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NORTHERN AND WESTERN GEELONG GROWTH AREAS

CLEVER AND CREATIVE CORRIDOR

Quality Information

Northern and Western Geelong Growth Areas

Clever and Creative Corridor **(DRAFT)**

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Table of contents

Executive summary 1

Introduction 2

Part 1 - Justification for the corridor (Why) 3

Public transport trip absorption 4
Synergies with additional planning priorities 6
Environmental and social benefit 15
Minimisation of car infrastructure 16
Urban design implications 18

Part 2 - Location of the corridor (Where) 19

Growth area design framework 20
Public transport context 21
Corridor arrangement 24
Station locations 25

Conclusion 53

Part 3 - Definition of the corridor (What) 26

Light Rail Transit (LRT) 27
Bus Rapid Transit (BRT) 32
Alternative technologies 36
Recommended corridor width 37
Recommended station design footprint 39

Part 4 - Staging of the corridor (How) 43

Considerations 44
Options 45
Recommendations for short term use 48

Executive summary

Clever and Creative Corridor

The Northern and Western Geelong Growth Areas are together projected to accommodate a combined population of 110,000 residents within the next 30 years, as well as approximately 100,000 square metres of activity centre development.

While the existing mode splits in suburban Geelong would suggest a conventional approach to satisfying this demand through the strategic widening of key road corridors, it is recognised that a shift toward sustainable modes or alternate travel patterns is preferred to minimise long-term environmental impact and maximise future mobility options.

This report addresses the spatial reservations that are required to implement the City's ***Clever and Creative Corridor*** initiative, an effort to preserve a key corridor throughout the growth areas for future high-priority public transport use. In addition to helping to refine the corridor requirements and locations (the 'what' and the 'where') it also helps to initiate a discussion about the overall need for the corridor and its potential staging prior to implementation of a public transport service (the 'why' and the 'how').

Why

The preservation of a Clever and Creative Corridor would bring a variety of benefits:

- Higher potential for future public transport mode share as compared with conventional bus services
- Support for the complementary objective of maximising active transport and its associated health benefits
- Environmental and social benefits including significant potential savings in carbon dioxide emissions
- Lesser land requirements to accommodate future parking

Where

The corridor would be located in a generally north-south orientation through each of the two growth areas, primarily on local streets with a median alignment. These have been organised into primary and secondary corridors based on potential interconnectivity with the wider Geelong public transport context, with the flexibility to shift amongst them in response to future development patterns.

What

The potential combinations of cross-sectional elements to include within the corridor — and their measurements accounting for various forms of buffer treatment as well as numerous potential vehicle types — is nearly infinite. As a result, this process has aimed to simplify the corridor reservation requirements to enable maximum flexibility in accommodating various vehicle technologies and amenities.

The resulting recommendation is a corridor reservation width of 14 metres (beyond what is otherwise needed for their encompassing roadways) predicated on a public transport reservation of 7 metres — which is wide enough to accommodate various forms of Light Rail Transit (LRT), Bus Rapid Transit (BRT) and many alternative technologies — plus a 3.5-metre buffer on either side to safely and attractively separate the adjacent road users from the public transport corridor. The value of the buffer strip is twofold: It negates the loss of greenery that would otherwise occur with later corridor conversion and enables flexibility in the locating of stations by accommodating the full width of future station platforms in any location along the routes.

How

The staging of the corridor needs to be carefully considered to avoid creating a high-value asset in the shorter term that may be difficult to convert to its intended future public transport use, while ensuring that the corridor reserve will be viewed as an attractive and worthwhile use of space.

To achieve this balance, it is recommended that the corridor be reserved in the form of a primarily passive green strip with low to mid-level landscaping, with the potential for several formalised landscaped areas in locations where these may be replaceable outside the corridor in the longer term. The potential for a pathway in the median could also be considered given suitable width elsewhere in the road reserve to relocate this asset when the public transport service is initiated.

Introduction

The Northern and Western Geelong Growth Areas are together projected to accommodate a combined population of 110,000 residents by 2050, as well as approximately 100,000 square metres of activity centre development.

While the existing mode splits in suburban Geelong would suggest a conventional approach to satisfying this demand through the strategic widening of key road corridors, it is recognised that a shift toward sustainable modes or alternate travel patterns is preferred to minimise long-term environmental impact and maximise future mobility options.

In parallel, the City of Greater Geelong has released its vision for 2047, titled ***A Clever and Creative Future***, which in turn led to the development of the Clever and Creative Corridor concept. This concept seeks to address some of the challenges experienced by contemporary greenfield development.

This report addresses the spatial reservations that may be required to preserve a key corridor throughout the growth areas for future high-priority public transport use, for the purposes of ensuring sustainable transport options as these areas are built out.

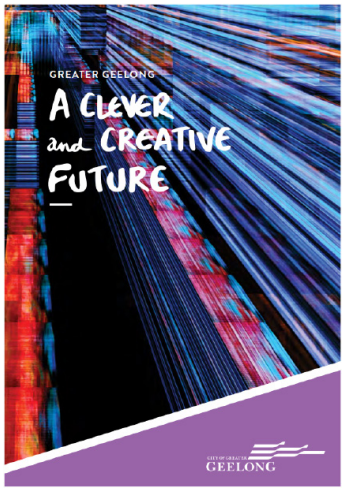
In particular, this process entails the following steps in defining the requirements and merits of preserving space within the defined corridors for future public transport, specifically:

- **Why:** The justification for the reservation of the corridor, including the potential level of future trip absorption and potential synergies with other Geelong transport initiatives at a systematic level
- **Where:** The alignment of the corridor including responsive options to varied development outcomes
- **What:** The form of the corridor including its width and any potential additional station reservations
- **How:** The staging of the corridor, including short-term (pre public transport) uses and interim aesthetic treatments.

This report is structured around each of these four questions, with documentation of how various forms of public transport could be accommodated in several future scenarios. The forms of public transport addressed include Light Rail Transit (LRT) and Bus Rapid Transit (BRT) as well as several experimental and emerging technologies. The report Conclusion documents the recommendations for corridor reservation and staging.

- A prosperous economy that supports jobs and education opportunities
- A leader in developing and adopting technology
- Creativity drives culture
- A fast, reliable and connected transport network
- A destination that attracts local and international visitors
- People feel safe wherever they are
- An inclusive, diverse, healthy and socially connected community
- Sustainable development that supports population growth and protects the natural environment
- Development and implementation of sustainable solutions





Part 1 - Justification for the corridor

The justification for the application of the Clever and Creative Corridor concept to the Northern and Western Geelong Growth Areas includes the following benefits:

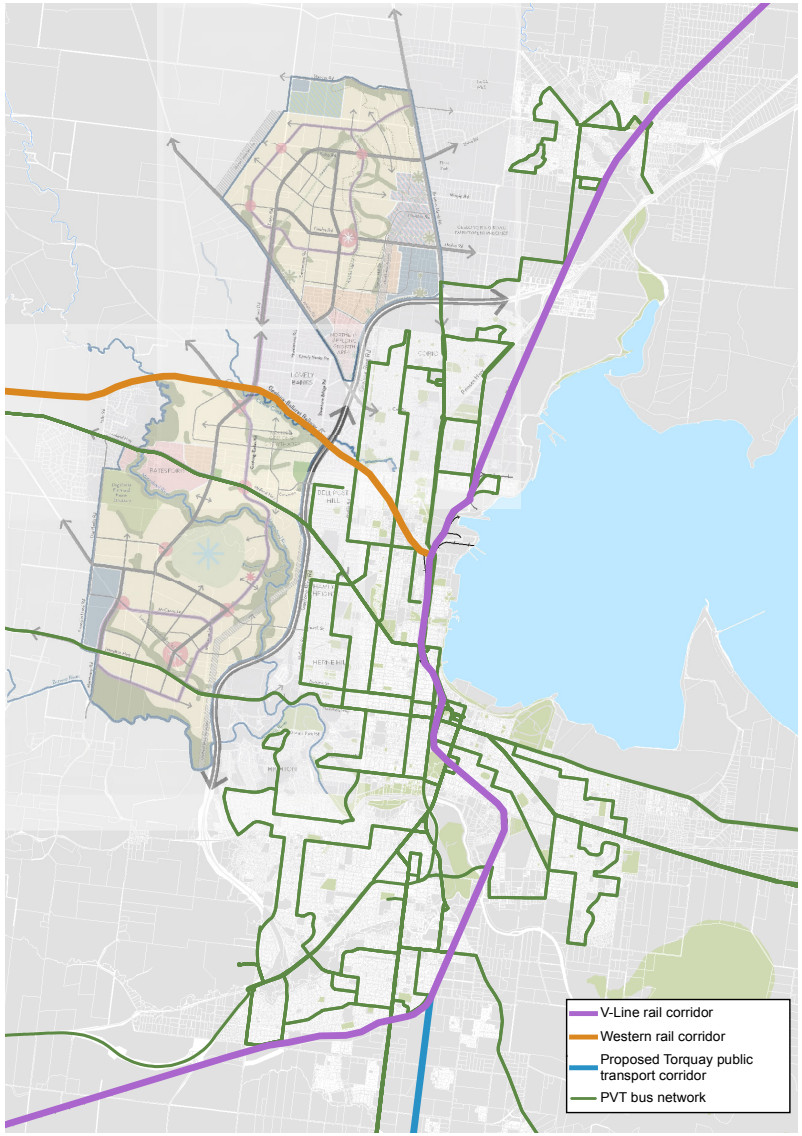
- Higher level of public transport trip absorption than that which could be achieved with conventional buses
- Connection with key destinations in Geelong and (through connection with V/Line) Melbourne
- Potential combination with other services into a Greater Geelong high-capacity public transport network
- Support for additional transport priorities such as the maximisation of walking and cycling, and associated health benefits
- Environmental benefits from the reduction in expected mode share of lower-occupancy vehicles
- Lower magnitude of traffic bottlenecks compared with what could be the case without a premium transport option
- Less of a need to devote land internal to the growth areas to parking.

This chapter discusses each of these benefits drawing upon experiences in other cities.

This section is organised according to the following sub-topics:

- Public transport trip absorption
- Public transport connectivity
- Support for additional transport objectives
- Environmental and social benefit
- Minimisation of traffic infrastructure
- Minimisation of land requirements for parking
- Urban design implications.

While several of these relate specifically to the planning context in Greater Geelong, others use statistical data from public transport initiatives in other locations to estimate at a high level the benefits of similar public transport strategies.



Greater Geelong public transport context

Public transport trip absorption

Light rail and bus rapid transit are high frequency, medium-to-large capacity rapid transit modes that can be integrated alongside other mode of transports.

With accretion of congestion time due in large part to the increase in both frequency and length of private vehicle commuting, analysed data from the Australian Bureau of Statistics found that only one in ten commuters relies on public transport, and that nearly two in three Australians drive to work alone in a private car (ABS, 2014). Transport modes chosen by users are inherently dependent on current land use and availability of transport infrastructure. Research has demonstrated how urban travel patterns and modal choice decisions are influenced by residential dispersal, leading to a greater level of car dependency and more complex commuting (BITRE, 2012).

As such, LRT and BRT allow for a significant increase in mobility, connecting centres to hinterlands, revitalising neighbourhoods, and helping to reduce both congestion and carbon emissions. Positively perceived for their reliability, quietness, speed and modernity, both LRT and BRT are undergoing a global resurgence in both large and smaller cities.

The success of implemented LRT and BRT corridors across the world have highlighted key factors influential in their successful integration and operation, and how they can lead to significant modal shift amongst road users. The key contributors to this outcome have been shown to include:

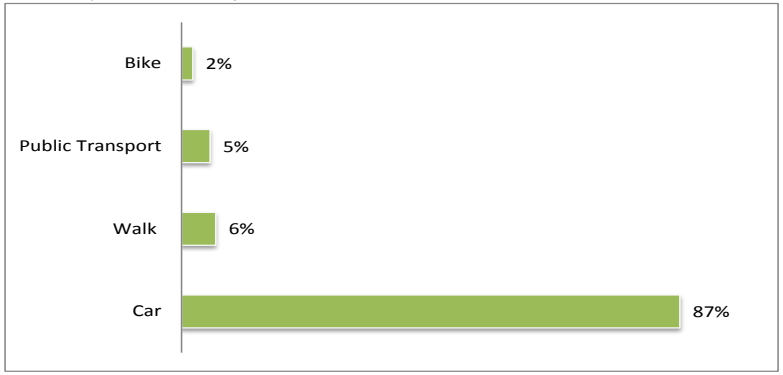
- Improvements to journey time when compared with conventional buses and travel by car
- Frequencies that support unplanned or 'turn up and go' travel patterns
- Reliability, as is generally intrinsic to LRT and BRT due to their separation from road traffic
- Comfort, both at the stations and within the vehicles
- Effective marketing and branding.
- Real-time information about primary and connecting services
- Convenience of station locations with respect to various forms of access.

The current high level of commuting by private car represents an inefficient use of the space dedicated to transport, in terms of both their impact along main travel corridors and their storage requirements at both ends of every trip. While innovations such as autonomous vehicles are expected to lead to incremental improvements in offering a more efficient use of transport space — by increasing the occupancy per vehicle and decreasing the static storage requirements — this is still far below the benefit of LRT or BRT with respect to numbers of people who can ultimately be carried within a given amount of corridor space.

Reviews of new light rail systems implemented within established transport networks in the US and the UK have found a significant modal shift of up to 20 percent above what had been carried by the conventional bus routes they had supplanted (Brinckerhoff, 2004). Although light rail had been shown to be particularly effective in achieving mode shift away from privately owned cars, very recent advancements in BRT system design have narrowed the perceptual differences between these two forms of transport.

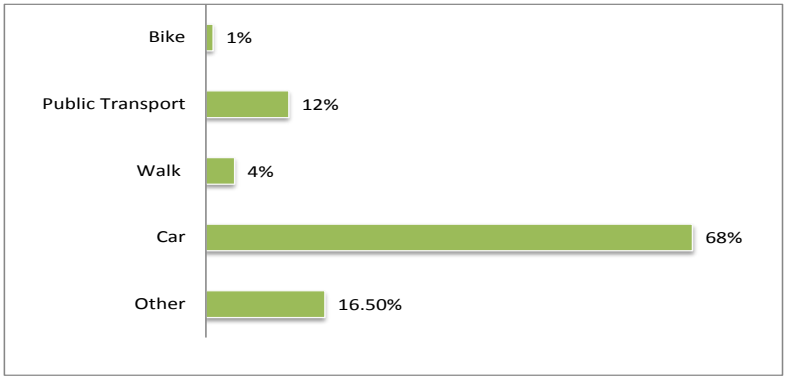
Trips into Central Geelong by transport mode

Source: City of Greater Geelong, 2018



Australia commuting statistics by transport mode

Source: Australian Bureau of Statistics, 2016; Census of Population and Housing 2011 and 2016. Compiled by .id.com



Transport interconnectivity

The interconnectivity amongst premium public transport services is a key benefit of extending LRT or BRT (or other advanced techonology) into the growth areas, as the utility of public transport services to prospective riders is often defined by the quality of its weakest or slowest component.

As the Northern and Western Geelong Growth Areas are currently isolated from the main railway corridor between Geelong and Melbourne, the absence of a strong connecting service would mean that public transport trips to most major destinations would require either a long conventional bus ride (to a V/Line station or central Geelong) or a connecting car trip to a park-and-ride facility along the train line.

While the former generally suffers from a journey time disadvantage in comparison with driving, the reliance on park-and-ride requires considerable spatial outlay at the station for parking (which often contradicts the goal of walkability) and exacerbates localised bottlenecks and access corridor congestion.

The provision of a high-capacity traffic-separated public transport link would offer clear benefits to potential riders without necessitating significant accompanying expansion of car oriented infrastructure.

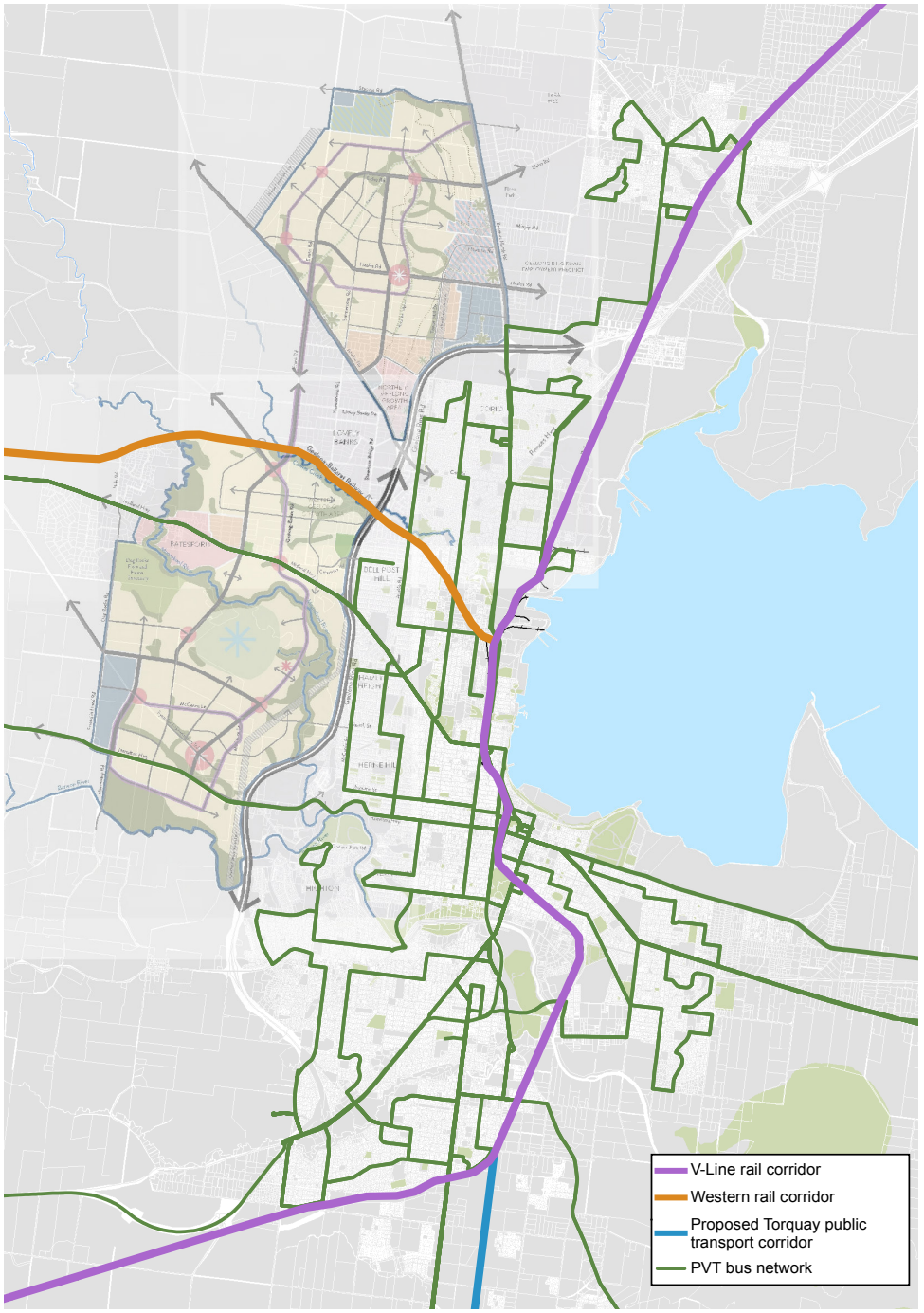


PTV Geelong bus service



V/Line V/locity trainset

Source: Railway Pro



Greater Geelong public transport context

Synergies with additional planning priorities

Strategic initiatives for sustainable development

The City of Greater Geelong aims to transform itself into a creative, innovative and carbon neutral city-region through effective planning and development strategies focussed on connected and sustainable communities. Developing a BRT or LRT corridor aligns with City of Greater Geelong planning strategies identifying a range of opportunities to transition to a low carbon future while accommodating growth and enhancing liveability. These include:

- Adoption of the Principle Bicycle Network and new cycling facilities across Greater Geelong
- Geelong Active Streets
- Adoption of the Urban Forest Strategy 2015-2025
- One Planet Living Action Plan
- A Clever and Creative Future
- Geelong Regional Alliance (G21)
- Western Alliance for Greenhouse Action
- Zero Carbon Emissions Strategy 2017-2020
- Environmental Management Strategy 2014-2017

This commitment to sustainable development has been measured against the ten principles of One Planet Living, an international sustainable initiative which provides a framework for comprehensive sustainable urban development.

Further development and implementation of policies and initiatives aligned with the One Planet Living principles led the City of Greater Geelong to become the third City in Australia to be awarded the One Planet certification.



The 10 principles of One Planet Living framework

Source: Bioregional Australia

Public transport and sustainability

Providing sustainable transport options has been identified as a key strategic commitment for the City of Greater Geelong in recognition of its contribution to multiple aspects of sustainability as described below.

Community design

The City of Geelong has developed its strategic long term vision focussed on promoting sustainable development and population growth. The community-led Clever and Creative Future for Greater Geelong will be a carbon-neutral, zero waste city-region that supports the concept of active streets by reducing vehicle trips, enabling greater flexibility in the design of neighbourhood and commercial streets.

The Clever and Creative Corridor initiative aligns with the City and local communities' goal to promote sustainable urban development and improve the overall quality of life of its inhabitants. Providing integrated transport systems is amongst the key goals endorsed by the community.

Investment in a rapid transit corridor will address the significant level of service improvement required to support the objective of reduced car dependency.

Sustainable mobility

Developing a BRT/LRT corridor will reduce the dependance on private motorised modes whilst encouraging low and zero carbon alternatives modes of transport to reduce emissions in pursuit of a carbon neutral future.

The City of Greater Geelong has been enhancing and promoting walking and cycling facilities in an effort to offer sustainable access between all parts of Greater Geelong within a journey time of 30 minutes. It is the Council's aim that 50 percent of all journeys to work within the City are undertaken by public transport, walking or cycling.



Bicycle path in Geelong

Source: City of Greater Geelong

Synergies with additional planning priorities

As Geelong's population is projected to increase significantly over the next decades, city shaping projects such as a main public transport corridor would help ensure that Geelong is a connected and accessible city-region with an integrated transport system that will support compact urban growth while promoting public and active transport.

Extensive work and consultation was undertaken in 2014 to establish the Principle Bicycle Network, a safe, accessible and connected cycling network for the communities of Greater Geelong. This has allowed for better connectivity between Geelong's CBD and its surrounding suburbs while providing alternate transport options in line with the City's long term sustainability strategies. Public transport projects represent a further opportunity to decisively shift urban development in a positive and sustainable direction.

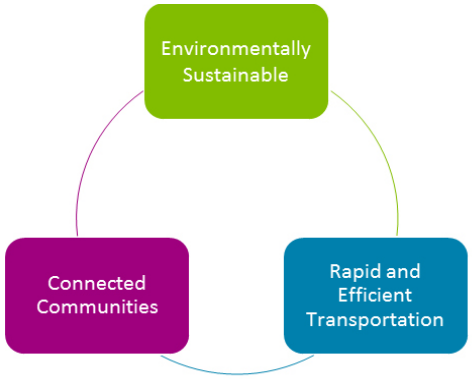


Cycling infrastructure complementing LRT

Source: Nacto

Public transport corridors can be configured to accomodate shared bicycle and walking paths with the intention of providing safe and attractive urban environments to draw pedestrians to areas with well-designed amenities. This can provide a green integrated transport network resulting in less congestion and cleaner air both locally and on a wider scale.

Moreover, a strategically located public transport corridor could also help overcome any further geographic dispersion of development by providing an alternate form of connectivity among housing, work, school, shopping and leisure destinations.



Environment and urban tree canopy

Support for a healthy environment is a key benefit of high-quality public transport. In addition to the shift towards less car dependancy, rapid transit projects can also support environmental goals by reducing the impacts of car transport. Their moderating effect on the environment are a benefit to both air quality (by limiting vehicle emissions) and ground-level greenery (by reducing the need for large roads and excessive car parking).

Through its Urban Forest Strategy and its Clever and Creative vision, the City of Greater Geelong has been working toward increasing its suburban tree canopy. Currently, Geelong's urban tree canopy cover is approximately 14 percent with plans to increase it to at least 25 percent. Tree-lined streets, urban bushland and tree cover form a green infrastructure that mitigates the urban heat island effect. It has been estimated that a 10 percent increase in tree canopy cover could reduce land surface temperature by 1.13 degrees (Greater Sydney Commission, 2017).

Implementing a BRT or LRT corridor would have a significant benefit in promoting a greener urban development pattern by increasing opportunities for widespread planting and green infrastructure. Large trees planted along the proposed corridor can provide shade and contribute to the streetscape, character and amenity of the City of Greater Geelong.

In addition, increased tree cover supports cleaner air and water as trees remove fine particules from the air and contribute to ground level permeability. Additionally, trees help insulate against noise pollution, particularly along busy urban corridors.

As Geelong continues to grow and change, urban tree canopy will become even more important to address the liveability needs of an expanding population. As such, the implementation of the green corridor option as defined in Part 3 of this report would support sustainable and liveable neighbourhoods.



Geelong's greenway revegetation project

Source: Geelong Australia

Synergies with additional planning priorities

Accessibility and Mobility

Light rail and bus rapid transit are public transportation systems that allow for faster and more efficient service than conventional bus services. They provide fast, comfortable and cost effective urban mobility through the following:

- Provision of traffic-separated right-of-way or dedicated infrastructure
- High level of service in terms of quality and frequency
- Strong brand and marketing strategy.

Promoting access and mobility are critical objectives for transport investments, as lack of access to alternative and efficient modes of transport can lead to social exclusion and impede economic opportunities by limiting connectivity with employment, services and markets.

Modern LRT and BRT systems are designed to be fully inclusive to people with mobility, sensory or cognitive disabilities. Design features supportive of this objective include wheelchair ramp access, accoustic and tactile platform features, fully accessible pathways, and low-floor vehicles.

Access to affordable housing and economic opportunities are also greatly influenced by public transport.

Implementation of the Clever and Creative Corridor would support the City of Greater Geelong's goal to make 100 percent of all public places disability access compliant. It would also improve the efficiency and reach of feeder services by integrating the corridor with existing transport networks across Greater Geelong. This would align with Council's goal to ensure access between all parts of Greater Geelong within 30 minutes through a variety of travel options.



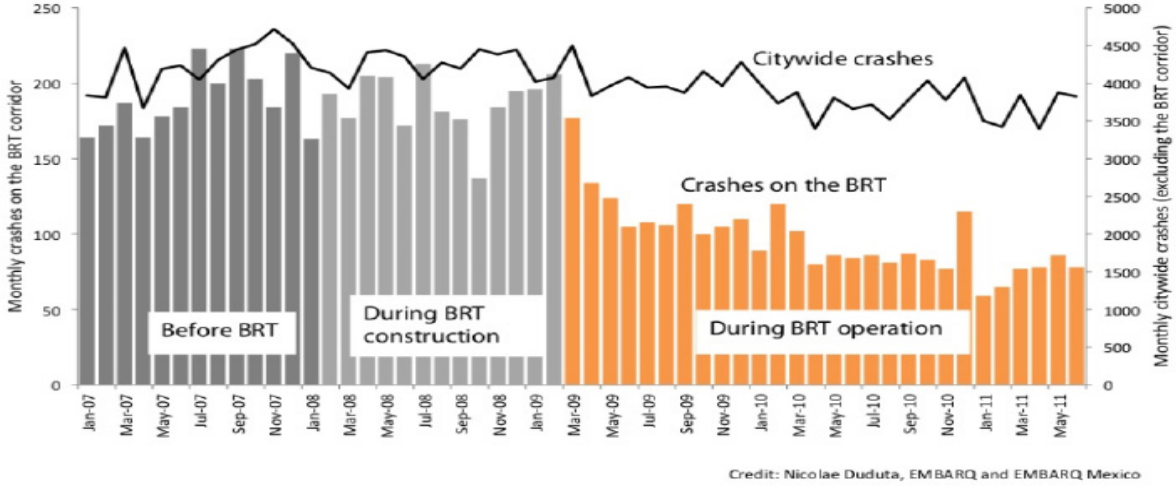
Mexico City BRT

Source: EMBARQ

Safety

The implementation of LRT and BRT corridors can often involve a significant redesign of the roads on which they travel, allowing for concurrent improvement to road conditions and overall safety. This may include the implementation of traffic calming features along the corridor to protect the typically most vulnerable groups of road users including pedestrians and cyclists.

Any reduction in car travel (or reduction in the rate of growth of car travel) resulting from the implementation of a public transport system will result in fewer accidents and increase street-level safety for local communities.



Credit: Nicolae Duduta, EMBARQ and EMBARQ Mexico

Decrease in crashes since the Guadalajara BRT corridor was implemented

Source: Nicolas Duduta/EMBARQ Mexico

BRT Case study: Eugene, Oregon

The Emerald Express (EmX) is one of the newest BRT systems in America, serving the Eugene-Springfield region of Oregon in the environmentally sensitive Pacific Northwest. Operating in a city with a population of 156,000 and an extended metro area of 245,000 (2017 census) the EmX launched in 2007 and has experienced high ridership along its pilot Green Line. It is estimated that approximitely 10,000 riders use this service daily (BRT Data 2018).

Over the past couple decades, the city of Eugene and its community has been very active in their efforts to promote sustainable development. Sustainability goals are included in several overarching community plans identifying planning and design priorities, with a focus on the development of sustainable and smart communities while addressing economic, environmental and social issues.

A BRT system for sustainable growth

Planning for the BRT route started in 1996 as a way to use public transport to provide more efficient connections within urbanised neighbourhoods. The BRT option was selected over light rail in 2001 due to the area's modest population.

Eugene's BRT system is representative of emerging rapid transit design. The EmX design was guided by a focus on community integration and concern for the environment. As such the operator consulted arborists, urban foresters, landscapers and other environmental specialists during each phase of the project.

The BRT corridor was also designed to highlight Eugene's natural beauty and history.

The City also worked closely with local cycling groups and people with disabilities to design a BRT corridor with optimal accessibility for everyone (FTA, 2012) .



Public art adjacent to a station
Source: FTA

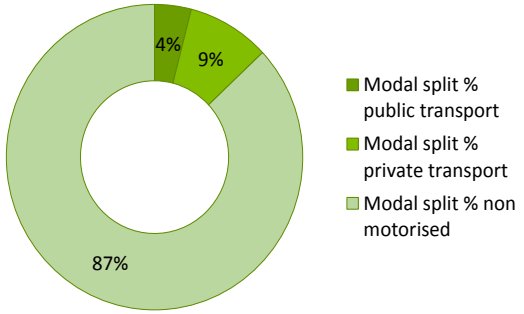
Indicator	Value
Passengers per day	10,000
Population	156,185
Annual demand (passengers per year)	3,000,000
Total length corridor (km)	19
Corridors	2
Stations	24
Station spacing (m)	787
System start year	2007
Population density (p/skm)	29
Citywide fare integration	Yes
Peak load (buses per hour)	6
Real-time information	Yes



Eugene BRT vehicles showing dual-sided doors
Source: BRT Data 2018



Level accessible boarding
Source: Berkeley-Charleston-Dorchester Council of Governments



Key Eugene statistics
Source: BRT Data 2018

BRT Case study: Eugene, Oregon

Eugene's BRT, a successful inclusive public transport strategy

Construction started in 2004 with the first EmX service commencing in 2007. Over 12 kilometres were subsequently added to the corridor and opened as the Gateway extension in 2011.

Sixty percent of the route is served by dedicated bus lanes separated by curbs and clearly demarcated travel lanes. EmX vehicles are also provided signal priority along the entirety of the route (BRT Data 2018).

BRT vehicles are custom-built and include doors on both sides to provide optimal service to a variety of platform and kerb stop configurations.

Eugene's BRT system integrates several important elements that distinguish BRT from traditional bus routes such as exclusive running ways, fully accessible stations, integrated fare collection, Intelligent Transportation Systems, and strong branding elements.

Since its inception, the corridor ridership has already surpassed its initial 20-year projection with a sharp uptake within the first 17 months of service (GAO, 2012).

Eugene's BRT was recognised by the Institute for Transportation and Development Policy (ITDP) for its world-class passenger experience, its positive environmental impacts, and its significant economic benefit.

As a mid-size city which has experienced strong population growth since the 1990s, Eugene's BRT system was conceived in support of the following goals:

- Containing urban sprawl
- Encouraging economic growth in the city centre and along the BRT route
- Reducing the dependance on private motorised vehicles.

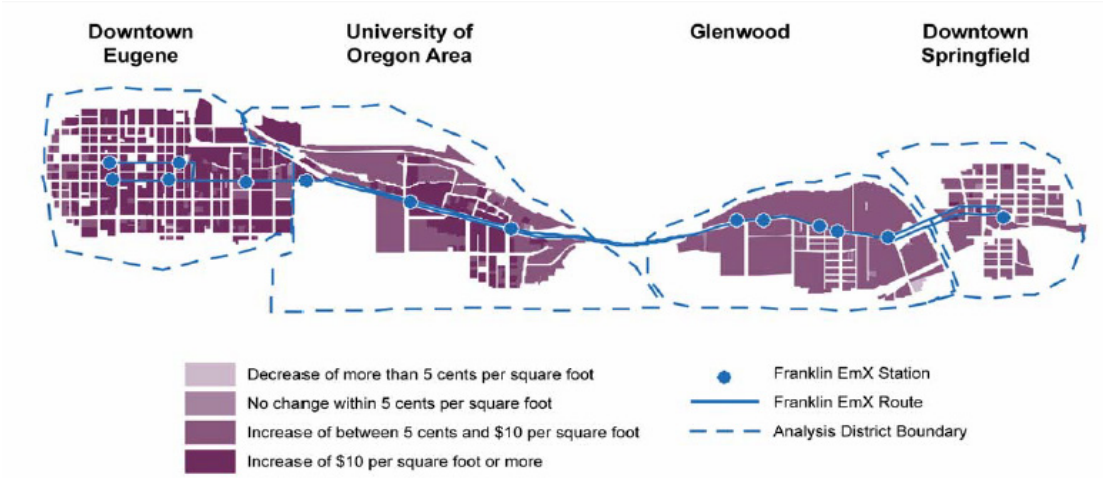
The majority of the operating costs are funded through local payroll taxes, which has been regarded as contributing to strong connections between Eugene's business community and the BRT service.

Studies have shown that between 2004 and 2010 there was a 10 per cent average increase in jobs within 0.25 miles of a BRT station and a general increase in residential land value for properties proximate to a BRT line (GAO, 2012).



Eugene BRT on approach to a station

Source: BRT Data 2018



Land value changes near Eugene/Springfield, 2005 to 2010

Source: GAO 2012

BRT Case study: Amsterdam

Accessibility is a key factor in the development of cities.

Coordinating spatial growth as cities expand with investment in transport infrastructure is essential to optimising sustainability and creating economic opportunities.

Towns and cities throughout the Netherlands illustrate very well the shift in global urban planning toward Transit Oriented Development as a comprehensive and integrated approach to sustainable urbanisation.

This approach has supported a 1992 Amsterdam referendum to implement strong car restrictions and pro-bike policies (Pojani and al. 2014).

The public transport corridors that have been developed in response to this shift have now become some of the most successful examples of integrated BRT and LRT in the world.

R-net (Zuidtangent), Amsterdam: This well utilised Bus Rapid Transit service runs between Harleem, Nieuw-Vennep, and Amsterdam in the Netherlands, also serving Schiphol Airport.

The Zuidtangent service was established in 2002 before being renamed R-net when it became part of the eponymous regional service in 2011.



R-net Zuidtangent BRT

Source: BRT Data

The R-net Zuidtangent BRT network runs along exclusive dedicated bus lanes with viaducts and tunnels at major intersections. This design minimises the impacts of road traffic while also establishing infrastructure suited to a possible future conversion to tram or light rail operation.

The service is operated with 18-metre long single-articulated buses which comply with all the benchmarks of high quality BRT service and clean emission standards. Since 2018, 100 electric articulated buses have been introduced. These vehicles have the latest battery technology and their operational availability has been optimised through a rapid charging concept (VDL, 2018).

Since its opening, the Zuidtangent has experienced a spectacular ridership growth thanks to improved services and carefully targeted marketing campaigns. In 2007 more than 33,000 passengers per day used the two corridors, a jump of approximately 15 percent over the previous year (Ministry of Transport, Public Works and Water Management, 2010). By 2011, over 40,000 passengers per day were using the system (BRT Data, 2018).

The transport value now appears to be high enough to convert part of the BRT corridor to a light rail line to provide additional capacity for continued passenger growth, highlighting the design interchangeability of these two technologies.



Segregated busway on the Zuidtangent system

Source: Transportxtra.com



BRT station on the R-net Zuidtangent network

Source: Transportxtra.com

LRT Case study: Rotterdam

Overview

The RandstadRail network located in the southern part of the Randstad, the western conurbation of the Netherlands, consists of a light rail line between The Hague and Rotterdam and two hybrid tram-train lines between The Hague and Zoetermeer.

The network mainly uses old railways and tramways, with a new viaduct in The Hague and a new tunnel under construction in Rotterdam.

Development of the system took place over 15 years as The Hague and Rotterdam were expanding with new neighbourhoods and centres during the 1990s and early 2000s.

RandstadRail is now essential to the structuring of urban development in Rotterdam, as metropolitan densification has led to effective use of transit-oriented development by municipalities along the system.

Within its service area, it is estimated that 40 percent of new spatial allocations to land development have occured within the walking and cycling catchments of public transport stops in anticipation of intense urbanisation (Schouwenaars, 2014).

A major example of TOD spatial planning is the newly built city of Zoetermeer. Within this city, rail links connect almost all neighboorhoods with multiple train stations.

This new regional public transport system has enhanced service reliability and efficiency through increased travel speeds and higher frequencies than its predecessor bus and rail networks. The tram components include a high percentage of segregated lanes, exclusive right of way, and priority at traffic lights (BRT Data, 2018).

The city of Rotterdam has also been purchasing electricity from a company that produces 100 percent renewable energy, aligning with the city's goal to achieve a 50 percent reduction in vehicle generated emissions by 2025 (Rotterdam Climate Initiative, 2018).



Proposed Lansingerland-Zoetermeer Station, future hub and terminus of RandstadRail 4

Source: Arcadis/Van der Bilj and al. 2018



RandstadRail LRT on a dedicated corridor

Source: BRT Data



RandstadRail Bus near Berkel en Rodenrijs

Source: Google Image - Michiel1972



Tram stop at Rotterdam's Central Station

Source: Claire Droppert/Huffington Post



RandstadRail on an elevated structure

Source: De Hook Consultancy

Innovation and co-location of services

Integrated water management

Integrated rainwater harvesting and management has been used in many cities across the world to help manage growing water scarcity, climate change and rapid urbanisation.

Rainwater harvesting and management can greatly reduce water consumption while providing an alternate source of drinking water and alleviating stormwater runoff.

As the City of Greater Geelong aims to become a carbon neutral city-region, the long-term benefits of integrated rainwater harvesting and management align with its exisiting strategies for sustainability. It also represents an opportunity to reinforce Geelong's current water conservation efforts. The following cities have implemented integrated rainwater harvesting and management in conjunction with upgrades to their public transport networks.

Mernda Rail Project, Victoria, Australia

Many aspects of this project have incorporated sustainability to reduce the impact on the environment.

Amongst its component design initiatives, Water Sensitive Urban Design (WSUD) will be implemented to filter rainwater at its station sites allowing for the removal of pollutants from roads and carparks before it enters the local drains.

Rainwater will also be harvested for operation of station toilets and for washing of station platforms.

During the construction process, rainwater will be captured by capture dams that will be installed along the corridor for dust suppression.

Hyderabad Metro, India

The city of Hyderabad is constructing dual-purpose rainwater harvesting structures as a response to the rising concern for India's shortage of groundwater supply, while also addressing frequent road flooding.

Three hundred harvesting structures will be constructed, each of which can store 5,000 litres of water. One hundred of these will be innovative rainwater harvesting structures with injection borewells to help recharge the fast-depleting water table in the city.

This harvesting system will be implemented across the city's entire metro network. Moreover, improvement of storm water drains and construction of new ones will be simultaneously undertaken on a wide scale across the whole transport network.

In addition, the public transport operator will be harvesting solar and wind energy in a bid to acquire one-third of its total energy requirements from renewable sources.

Solar rooftop structures are currently planned for four metro stations. A total of 100 acres of open areas across the corridor are also being equipped with solar units. The panels will be installed based on the Resco model where private firms/stakeholders invest in the equipment and supply power at a fixed cost.



Solar panels at Hyderabad Deccan Station

Source: Railwaypro.com

Innovation and co-location of services

Namma Metro, Bengaluru, India

The innovative design for this metro network in Bengaluru includes rainwater harvesting from many of the viaducts on the rail system. The operator, Karnataka Rural Infrastructure Development (KRIDL), is in charge of collecting water at multiple points across the rail system, which is then treated and sold by KRIDL in bulk as potable water.

Each metro viaduct pillar has pipes that allow the rainwater to be carried from the viaduct down to underground tanks located beneath the median of the roadway. Two 5 metre deep rainwater harvesting pits have been installed between each pillar to collect the water.

In 2017, approximately 33 kilometres of the elevated metro were included in the rainwater harvesting system, with an expected capture of 80,000,000 litres annually.

Water will also be harvested at the system's main depot, which has a roof designed to filter water to two tanks with a capacity of 50,000 litres each.

The water harvested will be used where needed and any excess will be used for groundwater recharge. Some of the collected rainwater is also planned to be used to rejuvenate Kengeri and Veerasandra lakes.

Vertical gardens

Additionally, Hydrobloom shydroponic plants are grown on the pillars of the Namma Metro, for the purposes of beautification and reduction of air pollution. These are locally referred to as vertical gardens.

Each vertical garden can include approximately 3,500 saplings on a single vertical pier. The chosen saplings can reportedly reduce the local prevalence of noxious gases by up to 80 percent.

The positive reaction to the first pillar to accommodate this experiment in Bengaluru has led to the approval of the implementation of this concept on each of the 275 piers on the elevated corridor.

The implementation of vertical gardens on metro pillars to reduce pollution was first introduced in Mexico City in 2016. The program, Via Verde, aims to convert at least 1,000 highway pillars into vertical gardens to help absorb pollution and smog.



Bengaluru Metro prior to greening

Source: IndiaTimes, 2018



Bengaluru vertical garden

Source: IndiaTimes, 2018



Bengaluru vertical garden

Source: IndiaTimes, 2018



Mexico City vertical gardens

Source: The Civil Engineer.org, 2018

Environmental and social benefit

Transit modes such as light rail are considered not only efficient but socio-environmentally friendly as they can blend into existing established urban landscape easily with minimal disturbance.

Benefits with respect to the local atmospheric and social environment include the following:

Reduction of greenhouse gas (GHG) emissions and local air pollution: Public transport is generally conducive to decreasing the overall atmospheric pollution caused by privately owned vehicles. With their higher carrying capacity, BRT and LRT each allow for reduced Vehicle Kilometres Travelled (VKT), thus reducing the GHG emissions that contribute to global climate change, as well as local air pollutants which commonly lead to smog and respiratory issues.

For example, in Bogota Colombia the implementation of the TransMilenio BRT system was reinforced with new regulations on fuel quality, together reducing carbon dioxide emissions by an estimated one million tonnes per year since its opening. (Turner et al., 2012)

The city of Calgary now boasts the first LRT network powered exclusively by electricity generated from wind power.

Reduction of noise pollution: Modern light rail vehicles are designed to be relatively quiet (less than 65 dBA) which make them less noisy than conventional buses, with tracks that are designed to absorb shocks and vibrations during the operation of vehicles.

The noise emission profile of many BRT systems has also been reduced through the advancement of non-diesel propulsion options that minimise the weight of the vehicles by decreasing the need for on-board fuel storage.

Additional design options could also help further reduce noise emissions. For example, the selective use of a partially grass bed for the running way can help absorb engine noise by up to 40 percent (ITDP, 2013).



Green BRT treatment, Nantes

Source: IDTP, 2013

Public health benefits: Public health benefits of public transport can be classified into several key categories:

• *Road safety improvement:* High quality rapid transit enables a decrease in the number of trips taken and distances travelled in privately owned cars, thus moderating the highest risk factors influencing the number of road crashes and fatalities. It has been estimated that Latin American BRT systems have contributed to an overall reduction in injuries and fatalities of over 40 percent on the roads where they have been implemented. (Bocarejo et al, 2012)

Segregation of public transport from vehicle lanes — as is typically the case with LRT and BRT — further helps to limit the potential for the public transport vehicles themselves to be involved in road crashes. Moreover, technological improvements such as optical and magnetic guidance systems further improve the road safety aspects of public transport by limiting the potential for incidents related to driver error.

• *Increased physical activity:* Due to its synergies with walking and cycling, public transport contributes to an overall increase in the average daily active movement of its users. In Beijing it has been estimated that BRT passengers walk an additional 8.5 minutes per day than motorists.

Social benefits: Integrated transport systems encourage interaction between communities and commonly attract investment and skilled workers along their proposed routes.

A study of travel behaviour and resident attitudes in Salt Lake City, Utah identifies light rail commuters as healthier than typical drivers, pointing to increased walking habits, lower car use, decreased obesity prevalence, and better neighbourhood satisfaction as the main socio-environmental benefits from transit-oriented development for local residents. (Brown et al., 2009)



Naturalised community space, London

Source: Behance/Hargreaves Associates

Minimisation of car infrastructure

Traffic

Based on the preliminary traffic projections for the Northern and Western Geelong Growth Areas — which did not anticipate the introduction of a high-capacity public transport corridor as is postulated in this report — many of the roads and intersections in the areas surrounding the NWGGAs could become significantly congested as the two areas are built out. While these could be addressed through road-based design solutions, there would be several significant drawbacks of doing so:

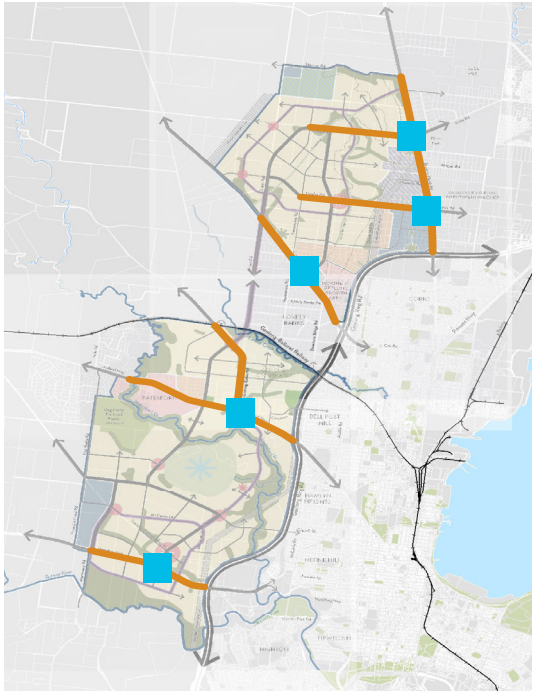
- There would be considerable design implications resulting from the expansion of intersections and corridors, including the potential discouraging of walking and cycling by detracting from the safety and comfort of these types of movements. This in turn could lead to car-centric suburban design patterns that could lead to further decreases in the propensity to use active transport.
- These types of solutions are often temporary in nature, as they do not address the underlying movement paradigm that leads to continual increases in vehicle kilometres travelled. As such, further road expansions could continue to define the area into the future.

Anticipated areas of external traffic bottlenecks

Preliminary traffic projections upon buildout of the growth areas show that peak traffic flows between the Northern and Western Growth Areas and central Geelong could amount to approximately 7,000 and 8,000 vehicles per hour, respectively. Peak-hour travel between the two growth areas and Melbourne could combine for a further 8,000 vehicles.

Without a higher-order form of public transport supporting these major travel desire lines, the accommodation of this magnitude of traffic volumes will require either significant road expansion – which may prove counterproductive to other stated sustainability and active transport goals for the growth areas – or result in traffic bottlenecks at critical locations particularly around the periphery of the sites.

Specific areas of concern would be the entrances to the growth areas on Midland Highway, Hamilton Highway, Anakie Road and Bacchus Marsh Road, each of which would need to carry high levels of right-turning traffic in either the AM or PM peak periods for outbound or inbound traffic, respectively.



Roads and intersections projected to require significant expansion with a car-focussed approach to access and circulation

Accommodation of these flows through the road network would potentially require dual right-turn lanes at each of these critical locations, which would necessitate expanded intersections and longer signal cycle times, both of which are commonly considered as hindrances to walking and cycling activity.

Providing an LRT or BRT service that supports these trips patterns at even modest service headways of 8 to 10 minutes could provide the capacity needed to reduce the vehicle burden on each of these key directional movements by approximately 1,000 to 1,500 vehicles per hour depending on vehicle size.

More aggressive headways of 4 to 5 minutes – together with a reliable high-quality service offering successful in attracting riders – could provide enough capacity to reduce critical hourly traffic flows by 2,000 to 3,000 vehicles, thoroughly changing the anticipated long-term nature of the road corridors serving the sites in favour of a form more consistent with broader transport and environmental objectives.

Minimisation of car infrastructure

Parking

While the dedication of corridor space throughout the two growth areas could amount to significant total land area, it should be noted that this would be partially offset by the lesser need for setting aside significant amounts of land for parking.

In comparison among the two, the setting aside of land for parking has little side benefit to the community — and could be interpreted as a significant visual intrusion — whereas the setting aside of the Clever & Creative Corridor would have the following additional value:

- Provision of a continous green strip through the lengths of the growth areas and beyond
- Use as a wildlife corridor
- Support for pedestrian and cycling connectivity.

As each car parking space requires a total surface area of approximately 12 to 15 square metres (including access allowances) the cumulative land impact of the potential increased car traffic to central Geelong and Melbourne (via local park-and-ride stations) is significant.

For Geelong, the projected combined additional peak traffic volume of 15,000 vehicles could require 200,000 additional square metres of space devoted to parking in and around the central area. Although the footprint required to accommodate this could be reduced by providing these spaces in expanded or new parking decks, this approach entails significant additional cost and does not address the traffic access issues that would be intrinsic to this magnitude of additional car traffic.

Similarly, if the projected 8,000 peak trips destined for Melbourne were to be accommodated at local train stations (given similar challenges to parking in Melbourne's CBD) another 100,000 square metres of parking space could be required at Lara, Corio, and/or a new station near the Ring Road. Land constraints at Lara would almost certainly require a parking deck to accommodate this level of increase, which may be deemed out of character with its positioning within a neighbourhood centre.

Any significant attractors within the growth areas themselves would face similar challenges if a significant portion of arrivals could not be accommodated through means other than driving.



Traffic congestion on Torquay Road

Source: Geelong Advertiser



Bus on freeway shoulder in Ottawa, Canada

Source: McCormick Rankin Corp

Urban design implications

The setting aside of the Clever and Creative Corridor can serve as a framework to which land use and urban design decisions can be correlated. Specifically, the potential for future high-capacity public transport would suggest that mixed, higher-intensity uses should be focussed along these spines, offering the potential to support future growth without requiring an excess of conventional traffic or parking infrastructure.

From an urban design perspective, the Clever and Creative Corridor would support the organisation of all developable lands within the growth areas to a pedestrian rather than car-focussed standard. While this would have little benefit in the absence of a future high-capacity public transport option beyond local circulation (for shop access etc.) with the LRT or BRT option the pedestrian-focussed orientation of the growth areas could result in the most sustainable possible travel option for local, City, regional and even long-distance circulation given the potential interconnectivity with Victoria's public transport framework.



Vibrant community space, Geelong

Source: A Clever and Creative Future





Before/after with contrasting design outcomes, Sacramento

Source: landscapeonline.com



Biking in Geelong

Source: Cycling Geelong



Local species landscaped elements in Sacramento

Source: landscapeonline.com

Part 2 - Location of the corridor

The purpose of this task is to identify the optimal location for the public transport corridor, both within the road reservation and with respect to its strategic alignment through the Northern and Western Geelong Growth Areas.

Strategically, the discussion of optimal route alignment includes consideration of its possible integration with other long-range public transport initiatives in Greater Geelong.

With respect to road alignment, this chapter identifies which of the corridor design variations may be best suited to various segments of the proposed routes.

This section is organised according to the following sub-topics:

- Review of the Northern and Western Geelong Growth Areas strategic framework, including the relationship between the Clever and Creative Corridor and proposed primary cycling routes
- Review of the wider public transport planning context in Greater Geelong
- Identification of potential route permutations and connection points of a future high-priority public transport service
- Identification of specific corridor arrangements along the preferred primary public transport corrridor alignment
- Discussion of potential station locations



Clever and Creative Corridor location

Source: Google Earth

Growth area design framework

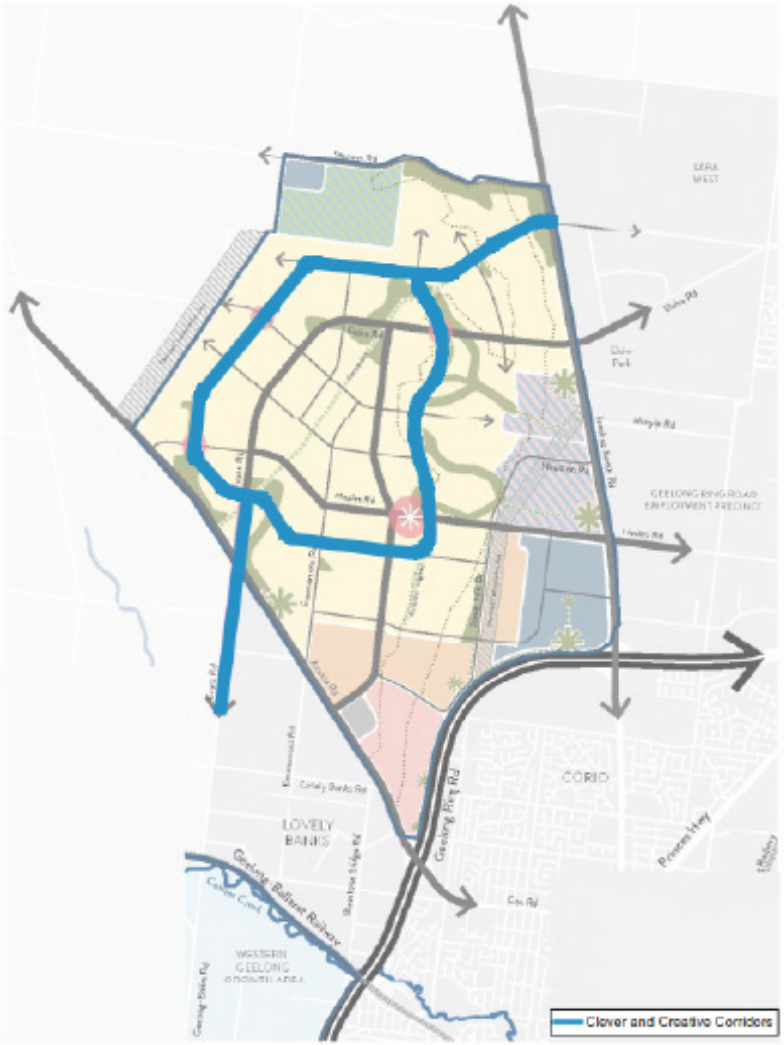
The preliminary framework plan for the Northern and Western Geelong Growth Areas show the Clever and Creative Corridor concept applied to varying locations throughout the two precincts. These are generally co-located with roads but separate from the primary traffic corridors. In some locations they overlap with the proposed primary cycling/open space corridors, while in others they follow separate alignments.

In most locations the proposed corridor is framed by development of residential or commercial property on each side — suggesting a median public transport corridor alignment to best manage turning conflicts — yet in some areas a limited number of cross-connections may support the use of a side alignment.

In several locations the Clever and Creative Corridor is proposed to split into a 'loop' configuration as shown in the accompanying figures.



Western Geelong Growth Area framework plan



Northern Geelong Growth Area framework plan

Public transport context

Bus network

Greater Geelong is currently served by a network of conventional bus routes emanating from central Geelong, operating on streets in mixed traffic at modest frequencies.

In the short term, it is envisioned that extension of several of these routes could support the initial development stages of the two growth areas. However — given their distances from central Geelong — it is anticipated that a higher order of public transport service will be required in the longer term to offer a competitive option to driving, therefore supporting the goal of sustainable transport.

Rail connections

Greater Geelong is also served by a V/Line corridor stetching from Melbourne to Waurn Ponds, with some services continuing southward (at far lower frequencies) to Warrnambool.

In addition, there is a planned high-capacity public transport corridor proposed to run from Marshall Station to Torquay via the rapidly growing area of Armstrong Creek. While the current stated preference is for heavy rail, LRT and BRT options have also been considered.

Finally, the Western Rail Corridor — which formerly carried both passenger and freight services — passes between the two growth areas, splitting from the main north-south rail line at North Geelong.

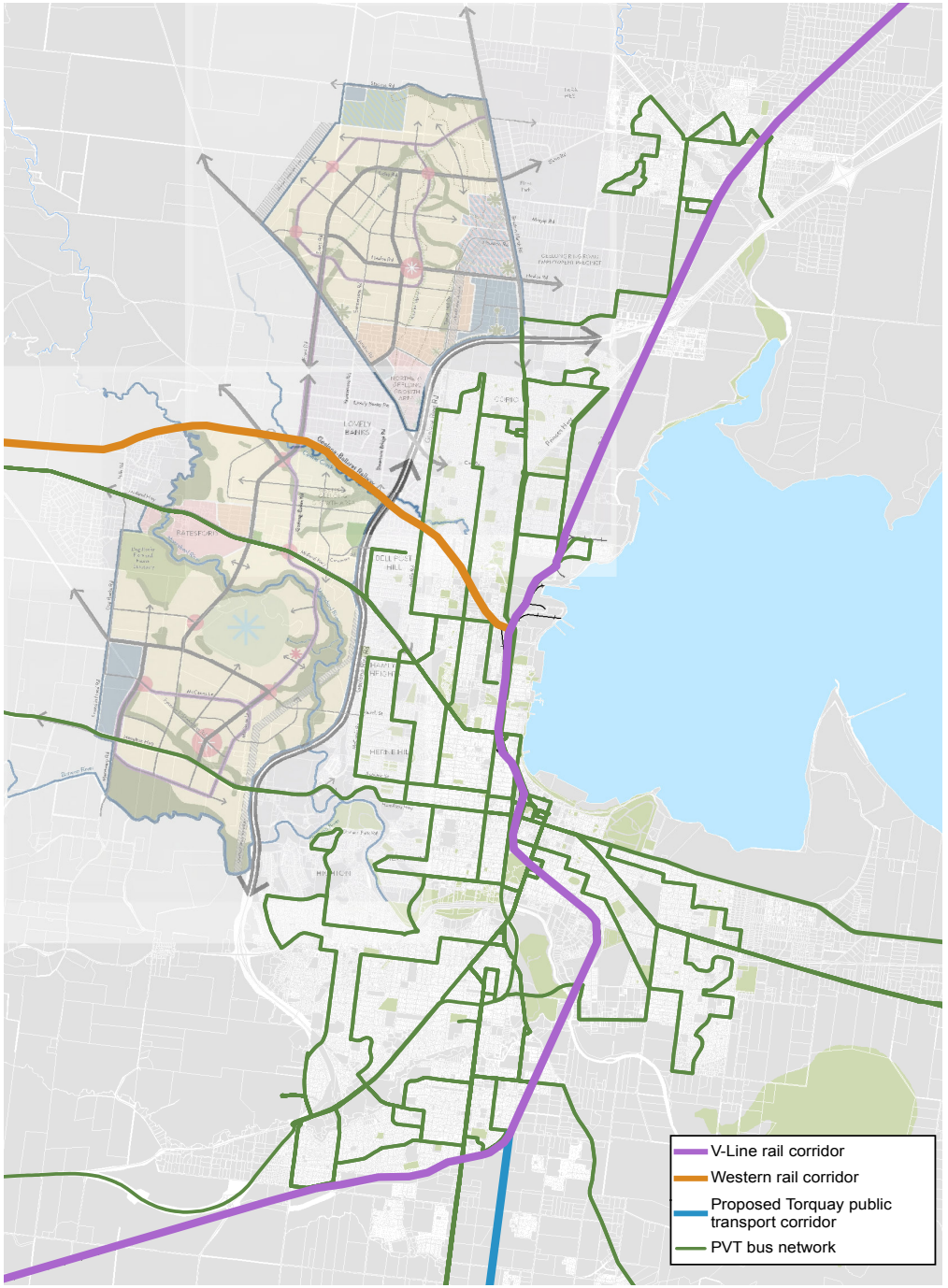


PTV Geelong bus service



V/Line V/locity trainset

Source: Railway Pro



Greater Geelong public transport context

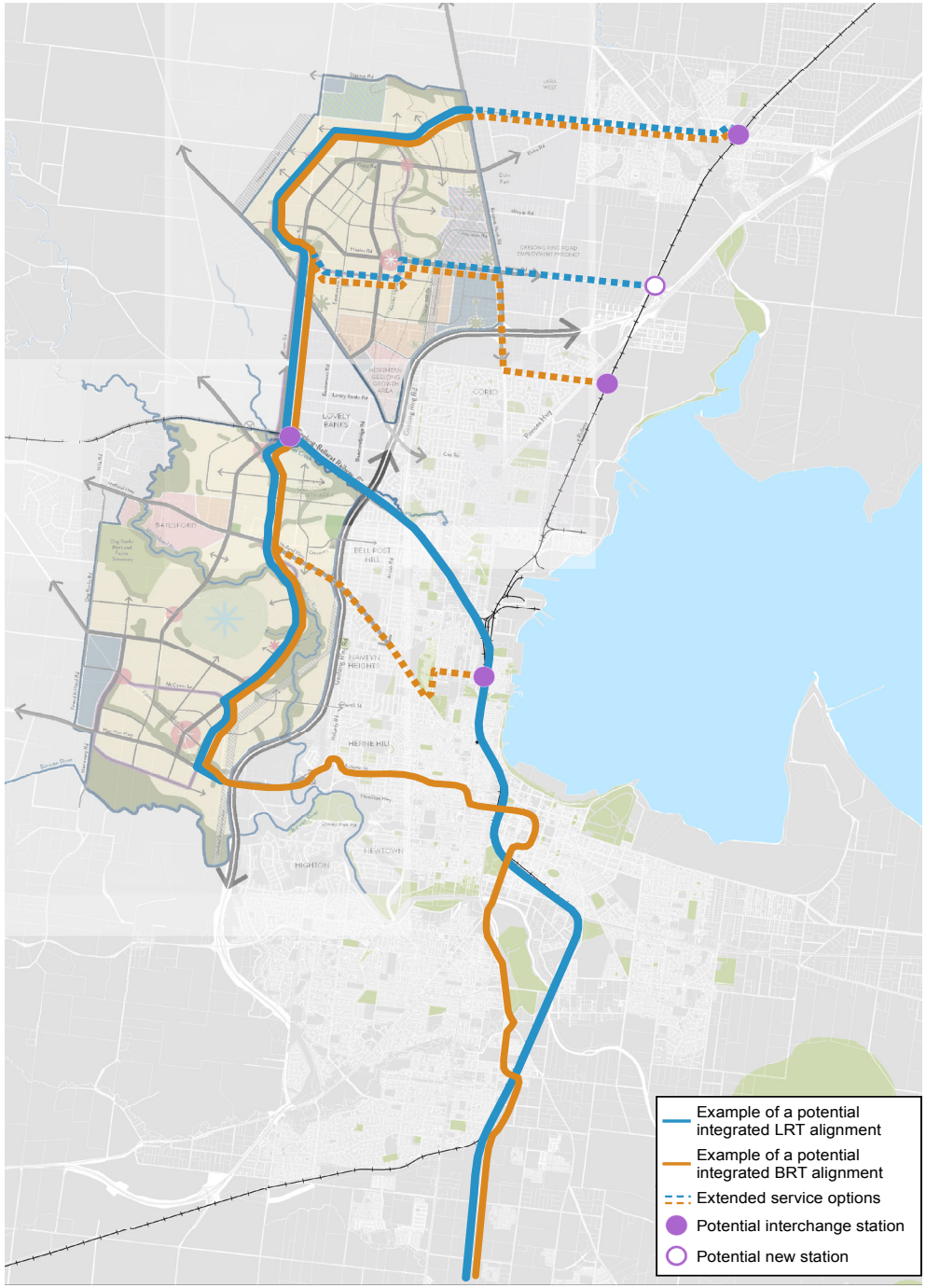
Public transport context

To maximise the utility of future traffic-separated public transport routes through the Northern and Western Geelong Growth Areas, it is critical to examine options for interconnecting them with key destinations or transfer points, including:

- **Central Geelong:** With an expected increase in employment and commercial activity in central Geelong coupled with the population growth in the Northern and Western precincts, it may be optimal to create an unbroken traffic-free public transport connection to the CBD to maximise potential attraction of riders. Use of on-road bus lanes or the Western Rail Corridor could be considered.
- **Melbourne:** Given proposed upgrades on the Geelong to Melbourne V/Line rail service -- potentially including electricification and higher-speed rolling stock -- the provision of convenient connections with the Clever and Creative Corridor could further support public transport use for new residents while decreasing road and parking pressures on main line railway stations.
- **Armstrong Creek:** From an operational, stabling, and fleet acquisition perspective, it may be beneficial to consider the integration of the Northern and Western Geelong Growth Areas and Armstrong Creek routes into a consolidated Geelong system using a common technology.

The accompanying diagram shows prospective LRT and BRT configurations that could help optimise regional connectivity. In response to both the local and regional planning and operational contexts, the initial recommendations for the organisation of the Clever and Creative Corridor include:

- **Designation of a primary public transport alignment:** For the purposes of offering a consistent and efficient future public transport service, a primary route alignment should be selected through each growth area. That indicated at right represents the most efficient routing pattern in the absence of greater detail about the mix, density and distribution of uses throughout the growth areas.
- **Secondary routes:** If warranted, the 'alternate' routes shown in the maps could also be used as part of the high-priority public transport corridor if the development program is uniform enough to justify the 'splitting' of the trunk corridor in these locations. Otherwise they can be used for alternate purposes, or retained in their short-term passive state.
- **Two-way service:** The implementation of a one-way loop operation in not recommended due to long walking distances that would be incurred for travel in one direction or the other.



Potential integration with other key corridors

Public transport context

External connections

The provision of external 'extensions' of the future public transport service would be subject to operation on public roads, which would not necessarily afford the ideal outcome of full separation from traffic. In these cases — particularly with respect to connections to Lara or Corio rail stations — the implementation of other potential bus priority measures such as bus lanes, dynamic signal prioritisation, and queue-jump lanes should be explored to maintain a suitable level of reliability beyond the extent of the Clever and Creative Corridor.

For direct access into central Geelong, potential use of the western rail corridor would have an advantage over the on-road options (given the constrained nature of most of the radial road corridors) in that it could potentially support the continuation of a traffic-separated run into the city. This could take the form of either a trunk route for the Clever and Creative Corridor services that could split off into the two growth areas, or a separate independent service running further westward along the rail corridor with which the Clever and Creative Corridor would intersect via a main interchange station.

Site grades

Grades throughout the sites of the Northern and Western Geelong Growth Areas may influence the ultimate choice of technology for the public transport service, depending on the final alignment of the corridor. In general, buses and shorter trams are more capable of negotiating steep grades than heavier longer trams. Electric buses in particular have the ability to perform well on steep grades due to their relatively light weight (as on-board fuel storage is not required) and the high coefficient of friction of their treaded rubber wheel surfaces (in comparison with the steel-on-steel of typical trams). Additionally, the extended time frame of implementation for the proposed public transport corridor will likely result in further technological or tailored design solutions for negotiating steep grades that may be applicable to portions of the Clever and Creative Corridor as required.

The Ballarat Line

The future public transport service could be very effectively integrated with any future reinstatement of longer-distance commuter or intercity rail service on the Ballarat corridor, presumably via a major interchange station that would allow LRT or BRT passengers to seamlessly transfer between lines at the periphery of the Western Geelong Growth Area. Depending on the chosen technology it is also possible that this corridor – at least its innermost section toward Geelong – could be shared by both local and regional services.



Geelong central train station

Bus configuration

If BRT is chosen as the optimal technology for the corridor, the characteristics of the vehicles may impact some specific elements of the corridor alignment. In particular, the sides of the bus on which the doors are set may limit either the typologies of the stations that can be used (see Part 3) or restrict the flexibility for the buses to operate outside the corridor in a typical kerb-side traffic condition.

Although the option of acquiring BRT vehicles with dual-side doors appears to be the most flexible option, several drawbacks of this configuration would need to be considered:

- Having doors on both sides of the vehicles detracts from their structural stability, requiring additional reinforcement in the main chassis which can significantly raise the cost of the buses.
- The presence of doors on both sides would limit the seating configuration options, and in most cases reduce the numbers of seated passengers that could otherwise be accommodated within the vehicles.

Corridor arrangements

The recommended road alignment configurations and reservation widths are indicated on the accompanying diagram for each corridor segment. These generally consist of a 14-metre median reserve for the public transport corridor including landscaped strips on each side. See Part 3 for further discussion on required corridor width.

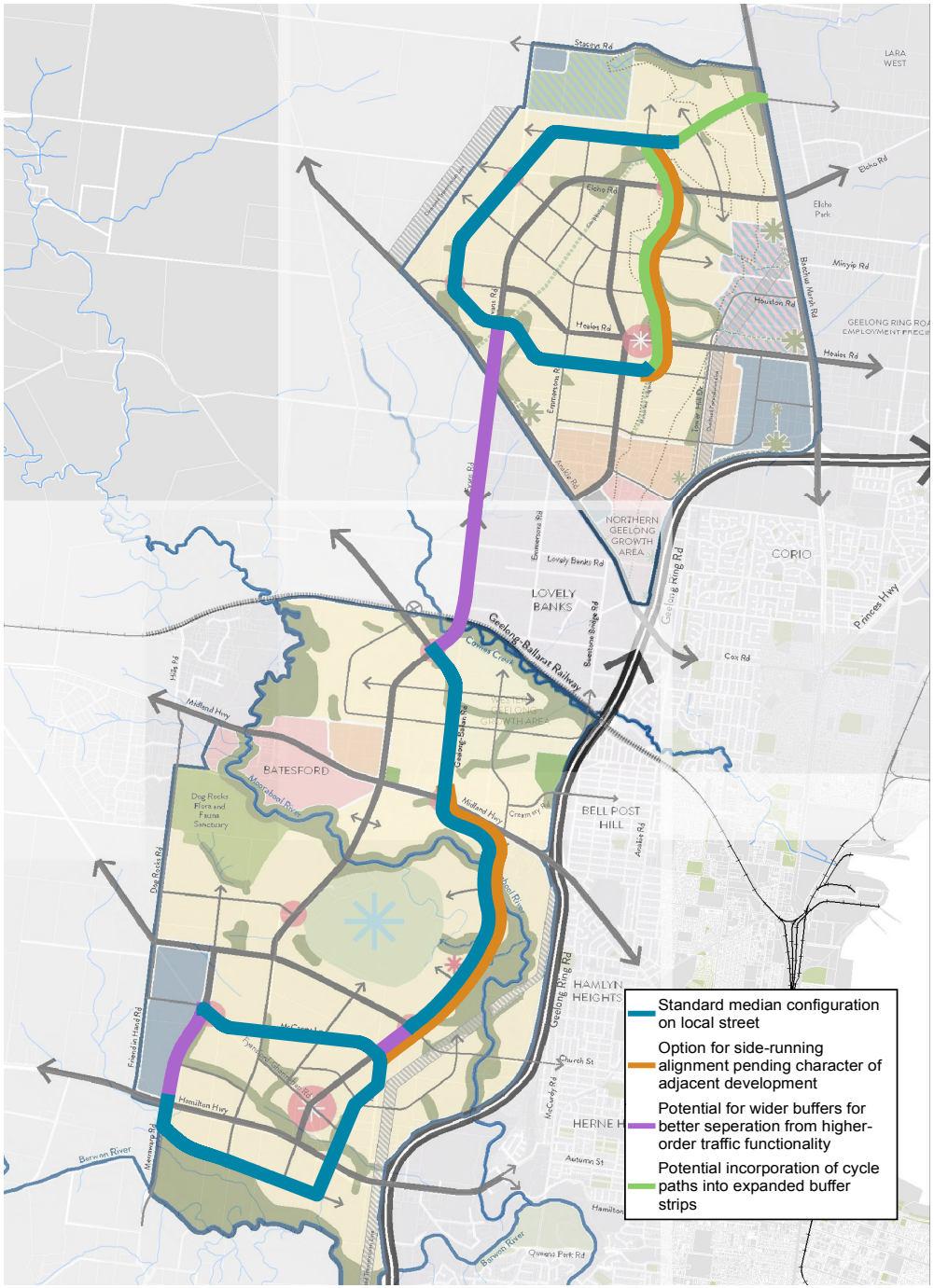
The key potential variation may be the inclusion of cycle paths within or adjacent to the landscaped buffer strips in areas with few traffic conflicts. This would be best suited to any corridors where longer-distance through-movement (either for commuting or recreation) would be expected to be of greater importance than local cycle access to adjacent shops and housing. In these cases the preferable width would be 2 metres for a one-way path on each landscaped strip, or 3.5 metres for a consolidated two-way path on one strip or the other. This would entail the addition of up to a further 4 metres to the total preferred corridor reservation width, for a total of 18 metres in these locations.

Side-running alignments

Two-way side-running alignments may be applicable to some sections with one-sided development and limited cross-connections. A side running alignment may be applicable to any sections of the corridor that border an extended green space or undeveloped area.

Secondary routes and their potential

Due to the uncertainty around which arcs of each of the two 'loops' in the Northern and Western Geelong Growth Areas would carry the primary versus secondary public transport routes, the recommended reservation widths would be the same for each (14 metres) in the immediate term. If, however, in the near or medium terms the development programs for the two growth areas have been clearly established, it may be possible to identify the primary versus secondary routes and allow the reservations for the latter to be converted to alternate purposes. This however would be dependent on the secondary routes no longer being anticipated to require traffic-separated public transport due to lower development intensities.



Corridor arrangement options

Station locations

As will be discussed in Part 3 of this report, the identification of specific station locations may not be strictly necessary in the short term given the flexible nature of the proposed design template for the corridor, as the stations would not require any additional width beyond the base 14 metres.

However, it is useful to establish the general parameters of potential stations for planning purposes.

- **Spacing:** Typical station spacing for both LRT and BRT systems range from 500 metres to 1500 metres, although there is considerable flexibility for both based on density of activity.
- **Location:** Stations are generally best placed where there is a mix of activities to maximise their use and support two-way (i.e. origin and destination) travel patterns.
- **Access:** All platforms should have at least one clear access path across the encompassing street. It is preferred that longer platforms have a marked crossing (signal-controlled, stop-controlled, or give-way) on each end of the platform, as is typical of most modern tram superstops in Melbourne.

The accompanying diagram shows indicative potential priority station locations based on the expected distribution of uses across the Northern and Western Geelong Growth Areas.



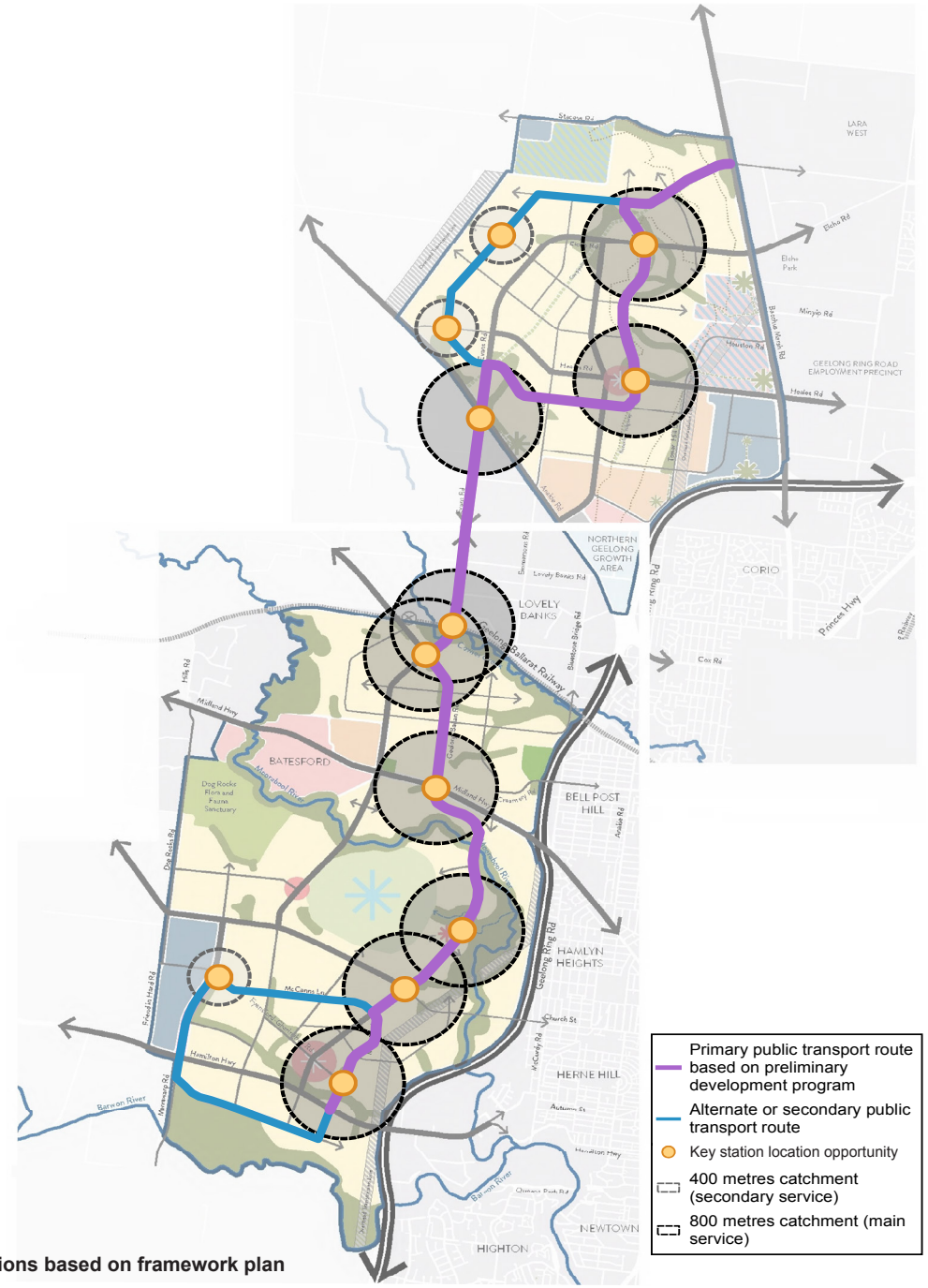
BRT station in Mexico City

Source: EMBARQ



BRT station in Los Angeles

Source: APTA



Preliminary station locations based on framework plan

Part 3 - Definition of the corridor

The purpose of this task is to identify the physical requirements of potential future public transport corridor through the Northern and Western Geelong Growth Areas, based on a range of potentially applicable technologies including Light Rail Transit (LRT) and Bus Rapid Transit (BRT). This has entailed a review of the basic dimensional requirements for the corridor — based on vehicle dimensions along with amenities such as landscaped buffers and pathways — as well as for potential future stations in strategic locations.



Autonomous shuttle, Ann Arbor USA

Source: American Planning Association, Make Great Communities Happen 'Preparing communities for AV' Jennifer Henaghan, AICP

This section is organised by transport mode and general subject matter, as follows:

- Tram / Light Rail Transit (LRT)
  - Vehicle dimensions
  - LRT corridor width requirements
  - LRT station configuration options
- Bus Rapid Transit (BRT)
  - Vehicle dimensions
  - BRT corridor width requirements
  - BRT station configuration options
- Alternative Technologies
  - Autonomous Vehicles (AVs)
  - Public transport variants
- Recommended corridor reservation width
- Recommended station design footprint



Light rail, Melbourne

Source: Yarra Trams



Bus rapid transit, Bogotà, Colombia

Source: ITDP



Trackless tram, Zhuzhou China

Source: Financial Tribune

Light Rail Transit (LRT)

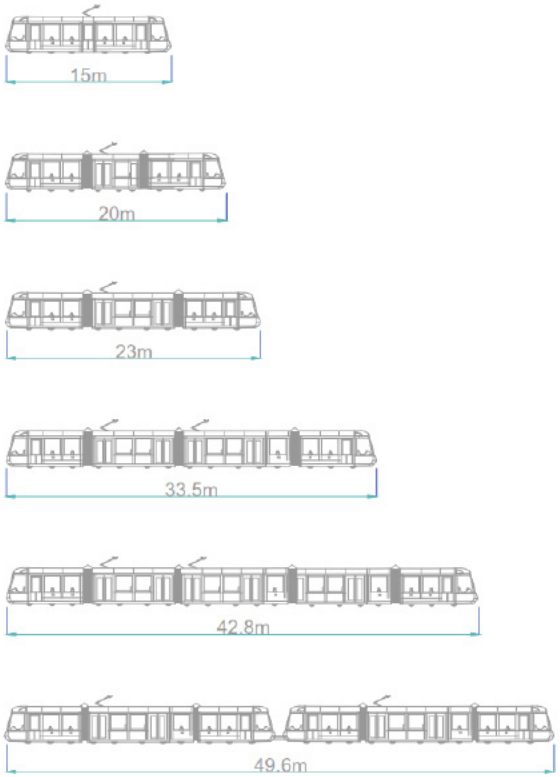
Light Rail Transit (LRT) is a term that applies to all forms of surface-running rail transport capable of operating either in streets or in dedicated rights-of-way, and includes the categories of vehicles commonly referred to as trams or streetcars.

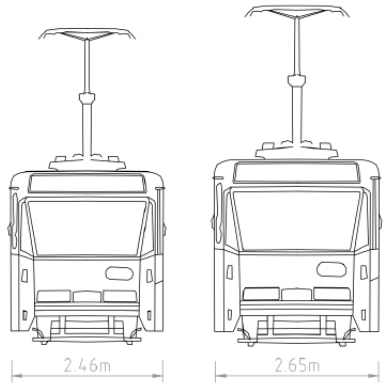
Light Rail Vehicles (LRVs) have historically exhibited a variety of dimensions based on the widely varied contexts in which they operate, although in recent years some of these dimensions (particularly the vehicle widths) have been standardised to several common options owing to consolidation of suppliers and interchangeability amongst systems.

Standard available vehicle widths are generally considered as 2.46 metres and 2.65 metres.

The wider dimension is typical of most modern global tram and LRT systems including the vast majority of LRVs deployed in Australia including Melbourne. The narrower dimension is characteristic of some modern American streetcar systems (i.e. Portland, Dallas) and a number of eastern European tram networks. Outliers with specialised fleets include Brussels (2.30 metres) and Toronto (2.54 metres) based on historical constraints and compatibility issues.

Vehicle and trainset lengths are highly variable, ranging from 15 metres for a Melbourne A-class tram to 43 metres for the world's longest single-unit tram in Edinburgh, and up to 75 metres for a three-car LRV consist as is typical in some North American cities such as Edmonton and Sacramento.





Function	Moderate to high capacity/demand
Service Plan	Low to moderate demand throughout day with high peak demands
Grade Separation	Minor to extensive
Power	Electric – Overhead wire. In some cases, embedded underground
Vehicle Length Minimum	13 – 20 m
Vehicle Length Maximum	23 – 28 m
Vehicle Width Minimum	2.3 – 2.46 m
Vehicle Width Maximum	2.65 m
Rights-of-way	Exclusive (elevated or barriers) or shared (at-grade)
Running ways	Steel track – pavement
Maximum Capacity (passengers/vehicle unit)	170-280
Vehicles	1-4 cars



C-class tram, Melbourne (23 metres)

Source: VICSIG 2002, https://vicsig.net/trams/class/C/1



A-class tram, Melbourne (15 metres)

Source: Peter Jacono, 2004, https://vicsig.net/trams/class/A2



E-class tram, Melbourne (33.5 metres)

Source: Ian Green, 2018, https://vicsig.net/trams/class/E2/1

LRT corridor width requirements

Basic corridor dimensions

The required corridor width for LRT is determined by the desired lateral components to be included. These comprise LRT lanes and separation buffers.

LRT lanes: Given that the precise manoeuvring envelope of an LRT vehicle is fixed by its operation on tracks, these would equate to the width of the vehicles plus small allowances for protrusions such as viewing mirrors at their maximum extensions. No additional clearances would be required for driver manoeuvring room as would generally be needed for a corridor accommodating driver-steered vehicles (i.e. buses).

Separation buffers: These would equate to the additional increment of width required to cater to various forms of protection buffers between public transport lanes and other uses in the corridor, generally traffic lanes or pedestrian or cycling paths. These buffers often consist of a fence treatment, landscaped strip, raised kerb, or some combination thereof.



Light rail corridor, Germany

Source: Shutterstock.com



Light rail corridor, Lyon, France

Source: Wikipedia Commons



Light rail with rail buffer, Houston, U.S.A

Source: Houston Metro

Corridor variables and add-ons

In addition to the core components of the corridor reservation, some additional features also require consideration pending specific technological options and objectives for the corridor:

Catenary supports: Traditional LRT relies on the transmission of electric power through overhead wires strung along the route. The poles required to support these wires are generally placed either between the two LRT lanes or along each edge of the running way, generally the former in unconstrained areas to minimise duplication of infrastructure and excess visual intrusion.

Typical fixings are usually between 6 and 8 metres above rail level. Support pole diametre are on average 250 mm.

As such, space may need to be preserved to support the width and clearance requirements for the overhead line equipment.

Ground level power: Several modern LRT systems — including the tram route currently under construction along George Street in Sydney — draw their power from a third rail embedded beneath the surface rather than from overhead wires, and therefore do not require additional space within the corridor for catenary supports.



Catenary poles in Poland

Source: Valmont Structures



Ground level power system, Bordeaux, France

Source: Christoph Groneck/Trams in France

LRT corridor width requirements

Cycle or pedestrian paths: While technically not a direct component of the public transport operating requirements, the concept of the Clever and Creative Corridor may in some locatons warrant the inclusion of a cycle or pedestrian path adjacent to the public transport lanes to satisfy further objectives for the corridor.

While the design of the LRT system should establish a clear priority for transit vehicle operation, it also integrates strong pedestrian and active user amenities to create transit-friendly streets for encouraging modal shift from vehicle use and for supporting social activities.

Landscaping: In addition to the minimum required safety buffers to separate the public transport space from other users, it may be desirable in the context of the Clever and Creative Corridor concept to set aside additional width for permanent raised landscaping for its aesthetic and protective value.

An integrated landscape approach along the LRT route could encourage residents to adopt a less car-dependant lifestyle by improving the general quality of the outdoor environment.

Lighting: A reservation for lighting and wayfinding features may also be important particularly if the corridor includes a cycling path alongside. Lighting not only supports the presence and use of pathways and street furniture but also contributes to the overall safety of the public realm.

Lighting could potentially be combined with catenary supports if a traditional form of power is selected for the future service.

Wayfinding: Directional signage at a pedestrian and cycling scale can enhance the user-friendliness of the rail corridor by supporting both station access and through-travel.

This is particularly important in areas which may attract visitors who would not be as familiar with the local surroundings as residents or commuters.

Wayfinding will also be an important component to directing cyclists along any co-located cycle paths.



Bicycle path along LRT corridor, Germany

Source:Google Image/City of Greater Auckland



Pedestrian friendly LRT corridor in Strasbourg,

Source: Pinterest



Light rail corridor, Europe

Source: Shutterstock.com



Illuminated station at night, Paris, France

Source: Comatalek Schreder

LRT corridor width requirements

Benchmark options

As there are an infinite number of combinations of elements and sizes that could potentially define the width of the corridor, this discussion has been simplified to a handful of primary design schemes using standard widths for various features as exhibited in various cities across the globe.

Minimum Width: The Minimum Width option adopts the narrowest possible standard for all critical features without any further add-ons, specifically:

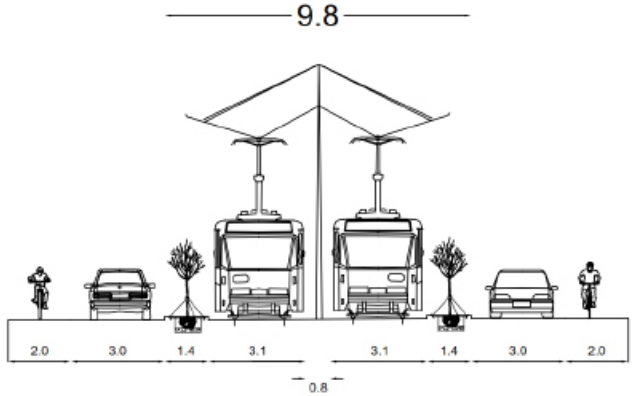
- Narrow (2.46 metre) LRT vehicles
- Sub-surface third-rail power to avoid the need for a catenary support reservation
- Raised kerb orientation for minimal separation between LRT and traffic

Minimum Standard: The Minimum Standard option assumes the Melbourne-standard 2.65 metre vehicle width and overhead catenary power transmission, along with a raised kerb orientation with minimal traffic separation.

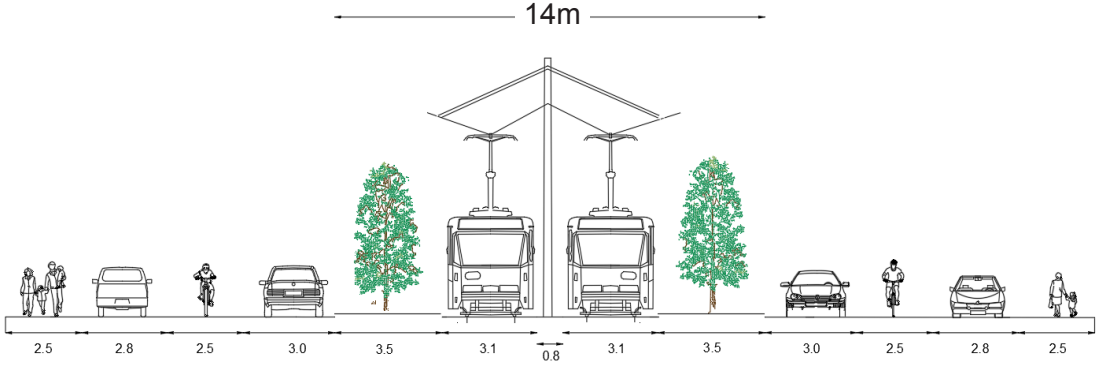
Green Corridor: This option assumes additional landscaping to help achieve an attractive configuration in both the short and long terms, maintaining a green appearance even after the reservation is eventually converted to LRT.



Minimum width option with sub-surface power



Minimum standard option with overhead power and green strip



Green corridor option with overhead power and expanded green buffers

Comparison of corridor dimensions for various LRT configurations

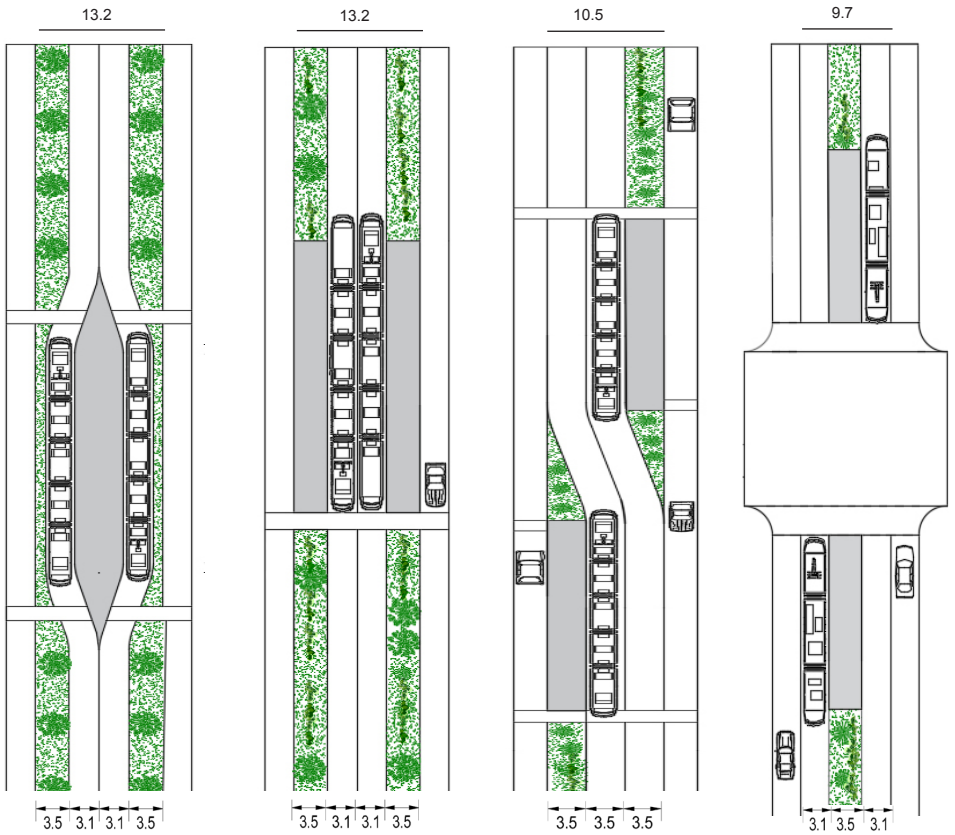
Light Rail Rapid Transit	Vehicle Width	Clearances	Power Supports	Safety buffers	Total
narrow tram with overhead power	2.46 m	0.4 m per lane	0.8 m	0.5 m to 3.5 m	7.5 m to 13.5 m
narrow tram with subsurface power	2.46 m	0.4 m per lane	-	0.5 m to 3.5 m	6.7 m to 12.7 m
standard tram with overhead power	2.65 m	0.4 m per lane	0.8 m	0.5 m to 3.5 m	7.9 m to 13.9 m
standard tram with subsurface power	2.65 m	0.4 m per lane	-	0.5 m to 3.5 m	7.1 m to 13.1 m

LRT station configuration options

Station types

The potential station configurations for LRT consist of four main types, which could be of variable length pending the type of vehicle to eventually be used for the service. These include:

1. **Median shared platform:** This option consists of a centrally aligned double-width platform to accommodate loading operations in both directions. This configuration requires an additional transition distance to allow trams to shift laterally to the outsides of the platform.
2. **Bilateral opposing platforms:** This option consists of two separate one-way platforms on either side of the LRT running way. These do not require an additional transition distance as trams would not be required to shift away from their straight running alignment.
3. **Bilateral offset platforms:** These are side-aligned platforms that are offset from each other along the corridor, requiring less total width but a modest alignment shift between the separate stop locations.
4. **Central offset platforms:** This represents the use of two separate median platforms for each direction, often offset on either side of an intersection. In comparison with a consolidated shared median platform, this option requires less total width but more total length.



Median shared platform | **Bilateral opposing platform** | **Bilateral offset platform** | **Central offset platform**

Station variables and add-ons

Considerations that would influence the types of platforms to choose include:

- Total projected demand
- Expected operating frequency
- Spatial constraints
- Design vehicle
- Type of road corridor
- Pedestrian access
- Platform amenities including ticketing machines and seating areas

In general the tradeoff between the shared/opposing platform options and the offset platform options is that the former require more width while the latter require greater length to, in effect, spread the demand for the two separate directions along the corridor.

Manoeuvring characteristics of the design vehicle can also influence this choice, particularly for the options that require the LRT vehicle to deviate from a straight path to navigate around a central median or bilateral offset platform configuration.

Bus Rapid Transit (BRT)

Bus Rapid Transit (BRT) refers to bus operations that are predominantly free from traffic impedance, running in exclusive bus lanes or dedicated two-way reservations. Although the precise definition of BRT is often debated, the *International Association of Public Transport* (UITP) has developed a scoring system that classifies BRT systems according to how closely they adhere to an idealised design standard that emphasises maximum separation from traffic.

The advantages of BRT over conventional street-running buses include its consistency, reliability and speed resulting from its separation from traffic. In layout and operation — and in many cases vehicle appearance — BRT systems generally resemble LRT and are often considered to have a comparable attraction potential due to their similar operational advantages.



12-metre BRT vehicle in Guangzhou, China

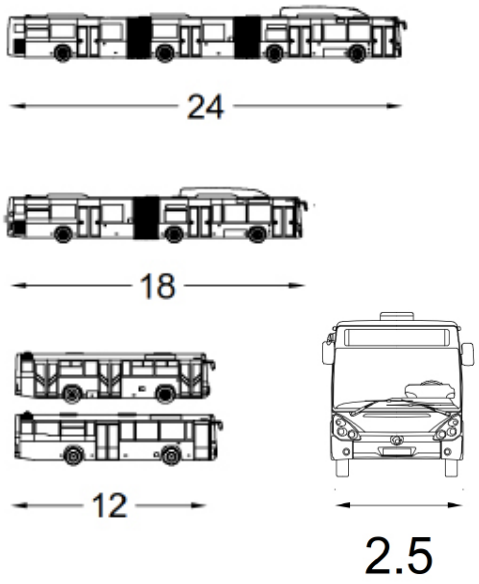
Source: DEVelopment Asia

The dimensions of BRT vehicles are generally similar to those of street running buses, with the exception (in some instances) that they lend themselves to further flexibility with respect to their lengths due to the absence of a need to manoeuvre in complex traffic conditions.

Widths are generally consistent at 2.55 metres, which represents the standard design width of public buses in most developed countries.

Lengths are primarily standardised to three basic widths of 12 metres, 18 metres and 24 metres, although there can be some variability to the precise measurements based on location and manufacturer.

Buses of approximately 12 metres in length are the equivalent of a standard city bus. Vehicles with an 18-metre length are typically 'single-articulated', i.e. they consist of two body segments connected by a flexible accordion-style construct allowing the bus to manoeuvre without excessive turning clearances despite its elongated nature. The longer 24-metre vehicle type represents a less common double-articulated design, with three main sections.





Branded 18-metre BRT vehicle in Jakarta

Source: ITDP

Function	Low to moderate-high capacity/demand
Service Plan	Low to moderate demand throughout day with high peak demands
Grade Separation	Minor to extensive
Power	Diesel, Electric
Vehicle Length Minimum	12 m
Vehicle Length Maximum	18 m
Vehicle Width Minimum	24 m
Vehicle Width Maximum	2.4 – 2.55 m
Rights-of-way	Exclusive (elevated or barriers) or shared (at-grade)
Running ways	Steel track – pavement
Maximum Capacity (passengers/vehicle unit)	170-280
Vehicles	1-4 cars

BRT corridor width requirements

Basic corridor dimensions

The required corridor width for BRT is determined by the desired lateral components to be included. These comprise at a minimum BRT lanes and separation buffers:

BRT lanes: Given that the manoeuvring envelope of a BRT vehicle is usually subject to driver variation -- unless entirely automatically guided -- the width of the BRT lanes would equate to the width of the vehicles plus allowances for drive path variability.

Separation buffers: These would equate to the additional increment of width required to cater to various forms of protection buffers between public transport lanes and other uses in the corridor, generally traffic lanes or pedestrian or cycling paths. These buffers often consist of a fence treatment, landscaped strip, raised kerb, or some combination thereof.



Shared cycle and bus lane, Washington

Source: ITDP, 2016

Corridor variables and add-ons

In addition to the core components of the corridor reservation, some additional features also require consideration pending specific technological options and objectives for the corridor:

Automatic guidance: There are several forms of automated guidance that can reduce or eliminate the driver operation buffer otherwise embedded into the BRT lane width:

- *Optical guidance:* Bus-mounted lasers calibrated to painted markings in the bus lane keep the bus on a precise path; this is highly dependent on the upkeep of the laser equipment and line markings and are often used on the approaches to stations for precision docking.
- *Magnetic guidance:* In this scenario buses are locked to a precise path through the attraction between bus-mounted magnets and coils embedded in the pavement surface; this is more expensive yet generally more reliable than optical guidance.
- *Track guidance:* Pioneered on a large scale by the O-Bahn in Adelaide, this type of system relies on bus-mounted guide wheels in contact with raised guiderails alongside the bus lane; this is typically only practical for long uninterrupted run paths with few street crossings.

Cycle or pedestrian paths: While technically not a direct component of the public transport operating requirements, the concept of Clever and Creative Corridor may in some locations warrant the inclusion of a cycle or pedestrian path adjacent to the public transport lanes to satisfy further objectives for the corridor.

Landscaping: In addition to the minimum required safety buffers to separate the public transport space from other users, it may be desirable in the context of the Clever and Creative Corridor concept to set aside additional width for permanent raised landscaping for its aesthetic and protective value.



Landscaped buffer on BRT route, Los Angeles

Source: APTA BTS BRT RP 002-10 2010

Lighting and signage: A reservation for lighting and wayfinding features may also be important particularly if the corridor includes a cycling path alongside. Lighting could potentially be combined with catenary supports if a traditional form of power is selected for the future service.



Cycle path on transit corridor, Miami

Source: Miami Herald



Landscaped buffer on BRT route, Bogota

Source: EMBARQ, 2018

BRT corridor width requirements

Benchmark options

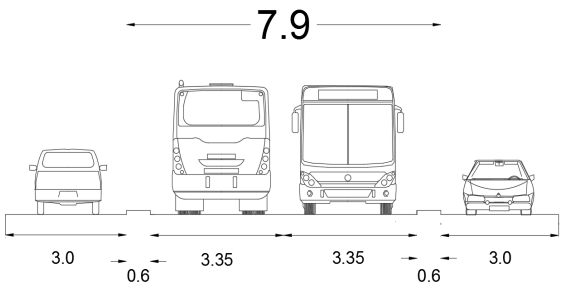
As there are an infinite number of combinations of elements and sizes that could potentially define the width of the corridor, this discussion has been simplified to a handful of primary design schemes using standard widths for various features as exhibited in various cities across the globe.

Minimum width: The Minimum Width option adopts the narrowest possible standard for all critical features, including:

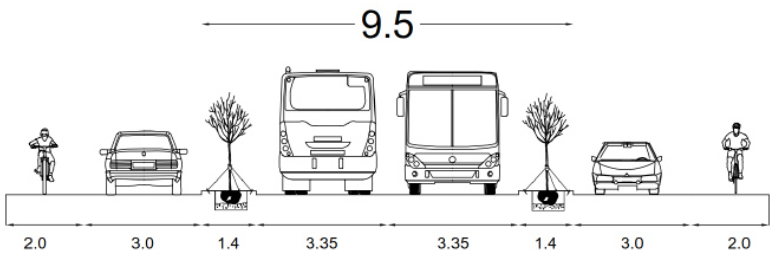
- Guided BRT vehicles
- Kerb and fence treatment to minimise separation from other corridor users

Minimum standard: The Minimum Standard option assumes driver-operated buses along with kerb and fence separation.

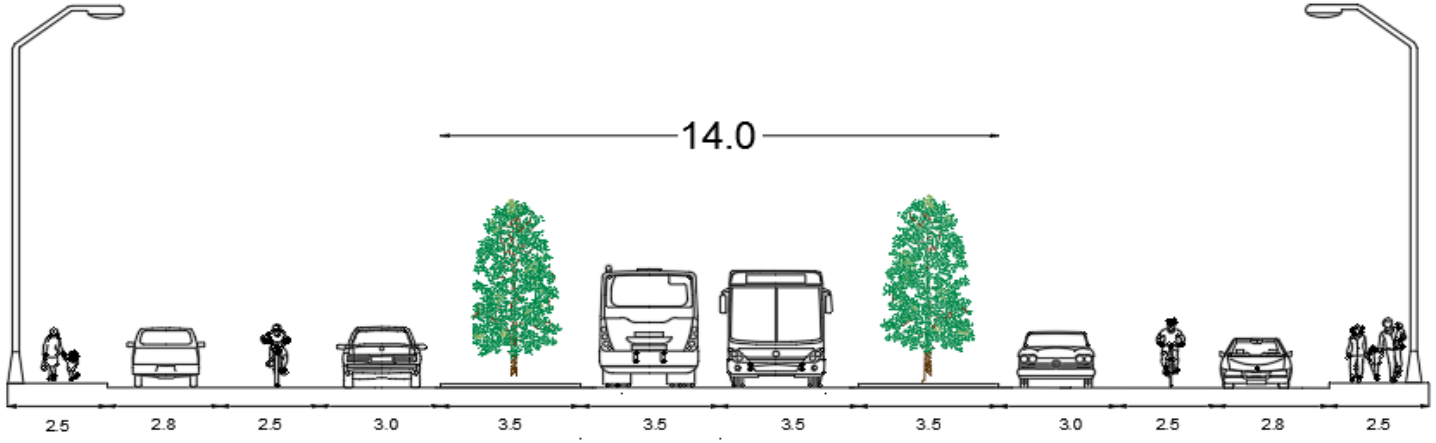
Green corridor: This option assumes additional landscaping to help achieve an attractive configuration in both the short and long terms, maintaining a green appearance even after the reservation is eventually converted to BRT.



Minimum width option with guided vehicles



Minimum standard option with manual vehicles and green strip



Green corridor option with manual vehicles and expanded green buffers

Comparison of corridor dimensions for variations of BRT

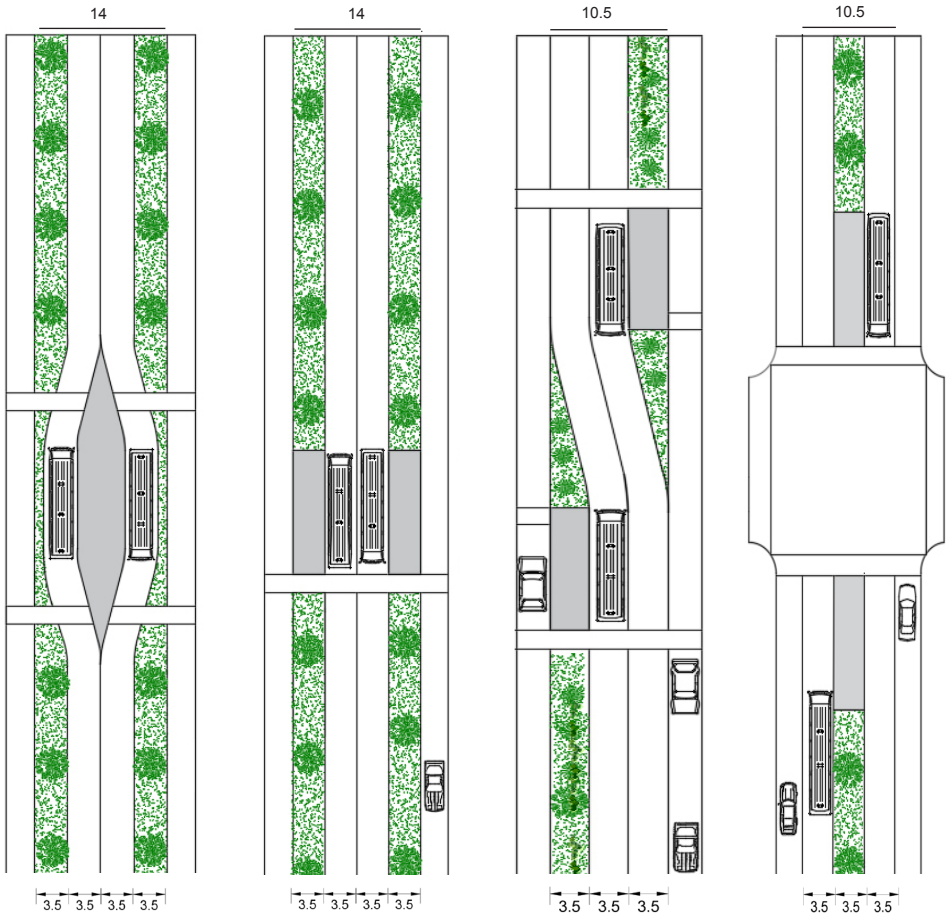
Bus Rapid Transit	Vehicle Width	Clearances	Power Supports	Safety buffers	Total
Driver operated	2.55 m	0.8 m per lane	-	0.5 m to 3.5 m	7.7 m to 13.7 m
Fully guided	2.55 m	0.3 m per lane	-	0.5 m to 3.5 m	6.7 m to 12.7 m

BRT station configuration options

Station types

The potential station congurations for BRT consist of four main types, which could be of variable length pending the type of bus to eventually be used for the service. These include:

1. **Median shared platform:** This option consists of a centrally aligned double-width platform to accommodate loading operations in both directions. It requires buses with off-side doors which is generally only practical with a dedicated BRT fleet with no partially street running routes using the corridor.
2. **Bilateral opposing platforms:** This option consists of two separate one-way platforms on either side of the BRT running way. These would enable operation with standard buses and offer the flexibility to open the corridor to bus routes that run partially on mixed streets.
3. **Bilateral offset platforms:** These are side-aligned platforms that are offset from each other along the corridor, requiring less total width but a modest alignment shift between the separate stop locations.
4. **Central offset platforms:** This represents the use of two separate median platforms for each direction, often offset on either side of an intersection. These have the same off-side door requirement for buses as median shared platforms.



Station variables and add-ons

Considerations that would influence the types of platforms to choose include:

- Total projected demand
- Expected operating frequency
- Spatial constraints
- Design vehicle
- Type of road corridor
- Pedestrian access
- Platform amenities including ticketing machines and seating areas

In general the tradeoff between the shared/opposing platform options and the offset platform options is that the former require more width while the latter require greater length to, in effect, spread the demand for the two separate directions along the corridor.

In contrast with LRT, BRT is generally well suited to bilateral offset platforms due to the buses' relative manoeuvrability over short distances.

Alternative technologies

Autonomous Vehicles (AVs)

Autonomous vehicles have the potential to transform some of the prevailing conditions of everyday travel, notwithstanding many questions remaining about their implementation, staging, operation, management and design requirements.

In the Clever and Creative Corridor context, it is worthwhile to consider that the central reservation could potentially be used as an exclusive AV lane in lieu of (or in combination with) public transport operation. Key operational and design considerations would include:

- If used exclusively as an AV lane, the total potential passenger capacity would be significantly less than that of a dedicated public transport lane but several times greater than that of a conventional traffic lane (owing to the closer allowable spacing between vehicles).
- Stations would not be needed for AVs, as these would be expected to enter and exit the corridor at designated points with onward travel on surface streets.
- With the exception of stations, the general design requirements for an AV corridor would be similar to those of a guided BRT lane (allowing for a variety of AV vehicle types and sizes).



Autonomous car prototype, Google

Source: Google



Autonomous shuttle, Paris demonstration

Source: Getty



Autonomous shuttle, Melbourne demonstration

Source: Carshowroom.com.au

Public transport variants

In addition to LRT and BRT, there are several additional existing and emerging technological options that may be applicable to the Clever and Creative Corridor at the time of public transport implementation. These include:

Trackless trams: Currently under development and demonstation in China, this concept represents a hybrid between LRT and guided BRT. Described as a tram without rails, it consists of a long tram-like chassis or multi-car 'trainset' which is magnetically or optically guided along an exclusive public transport lane. From a design perspective, this option shares the same general width requirements as non-overhead powered LRT.

Track-guided busses: Pioneered on a large scale by the O-Bahn in Adelaide, this type of system relies on bus-mounted guide wheels in contact with raised guiderails alongside the bus lane; this is typically only practical for long uninterrupted run paths with few street crossings.

More recent implementations of this concept have been implemented in Cambridge and Manchester in the United Kingdom. Several additional systems, including Nantes in France, have BRT systems that are track guided in the vicinity of stations in order to support precision docking alignment.



Trackless tram, Zhuzhou China

Source: Financial Tribune



Track guided bus, Adelaide O-Bahn

Source: EMBARQ

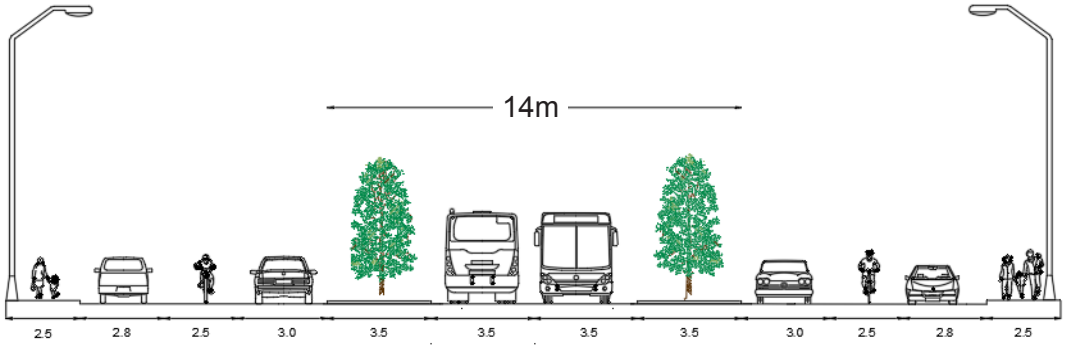
Recommended corridor reservation width

Given the uncertainty around which technology option might eventually be chosen for the corridor — and which additional technologies may emerge in the interim period — the objective of the Clever and Creative Corridor in the near term is to set aside a suitable reservation width that could accommodate most applicable vehicle options.

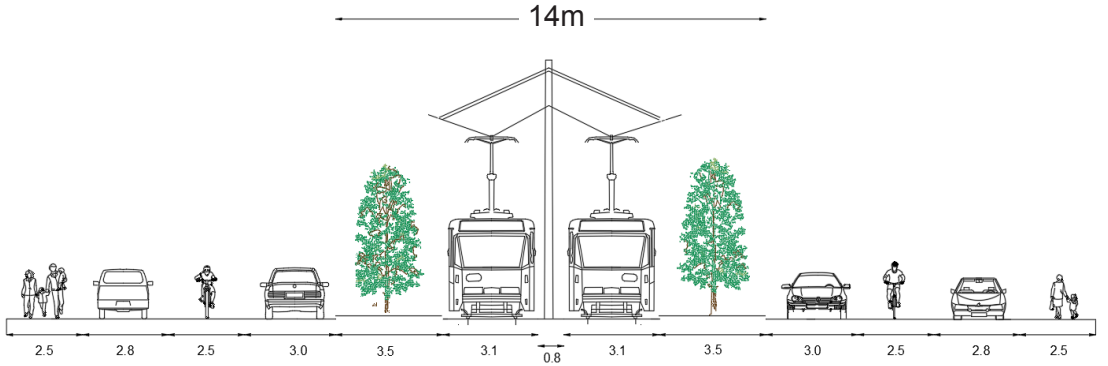
In choosing the appropriate width, the staging of the corridor should also be carefully considered to ensure a smooth transition from its short term to long term use. In particular, the chosen design option should include an allowance for preserving some aspects of the shorter-term interim use such as landscaping or walking/cycling paths.

In light of these considerations, the recommendation of this evaluation is to implement the ***green corridor*** option, which offers notable visual and safety benefits as well as practical advantages with respect to operation and implementation, as described below.

The 14-metre recommended corridor reserve is above and beyond the width required for all other road functions, including traffic lanes, parking lanes, cycle paths, footpaths and kerbside nature strips.



Green corridor - BRT



Green corridor - LRT

Recommended corridor reservation width

Design components

The recommended design allowances for the long term corridor reservation include the following:

LRT/BRT lanes: It is recommended that the maximum width of BRT lane be used as the standard placeholder width for the corridor, given the following:

- If LRT rather than BRT were selected, the additional width available would allow for either underground or overhead power, as the additional space could be used for catenary supports.
- If the corridor were used for guided BRT or an exclusive AV traffic spine, the additional width could be dedicated to further landscaping.
- The envelope of space represented by two standard BRT lanes would presumably be sufficient for any other emerging or future technology that may be suited for deployment within the corridors.

Landscaped buffers: The recommendation of continuous landscaped buffers has multiple benefits:

- They provide a continuous visual and safety buffer between the public transport operation and other users of the corridor.
- They would allow the preservation of a base level of greenery along the corridor in the long term even following conversion to public transport use. This is especially important if the short term interim use were to include an appreciable degree of greenery which could otherwise be entirely lost.
- It would simplify the operational and reservation requirements in the vicinity of the stations, by removing from the equation the manoeuvring variability amongst the different types of vehicles that may be considered for the corridor. With landscaped buffers of suitable width, the buffer strips themselves could accommodate the footprint of bilateral opposing station platforms, eliminating the need to alter the path of vehicles or acquire additional

Variations

The basic green corridor concept would consist of the public transport running way plus its landscaped buffers running within the road median flanked on each side by general traffic lanes. Depending on context within the growth areas, however, there are several additional variations that may be appropriate in specific locations:

Cycle paths: As the concept plan for the growth areas indicate cycle/greenway routes that occasionally overlap with the Clever and Creative Corridor, there are several options (depending on functionality) of how to best incorporate these within the short-range and long-range design concepts. These are discussed in Part 2 of this report.

Side-running alignment: While a median-running alignment generally minimises the complexities of traffic operations along a typical road corridor, a side running alignment could be preferable in locations where the corridor is bordered by a natural feature and/or devoid of cross-turning conflicts. The main benefit of a side running alignment in this context would be the minimisation of vehicle turning conflicts across the public transport corridor.

Wider buffer strips: While the proposed 3.5-metre buffer strips are suitable for local streets, there are a few locations where the Clever and Creative Corridor may overlap heavier traffic corridors and warrant wider buffers for added value.



LRT corridor with green enphasis, Portland

Source: City of Edlington



Bi-directional cycle tracks next to tramway in Rotterdam

Source: Bicycle Dutch/Wordpress



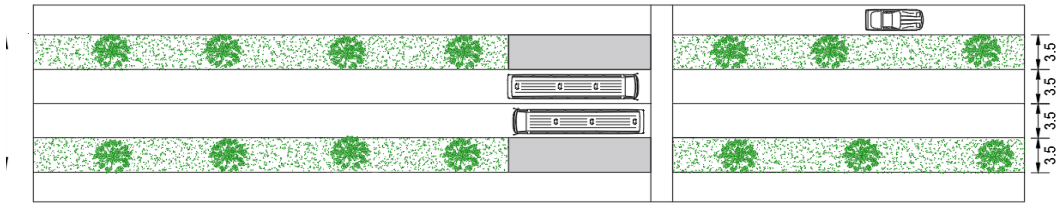
BRT corridor with green enphasis, Vancouver

Source: McCormick Rankin Corporation

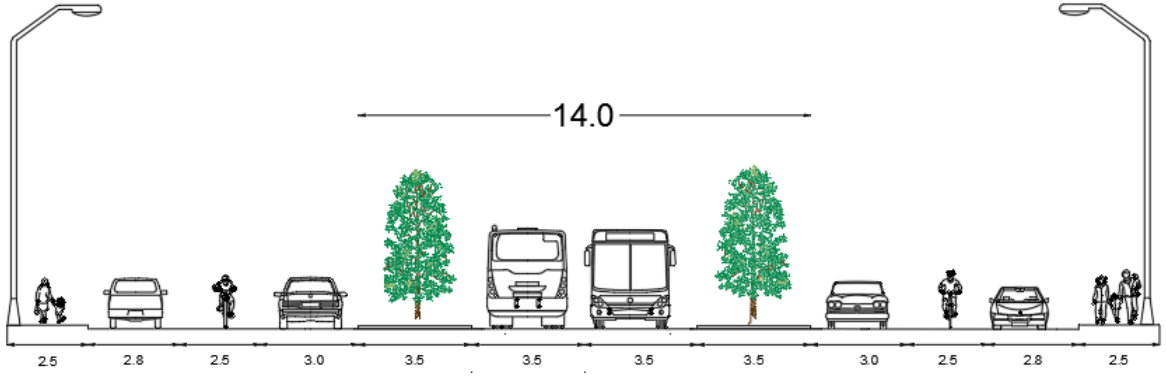
Recommended station design footprint

More so than the general corridor width, the design parameters at stations have the potential for significant variation based on the chosen technology and vehicle characteristics. Given the uncertainty in future direction with respect to these issues, the purpose of this task is to identify a station reservation dimension that would be suitable for most, if not all, the potentially applicable public transport technologies.

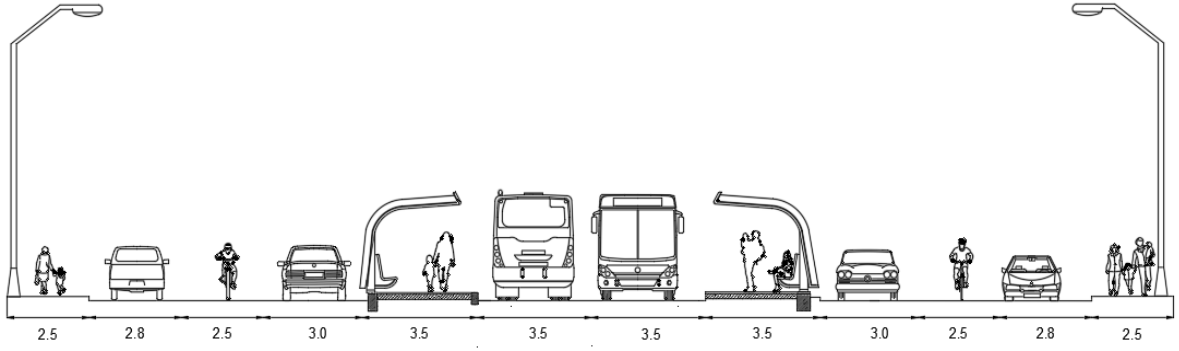
The preferred corridor alignment identified in the previous section helps to achieve this end, by enabling adaptation of a station footprint that is suitable for all potential modes of transport and not reliant on vehicle length.



Proposed bi-lateral opposing platform configuration



Predominant corridor arrangement



Corridor arrangement at station locations

Recommended station design footprint

Design components

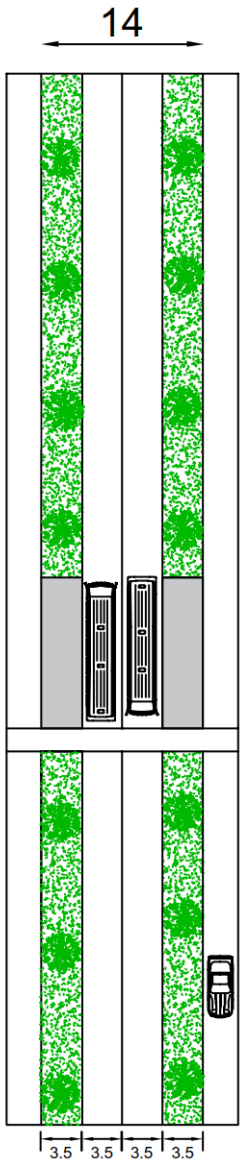
Bilateral opposing platforms: This platform configuration has a variety of advantages as related to the Clever and Creative Corridors concept:

- There is no requirement for lateral transitioning out of the predominant straight running alignment to navigate around platforms, as would be the case with each of the other configuration options; this removes the variability in the manoeuvring characteristics of the vehicles as a factor thereby enabling the deferment of the choice of technology and vehicle type to a future date.
- Station platforms would be placed along the alignment of the landscaped buffer strip and would therefore not be dependent on the reservation of additional width at the station locations, which has the significant advantage that it does not require the identification of precise station locations at this stage in the process. It also has the advantage that the vehicle length need not be determined in advance, and that the platforms would be continually expandable for larger vehicles into the future.
- This configuration maintains complete flexibility of bus operations (if BRT is chosen) by enabling the use of left-side doors as is typical of standard buses.

Protection buffers: The proposed width of the buffer strips is set to accommodate a generous pedestrian waiting depth along with the continuation of an approximately 0.5-metre protective buffer through the platform area, enabling an attractive buffer treatment while preserving the remainder of the platform area for passenger staging and other amenities. By comparison, tram stops in constrained locations typically consist of just a solid continuous fence or rail along the outer platform edge.

Cycle parking: Cycle parking could potentially be included on the station platforms preferably near their access points to minimise on-platform riding. They could alternatively be located beyond the outer kerbline of the road corridor given safe pedestrian crossings. The latter configuration often works best with onroad cycle lanes, particularly in areas of mixed-use activity with on-street parking where the cycle parking can be clustered onto an intersection kerb bump-out which would also help to calm traffic and shorten pedestrian crossings.

Ticketing machines: Modern ticketing machines could fit comfortably in the 3-metre width of a standard platform, although the requirement for these in the implementation time frame would be expected to be minimal given the emergence of alternate payment media.





Bilateral opposing tram platforms, Melbourne



Space efficient cycle parking, Geelong

Recommended station design footprint

Adaptability to land uses

The proposed general station configuration – particularly as related to its arrangement and width – is well suited to any potential adjacent uses. In recognition that some aspects of the built stations may vary according to the nature and intensity of the land uses surrounding them, the proposed platform footprint allows for linear extension to support multiple stopping bays or larger accumulations of waiting passengers.

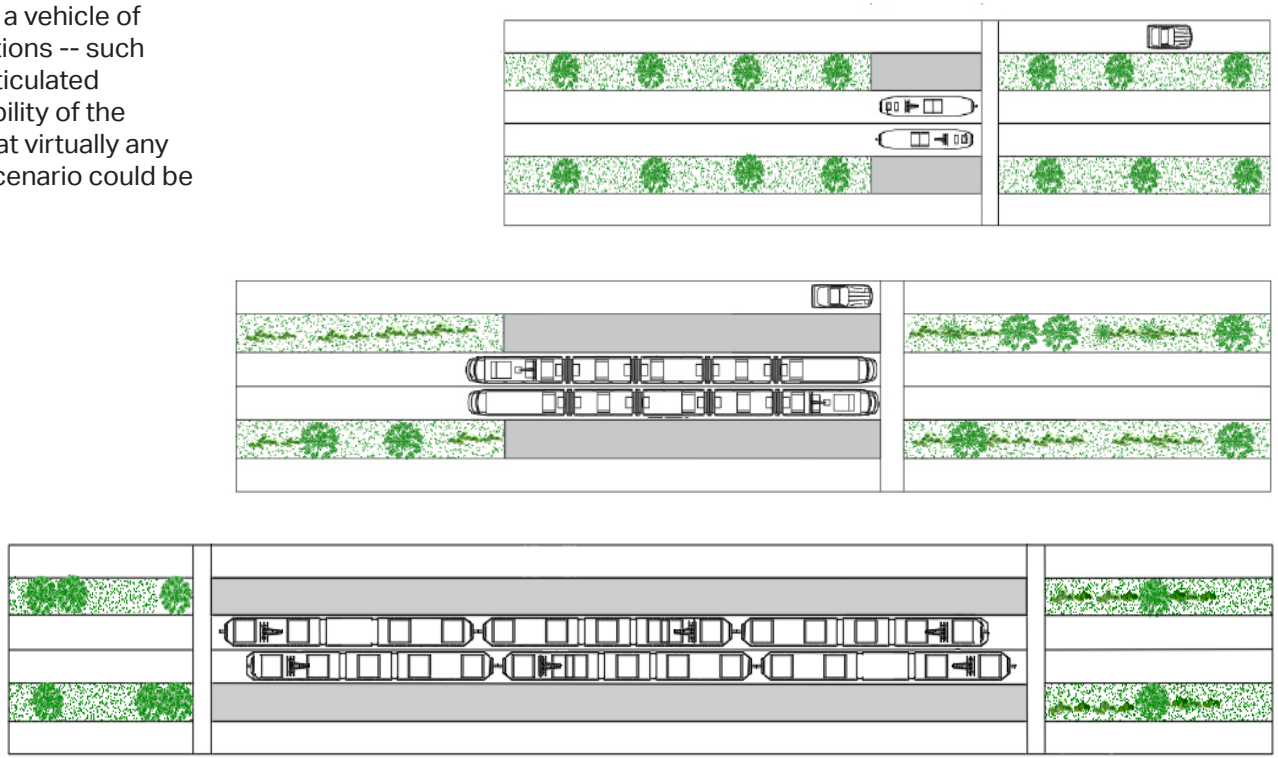
Extended platforms, for instance, may be warranted at major activity centres, transfer stations (for instance, to any potential independent service along the western rail corridor), and stations serving any special-event centres such as sporting grounds where passenger flows can be periodically very heavy.

The proposed dimensions are intended to allow for the continuation of attractive buffer strips through the platform areas, and to cater to peak passenger flows in an undefined long-term future. For comparison, Public Transport Victoria (PTV) design guidelines for modern tram stops in Melbourne allow for minimums of 3.1 metres for split platforms and 4.5 metres for shared central platforms, noting the highly directional nature of Melbourne commuting flows and stops that are generally more closely spaced (allowing for passenger spreading) than is likely to be the case in outer Geelong.

Variations

The flexible nature of the proposed platform configuration could accommodate any practical vehicle length in the longer term, given that the expansion of platforms would entail only their extension further along the adjoining landscaped buffer strips.

While it would be anticipated that early versions of the public transport service would most likely employ a vehicle of relatively modest proportions -- such as a mid-sized tram or articulated bus -- the lineal expandability of the platforms would mean that virtually any potential future growth scenario could be accommodated.



Adaptability of the green corridor concept to larger vehicles and longer platforms

Recommended station design footprint

Station configuration and bicycle parking

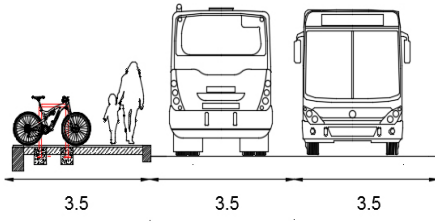
Cycle parking could potentially be included on the station platforms preferably near their access points to minimise on-platform riding. They could alternatively be located beyond the outer kerbline of the road corridor given safe pedestrian crossings. The latter configuration often works best with onroad cycle lanes, particularly in areas of mixed-use activity with on-street parking where the cycle parking can be clustered onto an intersection kerb bump-out which would also help to calm traffic and shorten pedestrian crossings.

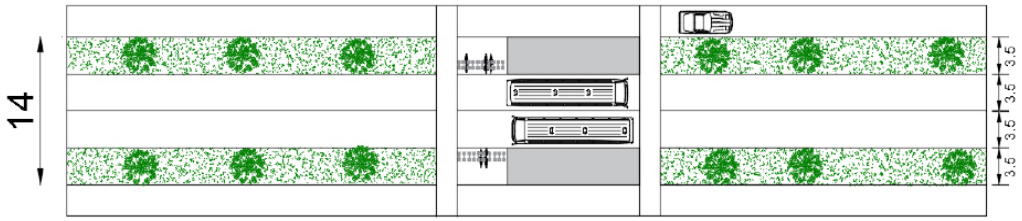
The optimal location for bicycle parking depends on a number of factors, specifically the orientation of the platforms and the alignment of any cycle paths or cycle lanes. In general the following guidelines should be followed:

- Where cycle paths are provided directly adjacent to the public transport corridor, bicycle parking should be provided as an extension of the platform footprint. The proposed 3.5-metre reserve would allow for a variety of cycle parking types within this area.
- Where cycle lanes run adjacent to the outer street kerbs or car parking lanes – separated from the public transport corridor by one or more lanes of moving traffic – it is preferable to locate the bicycle parking on the outsides of the street as near as possible to the controlled pedestrian crossings providing access to the station platforms. These can be co-located on intersection bump-outs that extend across the parking lanes at pedestrian crossing locations.
- If a split platform configuration is implemented, it is generally preferable to provide the majority of bicycle parking on whichever side represents the peak AM commuter movement, which is usually the most time sensitive. This would help minimise the instances in which bicycle commuters would need to rush across the public transport corridor to catch a bus or tram.



Cycle racks at Eugene BRT station
Source: Berkeley-Charleston-Dorchester Council of Governments





Safety and accessibility: Each of the various station configuration options has comparable safety and accessibility characteristics; however it is important with each that a few key design principles are followed:

- Pedestrian crossings should be signalised or stop-controlled, or require that drivers yield to all pedestrian movements. All crossings should be DDA accessible (Disability Discrimination Act), with suitable landing areas outside the platform waiting zones.
- For platforms that exceed the length of one vehicle – i.e. those with multiple bus bays or which support extended length tram sets – access from each end of the platform should be provided wherever possible to minimise the occurrences of uncontrolled crossing movements.

Part 4 - Staging of the corridor

This chapter identifies the strategies that could potentially be employed to ensure effective staging of the Clever and Creative Corridor. In particular it focusses on the short-term spatial components needed to ensure a healthy and attractive interim use while not inadvertently creating a high-value amenity that would be difficult to later convert to its final intended public transport use.

The range of options potentially suited to this task include:

- Passive landscaping
- Active or informal landscaped areas
- Pedestrian paths
- Cycle paths
- Bus lanes (either within the reservation or along the outer kerb lanes with the implication that buses and general traffic lanes would be later transposed).

As some of the more formalised treatments (i.e. pedestrian and cycle paths) could run the danger of being difficult to convert to public transport use in the future – due to community attachment – it is critical to carefully consider the before/after conditions.

Key factors

The choice amongst these options would be based on a variety of key factors including the following:

- Short term value
- Short term appearance
- Implications of short-term use
- Potential for community attachment
- Consistency of appearance

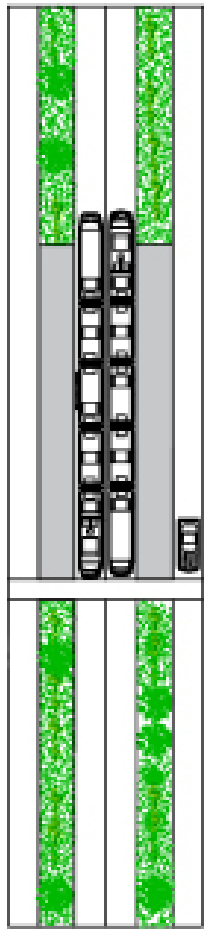
These will also be dependent on whether the corridor is median or side-aligned, whether it is co-located with a planned cycling or greenway corridor, and on the type of street in which it is embedded.

Options

The primary options in the context of the Northern and Western Geelong Growth Areas can be consolidated into the following specific treatments:

- Passive green strip
- Formalised landscaped areas
- Pathways
- Parking lanes
- Bus lanes
- Additional traffic lanes

The following pages introduce the key variables to consider when choosing an appropriate short term form for any segment of the Clever and Creative Corridor. This is followed by an evaluation of each of the primary options against each of these factors, which in turn results in a recommended short term treatment.



Proposed long-term corridor arrangement showing LRT

Considerations

Key factors

Short term value: Whilst the ultimate goal of the corridor reservation is to preserve its width for a future public transport service, the short term use should bring some degree of value to the community to avoid being viewed as a wasted, unsightly or inefficient use of space.

Short term appearance: As the corridor reservation will form part of the visible public realm of the Northern and Western Geelong Growth Areas, its short term treatment should add rather than detract from the visual value of the development areas.

Implications of short-term use: The short term uses for the corridor could lead to behavioural patterns that could either support or contradict the long term goals of this program. For instance, treatments that are attractive to pedestrians could establish a pattern of walking within the community for any viable purposes, while the dedication of the corridor in the short term to traffic or parking related uses could initiate a pattern of car-reliant behaviour or design.

Potential for community attachment: Short term uses that are too highly valued by the community may make it difficult in the future to convert the corridor to its intended long term use for public transport. This could be particularly acute where valued short term elements such as cycle pathways or landscaping are not suitably accommodated in the longer term.

Consistency of appearance: The visual impression of the long term 'after' condition should be comparable with that of the short term interim treatment, to avoid criticism of any perceived visual degradation when implementing the final scenario.



Opportunities for short term value

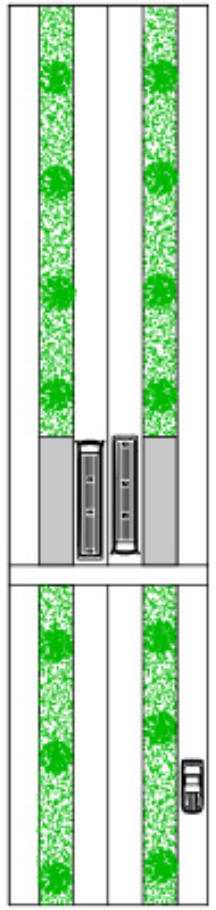
Source: Henkell.com

Variables

Median or side alignment: While the vast majority of the length of each of the Clever and Creative Corridors segments is likely to be embedded in the median of its encompassing roadways, there are several instances (as described in Chapter 2) where side-running may be preferable pending the projected development outcomes. In these cases an alternate short-term treatment may be appropriate pending specific conditions.

Co-location with planned cycle paths: Several segments of the Clever and Creative Corridors are co-located with planned cycle paths and greenways. In these instances these functionalities should be accommodated separately from the public transport corridor reservation, otherwise these strategic active transport linkages could be lost in the longer term.

Encompassing street type: While the Clever and Creative Corridors primarily follow local streets (by design) there are some instances where spatial constraints or convergence of travel demand patterns dictate that they overlap with higher-order traffic streets. The optimum short term treatment in these locations may differ from that which would be recommended for lower-traffic local streets.



Proposed long-term corridor arrangement showing BRT

Options

Passive green strip

This option represents the establishment of the corridor reservation as an informal green space, with no other functionality except to separate the opposing lanes of traffic and provide a softening visual effect. Given the plan for future conversion, it would be recommended that this consists of low-level landscaping only as larger trees would be more expensive and controversial to remove in the long term.



Source: landscapeonline.com

+ - comparative advantage

! - comparative disadvantage

neutral **- neither**

Short term value: The value of a passive green strip in the short term is limited to the visual and ecological benefits of providing a continuous green corridor. neutral

Short term appearance: The green strip would have the appearance of a natural informal corridor with basic landscape features the most predominant visual impression. +

Implications of short-term use: The short-term use of the corridor would have no implications for travel behaviour that would differ from that of a local street without the reserved corridor. neutral

Potential for community attachment: Although the landscaping itself could become highly valued, the assurance of a ongoing continuous landscaped edge to the future public transport corridor would limit the visual impacts of later conversion. +

Consistency of appearance: Assuming the maintenance of a generous landscaped buffer with implementation of the long term public transport corridor, the before and after appearance should be generally consistent with an overall image of green naturalness. +

Formalised landscaped areas

The formal lansdcape option is similar to the green strip with the exception that some of the green space would be established as interactive park-like spaces with seating areas, localised walking paths (but not long-distance through-paths), and other amenities. In general this can only be recommended in areas where the community value of these spaces could be readily replaceable following implementation of the long term public transport corridor.



Source: MVR

Short term value: The short term value of formal landscaped areas is generally high, as they can represent an accessible localised amenity that could otherwise be difficult to provide in growth areas without setting aside otherwise developable tracts of land. +

Short term appearance: The short term appearance of formal landscaped areas would be at least as good as the green strip, and better in areas which include some degree of professional landscape architecture treatment. +

Implications of short-term use: The use of the formal park spaces in the short term could help support the notion of walking and cycling by providing a complementary natural destination in the form of a community gathering space. +

Potential for community attachment: There is considerable danger of community attachment with this option, which without suitable replacement could make it difficult to eventually convert the corridor to its intended public transport use. !

Consistency of appearance: Pending the overall quality of the formal landscaped areas, it could be possible for the long term conversion of the corridor to public transport to be viewed as a downgrade in terms of visual appeal. neutral

Options

Pathways

The option for pathways includes the inclusion of a continuous pedestrian, cycling or shared use path down the reserve strip. In contrast to the formal landscape option which may include some localised pathways, this option is defined by its provision of longer-distance connectivity along the corridor.



Source: Valeri.Zoia Architetti Associati

+ - comparative advantage

! - comparative disadvantage

neutral **- neither**

Short term value: The short term value of pathways in the median would be very high, offering an attractive active transport option assuming that complications at intersections could be suitably designed for safe movement. +

Short term appearance: The short term appearance of the pathway option would be strong versus any vehicular options, but due to its requirements for a paved path and additional intersection treatments (including signage and potentially signals to control cross-traffic) these would be not as intrinsically attractive as either of the landscape-only options. +

Implications of short-term use: The use of the corridor for pedestrian and/or cyclist circulation would have a positive impact for establishing sustainable transport behaviour; however this may be tempered by the extensive pedestrian and cycling connections planned elsewhere. +

Potential for community attachment: This is the main drawback of using the corridor reserve for pathways in the short term, unless there is a coordinated plan to replace their functionality later. !

Consistency of appearance: The replacement of a central pathway network with public transport would represent a modest visual downgrade that could be minimised with continuous buffers. +

Parking lanes

It is feasible that a portion of the width required for the long term public transport corridor could be used in the short term for a parking lane, which would either duplicate a left-kerbside parking lane or serve as the only on-street parking flanking certain portions of the corridor. The benefit from a phasing point of view would be that the parking could support localised access prior to the implementation of the public transport service. The flexibility in the corridor reserve width could potentially support diagonal as well as parallel parking.



Source: Greater Greater Washington

Short term value: Parking could be viewed as a high-value short-term use depending on the adjacent land uses. +

Short term appearance: As the parking lanes would replace much if not all of the landscaped areas that are characteristic of the prior three options, the short term appearance would be less appealing by comparison. !

Implications of short-term use: The presence of excessive parking could have a counterproductive effect to the long-term objective of the public transport corridor, contributing to travel behaviour and urban design qualities that are more reliant on cars and parking than what would be desirable in the longer term. !

Potential for community attachment: Though not similar to the manner in which communities can become attached to landscaped park areas and walking/cycling paths, the establishment of a parking-dependent transport paradigm could make it very challenging to remove car parks in the longer term. !

Consistency of appearance: Unlike the previous options, the look of the corridor in the long term versus short term under this option is likely to improve, rather than deteriorate, with the proposed landscape strips and supporting visual features of the long term condition. !

Options

Bus lanes

It is possible that the long-term public transport use of the corridor could be precedented with shorter-term bus lanes, which could help set the public transport focus of the corridor. The most likely scenario for this would be for these to be located in the left-side kerb lanes (to avoid the need for separate boarding platforms not contiguous with the roadside footpaths) which would later be flipped into the centre of the road when the contiguous running way is developed.



Source: Greater Greater Washington

+ - comparative advantage

! - comparative disadvantage

neutral **- neither**

Short term value: Although bus lanes would add some value in the short term to ensure traffic-unimpeded journey times through the corridor, it might not amount to much given the low expected traffic levels and partially developed nature of most of the local streets on which they would run. neutral

Short term appearance: Bus lanes in the short term would equate to an expansion of the street width and would not contribute the aesthetic value of a landscaped median. **!**

Implications of short-term use: The initiation of a traffic-separated bus corridor from the outset of the project could help with promotion of public transport and affect travel behaviour accordingly. **+**

Potential for community attachment: Community attachment to the bus lanes would be limited to the service benefits only, which would be further improved with the implementation of the long term public transport corridor. **+**

Consistency of appearance: The appearance of the corridor would be enhanced with implementation of the long term transport corridor given the addition of landscaped buffer strips and potentially a more attractive paving treatment in the running way. **+**

Traffic lanes

As the kerb-to-kerb width of the road in the short term (i.e. including the public transport reservation) would contain excess space, it is possible this could be used for an additional traffic lane to assist with short term vehicle circulation.



Source: Google Image

Short term value: The local streets along which the Clever and Creative Corridor primarily would run are not projected to have high short term vehicular traffic volumes, therefore the added benefit of an extra traffic lane would be minimal. neutral

Short term appearance: An extra traffic lane would represent an expansion of the road surface over its required configuration and would not have any visual benefit. **!**

Implications of short-term use: This would be a very large concern with an extra traffic lane, as the excess capacity could contribute to travel behaviours and design patterns that could be later difficult to reverse. **!**

Potential for community attachment: There is a danger that the extra traffic lane could be difficult to remove in the long term due to community reaction regardless of whether or not it is strictly needed according to projected traffic volumes. **!**

Consistency of appearance: The appearance of the corridor would be significantly improved with implementation of the long term public transport corridor, so there are not likely to be any objections to conversion on aesthetic grounds. **+**

Recommendations for short term use

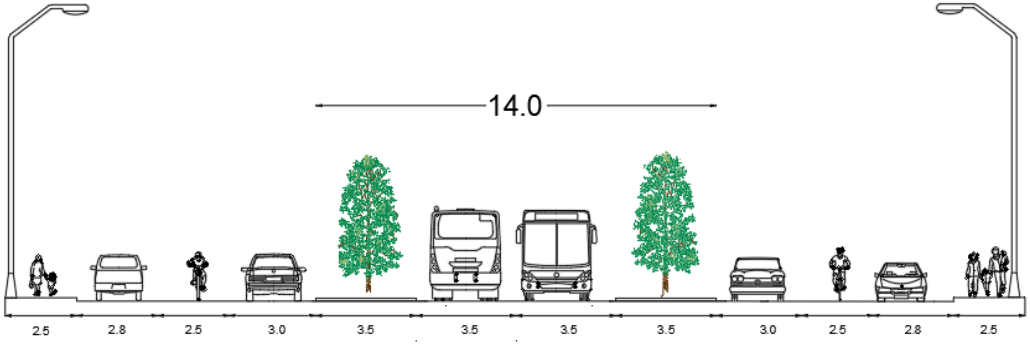
It is recommended based on the preceding considerations that the most appropriate short term use for the public transport reservation would be a green strip with some formalised landscaped areas.

This owes primarily to the visual and environmental value of these treatments balanced with their modest or replaceable amenities. Key elements could be summarised as follows:

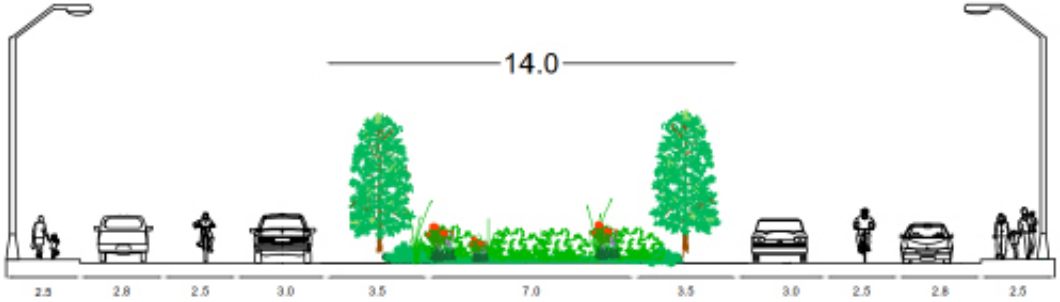
- The vast majority of the corridor would be held as an informal green strip, with low or mid-level landscaping that would not incur any deep root structures or difficult-to-remove plantings.
- The outside edges of the median strip -- which would continue to be preserved as narrower green strips in the long term under the proposed design scenario -- could support taller more significant plantings that would be retained indefinitely.
- Certain areas meeting specific conditions may be suitable for more formalised landscaped treatments or activated green areas, *provided that these could be replaced outside the reservation* once the public transport service has been implemented.

Summary of advantages and disadvantages

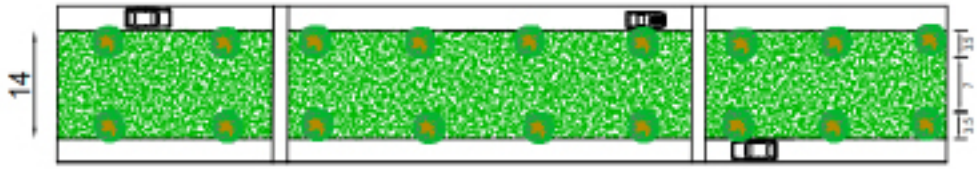
	Passive green strip	Formalised landscaped areas	Pathways	Parking lanes	Bus lanes	Traffic lane
Short term value		+	+	+		
Short term appearance	+	+	+	!	!	!
Implications of short term use		+	+	!	+	!
Potential for community attachment	+	!	!	!	+	!
Consistency of appearance	+		+	!	+	+



Long term proposed section



Short term proposed section



Short term overhead view

Recommendations for short term use

Near term bus operations

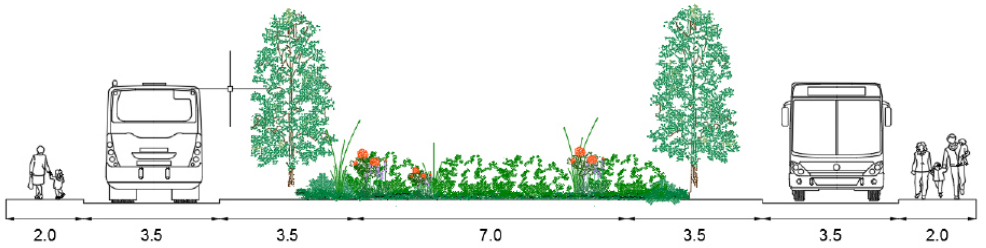
There is flexibility in how buses could be run along the Clever and Creative Corridor in the shorter term, i.e. before the full traffic-separated transit corridor is implemented.

Option A

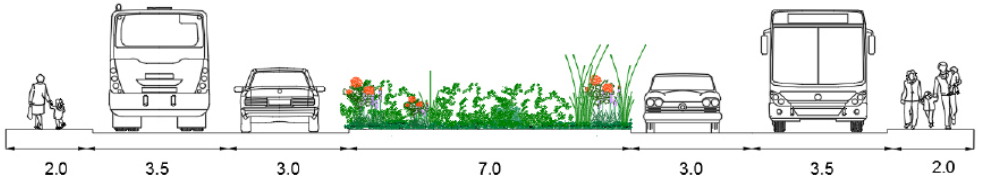
The first option (Option A) is to have buses run on-road independent of the transit corridor reservation (i.e. within the general traffic lanes). This would not affect the corridor reservation width but would subject buses to potential delays in general traffic.

Option B

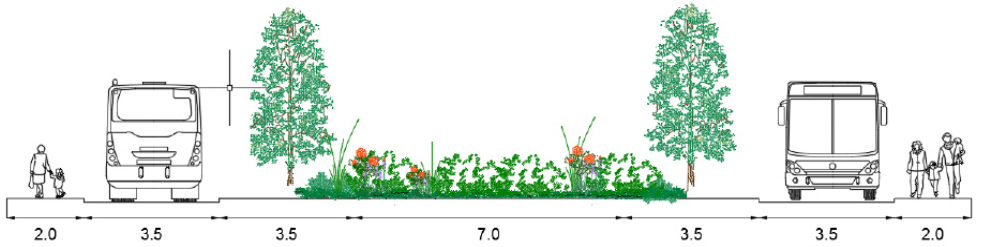
The second option (Option B) is to run buses in dedicated kerb-side bus lanes. This would necessitate an 'extra' lane in the short term (i.e. for buses only) which could be carved out of the required width for the long-term median reservation. When the transit corridor is eventually implemented, the buses could be transferred into the median (refer to the long-term diagram) and the car lanes shifted outward to allow for construction of the landscape/platform strips.



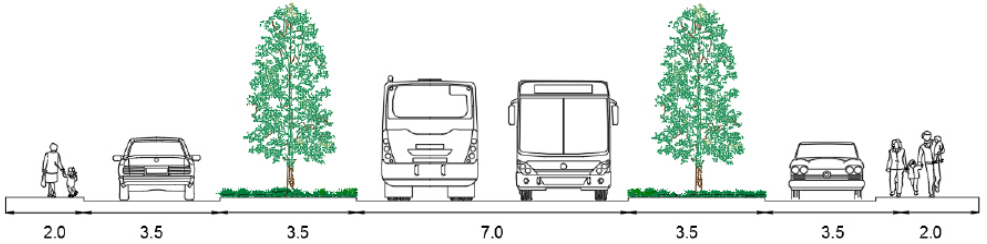
Short term bus running option A



Short term bus running option B



Option C predominant bus running alignment



Option C at proposed station locations

Option C

A third option would have buses running predominantly on-road but potentially merging with the transit corridor in the vicinity of key stops, stations or transfer areas, to draw demonstrable value from the reservation in the shorter term. This would represent a combination of Option A and (at stations only) the long-term transit corridor buildout configuration.

Recommendations for short term use

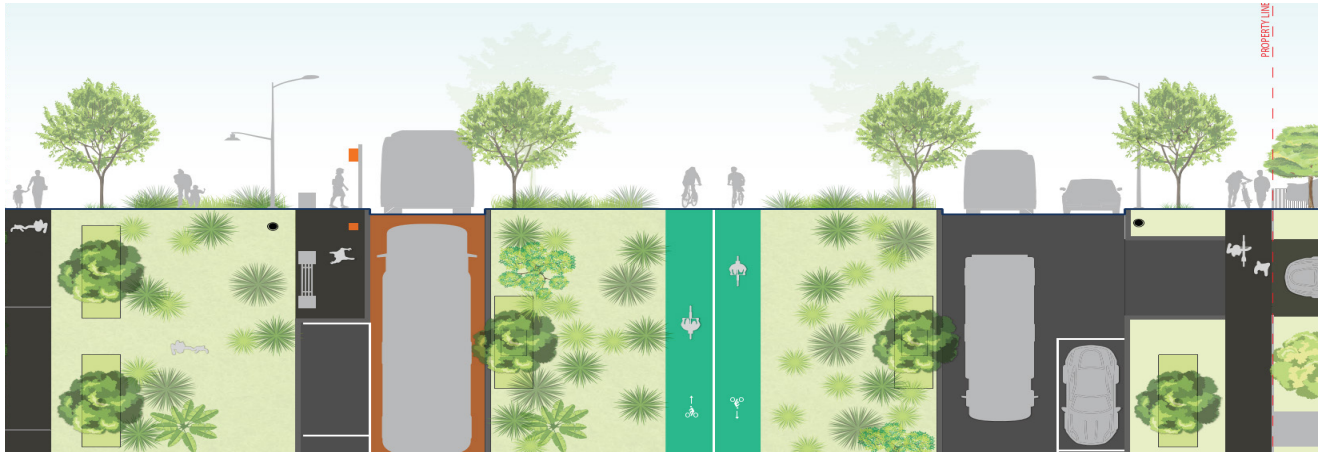
Potential for median pathway

Interim use of the median for a cycling or pedestrian path may be a viable option pending the preservation of sufficient space elsewhere in the corridor to support its relocation when the public transport service is implemented. This can be achieved by setting aside an additional nature strip beyond the outer kerbs.

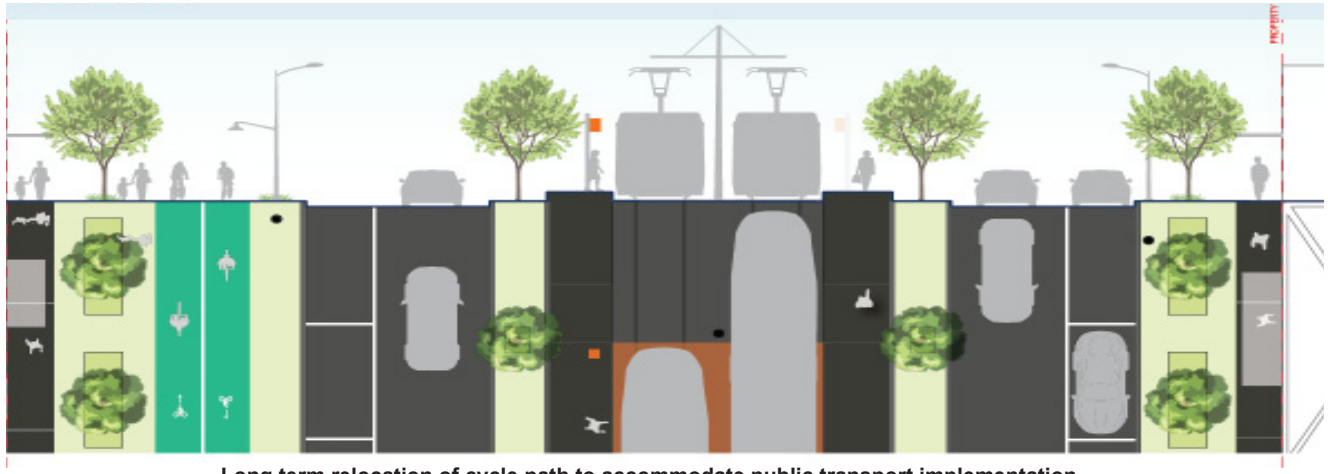
The benefits of this staged approach would include:

- It establishes the median as a transport orientated land use in the short term.
- It has long term utility if ultimate transition does not occur.
- It encourages active transport movements.
- It allows rapid active transport movements that avoid frequent cross overs.

The main short term challenge of this approach would be designing major road intersections to safely accommodate cyclist movements, which may require car turning restrictions or a dedicated signal phase for cyclists.



Potential interim median pathway treatment with additional kerbside green reserve



Long term relocation of cycle path to accommodate public transport implementation

Recommendations for short term use

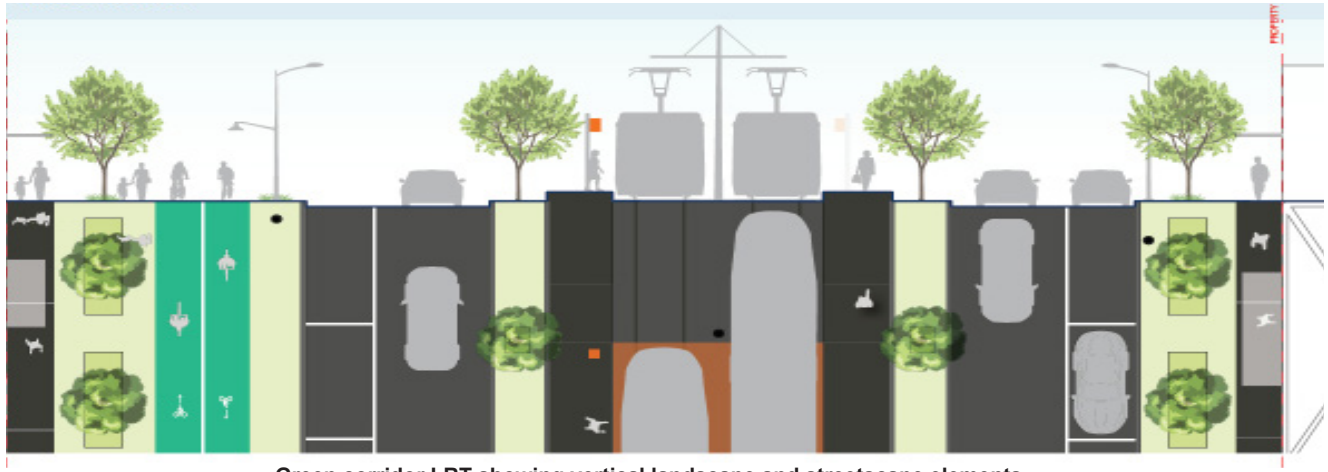
Vertical elements and street scale

In order to ensure that the scale and enclosure of the street is not compromised, it will be essential to include significant vertical elements within the median reserve.

The proposed 3.5-metre landscaped buffers that would run alongside the public transport lanes are wide enough to accommodate trees of sufficient height — along with other vertical decorative features including public art or supplemental lighting fixtures —helping to manage the perceived breadth of the corridors in both the short and long terms.



Green corridor BRT showing vertical landscape and streetscape elements



Green corridor LRT showing vertical landscape and streetscape elements

Recommendations for short term use

Other considerations and alternatives

The potential use of native vegetation within the short-term corridor reserve could add a significant degree of aesthetic and environmental value. It will be important, however, to also include these treatments in the longer-term landscaped buffer zones (along each edge of the median) to ensure that a significant amount of this vegetation could be retained into the longer term to reduce any potential future controversy around replacing it with public transport lanes.

If more formalised tailored landscapes were to be included, these would be most effectively placed in the areas of higher concentration activity to maximise their usage without their value becoming associated with any specific residential properties, which could otherwise make them more difficult to displace in the longer term.



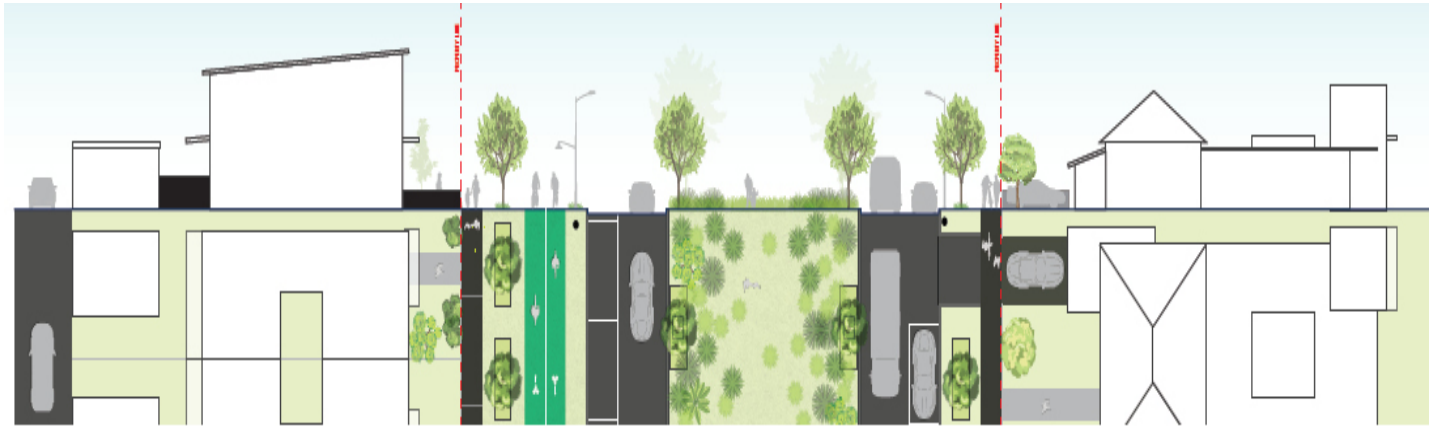


Examples of low to mid level native vegetation





Examples of native vertical vegetation



Green corridor scenario showing cycle path along one side of the roadway

Conclusion

Summary

This report has evaluated the key aspects of implementation of the Clever and Creative Corridors concept in the Northern and Western Geelong Growth Areas. This has been organised according to four key questions about the nature of the corridor:

- **Why:** Justification for the corridor
- **Where:** Location of the corridor
- **What:** Design of the corridor
- **How:** Staging of the corridor

Due to the uncertainty of the public transport technology to be eventually used for the system -- and their varying design requirements -- the primary conclusion from this process has been that a flexible design should be chosen to cater to any of the potential candidates.

This has included provisions for an expandable station template that would not require additional width in the proposed stations areas, allowing flexibility in the locating of specific station sites as the development program in the growth areas is solidified.

The proposed short term use for the corridor has been selected based on its balancing of visual and practical objectives, adding aesthetic value to the corridor while not risking the introduction of irreplaceable community amenities.

Why

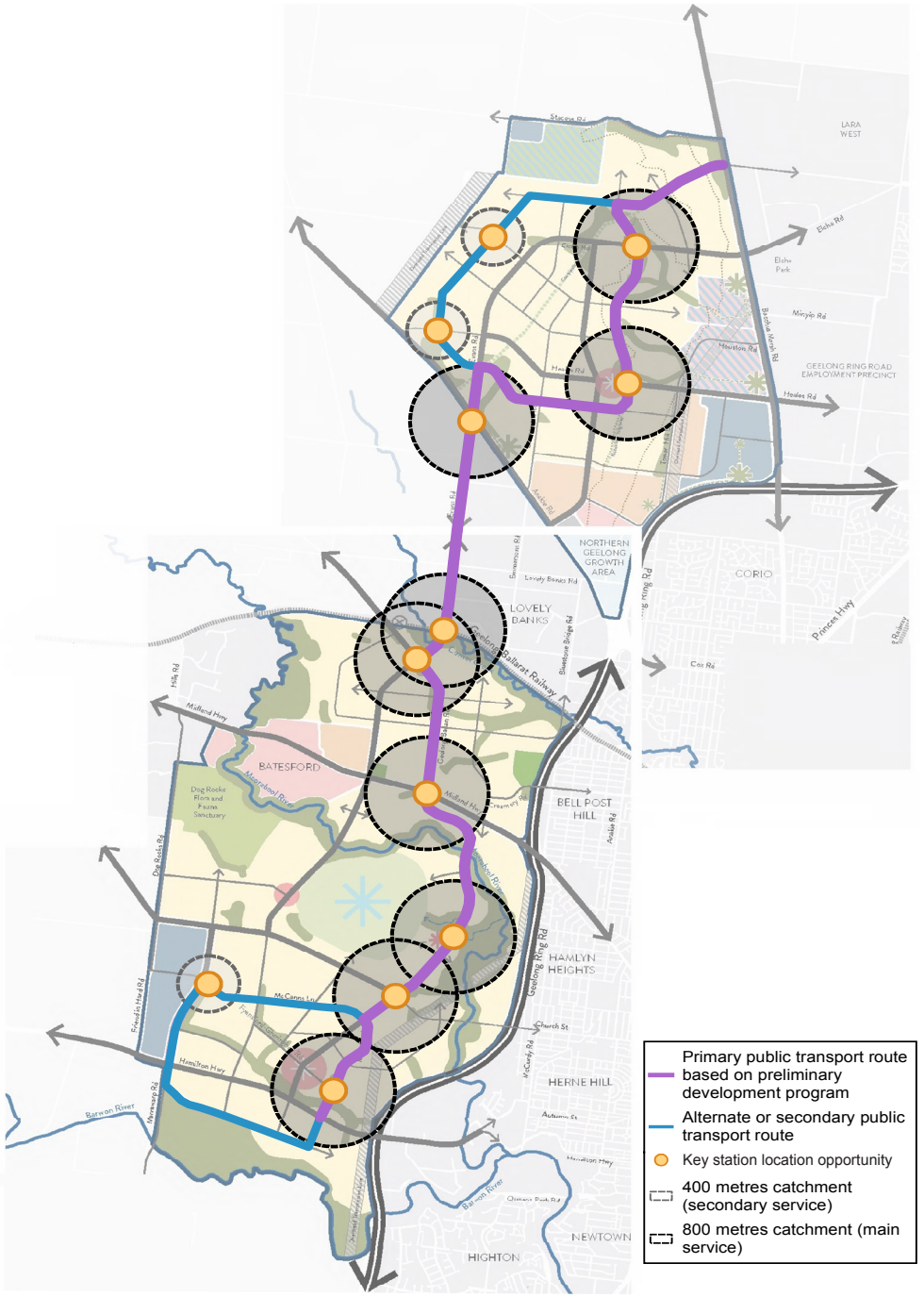
The benefits of public transport are well documented and extend to various facets of life, including personal mobility, environmental health, personal health, road safety, community design and social cohesion.

From a transport perspective, the preservation of the Clever and Creative Corridor for future public transport could – in addition to the promise of efficient mobility regardless of car ownership status – help minimise the future monetary and land costs that could otherwise be required to support further expansion of roads and provision of large quantities of off-street parking.

Where

The proposed corridor location travels north-south through the two growth areas primarily in the median of its encompassing roads.

Pending the evolution of development patterns within the sites, it is recommended that the main corridor is streamlined into a linear system serving the most intensely developed areas with the most suitable mix of uses. The corridor would ideally extend beyond the borders of the growth areas to connect with central Geelong and one or more main line rail stations.



Conclusion

What

The proposed design corridor consists of a central running way flanked by two continous landscaped strips. This configuration -- in conjunction with the proposed 'bilateral opposing' station platform arrangement -- has the following benefits:

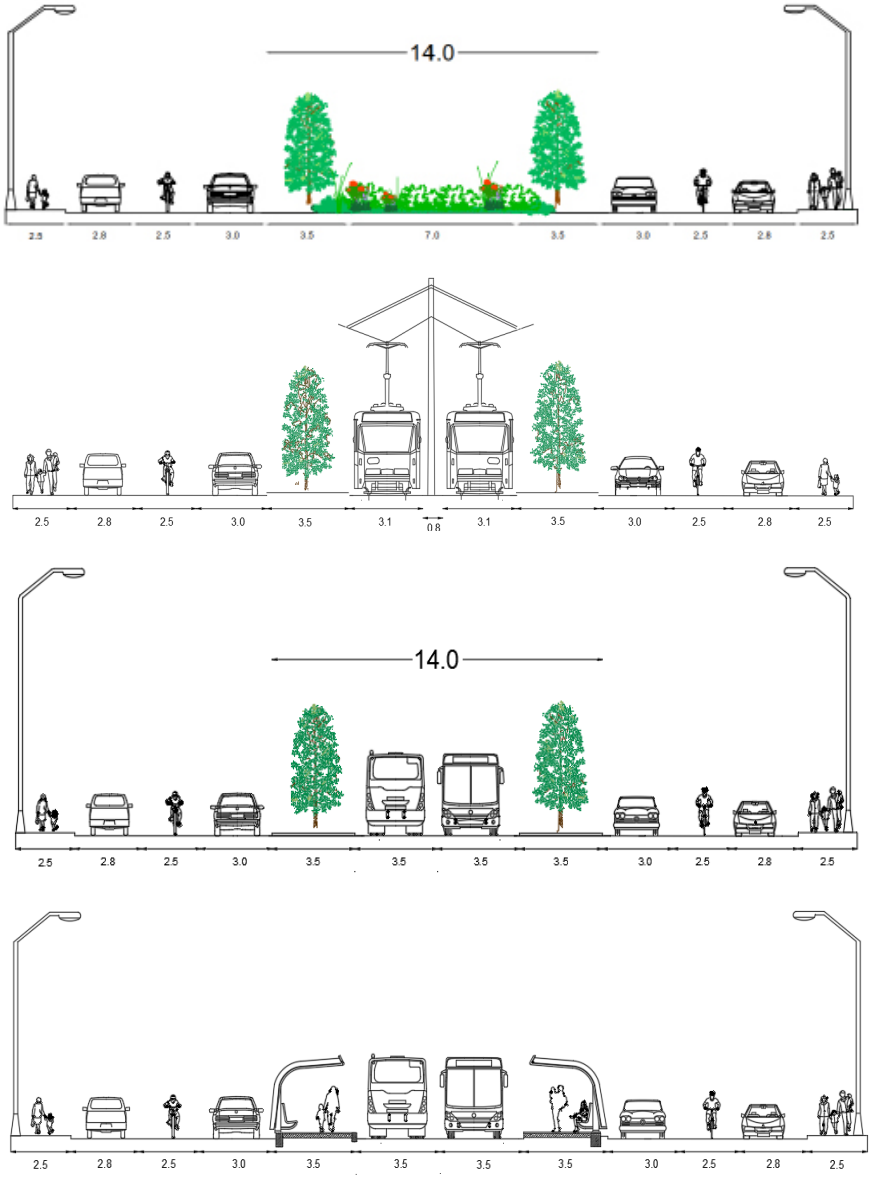
- Public transport vehicles would be safely and attractively separated from other corridor users.
- Stations could be inserted at any location along the route, utilising the street width otherwise taken up by the landscaped buffer strips.
- Stations would be expandable at any point in the future when unexpected conditions may warrant an upgrade in public transport vehicle size. This would be accomplished by simply lengthening the platforms along the adjoining landscaped strips.
- The ultimate design would accommodate aesthetic continuity from the proposed short term interim use as an informal green median, by maintaining an attractive landscaped buffer on each side of the transport running way.

The proposed reservation width for the public transport corridor (including buffers) is 14 metres above and beyond what is needed for other road uses.

How

The staging of the corridor requires careful management of the utility of the interim condition. As discussed in this report, this interim use should provide a tangible level of value while not risking the creation of irreplaceable amenities to which the community may become excessively attached.

To this end, it is proposed that the Clever and Creative Corridor is held primarily in a passive green state until needed for its intended ultimate public transport use, potentially with some formalised landscaped areas or a pathway provided these assets can be shifted elsewhere in the longer term. This enables the establishment of the corridor as an environmentally responsible and aesthetically pleasing conduit prior to its long term conversion, at which point it would still retain much of its green identity assuming implementation of the 'green corridor' public transport alignment.



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