenity affects for nearby residents (noise, dust, vibration, traffic)		5		• Identify alternative loading zones • Traffic management planning (including pedestrian management • Construction EMP (noise, dust, vibration), ongoing consultation and communication with affected business owners and residents	
Cumulative					
Concurrent construction of Queen's Wharf Brisbane precinct and other CBD developments (traffic, noise, dust, pedestrian access)		2		• Consultation with DSDIP (Queen's Wharf Brisbane) and BCC (Albert St, Kangaroo Pt ped bridge) about construction management • Implement CBD construction traffic management strategy	
OPERATION					
Traffic and transport					
Improved bus and rail access at George Street		>10	-	• Pedestrian access improvements to footpaths in George Street and Mary Street • Detailed design to provide for predicted passenger movements in station and on the surface streets	
Air quality					
Emissions from ventilation outlet		>10	-	• Integrate ventilation outlet in building above station if possible, with outlet to situated at roof-top level • Design of ventilation outlets (at height) to direct air flow away from sensitive receptors	
Noise and vibration					
Regenerated noise and vibration		>10	-	• If required, design measures (track fastening) to comply with QR Noise Code	
Socio-economic					
Business impacts – benefits for some businesses due to increased pedestrian traffic Improved public transport access to community services, facilities and employment (QUT Gardens Point, Botanic Gardens, southern part of Brisbane CBD)		>10	-	• Design and site station entrances to optimise pedestrian accessibility and movement between the surface and the street • Design surface infrastructure to accommodate predicted peak traffic flows	

Table 34 Summary of impacts – Roma Street Station

Benefits/ impacts	Significance	Duration (yrs)	Nature	Proposed mitigation	Residual
DESIGN					
Landscape and visual amenity					
Visual impact of ventilation outlet		>10	-	• Design and siting of ventilation outlet to be sympathetic to adjacent built form and to minimise visual impacts	
CONSTRUCTION					
Traffic and transport					
Construction traffic – use of Parkland Boulevard for construction access, worker parking Changes to pedestrian, cycle and public transport access (Platform 10, access between existing station and Parkland) Loss of car parking (Station 10 and Roma Street Parkland)		5		• Construction traffic management plan • Relocate Platform 10, including drop-off, while maintaining long-distance rail services • Maintain safe pedestrian and cyclist movements near construction works, including between station and Parkland	
Land use and tenure					
Temporary change in land use for construction activities (Emma Miller Place, Gallipoli Place, Roma Street Parkland car park)		5		• Reinstatement and rehabilitation of affected areas as soon as practicable	
Soils and topography					
Differential settlement from excavation of station cavern (1:2000 to 1:5000)		<1		• Tunnelling and station construction methods to address settlement, predictive settlement modelling, building condition surveys	
Disturbance of contaminated soil (former rail yard), including possible interaction with containment cell Possible asbestos contamination of Queensland Rail structures		2		• Design to minimise risk of interaction with containment cell, soil testing, management planning • Preparation of Asbestos Management Plan prior to demolition, use of licenced disposal to registered facilities	
Air quality					
Dust from construction activities (ie site establishment, excavation, spoil handling and transport)		2		• Construction EMP (dust management), loading of spoil from station excavation in a ventilated, acoustic shed, use of water sprays, covered loads, sealing access roads • Ongoing monitoring	

Benefits/ impacts	Significance	Duration (yrs)	Nature	Proposed mitigation	Residual
Noise and vibration					
Noise from daytime surface works (demolition of office building, site establishment, piling and initial shaft excavation)		5		• Construction method, plant and equipment, hours of work for particularly intrusive activities to minimise noise and vibration	
Ground-borne noise from rock-breaking at residential, and commercial uses		<1		• Prepare and implement a site-specific Construction EMP (noise and vibration) based on predictive modelling of potential impacts, to manage intrusive construction works through hours of work, site specific work methods (eg cut-off walls, drill and blast) and advance consultation with affected parties	
Noise from roadheading of station cavern at residential uses (Parkland Boulevard)		2		• Early and ongoing consultation with affected residents and building occupants • Ongoing monitoring	
Potential for vibration effects on heritage building at Roma Street Station		2		• Undertake predictive modelling for proposed construction method to inform development of management method • Pre-construction building condition surveys • Consultation with affected building occupants to identify sensitive equipment • Ongoing monitoring	
Cultural heritage					
Construction activities near to State heritage listed station building Potential impact on residual Indigenous heritage values		2		• Construction EMP (vibration and settlement) • Preparation of CHMP for State heritage place (Old Roma Street Station building and management of Indigenous heritage values	
Landscape and visual amenity					
Impacts on landscape character from use of Emma Miller Place and Gallipoli Place as construction worksite		5		• Reinstatement and rehabilitation of park areas as soon as practicable	
Socio-economic assessment					
Increased demand by workforce for local goods and services		5		• Develop and implement a strategy to enhance training and employment of local people, including Aboriginal people on Project works	
Amenity affects for nearby businesses and residents (noise, dust, vibration)		2		• Construction EMP (noise dust, vibration), ongoing consultation and communication with affected business owners and residents	
Access changes – pedestrian, cycle, vehicle (Roma Street Parkland, residential use, Platform 10)		2		• Construction traffic management plan, relocation of Platform 10, including drop-off, maintenance of pedestrian access near construction works, including between station and Parkland	
Temporary loss of park areas (ie Emma Miller Place and Gallipoli Place)		2		• Reinstatement and rehabilitation of park areas as soon as practicable	

Benefits/ impacts	Significance	Duration (yrs)	Nature	Proposed mitigation	Residual
OPERATION					
Traffic and transport					
Improved bus and rail access (interchange with existing Roma Street Station)	■	>10	-	• Detailed design to optimise inter-changing between all modes	■
Air quality					
Emissions from ventilation outlet	□	>10	-	• Design of ventilation outlet, siting (at height) away from sensitive receptors	□
Noise and vibration					
Regenerated noise and vibration	◪	>10	-	• If required, design measures (track fastening) to comply with QR Noise Code	□
Socio-economic					
Improved public transport access to community services, facilities and employment (ie Roma Street Parkland, northern part of Brisbane CBD)	■	>10	-	• Detailed design to optimise access from the station entrance to the central CBD and to provide for access to Roma Street Parkland	■

Table 35 Summary of impacts – Spring Hill (Northern Connection)

Benefits/ impacts	Significance	Duration (yrs)	Nature	Proposed mitigation	Residual
DESIGN					
Land use and tenure					
Change in land use from playing fields to transport infrastructure		>10	-	Minimise area of playing fields required for permanent infrastructure	
Hydrology					
Potential for flooding due to overland flow path		>10	-	Design of on-site stormwater network to minimise impacts on or from overland flow	
Cultural heritage					
Impact on intangible Indigenous heritage values Impact on heritage setting of Victoria Park		>10	-	Design to avoid impacts on York's Hollow and surrounds, recognition of Indigenous heritage values in design of surface infrastructure (ie busway bridge) Reinstatement and rehabilitation of Victoria Park as soon as practicable, in consultation with Brisbane City Council, local community and Turrbal Association	
Landscape and visual amenity					
Visual impact of ventilation outlet and feeder station		>10	-	Design and siting of ventilation outlet and feeder station to minimise visual impacts, provision of landscape screening	
Visual impact of busway bridge over the ICB		>10	-	Incorporate urban design measures to minimise visual impacts from Victoria Park and also from the ICB	
CONSTRUCTION					
Traffic and transport					
Construction traffic – spoil haulage to ICB, worker parking		5		Consult with BCC to develop a construction traffic management plan, use of agreed haulage and access routes, provision of on-site worker parking	
Delays and disruptions for motorists from works within ICB corridor		5		Notification about proposed changes Develop works program so disruptive works occur during holiday periods and weekends	
Changes to pedestrian and cycle access near to construction worksite		5		Maintain pedestrian access near construction works, including over Land Bridge	
Soils and topography					
Soil erosion		5		Implement Construction EMP (erosion and sediment control)	
Disturbance of contaminated soil within railway corridor, possible asbestos contamination of Queensland Rail structures		<1		Soil testing, management planning, preparation of Asbestos Management Plan prior to demolition, use of licenced disposal to registered facilities	

Benefits/ impacts	Significance	Duration (yrs)	Nature	Proposed mitigation	Residual
Air quality					
Dust from construction activities (ie site establishment, excavation, spoil handling and transport)		5		Construction EMP (dust management), use of water sprays, covered roads, sealing access roads Ongoing monitoring	
Noise and vibration					
Noise from daytime surface works (ie excavation of transition structure, TBM retrieval shaft) Regenerated noise and vibration from TBM dis-assembly and surface works		>10	-	Construction EMP (noise and vibration), use of acoustic screens Early and ongoing consultation with affected communities	
Cultural heritage					
Potential disturbance of archaeological deposits or residual Indigenous heritage Temporary impact on Victoria Park		5		Preparation of CHMP for Victoria Park and management of Indigenous heritage values Reinstatement and rehabilitation of Victoria Park as soon as practicable, in consultation with Brisbane City Council, local community and Turrbal Association	
Landscape and visual amenity					
Establishment of construction worksite in Victoria Park (loss of mature trees and vegetation, disruption to park access)		>10	-	Rehabilitate and reinstate park areas as soon as practicable in consultation with Brisbane City Council, Traditional Owners and the local community	
Socio-economic assessment					
Temporary disruption to park areas, impact on community values associated with Victoria Park Amenity impacts for park users and nearby facilities (ie Centenary Aquatic Centre, schools, playing fields) Changes to pedestrian and cycle access near construction works (safety, disruption)		5		Rehabilitate and reinstate park areas as soon as practicable Maintain safe pedestrian and cycle access	
Cumulative					
Prolongation of construction effects with other infrastructure projects (ie Legacy Way, Airport Link, Inner Northern Busway)		5	-	Early and ongoing consultation with near neighbours about construction program and progress in relation to programme Implement Construction EMP	
OPERATION					
Air quality					
Emissions from ventilation outlet		>10	-	Design of ventilation outlet, siting away from sensitive receptors	
Noise and vibration					
Noise from surface rail and busway operation Regenerated noise and vibration		>10	-	Establishment of noise barriers (if required) If required, design measures (track fastening) to comply with QR Noise Code	

6. Environmental management

A Draft Outline EMP has been prepared setting out the proposed approach to environmental management for the Project in its design, construction and commissioning. It establishes environmental design requirements for the Project which are intended to resolve most operational impacts through detailed design.

Environmental outcomes and performance criteria for the construction and commissioning phases of the Project are proposed to support the maintenance of reasonable environmental amenity during Project delivery. It also provides possible mitigation measures to maintain the environmental values and goals of the study corridor.

The Draft Outline EMP comprises a section focussing on construction, which outlines the approach to environmental management for the Project's construction phase, as well as a section focussing on commissioning, which outlines the approach to environmental management for the Project's commissioning phase.

The Draft Outline EMP is intended to guide the development of more detailed site-specific or activity specific EMPs and relevant sub-plans prepared by the Proponent prior to commencement of the Project's construction and commissioning phases. In preparing the detailed EMPs and sub-plans, the Proponent must address conditions imposed by the Coordinator-General as part of the Coordinator-General's Evaluation Report. Any conditions imposed by the Coordinator-General would prevail over any provision in the Draft Outline EMP.

The Draft Outline EMP establishes a broad framework which would be reflected in the Project Construction and Commissioning EMPs as they are developed. The framework consists of the following core elements:

- roles and responsibilities – identifies the Proponent and government agencies to provides a clear line of responsibility for the detailed design, construction and commissioning phases of the Project. Responsibilities include design approvals, monitoring, corrective actions and reporting
- community engagement – establishes a process and programme of activities for effective engagement of communities situated in localities potentially affected by the Project works or its operation
- approvals – identifies the range of approvals, permits, authorities or licenses that would be required for the construction and commissioning of the Project
- environmental design requirements – establishes design requirements for the Project to assist in avoiding, or minimising and mitigation impacts
- construction – provides an integrated framework of environmental objectives and performance criteria to be addressed in the Construction EMP, and implemented throughout the construction phase
- commissioning – provides an integrated framework of environmental objectives and performance criteria to be addressed in the Commissioning EMP, and implemented throughout the commissioning phase.

Worksite, Legacy Way *(Image courtesy of Rix Ryan Photography)*

The governance of the environmental management task must be clear and based on effective lines of reporting and responsibility.

For the purposes of the Draft Outline EMP, the State of Queensland represented by the Department of Transport and Main Roads is referred to exclusively as the Proponent. The Department of Transport and Main Roads would also be responsible for ensuring the Project is delivered in accordance with the Coordinator-General's conditions and for ensuring that a reasonable environmental amenity is achieved, consistent with the environmental outcomes.

To distinguish these separate functions, the Department is referred to as the Proponent in relation to Project delivery, and to the Chief Executive Department of Transport and Main Roads in relation to environmental management responsibilities.

The proposed governance structure for environmental management for the Project is summarised in **Table 36**.

Table 36 Proposed governance arrangements – environmental management

Entity	Role and responsibility
Coordinator-General	Administers the State Development and Public Works Organisation Act 1971 in respect of the Project conditions, having evaluated the EIS
Proponent	the State of Queensland (represented by the Department of Transport and Main Roads) responsible for the design, construction, commissioning and operation of the Project entity responsible for implementing the Coordinator-General's conditions, and for achieving the environmental outcomes, in design, construction and commissioning of the Project
Transport and Main Roads	Chief Executive: responsible for providing the Coordinator-General with advice about compliance with the conditions and the environmental requirements in detailed design, construction and commissioning responsible for obtaining all relevant Project approvals
Environment & Heritage Protection	Administering the *Environmental Protection Act 1994* and the *Queensland Heritage Act 1992*
Natural Resources and Mines Housing and Public Works	Owners of land affected by the Project
Brisbane City Council	A major stakeholder interests in land, local roads and other urban infrastructure, and natural assets provides input to urban design measures, EMP and worksite rehabilitation.
Environmental Monitor	An independent person or monitor engaged by the Proponent to: monitor the achievement of the environmental outcomes and compliance with the Coordinator-General's conditions during the construction and commissioning of the Project. provide advice to the Chief Executive Department of Transport and Main Roads, and on request to the Coordinator-General, about achievement of the environmental outcomes and compliance with the Coordinator-General's conditions
Community Relations Monitor	An independent person or entity engaged by the Proponent to: monitor community relations during the construction and commissioning of the Project. facilitate community advisory groups and liaison between affected parties and the Proponent or its contractors
Community Advisory Groups	Provide comments in an advisory role to the Proponent on the detailed design and the locality-based EMP sub-plans for construction and commissioning of the Project. Provide advice to the Proponent during the construction phase in relation to identifying and mitigating the impacts of construction in the locality for each worksite.

7. Conclusions

The Project addresses the critical bus and rail capacity constraints in Brisbane's inner city. The Project will deliver rail and busway infrastructure in a single, double-decked, 5.7km tunnel under the Brisbane River from Dutton Park to Victoria Park with new underground stations at Woolloongabba, George Street and Roma Street. The Project will double the capacity of the rail and bus networks across the Brisbane River and improve frequency, travel time and access benefits for passengers whilst reducing inner-city traffic congestion.

The EIS has been prepared in accordance with Part 4 of the *State Development and Public Works Organisation Act 1971*, to identify and assess the potential environmental, social and economic impacts associated with the construction and operation of the Project, and ensure that adverse impacts are avoided or appropriately managed. The overall objective of the EIS is to ensure that potential environmental, social and economic impacts of the Project are identified and assessed and that adverse impacts are avoided or mitigated.

The conclusions drawn from the reference design and the EIS provided in this chapter relate to:

- the strategic need for the Project to address existing constraints and to respond to patronage growth on the South East Queensland rail and busway networks
- the potential benefits and impacts of the Project on the environment of the study corridor, in both its construction and operation
- the scope of community and stakeholder interest in the Project
- the range of mitigation measures available to address community and stakeholder issues.

7.1 Rationale for the Project

Population growth within South East Queensland is expected to grow from 3 million people in 2011 to 3.7 million by 2021 and 4.5 million by 2031. This growth is primarily expected to be in areas outside of the Brisbane City LGA in the Gold Coast, Ipswich, Sunshine Coast, Moreton Bay and Logan regions. Approximately 290,000 additional people are expected to settle within the Brisbane LGA by 2031 to bring the total population to around 1.4 million.

Strong population growth in anticipated in the inner city areas of the CBD, South Brisbane, Spring Hill, Milton, Woolloongabba, Bowen Hills and Fortitude Valley over the next 20 years. Current planning intentions show support for growth around the CBD in South Brisbane and increased intensity of development in the Woolloongabba, Roma Street and Fortitude Valley areas.

The growth in population in surrounding regions will place pressure on the regional transport network with a focus on travel to Brisbane, particularly by road and rail, while the growth in inner city residents will place pressure on inner Brisbane travel, which includes rail and bus.

With the projected increase in population in South East Queensland, employment will also grow. An additional 290,000 jobs are predicted within Brisbane by 2031, with the city reaching a total employment base of almost 1.1 million. Approximately 100,000 of the additional jobs will be within the CBD and adjacent fringe areas of Milton, South Brisbane, Fortitude Valley and Bowen Hills. The growth in office-based professional, technical and business administrative jobs that concentrate in the CBD and adjoining areas, will result in significant increases in both commuting and business trips into Brisbane from surrounding areas.

7.1.1 Patronage increases

In 2012, rail services were approaching the CBD from the south were close to passenger capacity in commuter peak periods. In 2013, trains travelling from Beenleigh to the CBD in the morning peak were carrying around 660 passengers, exceeding the carrying standard for this type of service and around 200 more people than the fully seated capacity. With continued population growth and related travel demand, passenger capacity is likely to be reached south of Salisbury in 2021.

Similar to rail patronage, bus services are predicted to grow between 2012 and 2031. From 2012 to 2021, bus boardings would increase from 248,800 per day to 381,300 per day. By 2031, the boardings would be 496,600 per day, or double the 2012 patronage. The forecast passenger movements would require over 1,000 buses to enter the CBD in the morning peak by 2031.

7.1.2 Constraints on the transport network

Without the Project, rail service growth to meet demand to the Brisbane CBD would become more limited due to constrained capacity and resilience in the network. Population and employment growth are expected to cause increased congestion at existing stations, particularly at Central Station, resulting in impacts on reliability and passenger comfort. Network infrastructure to meet demand for peak period rail services on the Merivale Bridge (southern and eastern services) and the inner city network is close to capacity. Without augmentation, the rail network would not be able to cater for any additional growth past 2020.

Existing bus operations on the South East Busway into the Brisbane CBD are already congested in peak periods. The busway connection to the CBD and Inner Northern Busway is expected to experience congestion in the future. Overall, there is limited potential to provide additional capacity for additional bus services for accessing the CBD on the busway network, particularly from the south. The two main connections for bus services from the south, the Captain Cook Bridge and Victoria Bridge, are congested in peak periods, restricting the ability to provide additional services from the south.

The further development of the road network in the inner city is constrained similar to the rail and bus networks. Across the entire network, the transport task is forecast to increase by almost 40 per cent from 2012 to 2031 to a total of almost 10.3 million trips per day.

At the regional level, public transport is forecast to make up 1.1 million trips per day, leaving the road network to cater for much of the remaining 9.2 million trips per day. Between 2012 and 2031, total private vehicle kilometres travelled would increase by 60 per cent. This growth will lead to increasing congestion and travel time, and decreasing network reliability.

There are limited opportunities for further development of the road network in the inner city, due to land use, topographical and capacity constraints. As the dominant mode for travel to the Brisbane CBD in peak periods, public transport will have a key role in accommodating travel demand. Public transport is required also to support a reduction in traffic congestion.

Merivale Bridge

Cultural Centre Busway Station

7.2 Overview of Project benefits

The benefits of proceeding with the Project range across transport, land use and economic factors, discussed below.

7.2.1 Sustainable and efficient transport and land use

The Project would support the future growth and development of South East Queensland by providing improved public transport access to areas of future population and employment growth.

Specifically, the Project would:

- address the capacity constraints of the regional rail network capacity by improving connections between regional development areas to activity centres through high quality transport, resulting in the efficient and sustainable development of these communities and decreased car dependency
- address bus network capacity constraints across the Brisbane River and into the Brisbane CBD. This would improve access for commuters using the busway network from the north and the south, and remove buses from the CBD road network
- enhance the existing rail and bus networks, supporting the preferred land use patterns and the urban development densities envisaged in the of the SEQ Regional Plan and efficient and sustainable development activity
- provide rapid, high frequency connections between primary destinations and activity areas in inner Brisbane through the appropriate location of the Project's stations, with minimal disruption to surface land use patterns or land use planning intentions
- support planned urban developments and renewal projects, including Woolloongabba Central, Kangaroo Point South, the Woolloongabba Priority Development Area (PDA), the Boggo Road Urban Village, ongoing growth of the QUT and the PA Hospital, ongoing development of the Brisbane CBD, and preserve long term city expansion opportunities associated with the Brisbane Transit Centre and Roma Street rail yard
- support strategic regional development areas, such as Flagstone, Fitzgibbon, Coomera and Yarrabilba. Sufficient transit access is required in these areas to allow them to develop as selfsustaining communities with regional public transport connectivity to major employment and education centres, such as the Brisbane CBD.

7.2.2 Economic

In terms of economic benefits, the Project would:

- deliver significant transport benefits for passenger services, including travel time savings, on-time reliability, travel time and operating cost savings for road users
- deliver indirect economic benefits through increased accessibility across the transport network in South East Queensland and increased efficiency of movement in and around the region and the Brisbane metropolitan area
- deliver employment benefits directly and indirectly through the construction phase, as well as through the operational life of the Project
- deliver a range of wider economic benefits, in terms of land use, productivity and amenity
- generate a strong economic return, with a net present value of $641 million and a benefit-cost ratio of 1.16 based on transport system benefits.

7.3 Overview of Project impacts

7.3.1 Construction phase

In its construction, the Project would present a large transport infrastructure undertaking, extending across and beneath a number of inner city suburbs of Brisbane, including the CBD. While the scale and intensity of the construction of the Project is significant, the impacts would be of limited duration, ie five years, compared with the operational benefits.

During the construction phase, local communities near construction worksites would likely experience a number of adverse impacts that could potentially cause moderate to high levels of short-term disruption and nuisance, and reduced amenity. Construction impacts would be less obvious along the alignment of the tunnelling works, the material supply lines, the spoil placement sites and the haulage routes.

The key findings with regards to the anticipated Project impacts are summarised as follows:

- impacts would be temporary and finite, ie five years duration, and would be confined mostly to the locality of the worksites
- impacts would be greatest for sensitive receivers adjacent construction worksites, particularly at the Southern Connection, George Street Station and Roma Street Station worksites
- wider ranging impacts, such as construction transport, reduce in intensity rapidly with distance from the worksites
- impacts from tunnel construction, such as ground-borne noise and vibration, would last for approximately 5-7 days for the TBM passby at most locations and for approximately 7-10 days beneath the CBD.

Implementation of the mitigation measures, in combination with advance and on-going consultation with potentially affected owners and occupants of properties would address most, if not all impacts.

7.3.2 Operations phase

The potential adverse impacts associated with the operation of the Project would include:

- groundwater contamination, potentially influenced by groundwater drawdown, from existing contaminated soil or areas of potential acid sulphate soils
- permanent volumetric acquisitions of land surrounding the tunnel and underground stations, although these acquisitions would not impact on any existing or approved buildings or developments. Compensation would be provided for volumetric acquisitions in accordance with the *Acquisition of Land Act 1967*
- permanent surface acquisition of State owned land, including land currently used for open space, offices, and transport infrastructure (ie railway yards).

7.4 Summary of benefits and impacts

The Project would impart a range of benefits over its functional life and a number of impacts of varying intensity and duration in its construction. The Project design is intended to address and resolve environmental impacts as the most effective means of avoiding long-term operational impacts. Similarly, the intention in detailed design is to resolve as many construction impacts as possible before having to develop and implement mitigation measures.

The construction phase also would present a range of benefits mostly of a social and economic nature through direct and indirect employment and through the demand for goods and services.

On balance the significant and enduring nature of the benefits to the transport network, and society through enhanced accessibility and connectivity to high level facilities, services and employment, outweigh the short-term construction impacts.

An overview of the main benefits and impacts of the Project are presented in graphic form in **Table 37**.

Table 37 Bus and Train Project – impacts and benefits

Impacts / Benefits	Impact / Benefit	Significance	Duration	Mitigation measures	Residual
CONSTRUCTION PHASE					
Transport and traffic					
Heavy vehicle movements at worksites	●	◔	<5	Construction traffic management plan (CTMP)	◔
Possessions of rail corridor	●	◔	<5	Consultation, managed work	◑
Changed traffic conditions – George Street	●	◕	<5	Staged construction, CTMP	◔
Spoil and materials haulage	●	◔	<5	CTMP, haulage hours, designated routes	◑
Changed access (vehicle, ped, cycle)	○	◑	<5	CTMP, alternative access maintained	○
Work force car parking	●	◔	<5	Parking provided at worksites or elsewhere	○
Socio-economic effects					
Property acquisition (volumetric)	●	◑	>10	Acquisition process	○
Employment – direct, indirect	●	◔	<5	Training, local employment program	◔
Land use – land adjacent to worksites	●	◑	<5	Advance consultation, access, agreed and specific mitigation measures	◑
Cultural heritage – indigenous, non-indigenous	●	◕	<5	CHMP, construction planning, building surveys	○
Community amenity (open space)	●	◔	<5	Worksite planning and rehabilitation	○
Landscape & visual (busway, surface infrastructure including vents)	●	◔	>10	Urban design treatment, landscape screening	◔
Bio-physical effects					
Noise and vibration – stations, surface works, tunnelling	●	◕	<5	Advance notification, construction planning, agreed and specific mitigation measures, monitoring	◑
Air quality – surface works, transport, GHG	●	◔	<5	Construction planning, site- specific mitigation measures, monitoring	◑
Water quality – surface water, groundwater	●	◑	<5	Drainage management and treatment, construction planning, monitoring	○

Impacts / Benefits	Impact / Benefit	Significance	Duration	Mitigation measures	Residual
OPERATIONS PHASE					
Transport and traffic					
Enhanced public transport (bus, rail) – interchange, frequency of services, accessibility	●	◑	E	Optimise station designs for interchanging, and service plans for regional benefits	◑
General transport – relief to congestion in rail, bus and road networks – reliability of service	●	◑	>10	Optimise service plans and scheduling for peak periods	◑
Caters for growth in travel demand – population and employment	●	◑	>10	Optimise service plans and scheduling	◑
Enhanced public transport into inner city incl CBD	●	◑	E	Optimise service plans, integrate with land use and planning	◑
Socio-economic effects					
Enhanced social cohesion arising from connectivity and access to facilities and services	●	◑	E	Detailed design provides connections to key centres	◔
Increased economic activity (direct, indirect) – enhanced competitiveness, services, property	●	◔	E	Economic development plan (by others)	◔
Community amenity (Dutton Park, Woolloongabba, Victoria Park, George Street, Roma Street)	●	◔	E	Optimise service plans, enhanced interchanging at Project stations	◔
Land use – integration with planned activities, Gabba Stadium, major hospitals, BRUV	●	◔	E	Optimise service plans, integrate station design with surrounding land use	◔
Bio-physical effects					
Noise and vibration	●	◑	>10	Design modifications if required	○
Air quality – reduced vehicle emissions, ventilation outlets	○	◐	>10	Nil required, monitoring	○
Groundwater – balance, management	○	◐	>10	Design response, nil required, monitoring	○
Ground movement and settlement	○	◐	>10	Design response, nil required, monitoring	○

Effects
- ● Benefits
- ● Impacts
- ○ Neutral effect

Significance
- ◑ High
- ◔ Moderate
- ◐ Low

Duration
- E Enduring
- >10 >10 yrs
- 5 – 10 yrs
- <5 < 5 yrs

Residual effect
- ◑ High
- ◔ Moderate
- ◐ Low
- ○ Neutral effect

7.5 Recommendations

The Project addresses the significant need to increase the capacity of public transport infrastructure within the inner city areas of Brisbane, particularly the CBD. Parts of the current train and bus networks are operating at capacity during peak periods resulting in congestion, increases in travel times, reduction in on-time reliability and overcrowding. This situation will deteriorate in the future without investment in public transport infrastructure.

Commonwealth, State and local strategic policy frameworks recognise the need to augment the current public transport network to accommodate the future growth forecast for the region. The Project would address the strategic transport outcomes being sought by these policy frameworks.

The Project would provide an additional river crossing for each of the rail and bus networks resulting in substantial improvements to network capacity. This allows for growth in rail and bus services to meet demand for increased public transport passenger movements. Having regard to the findings of the EIS with respect to the beneficial and adverse impacts of the Project, the following recommendations are made to the Coordinator-General:

Recommendation 1

It is recommended to the Coordinator-General that the Project should proceed subject to:

(i) detailed design addressing the environmental design requirements as a means of resolving the potential or predicted impacts of the Project in its operational mode

(ii) environmental management adopting the governance arrangements proposed in the Draft Outline EMP, particularly with regards the Chief Executive, Department of Transport and Main Roads taking responsibility for the maintenance of a reasonable environmental amenity, and the Proponent taking responsibility for Project implementation in accordance with any conditions imposed by the Coordinator-General as well as appointing independent third parties to fulfil the roles of Environmental Monitor and Community Relations Monitor

(iii) the Proponent developing and implementing detailed environmental management plans for the construction phase and the commissioning of the Project, where such plans adopt the environmental outcomes and performance criteria, set out in the Draft Outline EMP

(iv) the Proponent consulting with potentially affected parties to develop and then implement effective mitigation measures to address and mitigate the construction impacts of the Project on local communities

(v) the Proponent establishing a regime of effective community engagement and consultation with affected parties, the wider community and stakeholders, to inform detailed design development, construction planning and implementation, and commissioning.

Recommendation 2

It is further recommended to the Coordinator-General that:

(i) all necessary approvals and permits be obtained for the Project, including, but not limited to, those required under the Sustainable Planning Act 2009, the Transport Infrastructure Act 1994 and related Acts, the Aboriginal Cultural Heritage Act 2003, the Queensland Heritage Act 1992 and the Environmental Protection Act 1994

(ii) a Working Group comprising the Proponent, the Department of State Development Infrastructure and Planning and the Brisbane City Council, be established to address the cumulative effects of construction traffic associated with both the BaT project and the Queen's Wharf Brisbane project on that part of the CBD bounded by Elizabeth Street, Albert Street, Alice Street and William Street

(iii) the Queensland Government develop and implement measures in consultation with the Brisbane City Council to coordinate the construction and delivery of the Project concurrently with a number of other major projects, including urban developments within the Woolloongabba PDA and Boggo Road Urban Village.

The Coordinator-General is requested to assess this EIS, and in preparing an evaluation report:

(i) recommend that the Project proceed

(ii) state the conditions for the Project under section 39 of the State Development and Public Works Organisation Act 1971

(iii) where there is no other relevant approval, impose conditions on the Project, under section 54B of the State Development and Public Works Organisation Act 1971, with the nominated entity for all such conditions being the Chief Executive, Department of Transport and Main Roads.

Connecting Queensland
delivering transport for prosperity

13 QGOV (13 74 68)
www.tmr.qld.gov.au | www.qld.gov.au