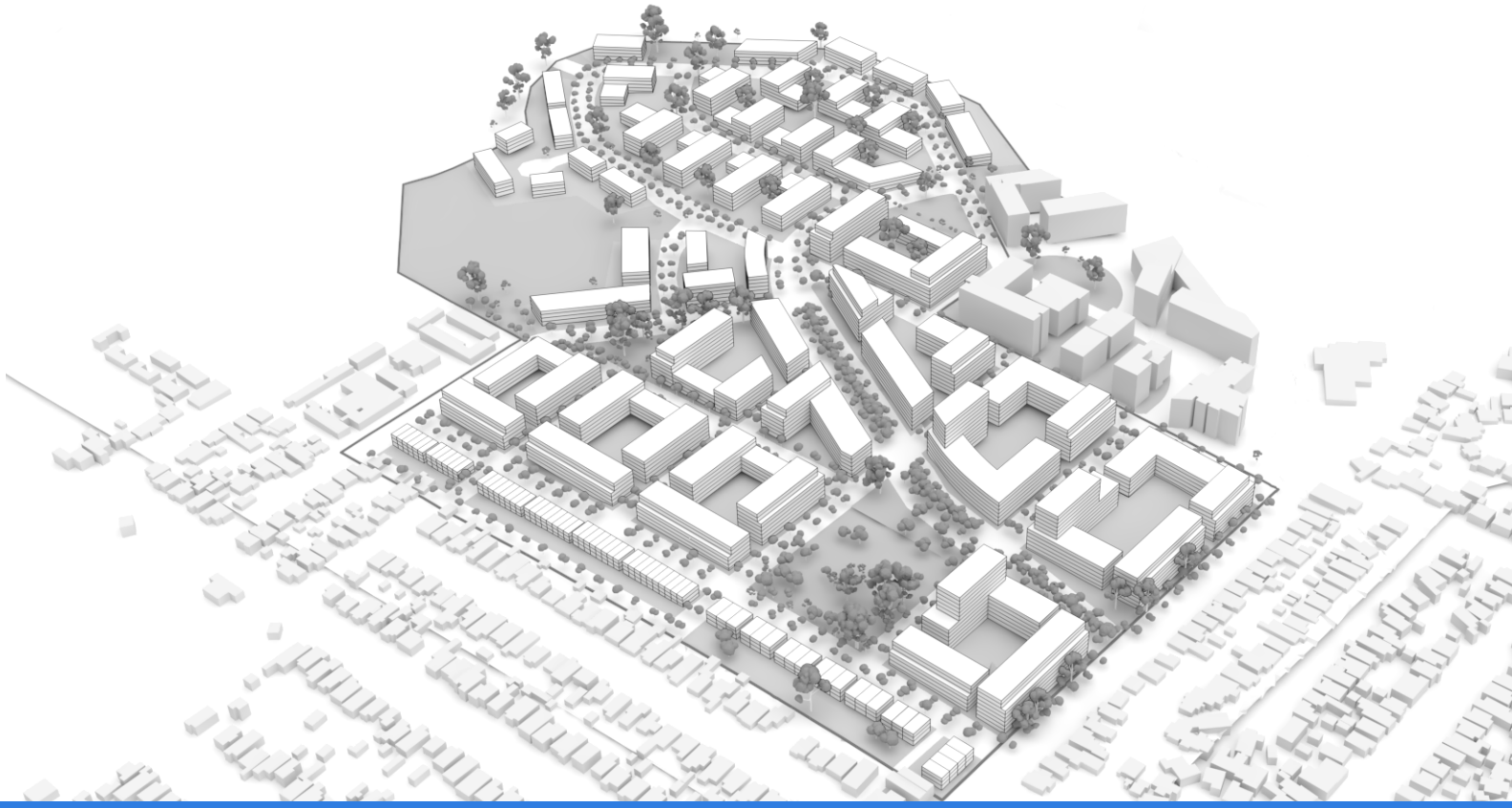

Riverwood Estate State Significant Precinct
Traffic and Transport Assessment

Prepared for:

NSW Land and Housing Corporation

16 June 2022

The Transport Planning Partnership

Riverwood Estate State Significant Precinct

Traffic and Transport Assessment

Client: NSW Land and Housing Corporation

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Table of Contents

Tables

Figures

APPENDICES

1 Executive Summary

The Project

The Riverwood Renewal project provides an opportunity to revitalise the Riverwood social housing estate into an integrated mixed-use precinct that will deliver a mix of social and private dwellings. The revitalisation of the Riverwood Estate offers the government the opportunity to renew aging social housing whilst significantly improving this area, and the quality of life for residents.

The Transport Planning Partnership and a consultant team have worked with LAHC to prepare a master plan for the redevelopment of the site that will replace the existing dwellings, provide for additional private dwellings, new streets and parks and community uses. The proposed master plan consists of approximately 3,900 social and private dwellings ranging between 3 and 12 storeys.

This traffic and transport assessment has been prepared by adopting a Movement and Place approach where site constraints and opportunities have been identified to set the frame for the vision and objectives to ensure they are strategically aligned and deliver the intended traffic and transport outcomes.

Traffic and Transport Assessment

Traffic surveys have been conducted at Washington Park development as a benchmark for trip generation rates and travel mode share of the residential component of the development. The derived rates have been increased to better reflect the driving characteristics shown in Census Data 2016. The traffic generation rates and target mode shares acquired from the survey results have been approved by Roads and Maritime (currently Transport for NSW) as part of the previous masterplan for the Riverwood Estate prepared in 2018 and deemed appropriate to use for estimating the future trip generation and travel patterns of the Study Area.

The proposed development is estimated to generate approximately 1,182 trips in the morning peak hour and 1,353 trips in the evening peak hour when it is fully operational (Year 2041).

Jacobs had developed a microscopic Aimsun model for the suburb of Riverwood which was reviewed and approved by Roads and Maritime in a separate study. As part of this master plan, Jacobs assessed the impacts of the proposed development and the upgrades to maintain an acceptable level of service using the Aimsun model. Key intersections surrounding the site have been assessed to determine the need for any road upgrades in order to support the background growth and development traffic.

In addition, TTPP has undertaken intersection capacity analysis of two intersections outside the extent of the Aimsun traffic model. These intersections have been analysed using SIDRA Intersection Version 8 modelling software.

Infrastructure Upgrade Works Required

Based on the traffic modelling results, intersection upgrade works would be required at the following intersections to accommodate the future traffic associated with the proposed development and background growth in Year 2031 (interim year):

- Belmore Road – Hannans Road – Washington Avenue
- Bonds Road – Hannans Road
- Bonds Road – Broadarrow Road
- Bonds Road – Romilly Street
- Bonds Road – Forest Road – Boundary Road

Additional upgrade works will be required at the following intersections in Year 2041:

- Bonds Road – Hannans Road (except for banning on-street parking in Hannans Road in Year 2031)
- Belmore Road – Roosevelt Avenue (however recommend upgrading to signalisation by year 2031 to provide a gateway intersection to the proposed development)
- Canterbury Road – Belmore Road (except for extending No Stopping Zone on Belmore Road to 90m in Year 2031)

The intersection of King Georges Road – Broadarrow Road is anticipated to operate at LoS E or F in these future years, even without the additional development traffic. It is noted that this intersection has been recently upgraded in 2020 as part of the Gateway to the South Pinch Point Program and that there is not enough road reserve in the area to accommodate any additional lanes in this built-up area. As such, opportunities for further improvements at this intersection is limited.

A recognised entry point to the Study Area would be provided on Belmore Road with a turning lane to facilitate the right turning movement into the Study Area, which would minimise interruption to the through movements on Belmore Road. Two options have therefore been developed for Belmore Road as follows:

- Option 1 was developed to provide a shared through and right turn lane at the Belmore Road- Roosevelt Avenue with the retention of the existing centreline.
- Option 2 was developed following additional stakeholder engagement to provide a right turn lane on Belmore Road at the Roosevelt Avenue intersection to separate the through and right turn movements. In this option, the Belmore Road centreline would be shifted to the west.

An assessment of the apportionment of the required infrastructure improvement works required to support the proposed development and background growth has been undertaken by Jacobs.

The Regional Infrastructure Contribution (RIC) is a recently introduced mechanism to collect contributions from development to help fund State and regional infrastructure such as transport infrastructure, state or regional roads etc.

The RIC is a charge that will apply to new residential development in Greater Sydney. The proposed RIC Framework will assist in the acceleration of the delivery of priority growth infrastructure. The base regional infrastructure contribution is forecast to levy, on average, $793 million per annum.

The RIC SEPP is proposed to commence on 1 July 2022. To minimise the potential for adverse impacts on current development supply, and in light of ongoing impacts of the COVID-19 pandemic, the RIC would be phased-in to allow industry stakeholders, councils and consent authorities to adapt to the new charge.

It is anticipated that the proposed payment of the RIC would address the off-site traffic impacts on the State and Regional Roads.

Impact on Public Transport

The master plan proposes to re-route the existing Bus Route 944 as such residents are located within 200m of a bus stop with great convenience to the bus services.

When the proposed development is fully operational, it is expected to generate a net increase in the order of 189 bus users and 354 train users. The existing spare capacity of these public transport services would not be sufficient to accommodate the future demands.

On this basis, the provision of additional bus services and rail network upgrades would need to be explored by TfNSW, Punchbowl Bus, Transport Sydney Trains, and other relevant agencies to relive existing deficiencies in the network, as well as to support future growth within the catchment areas. Consultation with TfNSW would be held to discuss the proposed public transport strategy to support the subject development.

Impact on Pedestrians and Cyclists

The existing internal road has a constrained layout due to its irregular and disconnected street pattern which limits movement around the site. The masterplan creates an opportunity to redesign the internal streetscape to accommodate a high-density neighbourhood with wide streets.

The site is relatively flat encouraging walkability and within easy walking distance to the Riverwood town centre, existing community facilities and Riverwood public school.

Parking Provision

Parking provision for local residents and the mixed-use centre are to meet relevant statutory requirements stipulated in Canterbury Development Control Plan (DCP) 2012, TfNSW Guide to Traffic Generating Developments (Guide) 2002, Apartment Design Guide (ADG) 2015, and State Environmental Planning Policy (Affordable Rental Housing) (SEPP) 2009.

The minimum parking requirement is approximately 4,062 car parking spaces associated with the residential apartments, mixed-use centre, childcare centre and various community uses.

Consideration should be given to implementing measures to minimise parking demand within the Study Area that may go beyond the intended parking provision, with the preparation of a Green Travel Plan and car share scheme to further reduce parking levels.

2 Introduction

NSW Land and Housing Corporation (LAHC) has engaged The Transport Planning Partnership (TTPP) to prepare a transport strategy and traffic assessment to support the planning proposal for the Riverwood Estate State Significant Precinct (the Study Area). This report has been prepared in accordance with the Movement and Place approach which incorporated the following Study Requirements issued by the Department of Planning, Industry and Environment (DPIE) for the Study Area as summarised in Table 2.1.

Table 2.1: State Significant Precinct – DPIE Study Requirements

No.	DPIE Study Requirements	Have the DPE Study Requirements Been Adequately Addressed?	Report Reference
Scope and Requirement			
1.	Identifies the existing situation, including constraints opportunities and key issues to inform a Study Area that appropriately covers transport infrastructure and services that should be assessed for the impact resulting from the proposed development	Yes	Sections 3 and Section 5.3
2.	The freight servicing needs of the precinct	Yes	Section 10.7
3.	Reviews the trip generating potential for all proposed modes and purposes, develops mode share targets and travel demand management measures and policies (including appropriate level of on-site car parking rates consistent with the site's proximity to public transport services) to achieve these targets	Yes	Sections 7 and 11.5
4.	Provides an understanding of the travel behaviours and patterns (all modes) of future workers, visitors and residents of the proposal in consideration of influencing factors such as changes in demographics and land uses through benchmarking (against best practice development on similar sites), forecast modelling tools (i.e., Strategic Travel Model and Strategic Traffic Forecasting Model) and other sources of evidence	Yes	Section 7
5.	Identifies and assesses the traffic and transport impacts resulting from the proposal with a detailed appropriate level transport network assessment for all modes including of pedestrians, cyclists, freight, on road public transport and private vehicles with consideration of the cumulative traffic and transport impacts from planned and committed developments in the surrounding area to year 2036;	Yes	Section 6.9, 7, 9.3, 9.4, 10
6.	Consider the transport needs of the Riverwood centre including parking needs and arrangements	Yes	Section 10
7.	Provides details of the proposed transport strategy including, any necessary transport	Yes	Section 11

No.	DPIE Study Requirements	Have the DPE Study Requirements Been Adequately Addressed?	Report Reference
	infrastructure and servicing improvements; the proposed approach to pedestrian and bicycle facilities, car parking; and access and egress requirements		
8.	Informs and supports the preparation of the proposed planning framework including any recommended planning controls or DCP/Design Guideline provisions and strategic cost estimates and delivery mechanism for the additional transport infrastructure and service requirements in support of the delivery of an appropriate planning outcome	Yes	Section 11
Considerations			
1.	A "vision and validate" approach to the precinct and adjacent street network to develop a street user hierarchy, including movement and place considerations, for the precinct	Yes	Section 5
2.	Inclusion of pedestrian analysis at access/egress points, at intersections with the road network along key desire lines	Yes	Section 8.3
3.	Measures to safeguard future transport infrastructure and traffic changes (for example any planned/future road closures, pedestrianised street sections, one way/two-way traffic operation etc. to the adjacent transport network)	Yes	Section 11
4.	The safety of all road users, particularly pedestrians and cyclists	Yes	Section 6.5
5.	The performance of the existing and future cycling, public transport and road network surrounding the precinct, including potential improvements	Yes	Sections 6.9, 6.9.6 Sections 9 and 11
6.	Cumulative growth of the surrounding area based on committed and planned developments to the year 2036	Yes	Section 6.9, Appendix B and Appendix C
7.	A realistic level of development yields that could be supported by the future planned transport infrastructures;	Yes	Section 6.9
8.	Potential impacts of construction traffic including a strategic construction approach and potential staging	Yes	Section 12
9.	Access for people with disability, older people and pram users	Yes	Sections 8.3

2.1 Background

The Riverwood Renewal project provides an opportunity to revitalise the Riverwood social housing estate into an integrated mixed-use precinct that will deliver a mix of social and private dwellings. The revitalisation of the Riverwood Estate offers the government the

opportunity to renew aging social housing whilst significantly improving this area, and the quality of life for residents.

TTPP and a consultant team have worked with LAHC to prepare a master plan for the redevelopment of the site that will replace the existing dwellings, provide for additional private dwellings, new streets and parks and community uses. The proposed master plan consists of approximately 3,900 social and private dwellings, buildings ranging between 3 and 12 storeys and local open spaces.

2.2 References

References have been made to the following documents in preparation of this report:

- Riverwood Estate State Significant Precinct – Study Requirements (December 2020)
- Riverwood Renewal Project Social Housing Development – Existing Traffic and Transport Assessment (GTA Consultants, 29 March 2017)
- Riverwood Staging – M5 Ramp Upgrade Impact (GTA Consultants, 20 October 2017)
- Riverwood Renewal Project Social Housing Development – Transport Modelling Summary (GTA Consultants, 21 June 2017)
- Riverwood Renewal Project – Transport Advice (GTA Consultants, 20 October 2017)
- Engineering Opinion of Cost for Mitigation Measures (GTA Consultants, 25 July 2017)
- Washington Park Traffic Generation (GTA Consultants, 19 December 2017)
- Practitioner's Guide to Movement and Place (Government Architect NSW and TfNSW, March 2020)

2.3 Report Structure

The remaining contents of the report are set out as follows:

- Section 2 provides an introduction of the project background, references adopted in the assessment and compliance to the DPE Study Requirements
- Section 3 discusses the existing conditions of the subject site
- Section 4 provides a brief description of the proposed development
- Section 5 presents the Movement and Place framework, constraints and opportunities in relation to the site, and sets the transport vision and strategy for the traffic and transport assessment
- Section 6 examines the existing and future conditions of the surrounding road network including implications of the proposed development
- Section 7 summarises the existing and future travel behaviour of people living, working and visiting the Study Area

- Section 8 assesses the existing and future conditions of walking and cycling facilities in the vicinity
- Section 9 assesses the impacts of the development to the existing public transport facilities
- Section 10 presents the indicative parking requirement of the proposed development
- Section 11 recommends transport strategies and mitigation measures to support the proposal
- Section 12 outlines the construction traffic impacts
- Section 13 provides a summary of the discussion points with TfNSW
- Section 14 provides a summary of the discussion points with Canterbury-Bankstown Council, and
- Section 15 presents the summary and conclusions of the assessment.

3 Existing Context

This section discusses the existing conditions and strategic context of the subject site and surrounding areas.

3.1 Study Area

The Study Area is an area of 30ha and is located within the Canterbury Bankstown LGA. It contains a large area of government-owned land (16.7ha owned by LAHC) and is of state importance in achieving key government policy objectives, particularly renewing social housing and increasing housing supply.

The Study Area is bounded by Belmore Road to the east, the M5 Motorway to the north, Salt Pan Creek Reserve to the west and Killara Avenue to the south. The majority of the site is located within walking distance, approximately 5-15 minutes, from the Riverwood Station. The site is also serviced by local bus route (944) providing connections to key centres including Bankstown, Hurstville, Mortdale, Roselands and Campsie.

The Study Area is well-serviced by existing social infrastructure, including existing parks and community facilities, including Riverwood Library and Knowledge Centre at Washington Park and Riverwood Community Centre close to Belmore Road. Riverwood Public School is located immediately adjacent to the study area, and Hannan's Road Public School is within proximity to the study area.

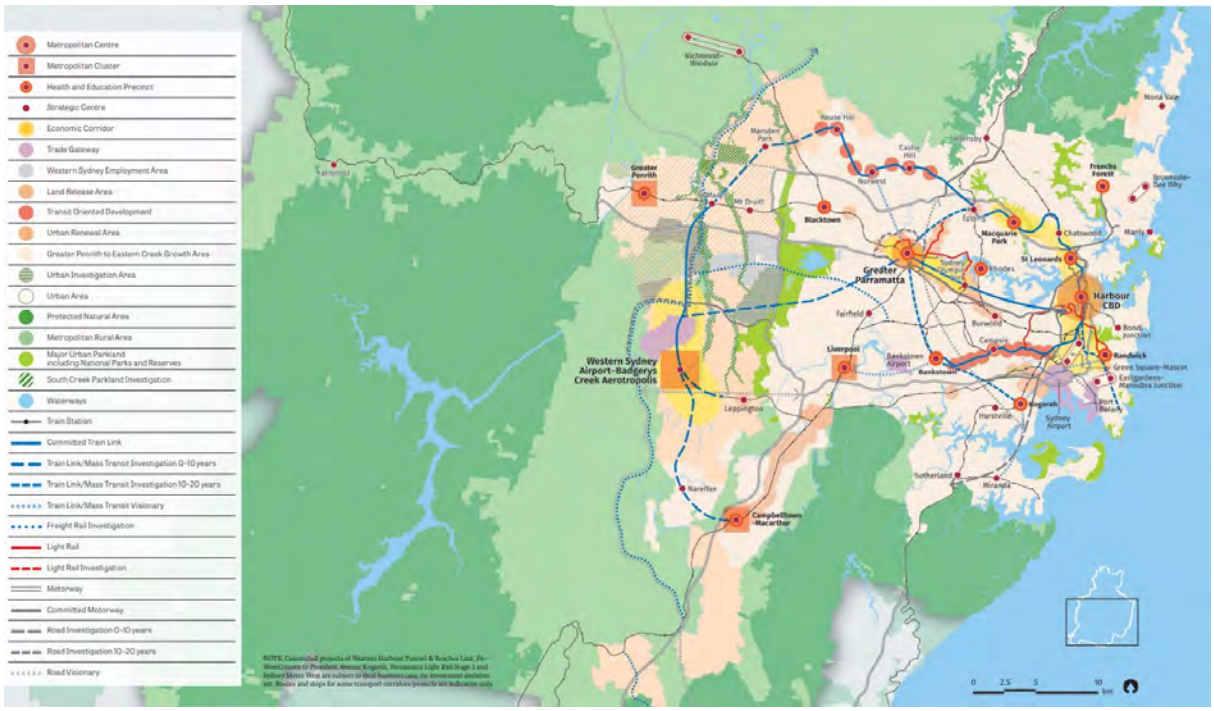
The Study Area comprises social housing dwellings, private dwellings and land owned by Canterbury Bankstown Council. A diverse range of dwelling types, including three-storey walk-up apartment buildings, studio apartments, free-standing cottages and nine-storey apartment buildings is located within the study area.

3.2 Strategic Context

3.2.1 Greater Sydney Regional Plan 2018

The Greater Sydney Region Plan is part of the NSW Government's Future Transport 2056 Strategy and informs Infrastructure NSW's State Infrastructure Strategy. The Greater Sydney Region Plan is a 20-year plan with a 40-year vision and has four key focuses: infrastructure and collaboration, liveability, productivity and sustainability. The Greater Sydney Structure Plan 2056 is shown indicatively in Figure 3.1.

Figure 3.1: Greater Sydney Structure Plan 2056 – The Three Cities



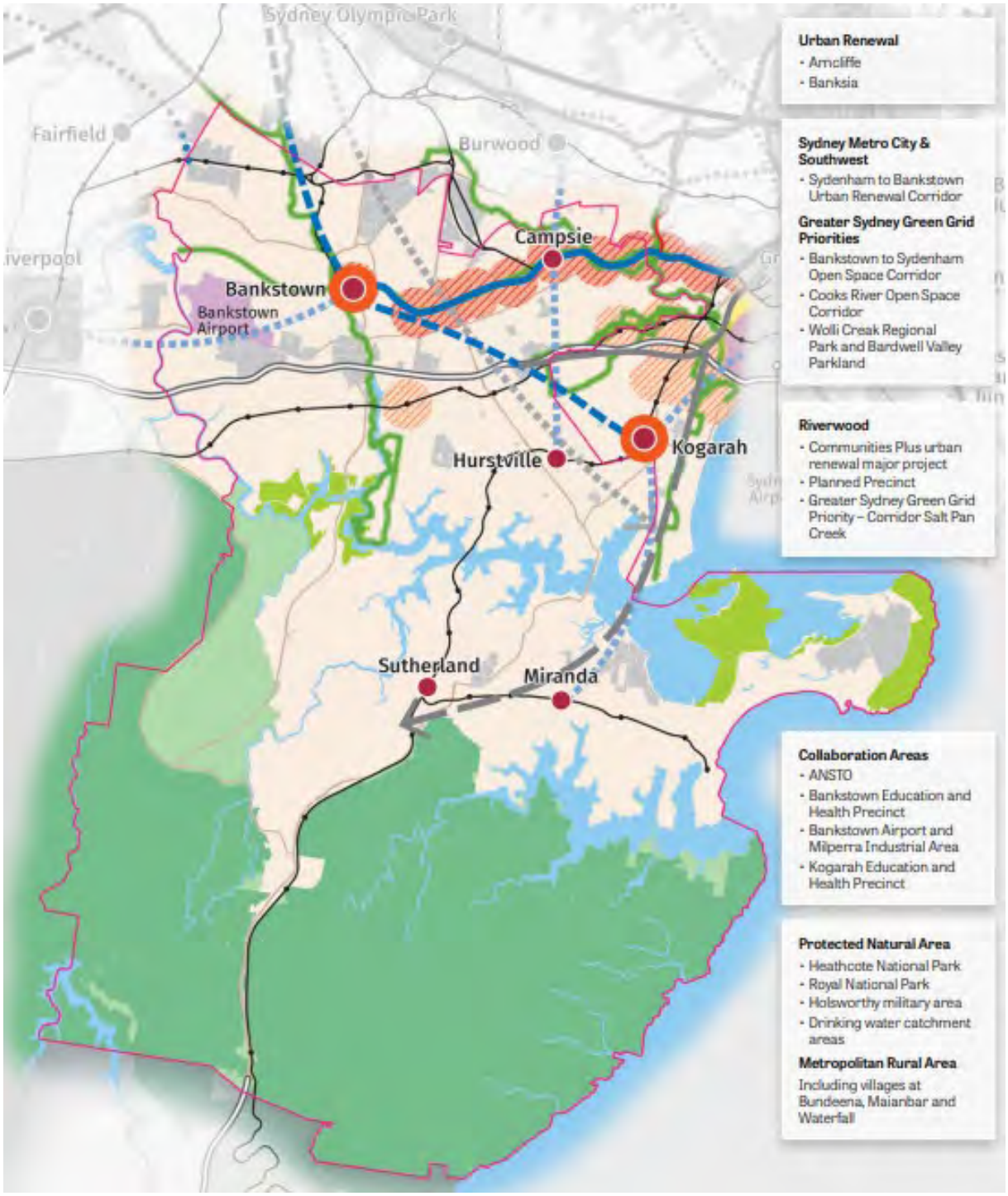
Greater Sydney Region Plan (June 2018)

The vision for Greater Sydney as a Metropolis of Three Cities – the Western Parkland City, the Central River City and the Eastern Harbour City and a 30-minute city – means residents will have quicker and easier access to a wider range of jobs, housing types and activities.

3.2.2 Greater Sydney Commission 2056 – South District Plan (June 2018)

One of the collaborative processes in the South District Plan is the LAHC initiatives for the renewal of the Riverwood Estate State Significant Precinct, with the Department of Planning and Environment (DPIE). This includes creating communities where social housing is part of the same urban fabric as private and affordable housing, has good access to transport and employment, community facilities and open spaces, which can therefore provide a better social housing experience.

Figure 3.2: South District Plan



Greater Sydney Commission 2056 (June 2018)

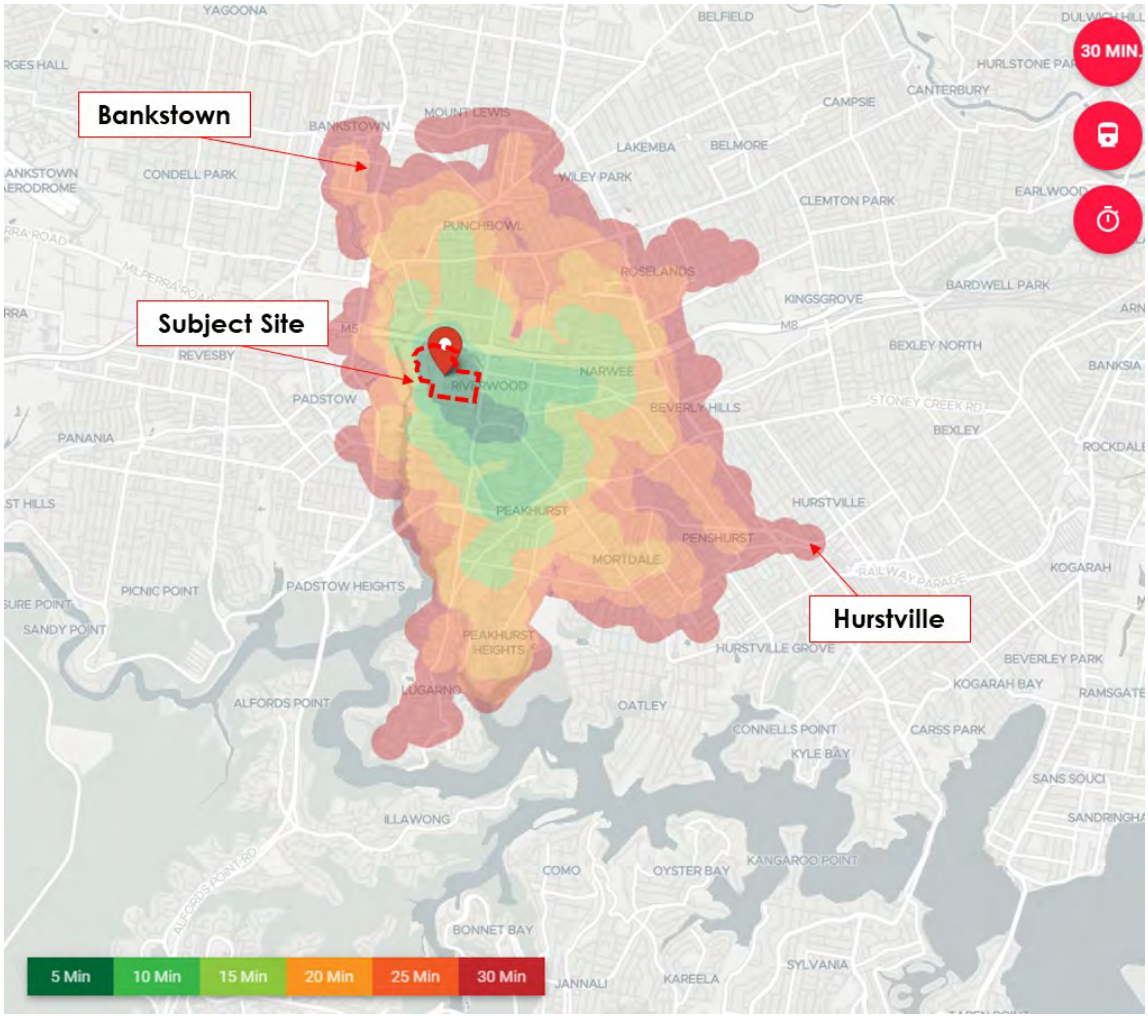
3.2.3 Sydney's 30-Minute Centres

A 30-minute city is where most people can travel to their nearest metropolitan centre or cluster by public transport within 30 minutes; and where everyone can travel to their nearest strategic centre by public transport seven days a week to access jobs, shops and services.

This is integral for economic competitiveness and will make Greater Sydney a more attractive place for investment, businesses and skilled workers.

The location of the Study Area, in the context of the 30-minute centre concept by public transport, is shown in Figure 3.3. The proposed development enhances the 30-minute centre by increasing dwelling density within the Riverwood Estate State Significant Precinct, with access to retail and employment opportunities. Bus services would be improved for access to the surrounding metropolitan centres in Bankstown and Hurstville (refer to Section 8.3 for details).

Figure 3.3: Travel Distance by Public Transport from the Study Area



Source: Targomo

3.2.4 Belmore Road 40km/h High Pedestrian Activity Area Study

Georges River Council is proposing a 40km/h High Pedestrian Activity Area along Belmore Road to improve the effectiveness of the existing pedestrian facilities and introduce additional traffic calming devices where required. The Study is currently not available to the

public. The proposed 40km/h High Pedestrian Activity Area is not expected to be extended to the proposed access to the development on Belmore Road.

3.2.5 Draft Georges River Transport Strategy 2021

Georges River Council has prepared a draft Georges River Transport Strategy to provide policy and directives for Council to enhance existing transport networks and plan for increased demand. The draft Transport Strategy dated June 2021 was on public exhibition from 7 July until 6 August 2021 and amended in response to submissions received.

The aims of the draft Transport Strategy (26 October 2021) include:

- Integrating transport planning and land-use planning;
- Identification of transport vision and objectives in alignment with state, regional and local planning;
- Addressing the challenges of the existing transport network within Georges River LGA in the context of Sydney;
- Addressing the growth and the needs of community, businesses and visitors;
- Informing and supporting the Council's strategic plans; and
- Identification of the actions for improvement of infrastructure, services, policy and behaviour.

The draft Transport Strategy includes the following component strategies:

- Integrated land use, transport planning and travel demand management strategy – Relates to achieving sustainability in transport and emphasising on movement of people and goods; and maximising accessibility;
- Active transport strategy - refers to non-motorised forms of transport involving physical activity, like walking and cycling;
- Public transport strategy – refers to movement of people in larger groups managed on organised schedules and routes, e.g. buses, trains and ferries;
- Road network and freight strategy – refers to planning for road network that is used by a variety of vehicles including buses, trucks, delivery vehicles, freight vehicles, private cars, taxis/ride share, bicycles, wheelchairs and electric powered devices;
- Car parking strategy – incorporates Council's Car Parking Strategy and Position Paper and provides recommendations to enhance it further by 2025; and
- Centres transport strategy – recognises that Council can accommodate more population in specific centres connected to transport and services.

The draft Transport Strategy makes mention of the following opportunities in relation to Riverwood and the Riverwood Estate State Significant Precinct:

- Link the T4 Eastern Suburbs and Illawarra line with the T8 Airport and South train line to improve connectivity within the Georges River LGA as the Riverwood Planned Precinct is developed. An option for this linkage may be the Parramatta/ Bankstown to Hurstville/ Kogarah rapid bus link.
- Provide strong connections between the Riverwood Estate State Significant Precinct to the Riverwood local centre, benefiting residents with goods and services, as well as opportunities for public transport. Access via walking, cycling and public transport from the Estate to Riverwood local centre is proposed on Belmore Road.
- Link the T4 and T8 train lines together with reliable and efficient active and public transport services, particularly to accommodate for the Riverwood Estate State Significant Precinct and the Riverwood Planned Precinct (i.e. Riverwood local centre). This should be achieved with the proposed public and active strategic transport networks, which propose both collector and feeder public transport routes accessing Riverwood via Belmore Road, and a cycling route accessing via Bonds Road. The rapid bus route should be supported with consolidated bus stops at key locations outside of the Riverwood Plaza and north of Riverwood Station.

3.3 Local Context

Riverwood is located within the Canterbury Bankstown and Georges River Local Government Areas (LGAs). Riverwood is located 18km from Sydney CBD and 5km from the metropolitan centres in Bankstown and Hurstville.

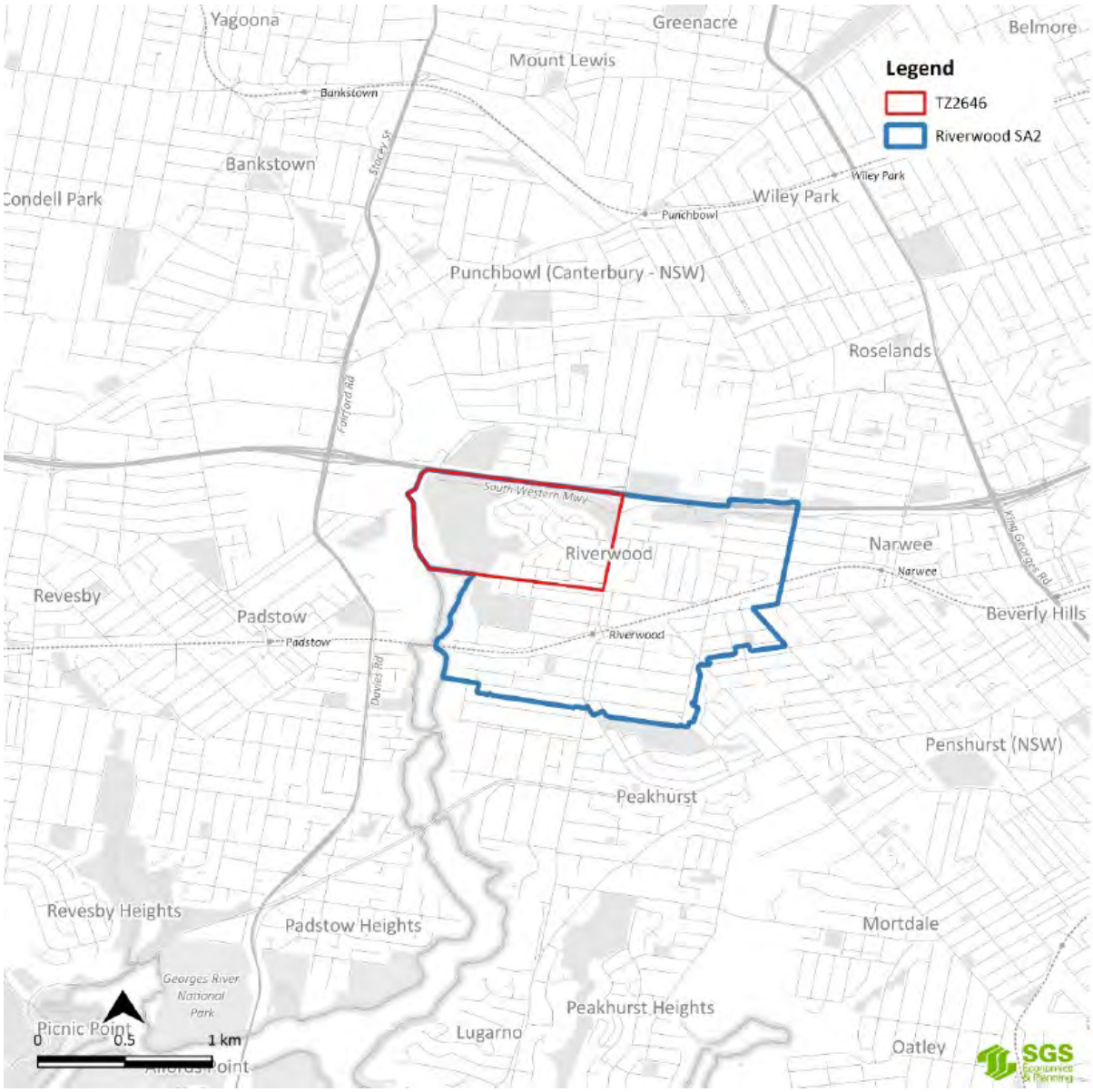
Riverwood is well supported by public transport being located on the T8 Airport, Inner West and South Line and with access to bus services along Belmore Road and provides connections to key centres such as Bankstown and Hurstville. The area also has excellent road access provided by the M5 motorway, Belmore Road, Canterbury Road and King George Road.

The main retail shopping strip for Riverwood is located on Belmore Road, located to north and south of the Riverwood Station, providing the primary local retail centre for the area. Access to Riverwood Station is within a 15 minutes' walk from the Study Area.

3.4 Existing Demographics

SGS did a research on the existing demographic of the existing residential population for TZ4626 as outlined in red in Figure 3.4. This includes Washington Park which is an established residential estate located immediately adjacent to the subject site.

Figure 3.4: Map of TZ2646 and Riverwood SA2



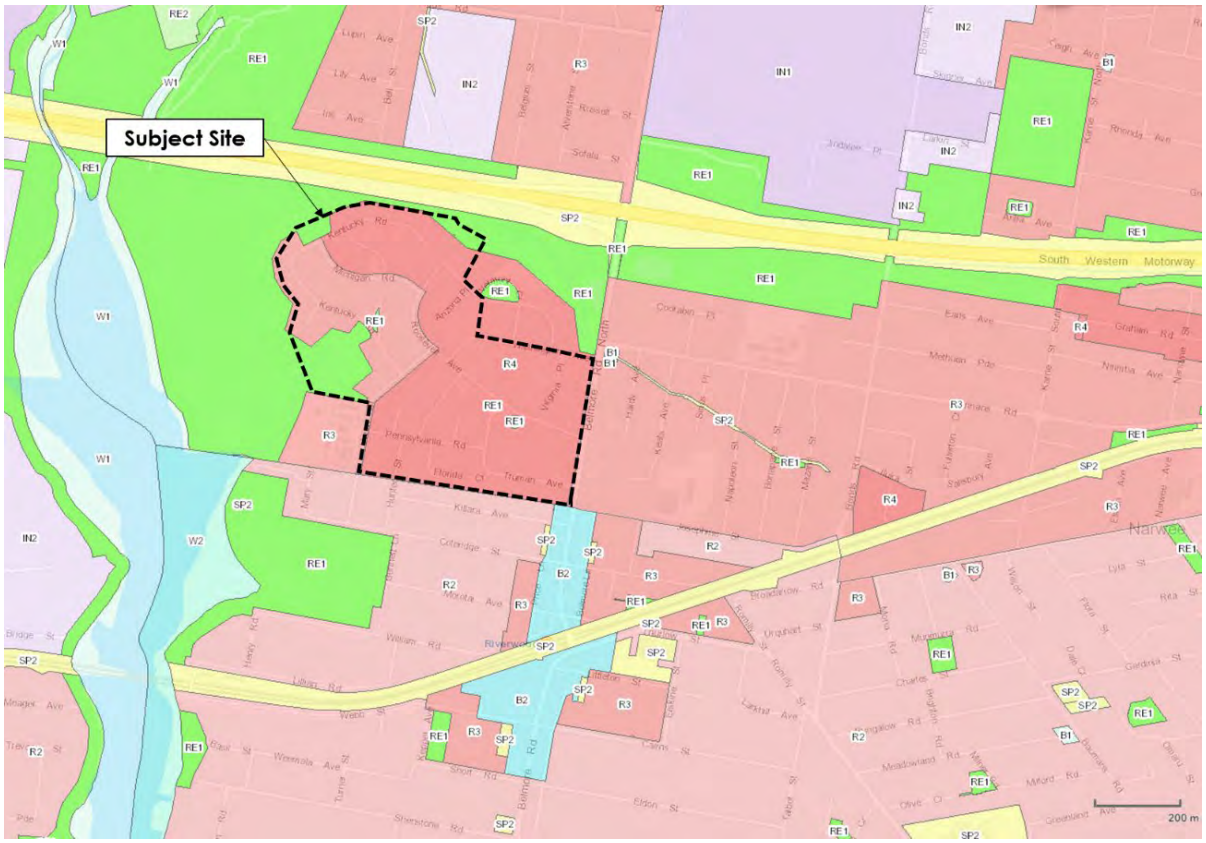
Source: Riverwood Estate State Significant Precinct Demographics & Retail (SGS October 2021)

The total population in TZ2646 was 3,185 in year 2016, of which 23% aged below 20 years, 59% aged 20-65 years and elderly residents (over 65 years old) made up 18% of the population.

3.5 Land Use Data

The existing land use of the site and its surrounds is shown in Figure 3.5.

Figure 3.5: Existing Land Use



As shown in Figure 3.5, the existing land use within the site and surrounding area is primarily residential as per Canterbury Local Environmental Plan (LEP) 2012.

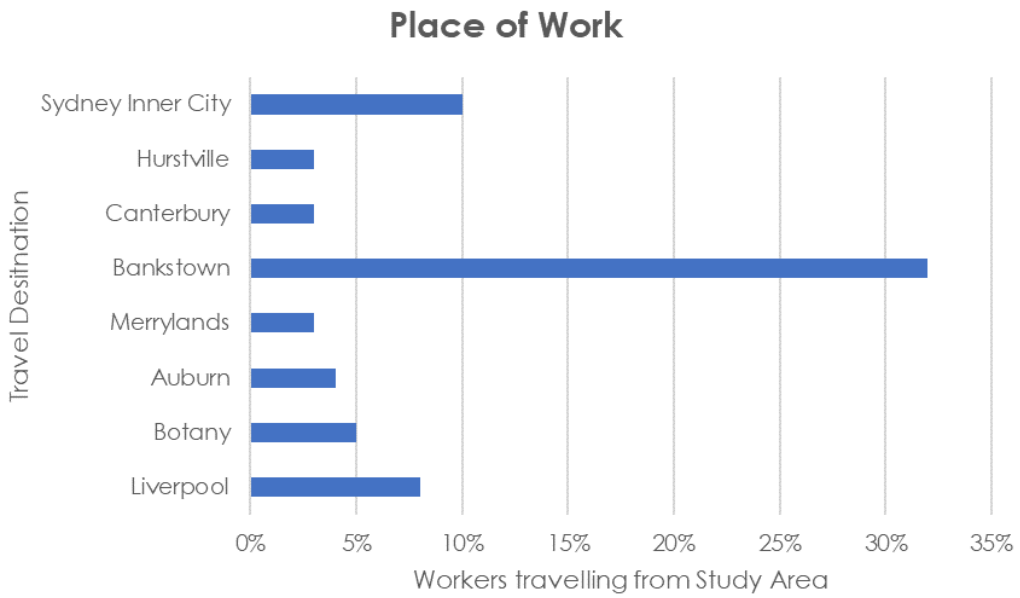
The portion of the site located west of Michigan Road, Roosevelt Avenue and Union Street is zoned as R3 Medium Density Residential whist the rest is zoned as R4 High Density Residential with a few green areas zoned as RE1 Public Recreation.

3.6 2016 Journey to Work Data

Mode share patterns were analysed using 2016 ABS Census data for the selected statistical areas to understand the existing travel patterns of residents and workers within the subject site and surrounding areas.

A summary of the existing place of work of residents who drive to work is shown in Figure 3.6, whilst existing place of origin of people working in the Study Area and surrounding areas is shown in Figure 3.7.

Figure 3.6: Top Destination Areas for Employed Residents



Source: Australian Bureau of Statistics (ABS)

The above graph indicates that the majority of employed residents (32%) who drive to work from subject site travel to Bankstown, followed by 10% to Sydney CBD and 8% to Liverpool.

Figure 3.7: Top Origin Areas for People Working in Riverwood

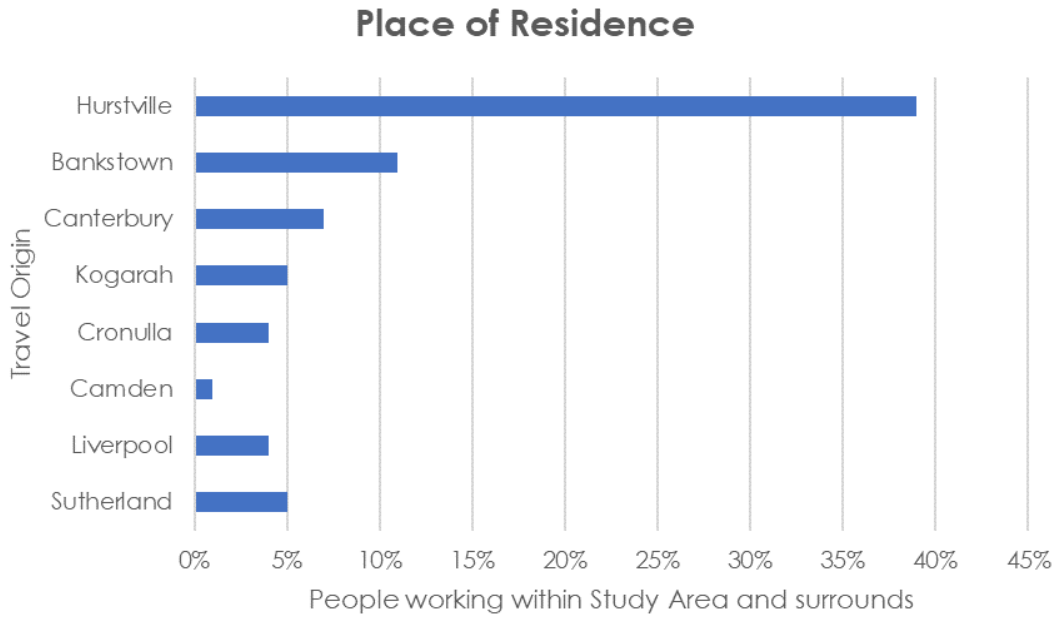


Figure 3.7 indicates that majority of the people (39%) who work within the Study Area and surrounding areas and travel by car are residing in Hurstville area. This is followed by people living in Bankstown area (11%) and Canterbury area (7%).

A summary of recent journey to work mode share in the precinct from 2016 Census data is provided in Table 3.1.

Table 3.1: Census Data 2016 – Method of Travel to Work (Employed Residents)

Main Method of Travel	Proportion of Employed Residents (%)	
	Riverwood Estate SSP	Greater Sydney Region Benchmark
Car, as driver	53%	63%
Car passenger	8%	5%
Train	30%	19%
Bus	5%	7%
Walking	2%	5%
Motorbike	2%	0%
Cycling	0%	1%
Total	**100%**	**100%**

Reference: Australian Bureau of Statistics (ABS)

Table 3.1 indicates that 61% of total employed people within the Study Area travel to work via private cars (as a driver or passenger), which is lower than the 68% recorded in the Greater Sydney Region. Conversely, the take up of public transport (train and bus) is 35% in the Riverwood Estate SSP Study Area as compared with 26% in the Greater Sydney Region.

Table 3.2: Census Data 2016 – Method of Travel to Work (People working in Riverwood)

Main Method of Travel	Proportion of People Working in Riverwood (%)	
	Riverwood	Greater Sydney Region Benchmark
Car, as driver	77%	62%
Car passenger	6%	5%
Train	8%	20%
Bus	2%	7%
Walking	6%	4%
Motorbike	1%	1%
Cycling	0%	1%
Total	**100%**	**100%**

Reference: Australian Bureau of Statistics (ABS)

Based on Table 3.2, 83% of the people working in Riverwood area travel to work using private cars. This is higher than the average car user percentage (67%) of people working in Greater Sydney Region. Usage of other travel modes are relatively equal, with train users comprising 8% of the total worker population followed by walkers comprising 6%.

3.7 School Activities

Riverwood Public School is located immediately adjacent the Study Area. It is a small school which has a capacity to accommodate up to 135 students from preschool to Year 6.

Based on the school's latest annual report, a total of 110 students enrolled in 2017.

Union Street fronting the school has a medium parking demand during the school peak periods. Most children were dropped off in Union Street and used the pedestrian crossing to get to the school. Overall, traffic generated by the school has a minimal impact on the surrounding road network even during the school peak periods.

4 Proposed Development

4.1 Proposal Description

The Riverwood Renewal project involves replacement of the existing housing with an integrated mixed-use precinct that will deliver a mix of social and private dwellings. The renewal will include:

- Approximately 3,900 new dwellings, ranging between 3 and 12 storeys.
- Extensive areas of integrated open space and five new parks, including two large new local open spaces Roosevelt Park and the Community Greenway.
- A mixed-use precinct, with approximately 4,000m^2 of non-residential floorspace, for local shops, cafés and services; and new community spaces, including a new multi-purpose community hub co-located with new open space, located close to Riverwood Public School.

The proposed land use strategy is shown in Figure 4.1.

Traffic modelling has been based on the scheme that delivers the above uses. Subsequent to the completion of the traffic modelling, LAHC advised that a minor yield change as follows:

- 2,889 market dwellings
- 1,037 social dwellings
- Library 500m^2 GFA
- Cultural use 150m^2 GFA
- Community centre 600m^2 GFA
- Child care centre 420m^2 GFA (60 place)
- Retail 3,130m^2 GFA (including 1,000m^2 GFA convenience store)

Minor amendments in land use as part of the master plan evolution have negligible change in traffic generation which is detailed later in Section 6.9.3.5. Therefore, the traffic modelling focuses on the earlier scheme, but parking assessment is based on the revised scheme.

Figure 4.1: Riverwood Estate SSP Proposed Land Use

Source: Architectus

4.2 Staging Plan

The proposed development is anticipated to be completed over a 15 to 20-year timeframe in four key stages (excluding development over private land). It is expected that the first stage of development would commence in 2026.

It is anticipated that the Study Area will be developed westward with developments closest to Belmore Road to be built first. Community infrastructure will be staged to keep pace with housing delivery and population growth.

The indicative staging plan and staging schedule are presented in Figure 4.2 and Table 4.1. It is noted that the staging plan will be subject to change during the detailed design and development stages.

Figure 4.2: Indicative Staging Plan

Source: Architectus

Table 4.1: Riverwood Estate SSP Indicative Staging Plan

	Stage 1	Stage 2	Stage 3	Stage 4	Private
Existing Dwellings (Demolitions)	185	236	308	290	62
Indicative Dwelling Numbers	710	999	910	836	470
Indicative Start of Demolition	2026	2029	2031	2034	-
Indicative Program for Construction	2026 – 2030	2030 – 2035	2034 - 2038	2038- 2043	2030-2035*

Reference: LAHC
**Assumes 5-year completion for dwellings on non-LAHC land (Private land)*

The demolition and construction schedule included in the Aimsun traffic modelling in Appendix C is based on the original schedule as the above revision is not anticipated to make a notable difference in the net change between the existing and future traffic generation.

5 Movement and Place

5.1 Introduction

The concept of 'Movement' and 'Place' considers the classification and use of the road network to determine the priority and design of the street to reflect the relative importance of the Movement and Place functions of the streets, as follows:

- Movement: the ability to travel between places
- Place: the ability to access origins and destinations of travel.

For example, the Movement function considers road classification (e.g., arterial roads to local streets), while Place function reflects the activities that the road serves (e.g., for residential and shops).

Movement and Place principles provide a framework to identify the function and role of any part of the road network, to enable the determination of the appropriate road treatment and priority. For example, an area considered to have a high Place and low Movement function may encourage greater interaction between people and places, where private vehicle movement and parking may be prioritised below other uses. By contrast, an area of low Place and high Movement function would be considered for clearways and other measures to prioritise traffic movement.

5.2 Framework

The Movement and Place framework has been developed in order to balance the accessibility needs of all road users. The framework identifies the role of each travel mode based on its significance to move people and goods, and the significance of the land use interacting the road.

The objectives of Movement and Place are to achieve roads and streets that:

- contribute to the network of public space within a location, where people can live, interact, and do their daily activities
- are enhanced by transport and have the appropriate space allocation to move people and goods safely and efficiently and connect places together.

Movement and Place supports TfNSW's *Future Transport* (2018) and *Our 10 Year Blueprint* (2019) by balancing movements, making safer environments, improving place amenity, supporting needs of all users, using space efficiently, and supporting economy and sustainable development.

The Movement and Place approach presented in this report is based on the guidelines presented in TfNSW *Practitioner's Guide to Movement and Place* (March 2020) and Austroads' *Guide to Traffic Management Part 4* (2020).

This section presents the analysis of Movement and Place, identified constraints and opportunities, and how the project objectives will be achieved.

Movement and Place analysis is based on the assessment of existing and proposed Study Area which are further discussed in Section 3, Section 4 and the *Public Domain, Place and Urban Design* report prepared by Architectus.

The movement and place functions of a street inform planning for the level of access across each of the transport modes. The subject development responds to the scale and character of each street.

Figure 5.1 and Table 5.1 present how the roads are classified based on its functionality in terms of movement and place framework in accordance with Austroads' guide.

Figure 5.1: Movement and Place Framework

Source: Austroads Guide to Traffic Management Part 4

Table 5.1: Functions of Various Road Types in the Movement and Place Framework

Road Type	Colour	Description	Road Class
Designated movement with no place aspects		Move people and goods rapidly over long distances with motorways playing a strategically significant function within the road network.	Motorways
Significant movement with some place aspects		Provide safe, reliable and efficient movement between and within regional centres and urban areas.	Arterial Roads
Significant movement with significant place aspects		High demand for movement and high pedestrian activity with often limited road space result in vibrant streets within urban and regional areas.	Arterial Roads, Distributor Roads
Some movement with significant place aspects		High pedestrian activity and lower levels of vehicle movement create places people enjoy, attract visitors and are places communities value.	Distributor Roads, Local Roads/ Streets, Tourist Routes
Some movement with some place aspects		The streets where people live their lives and that facilitate local access to their communities.	Local Road/Streets

Source: Austroads Guide to Traffic Management Part 4

Typical attributes of a Movement and Place framework for the future development of the Study Area is shown in Figure 5.2 for the role and function of a particular street.

Figure 5.2: Movement and Place Framework

	Motorways	Movement corridor	Vibrant streets	Places for people	Local Streets
	Motorways are strategically significant roads that move people and goods rapidly over long distances.	Movement corridors are main roads that provide safe, reliable and efficient movement between regions and strategic centres.	Vibrant Streets have a high demand for movement as well as destinations and activity centres within the same road space.	Places for People are streets with high demand for activities and lower levels of vehicle movement. They create places people enjoy, attract visitors, and are places communities value.	Streets that facilitate local access to communities.
TRIP TYPES	• Longer distance trips including freight	• Intermediate and longer distance trips including freight	• Mix of trip distances, through trips destination trips	• Destination trips	• Local access trips
TYPICAL SPEED LIMIT	• 80 – 110 km/hr	• 60-90 km /hr	• 40-60 km/hr	• 10-40 km/hr	• 10-50 km/hr
INTERSECTION TREATMENTS	• Long distances between intersections • Intersections generally grade separated • Grade separated pedestrian access across	• Signals limited to significant connections • Limited access and left in/left out for minor intersections • Signal-controlled pedestrian crossings • Road design prioritised for vehicle movement	• Signalised or sign posted • Some left in-left out turns • Signal-controlled pedestrian crossings • Mid-block signalised pedestrian crossings in areas of high demand • Road design balanced for vehicle movement and support place based activity	• Moderation and calming of traffic through a range of measures (sign posting, roundabouts, built out kerbs, raised thresholds, road narrowing etc) • High permeability for pedestrians crossings at intersections, mid-block and roundabouts • Road design prioritised for people/ pedestrians	• Signal controlled at major cross streets • Marked pedestrian crossings where required • Likely to have informal arrangements consistent with a low traffic volumes and lower speed environment
CLEARWAYS/ STOPPING ZONES	• No stopping, no parking • Arrangements for breakdowns, incidents and incident response	• Clearways or no stopping zones during times of high movement demand to facilitate movement of public transport, private vehicles prioritised	• In some instances, clearways during AM and PM peak to facilitate movement of public transport, private vehicles, freight and goods • No Stopping in select locations (intersection approaches, pedestrian crossing locations, public transport stops)	• No Stopping Zones by exception	• No Stopping Zones by exception
KERBSIDE PARKING	• Emergency zones only	• Kerbside parking and loading limited to non-peak times, where provided • Time restricted parking on Movement Corridor or adjacent local streets to support local commercial business	• Kerbside parking and loading outside peak times and on weekends • Time restricted parking to support adjacent commercial business	• Time restricted parking and loading to support adjacent commercial business, additional off-street parking, where possible. On-street parking may be restricted to improved pedestrian amenity • Increased footway width in areas to reduce carriageway width, limit parking and improve pedestrian crossing opportunities and safety	• Resident parking schemes or unrestricted parking • Loading and commercial parking provided on a needs only basis
PEDESTRIAN ACTIVITY	• Footway only in breakdown areas • No pedestrian volumes or activity	• Standard width footpaths provided • Generally lower pedestrian volumes or activity and limited facilities	• Standard or wider footpath widths provided with wider footways in high pedestrian areas • High pedestrian volumes or activity, including potential outdoor seating and facilities	• Standard or wider footpath widths provided with wider footways in high pedestrian areas • Very high to significant pedestrian volumes and activity, including outdoor seating and facilities • Road design prioritised for people/ pedestrians	• Standard footways consistent with low to moderate pedestrian volumes • Shared zones, where warrant is met and are likely to have informal arrangements consistent with a low traffic and pedestrian volumes
CYCLING PROVISION	• Restricted or fully segregated where possible	• Fully segregated where possible, sometimes on a shared path, on road cycling usually for experienced bike riders	• Generally on-road to allow for separation with pedestrian activity on the footway • Provision of cycle parking and destination and to support commercial premises	• Cyclists generally on-street and safer street environment for less experienced bike riders	• Cyclists generally on-street and safer street environment for less experienced bike riders
LAND USE INTERFACE	• Grade separated (viaduct or subterranean) • No direct vehicle access to properties	• Mix of uses residential and non-residential • Some active frontages – may be discontinuous • Generally wide lanes/narrow kerbs • Restricted vehicle access to properties to minimise disruption to traffic flows	• Higher density retail, commercial and entertainment uses attracting high pedestrian activity (retail, cafes/dining) • Active frontages over a significant street frontage • Standard lanes/varying kerb widths • Limited vehicle access to properties from the street, reducing conflicts with pedestrians	• Higher density retail, commercial and entertainment uses attracting high pedestrian activity (retail, cafes/dining) • Active frontages over a significant street frontage • Narrow lanes/widened kerbs • Restricted vehicle access to properties to reduce conflicts with pedestrians (i.e.: pedestrian prioritised)	• High degree of residential development • Narrow lanes/widened kerbs • Higher degree of vehicle access servicing individual properties

Reference: Parramatta Road Corridor Urban Transformation Planning and Design Guideline

A Movement and Place review based upon this framework has been undertaken for the existing surrounding and internal roads of the Study Area. These locations have been chosen for inclusion in the Movement and Place analysis as they provide the preliminary Place functionality within the vicinity of the site i.e., streets that operate as destinations in their own right, where residential and the mixed-use centre facilitate an environment where people choose to spend time. External roads surrounding the site have also been chosen in the Movement and Place analysis highlighting the likely travel routes to the wider road network.

Based on the Movement and Place framework presented in Table 5.1, the surrounding roads have been classified as follows as shown in Table 5.2.

Table 5.2: Movement and Place Characteristics in Each Key Road

Road Name	Trip Types	Typical Speed Limit	Intersection Treatments	Clearways/ Stopping Zones	Kerbside Parking	Pedestrian Activity	Cycling Provision	Land Use Interface	Movement Class	Place Class	Road Type
Belmore Road	A mix of through and destination trips	50km/h	Priority control at the proposed site access points	No Stopping zones or Bus zones on approach to intersections	Unrestricted parking	Standard footpath on both sides of the road but wider along retail strip	Watch for Cyclist signs only	Low residential density dwellings and retail strip near Riverwood Train Station	M3	P1	Significant movement with some place aspects
Washington Avenue	A mix of local and destination trips	50km/h	Priority control along the road	No Stopping zones on approach to Virginia Place, and unrestricted in other sections	Unrestricted parking	Standard footpath on both sides of the road	No cycling facilities but Council Plan indicates it is an existing cycling route	Low to high residential density dwellings	M2	P2	Some movement with some place aspects
Roosevelt Avenue	A mix of local and destination trips	50km/h	Priority control along the road	Unrestricted	Unrestricted parking	Standard footpath on both sides of the road	No cycling facilities	Low to medium residential density dwellings	M2	P2	Some movement with significant place aspects
Truman Avenue	A mix of local and destination trips	50km/h	Priority control along the road	Unrestricted	Unrestricted parking	Standard footpath on both sides of the road	No cycling facilities	Low to medium residential density dwellings	M2	P2	Some movement with some place aspects
Hannans Road	A mix of through and destination trips	50km/h	Signals at the Belmore Road intersection	No Stopping zones or Bus zones on approach to intersections	Unrestricted parking	Standard footpath on both sides of the road	On-road bicycle lane	Low to medium residential density dwellings and primary school	M2	P2	Significant movement with significant place aspects
King Georges Road	A mix of through and destination trips	60km/h	Signals at the Broadarrow Road intersection	Clearway	A mix of No Stopping and No Parking	Standard footpath on both sides of the road but wider along retail strip	No cycling facilities	Retail and commercial	M3	P1	Significant movement with some place aspects
Canterbury Road	A mix of through and destination trips	60km/h	Signals at the Belmore Road intersection	Clearway	No Parking	Standard footpath on north side but wider on south side of the road	No cycling facilities	Commercial and primary school	M3	P1	Significant movement with some place aspects

Based upon the framework, King Georges Road and Canterbury Road are the arterial roads in the wider road network with an emphasis on Movements.

In the immediate vicinity of the site, Belmore Road primarily functions as vibrant street with a mixed-use centre frontage and provides vehicular access to the wider road network. Belmore Road provides primary access to the existing local streets in the Study Area and will function as a gateway to the proposed development. A balanced focus should be emphasised to enable pedestrian and cyclist movements to the surrounding land uses as well as vehicle movements to the wider road network.

Roosevelt Avenue functions as a place for people in the local community and will become the future access route to the Study Area. The design should emphasise on pedestrian/ cyclist movements and public transport facilities to support the proposed residential and mixed-use facilities.

Washington Avenue, Truman Avenue and other internal roads are primarily in a lower hierarchy would serve as local streets that facilitate local access to the community. The Place function would be emphasised to be pedestrian and cyclist friendly in a local street environment with good accessibility to public transport services.

Further discussion is provided in Section 5.3 to identify Constraints and Opportunities in proximity of the Study Area prior to establishing the Movement and Place objectives to be adopted for the external and internal road networks.

5.3 Site Constraints and Opportunities

5.3.1 Constraints

5.3.1.1 External Road Network

The redevelopment of the Study Area presents transport planning challenges which require improved or new transport infrastructure to facilitate the additional trips that will be generated by new residents, visitors and employees of the development.

One of the challenges presented by the proposed intensification of the Study Area is the limited connection of the site with the external road network. The M5 motorway, Salt Pan Creek and the rail line present a barrier for vehicle access to/from the site, as such the only access to the site is via Belmore Road. The Study Area has a primary access route via Roosevelt Avenue, and secondary access routes along Washington Avenue and Truman Avenue.

Belmore Road provides main strategic access by car between the Study Area and the wider road network including the M5 motorway, Canterbury Road and King Georges Road etc. Observation of the existing site conditions suggests that Belmore Road- Hannans Road

intersection is currently experiencing long delays and queuing, particularly during the morning peak period. There are no turning lanes provided to separate the through and right turn movements on Belmore Road northbound onto Hannans Road. This indicates that any additional future traffic volumes could further exacerbate the poor intersection performance at this location. Furthermore, the Belmore Road- Washington Avenue intersection is located some 30m south of the Belmore Road- Hannans Road intersection, as such the "dog-leg" movements from Washington Avenue to Hannans Road may be impeded by the traffic queues on Belmore Road northbound. The right turn movement on Belmore Road southbound would also interrupt the through movement given there is no separate lane to accommodate the right turn movement.

Improvements on the intersections along Belmore Road could provide benefits to the existing and future traffic in the area. However, these benefits may just be temporary as traffic volumes will eventually increase through time and therefore previous congestion levels (i.e., pre-upgrade) will resume.

5.3.1.2 Internal Road Network

The existing local streets within the Study Area present the following constraints:

- Road layout is constrained due to its irregular and disconnected street pattern, limiting movement around the site
- Internal roads are too narrow and do not provide sufficient travel lane width to accommodate two-way traffic, bus movements and on-street parking
- Internal roads involve cul-de-sacs and narrow streets that restrict connectivity and permeability, creating poor pedestrian amenity and traffic connection throughout the site
- The existing bus route would not provide good coverage in the Study Area
- Pedestrian amenity is poor, and several streets lack pedestrian footpaths
- Limited provision of cycling facilities with no dedicated cycle paths within the study area.

5.3.2 Opportunities

5.3.2.1 External Road Network

The proposed development creates an opportunity review the network capacity and develop alternatives to creating more capacity on the road network to cope with additional traffic demands associated with the proposed development. Such opportunities to address future traffic demand and avoid ever-increasing levels of congestion could include:

- prioritisation of mixed-use developments (that reduce the need to travel)

- encouraging walking and cycling as much as possible (recognising the limitations of these travel modes)
- promotion of the use of public transport
- promotion of car share schemes.

5.3.2.2 Internal Road Network

The proposed development creates an opportunity to redesign the internal streetscape to accommodate a high-density neighbourhood with wide streets.

The site is relatively flat encouraging walkability and within easy walking distance to the Riverwood town centre, existing community facilities and Riverwood public school. The site is also well serviced by public transport with a bus route serving the local community and a 10-15 minute walk to Riverwood Train Station. Wide streets would create an opportunity to improve walking, pedestrian and bus routes to maximise the convenience, safety and accessibility of these modes of travel.

The internal streetscape design will need to provide an integrated and balanced approach to movement place-making to accommodate vehicle, pedestrian and cyclist movements from the main entrance on Belmore Road to the shops, community centre and residential dwellings.

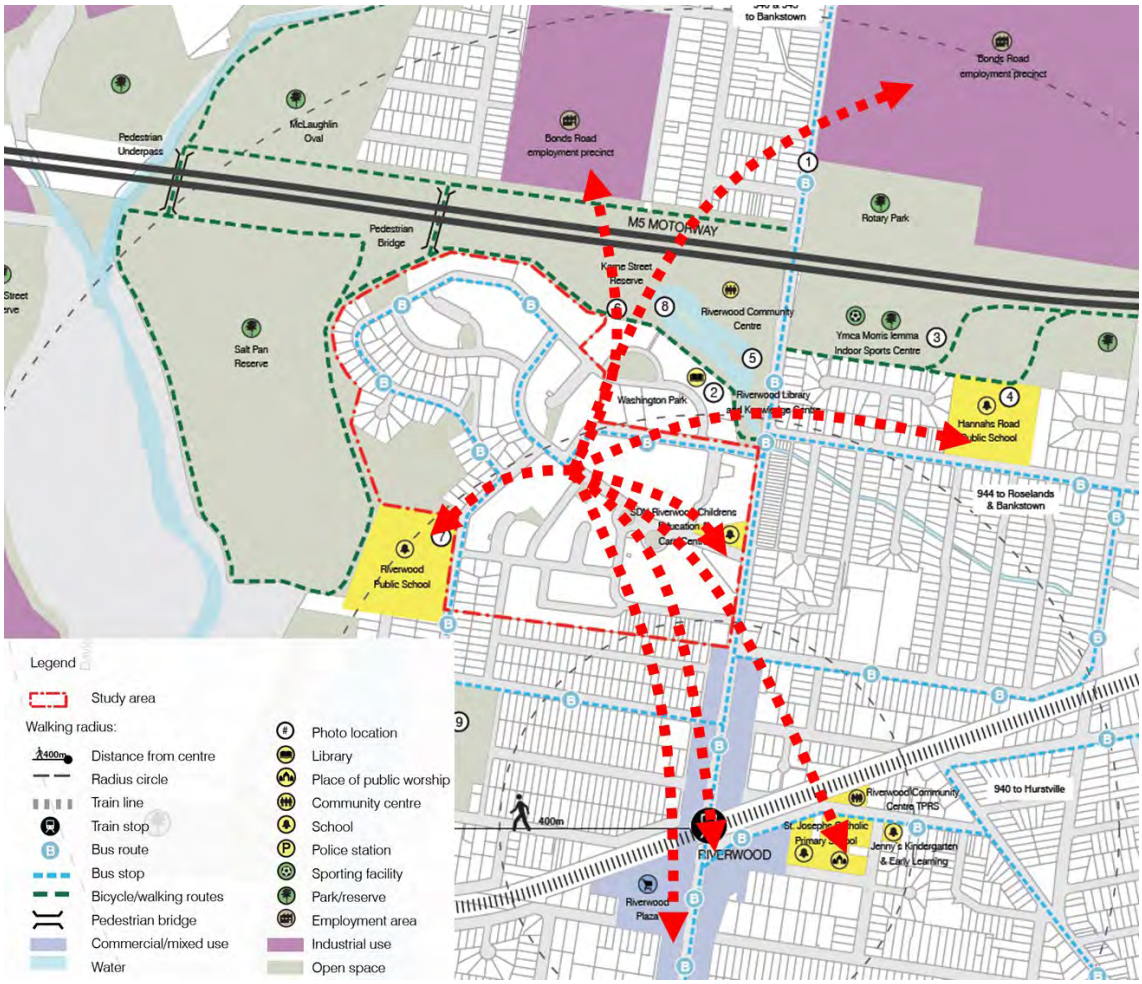
5.4 Place Function

The Study Area contains social and privately owned dwellings. Surrounding the Study Area is mainly low to medium density residential dwellings, including the higher density Washington Park site.

The site vicinity is well-serviced by existing social infrastructure, including Riverwood Public School, Riverwood Community Centre and Riverwood Library. A number of small and large open spaces are also present surrounding the site. Riverwood local centre is located south of the site which is a major retail centre in the area, whilst Riverwood Business Park and Bonds Road Employment area are located north of the site, which can be accessed via the footpath along Belmore Road and the bridge over the M5 motorway. The proposed development increases dwelling density within the Study Area with easy access to these employment opportunities.

Figure 5.3 shows the existing built area and key institutions surrounding the site, and their location in relation to the Study Area.

Figure 5.3: Place Analysis Map



Base map source: Architectus

As shown in Figure 5.3, there are no existing points-of-interest located within the Study Area, and residents have to travel outside the Study Area to do their daily activities. The proposed development would deliver an integrated mixed community with supporting retail, commercial and services within the Study Area.

5.5 Movement Function

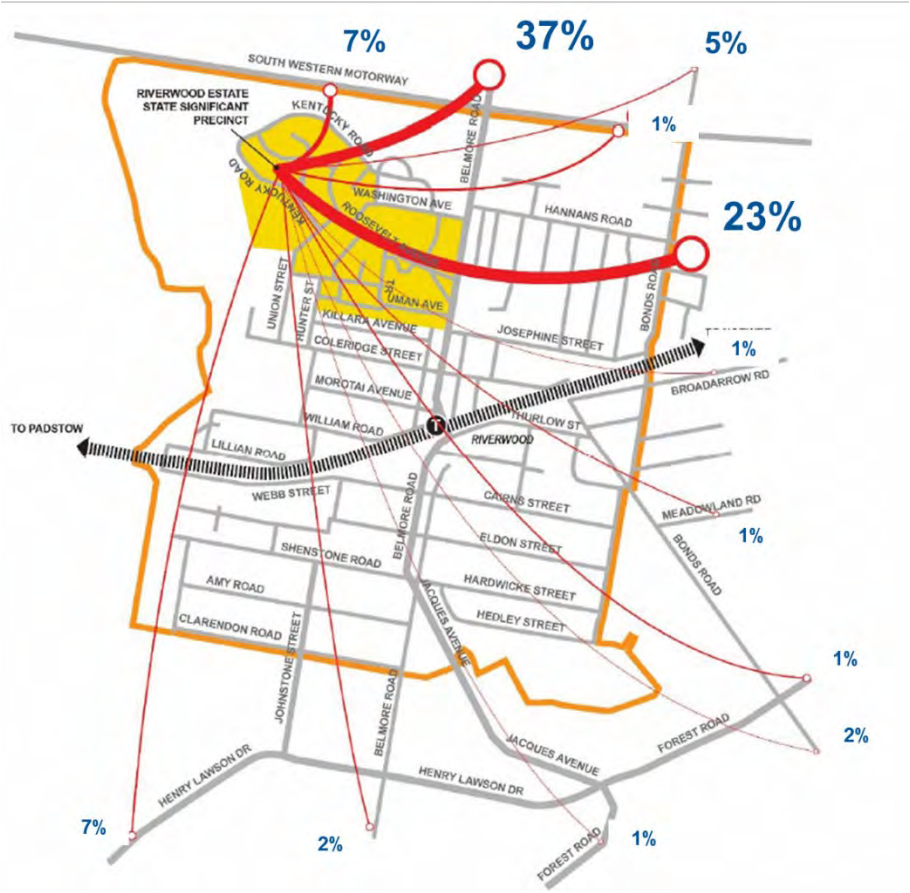
Belmore Road is a regional road servicing the site which currently carries over 20,000 vehicles per day. Belmore Road will provide access to the proposed development and connection to the wider road network including the M5 motorway, Canterbury Road and King Georges Road.

Detailed description of surrounding road network is further discussed in Section 6.1. The existing local street layout is shown in Figure 6.1.

A Movement analysis has been undertaken to review the classification of roads based on where the movement and place interact. To assist in assessing how the external roads are

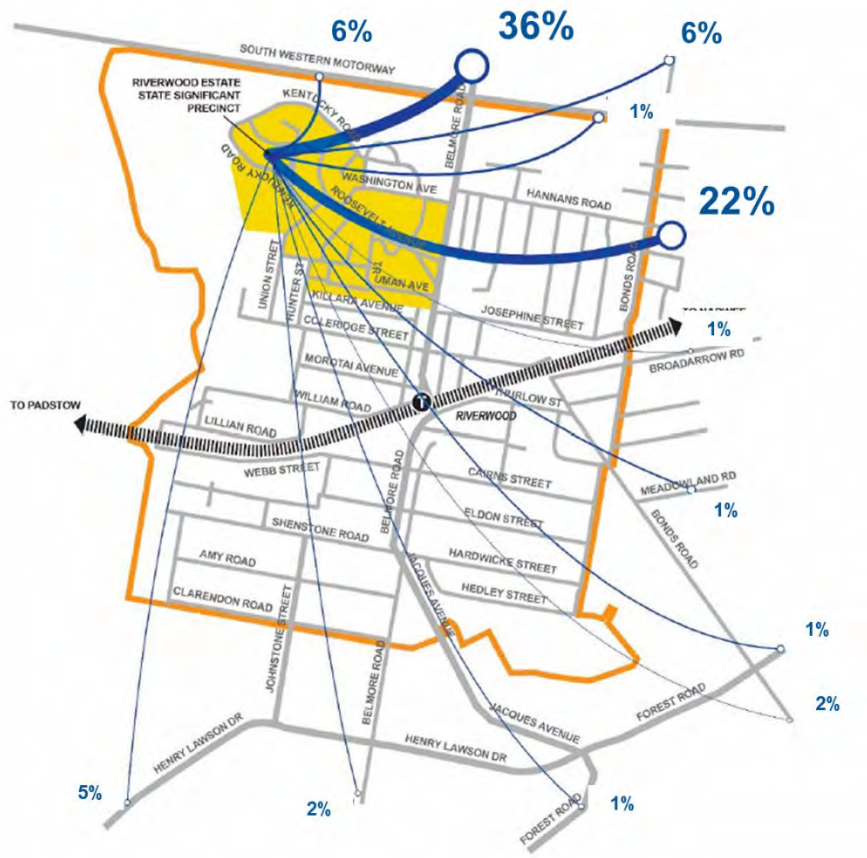
utilised by the Study Area, the projected development trip distribution by Jacobs' micro-simulation model extracted from Appendix D is presented in Figure 5.4 and Figure 5.5. An overview of modelling methodology and results are provided in Section 6.9 and with details presented in Appendices C and D.

Figure 5.4: Future Development Trip Distribution - AM



Data and base map source: Jacobs (average of in and out %)

Figure 5.5: Future Development Trip Distribution - PM



Data and base map source: Jacobs (average of in and out %)

The above figures show that most of the development trips travel to/from north and east of the site via Belmore Road and Hannans Road. The proposed development would increase traffic volumes on the road network, particularly the Belmore Road- Hannans Road intersection where the performance will have to be reviewed to ensure sufficient capacity could be provided to accommodate future traffic growth.

Belmore Road would service as the main vibrant street providing important north-south connections across the rail line, into the Riverwood town centre and to the arterial road network including the M5 Motorway, Canterbury Road and King Georges Road. However, Belmore Road will also fulfil its function to cater for pedestrian and cyclist movements to Riverwood Train Station and other points-of interest.

Of note, none of the proposed site accesses on Belmore Road is a signalised intersection, thus consideration should be given to signalisation to provide easy access to the Study Area without interrupting the through traffic along Belmore Road.

Roosevelt Avenue will have higher pedestrian activity and lower level of vehicle movement compared to the vibrant street (i.e., Belmore Road), which would create places of value for local communities and visitors.

5.6 Transport Vision and Strategy

The proposed development is envisaged to deliver a vibrant, green and connected community consisting of the following:

- Approximately 3,900 new dwellings, ranging between 3 and 12 storeys.
- Extensive areas of integrated open space and five new parks, including two large new local open spaces Roosevelt Park and the Community Greenway.
- A mixed-use precinct, with approximately 4,000m^2 of non-residential floorspace, for local shops, cafés and services; and new community spaces, including a new multi-purpose community hub co-located with new open space, located close to Riverwood Public School.

5.6.1 Vision and Strategy

The strategic planning context and the above Movement and Place framework enable to set the frame for the vision and objectives of this traffic and transport assessment to ensure they are strategically aligned and deliver the intended outcomes.

The following vision and strategies have been developed as a structure to approach transport and parking assessment of the proposed development:

- reinforce link between the proposed development and surrounding areas
- minimise external trips by providing complementary land uses within the site (i.e., school, retail and community centre etc)
- provide parking in accordance with relevant statutory guidelines
- implement appropriate transport initiatives and demand management to promote a mode shift towards more sustainable transport options
- encourage active travel by providing effective and quality walking and cycling facilities within the development

In general, the Planning Proposal intends to achieve better transport outcomes by focusing on movement of people through and within the site, and how the site interacts with the surrounding areas.

5.6.2 Movement and Place Objectives

The key Place objectives are to:

- improve walking and cycling amenity – encourage an increase in pedestrian and cyclist movements within the Study Area and the points-of-interest outside the Study Area.

- improve public transport provision – better integrate public transport within the Study Area by improving coverage and accessibility to serve the local community and the mixed-use centre.
- improve internal road layout – link neighbourhood and mixed-use centre that using a fine-grained street system that accommodates diverse modes of travel.

The key Movement objectives for the internal road network are to:

- provide access, on-street parking and street activity for local community and mixed-use centre
- provide suitable road design to enable service and freight vehicle access and circulate around the internal road network where appropriate
- provide parking to meet relevant statutory requirements
- accommodate safe pedestrian and cyclist access within the Study Area and to connect with Belmore Road.

The key Movement objectives for the external road network are to:

- provide a recognised entry point to the Study Area without interrupting the through movement on Belmore Road
- redesign key intersections in the external road network to maximise capacity in order to accommodate the future background traffic growth, other major projects and additional traffic associated with the proposed development. The target intersection level of service D has been set as a performance indicator
- provide adequate clearance to the design vehicle's swept path including service and freight traffic
- allocate space to accommodate vehicle, pedestrian and cyclist movements along Belmore Road as a vibrant street with connection to Belmore Train Station.

5.6.3 Walking and Cycling Infrastructure

To encourage active travel amongst future residents, staff and visitors, the proposed development should include an effective network of walking and cycling infrastructure. The walking and cycling network should focus on connection with Belmore Road to provide link towards Belmore Road bus corridor and Riverwood Train Station.

The walking and cycling network aim to consist of:

- primary east-west link along Washington Avenue, Roosevelt Avenue and Truman Avenue which connect with Belmore Road as part of the route to further destinations such as Riverwood Train Station, Riverwood Business Park and Bond Road employment centre
- cycling paths along major connections (i.e., Washington Avenue and Roosevelt Avenue)

- shared paths along the side roads that connect to Washington Avenue and Roosevelt Avenue
- signalised pedestrian crossings at intersection of Belmore Road – Roosevelt Avenue.

5.6.4 Public Transport Strategy

Existing bus stops along Belmore Road are located about 800m from the western edge of the Study Area. Bus routes should be provided within the development. It is also recommended that the frequency of these bus services should be every 15 minutes during peak periods.

5.6.5 Green Travel Plan

A Green Travel Plan will be developed at the DA stage. The Green Travel Plan provides measures to manage travel demand and to promote more sustainable transport modes. The main objective of green travel plan is to reduce private car dependency, especially single occupant trips. To encourage use of non-car travel modes, the site should be accessible by high-frequency public transport and should be well connected with surrounding areas via walking and cycling paths.

The Planning Proposal is a prime opportunity to promote the use of public transport, cycling, and walking. The internal movement and access network should reinforce this, with high quality wayfinding also provided.

5.6.6 Intersection Performance

A microscopic Aimsun model that was developed as part of a separate study by Jacobs was reviewed and approved by Roads and Maritime Services. The model has been adopted in this traffic and transport assessment to review the future intersection performance with and without the proposed development.

Traffic impacts of the proposed development would be assessed to determine the extent of the improvement works required at the key intersections to an acceptable level of service in order to support the background growth and development traffic.

To assess the requirements for upgrade works surrounding the Riverwood Estate, the performance of the road network under the forecast traffic demand associated with the development has been assessed, namely:

- intersections that currently perform at Level of Service D or better to maintain this operation
- intersections that currently perform worse than Level of Service D not to exceed existing average delays

Where possible, the recommendation of upgrade works has considered constraints including downstream capacity, structural constraints (such as bridge, retaining walls and existing structures) and land acquisition and sought to minimise the impacts on these constraints.

As discussed in the Movement objectives, a recognised entry point to the Study Area would be provided on Belmore Road with a turning lane to facilitate the right turning movement into the Study Area, which would minimise interruption to the through movements on Belmore Road.

5.7 Performance Indicators

Performance indicators presented in Table 5.3 have been defined to evaluate the Study Area in traffic and transport aspects.

Table 5.3: Traffic and Transport Performance Indicators

Indicator	Measure	Desired Outcome
Cycling and walking attractiveness	Access to quality cycleways and footpaths	Positive indicates a greater access to cycleways and more attractive walking environment
Public transport attractiveness	Comparison of travel speed using public transport vs private car and other factors	Reduction in difference in travel time Dwellings within 400m of a bus stop More frequent services
Parking provision	Statutory DCP and SEPP parking requirement and car share scheme	Adequate on street and off-street parking supply
Equal access for all road users	Equitable access for people with disabilities or limited mobility in comparison to the able or unencumbered	Reduced severance and connect communities
End of trip facilities	Count of parking/loading bays, bicycle racks and bus stands	Provision of adequate end of trip facilities to encourage sustainable travel modes
Local living	Walkable access to local living needs	Positive indicate increase in access to local living land uses
Intersection performance	Intersection delay, sufficient swept path for intersection modifications	Target level of service D (i.e., 56 seconds), design vehicle 12.5m long heavy rigid vehicle

The following sections of this traffic and transport assessment review the existing and proposed conditions of road network, travel behaviour, walking and cycling, public transport, parking aspects in order to achieve the Movement and Place objectives for good transport outcomes and minimise traffic impacts on the road network.

6 Road Network

This section covers the design and functionality of the existing and proposed roads and presents the impact of the proposed development to the surrounding road network.

6.1 Existing Road Network

Belmore Road

Belmore Road is a classified Regional Road that runs north to south between Canterbury Road in Punchbowl and Forest Road in Peakhurst. A speed limit of 50km/h operates within the vicinity of the subject site. It is configured as a two-way road with one to two traffic lanes in each direction. Unrestricted on-street parking is permitted on both sides of the road, south of the bus stops to the south of Washington Avenue.

Belmore Road serves as the main access to local streets within the Study Area. Intersections of Belmore Road with the Riverwood Estate SSP local streets (i.e., Truman Avenue, Roosevelt Avenue and Washington Avenue) are currently operating as priority-controlled intersections. Georges River Council is currently investigating the feasibility of a 40km/h High Pedestrian Activity Area along Belmore Road located south of the subject development.

Washington Avenue

Washington Avenue is a local road that runs in an east-west direction between Washington Park and the subject site. It is an undivided two-way road with an approximate carriageway width of 11m which carries one traffic lane in each direction. Unrestricted on-street parking is permitted on both sides of the road.

Bus Route 944 Bankstown to Mortdale serves Washington Avenue.

Roosevelt Avenue

Roosevelt Avenue functions as a local road and serves as the main spinal road of the Study Area. The intersection of Roosevelt Avenue and Belmore Road is located about 170m south of Washington Avenue and operates as a priority-controlled intersection. It has a carriageway width of about 11m with kerbside parking permitted on both sides of the road.

Truman Avenue

Truman Avenue is a local road that connects Belmore Road and Roosevelt Avenue. It is a two-way, two-lane road with unrestricted parking in each direction. Intersection of Truman Avenue with Belmore Road is located near the southern boundary of the Study Area.

Hannans Road

Hannans Road is a two-way, two-lane road with a general east-west alignment. It functions as a collector road and connects Belmore Road to King Georges Road via Broadarrow Road. The road has a posted speed limit of 50km/h. Unrestricted kerbside parking is permitted on both sides of the road.

King Georges Road

King Georges Road is classified State Road and is generally configured as a two-way road with three travel lanes in each direction. The road serves as the primary north-south corridor to the east of Riverwood. A speed limit of 60km/h applies to this road.

Wiggs Road

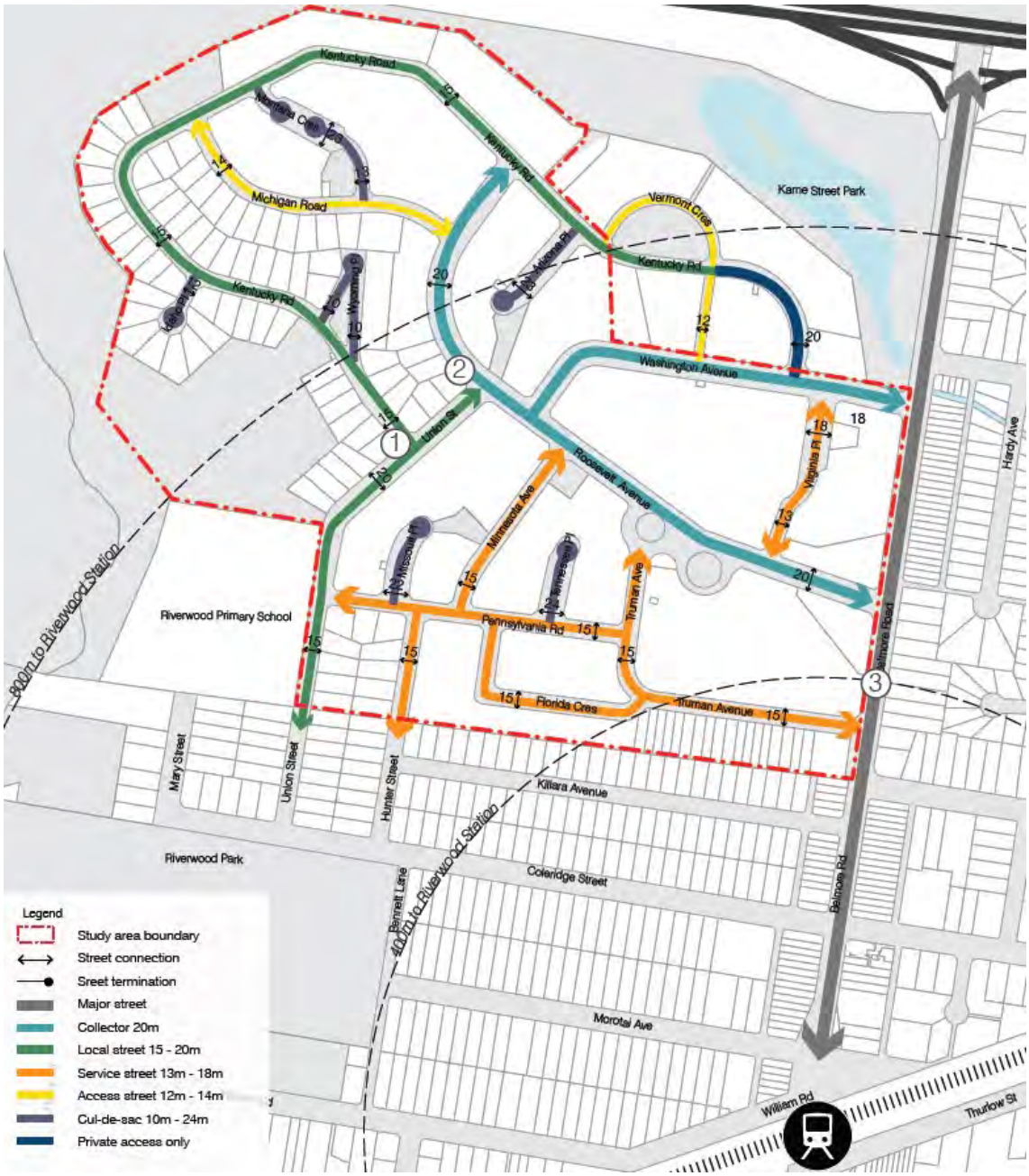
Wiggs Road is a two-way, two-lane collector road located north of the subject site. It serves as a major access to/from west of Belmore Road as an alternative to Canterbury Road. Unrestricted kerbside parking is permitted on both sides of the road.

Canterbury Road

Canterbury Road is a classified State Road and serves as the major east-west connection to the north of Riverwood. The road is configured as a two-way road with two travel lanes at each direction and a posted speed limit of 60km/h.

The existing internal road network is shown in Figure 6.1.

Figure 6.1: Existing Internal Road Network



Source: Architectus

As discussed in Section 5.3.1.2, the layout of the existing local roads within the Study Area is constrained due to its irregular and disconnected street pattern which limits movement around the site. These local roads are too narrow and do not provide sufficient travel lane width to accommodate two-way traffic, bus movements and on-street parking.

6.2 Existing Traffic Volumes

6.2.1 Tube Counts

A 7-day tube count survey undertaken at the following locations between 8 February and 14 February 2017:

- Belmore Road between Roosevelt Avenue and Washington Avenue
- Belmore Road between Josephine Street and Killara Avenue

The results of tube count survey are presented in Table 6.1, Figure 6.2 and Figure 6.3.

Table 6.1: Belmore Road Average Daily Traffic Volumes

Location	Time Period	Northbound Traffic	Southbound Traffic	Two-way
Belmore Road (between Roosevelt Ave and Washington Ave)	Weekday Average	11,188	10,514	21,702
	Weekend Average	8,760	8,453	17,213
Belmore Road (between Josephine St and Killara Ave)	Weekday Average	10,777	10,026	20,803
	Weekend Average	8,585	8,237	16,822

Figure 6.2: Belmore Road Weekday Average Daily Traffic Volumes (between Roosevelt Ave and Washington Ave)

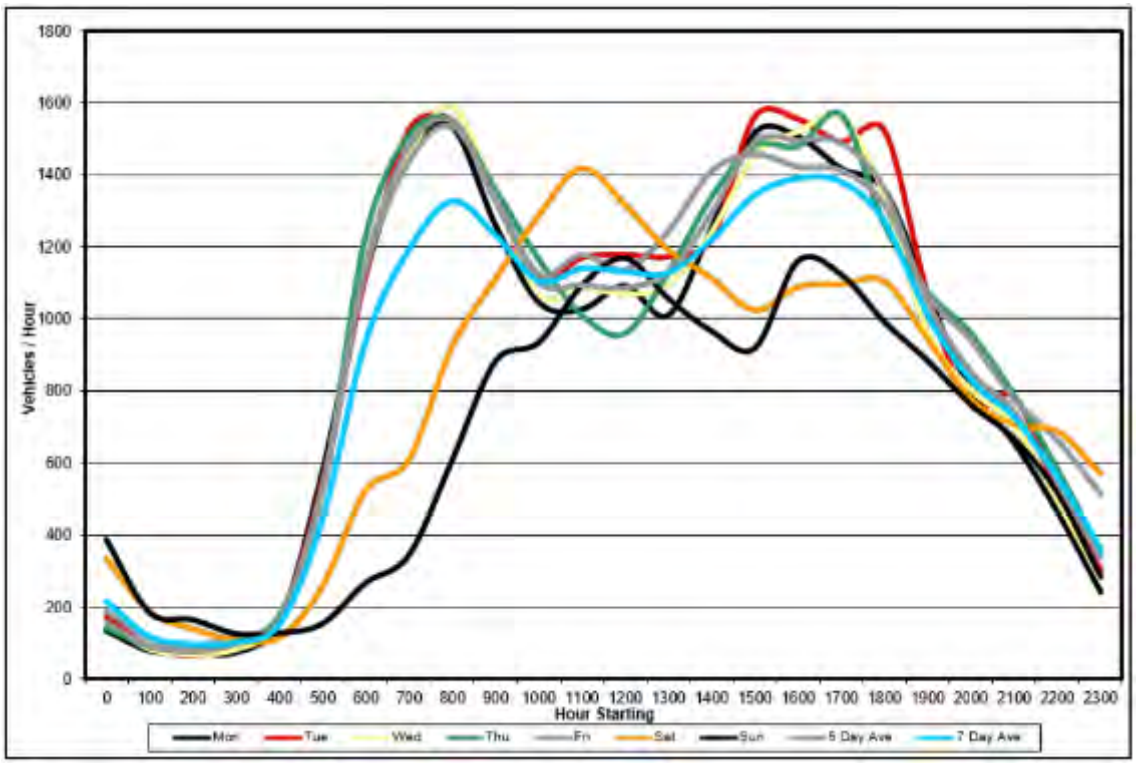
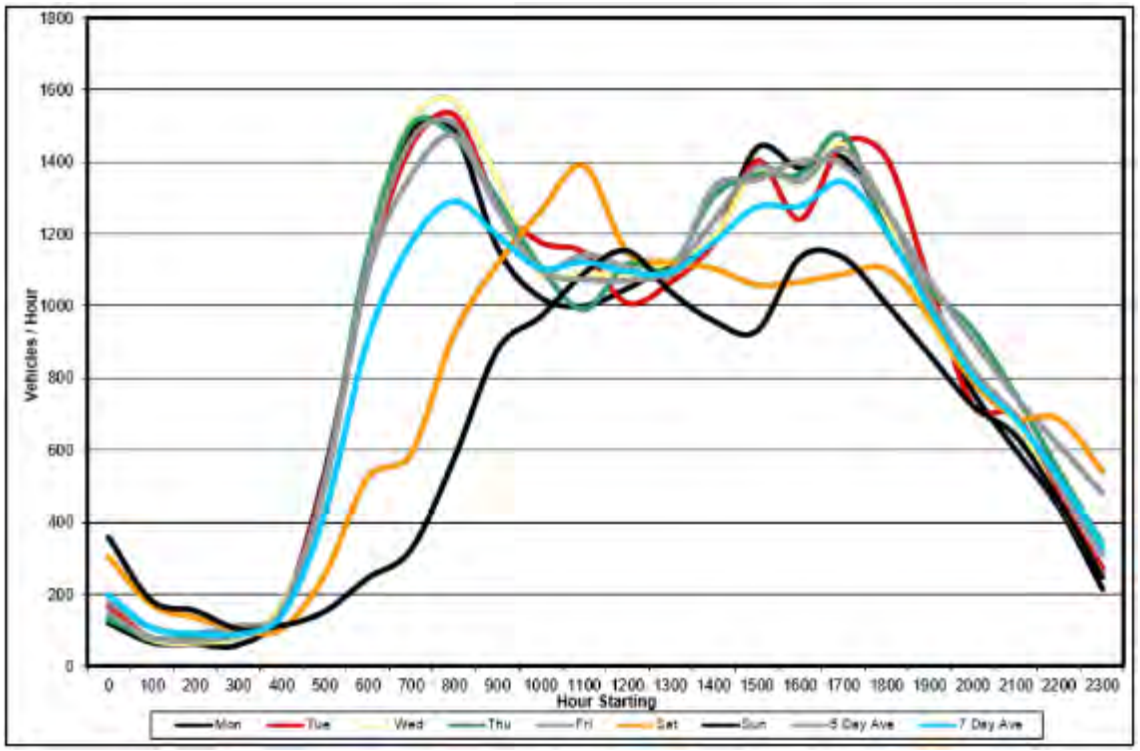


Figure 6.3: Belmore Road Weekday Average Daily Traffic Volumes (between Josephine St and Killara Ave)



Average weekday traffic volumes suggest that Belmore Road carried approximately 1,500 vehicles per hour in the AM peak (7am-8am) and 1,300 vehicles per hour in the PM peak (4pm-5pm).

It is noted that the 2017 tube counts were undertaken by a third party company when Washington Park was under construction. Refer to Section 6.9.1 for the adjustment of the existing traffic volume taking into account traffic associated with occupancy of Washington Park and demolition of dwellings in the area.

6.2.2 Intersection Counts

Traffic movement counts were undertaken at intersections within and outside the subject site during the weekday morning and afternoon period (6am-9am, 3pm-6pm) and Saturday midday period (10am-1pm).

Intersection counts were completed on Thursday, 9 February 2017 during weekday AM and PM periods for the following intersections:

- Hannans Road/ Belmore Road (signalised)
- Washington Avenue/ Belmore Road (priority)
- Roosevelt Avenue/ Belmore Road (priority)
- Truman Avenue/ Belmore Road (priority)

Additionally, traffic counts were undertaken on Tuesday, 14 March 2017 during weekday AM and PM periods, and Saturday midday period for the following locations:

- Canterbury Road/ Belmore Road (signalised)
- Wiggs Road/ Belmore Road (signalised)
- M5 Exit Ramp/ Belmore Road (signalised)
- M5 Entry Ramp/ Belmore Road (signalised)
- Hannans Road/ Bond Road (signalised)
- Hannans Road/ Penshurst Road (priority)
- Broadarrow Road/ King Georges Road (signalised)
- Thurlow Street/ Belmore Road (signalised)

The existing peak hour volumes are presented in Figure 6.4 and Figure 6.5.

Figure 6.4: Existing Intersection Peak Hour Traffic Volumes (Northern Section)

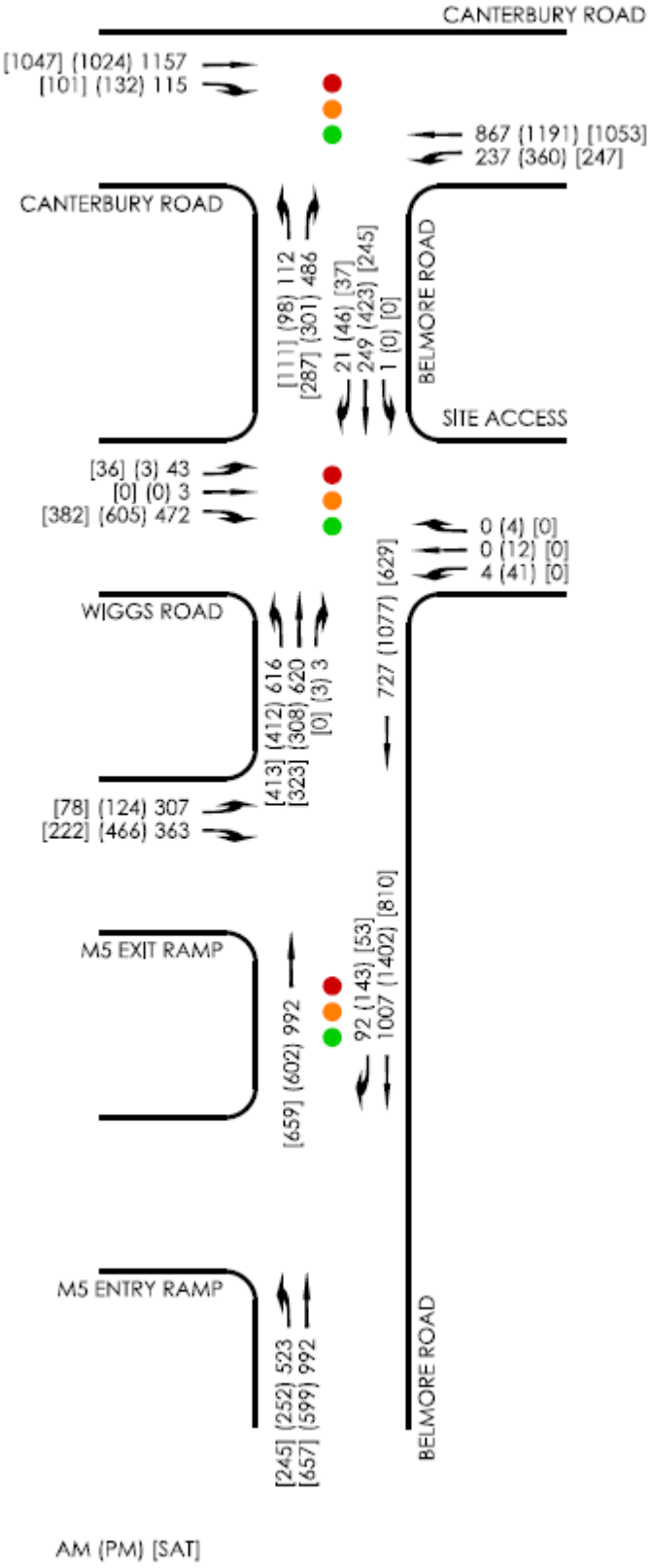
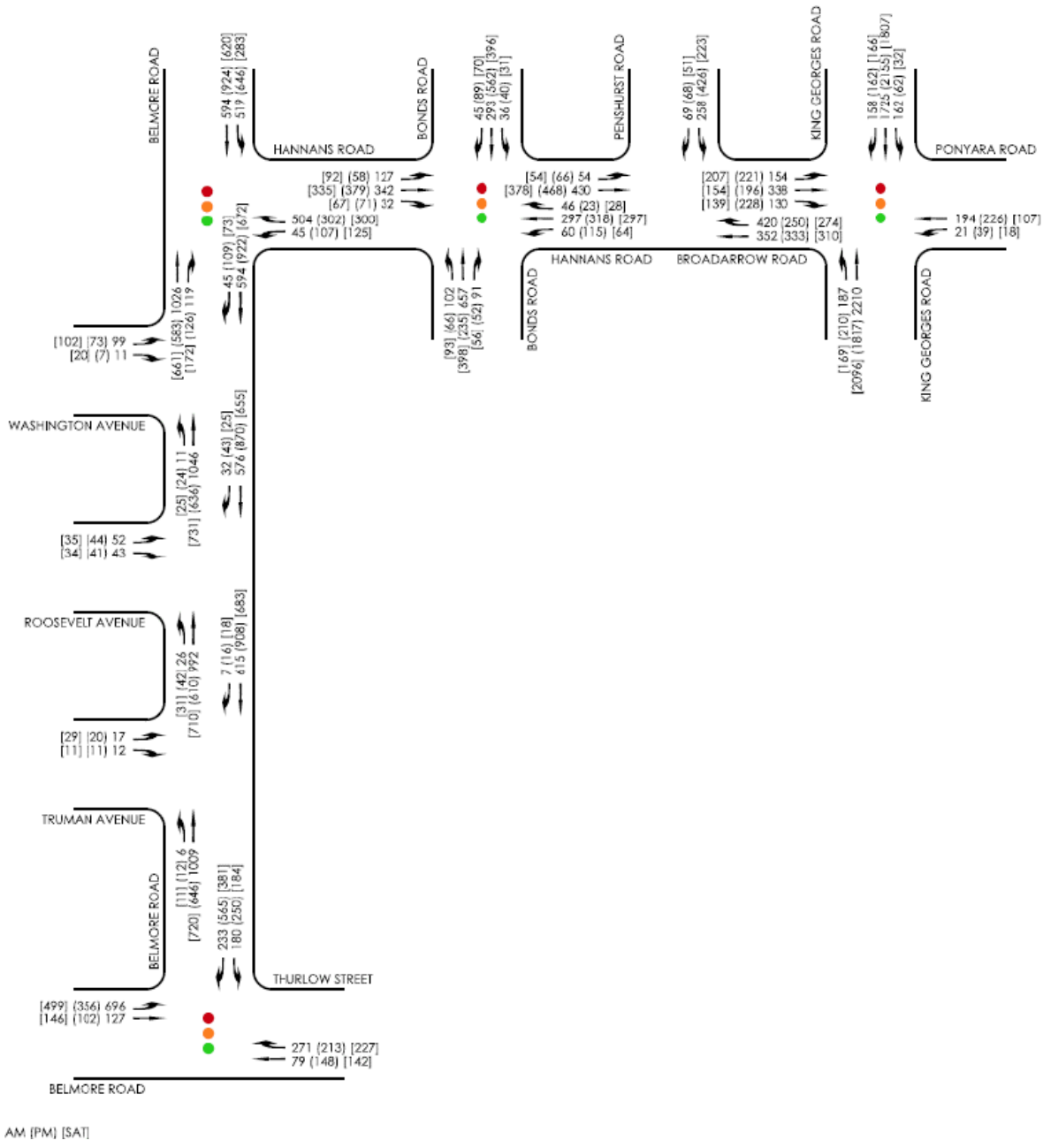


Figure 6.5: Existing Intersection Peak Hour Traffic Volumes (Southern Section)



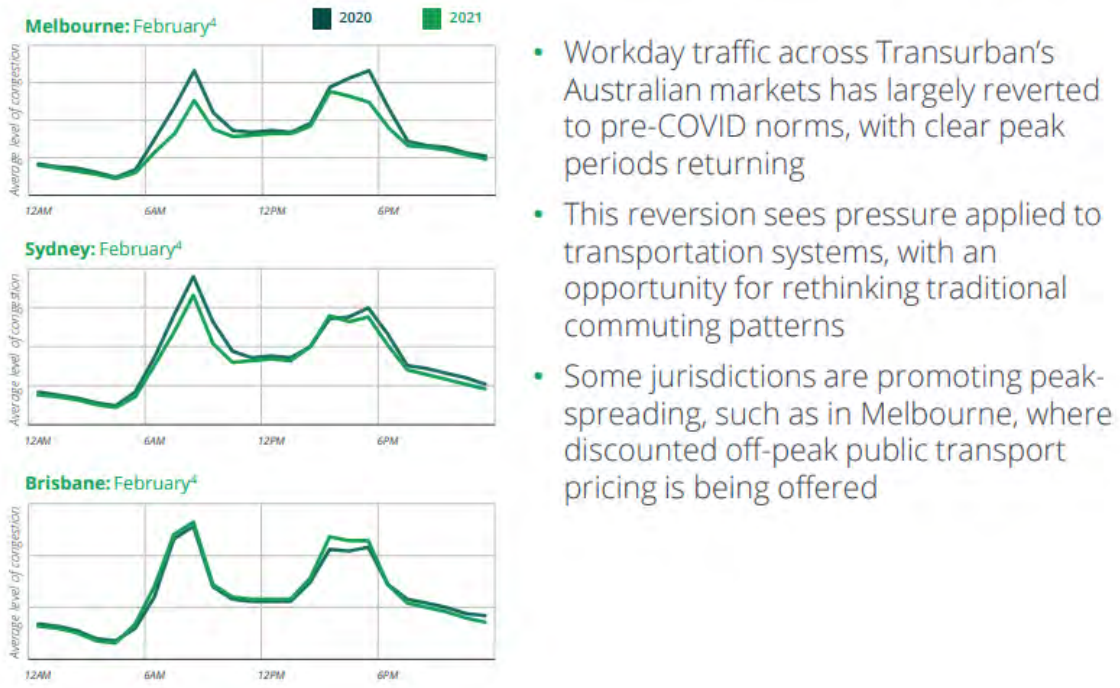
It is noted that the 2017 intersection counts were undertaken by a third party company when Washington Park was under construction. Refer to Section 6.9.1 for the adjustment of the existing traffic volume taking into account traffic associated with occupancy of Washington Park and demolition of dwellings in the area.

6.3 Comparison of 2017 and 2021 Traffic Volumes

6.3.1 Traffic Recovery in May 2021

Review into the recent research undertaken by Transurban (May 2021) indicates traffic was generally recovered since the first wave of Covid-19 on toll roads in the major cities in Australia. Figure 6.6 compares the level of congestion in February 2020 (pre-Covid) and February 2021 (pre-lock down that commenced in June 2021).

Figure 6.6: Traffic Recovery in May 2021



Source: Transurban Investor Day (May 2021)

The Transurban research provides the following key findings:

- Working from home prevalence has had neutral impact on workday travel patterns.
- Peak hour traffic patterns are similar to pre-Covid despite increased workplace flexibility.
- Preference for private vehicle travel over public transport.
- Flexible working may result in further diversion from public transport to private vehicles.
- Strong growth in car sales (new and used) and car ownership supports the view that public transport diversion is likely to continue in the medium term.

Based on the research results on Sydney tolled roads including the M5 South West located in close proximity of the subject site, it is believed that traffic has reverted to pre-Covid norms for the M5 ramps, as well as Belmore Road as a feeder road to the M5. Therefore, traffic surveys undertaken in May 2021 are considered representative of typical traffic conditions.

6.3.2 2019 and 2021 SCATS Counts

In order to appreciate the traffic changes since the pre-Covid situation, TTPP compared the SCATS counts at the M5 and Belmore Road intersection for a weekday during second week in school Term 2 on the following days in 2019 and 2021.

- Thursday 9 May 2019
- Thursday 29 April 2021.

A summary of the SCATS counts is provided in Table 6.2 for the AM peak period and Table 6.3 for the PM peak period.

Table 6.2: Comparison of 2019 and 2021 SCATS AM Peak Traffic Volumes

Road	Location	Direction	2019 SCATS		2021 SCATS		Traffic Change between 2019 and 2021 SCATS	
			7-8am	8-9am	7-8am	8-9am	7-8am	8-9am
Belmore Road	North of M5	Northbound	1,382	1,455	1,072	1,188	-22%	-18%
		Southbound	554	695	540	699	-3%	1%
Belmore Road	South of M5	Northbound	1,349	1,447	1,342	1,429	-1%	-1%
		Southbound	1,200	1,192	932	1,202	-22%	1%
M5 Eastbound Exit Ramp	West of Belmore Road	Eastbound	1,099	922	531	688	-52%	-25%
M5 Westbound Entry Ramp	West of Belmore Road	Westbound	551	595	590	605	7%	2%
M5 Eastbound Entry Ramp	East of Belmore Road	Eastbound	114	124	191	185	68%	49%
M5 Westbound Exit Ramp	East of Belmore Road	Westbound	56	77	85	103	52%	34%

Table 6.3: Comparison of 2019 and 2021 SCATS PM Peak Traffic Volumes

Road	Location	Direction	2019 SCATS		2021 SCATS		Traffic Change between 2019 and 2021 SCATS	
			4-5pm	5-6pm	4-5pm	5-6pm	4-5pm	5-6pm
Belmore Road	North of M5	Northbound	1,113	1,186	1,100	1,183	-1%	0%
		Southbound	992	1,077	923	916	-7%	-15%
Belmore Road	South of M5	Northbound	1,053	900	1,036	878	-2%	-2%
		Southbound	1,655	1,634	1,400	1,504	-15%	-8%
M5 Eastbound Exit Ramp	West of Belmore Road	Eastbound	627	683	726	818	16%	20%
M5 Westbound Entry Ramp	West of Belmore Road	Westbound	438	311	426	298	-3%	-4%
M5 Eastbound Entry Ramp	East of Belmore Road	Eastbound	112	99	151	131	35%	32%
M5 Westbound Exit Ramp	East of Belmore Road	Westbound	80	209	282	327	253%	56%

The traffic volumes presented in Table 6.2 and Table 6.3 indicate the following key findings:

- Comparison of the 2019 (pre-Covid) and 2021 SCATS counts indicates a mix of traffic changes on Belmore Road and the M5 ramps, with a minor reduction on Belmore Road and more notable increases on the M5 ramps. The mixed changes could be due to daily variations.
- SCATS data does not indicate a large volume of traffic using the M5 ramps.
- With regard to impact of Covid 19, both anecdotal and actual suggest traffic volumes returning to normal (pre-covid) from their lows in 2020 and expectation of future growth.

6.3.3 Traffic Survey (May 2021)

TTPP commissioned intersection counts at the M5 Interchange and the Belmore Road-Hannans Road intersection on Thursday 29 May 2021.

The objective of the intersection counts is to appreciate traffic volume changes since the 2017 survey which predates the opening of the east-facing ramps at the M5 interchange in February 2019. This is to determine the impact of the new M5 ramps and any background traffic growth that may have occurred in the Belmore Road corridor since 2017, with consideration given to the traffic forecast for year 2021 in the Review of Environmental Factor (REF) for Belmore Road M5 Interchange.

A comparison of the 2017 and 2021 intersection counts and the 2021 REF forecast for Belmore Road and the M5 ramps are shown in Table 6.4 for the AM peak period and Table 6.5 for the PM peak period.

It is noted that the 2017 survey data provided by a third party does not include a specific time for the AM and PM peak hours, and therefore the one-hour data has been adopted for comparison with the two-hour period in the 2021 REF forecast and 2021 traffic survey.

Table 6.4: Comparison of 2017 and 2021 AM Peak Traffic Volumes

Road	Location	Direction	2017 Survey	2021 REF Forecast		May 2021 Survey		Traffic Change between 2017 and 2021 Survey		Traffic Change between 2021 REF Forecast and 2021 Survey	
				7-8am	8-9am	7-8am	8-9am	7-8am	8-9am	7-8am	8-9am
Belmore Road	North of M5	Northbound	1,229	1,207	1,206	1,021	1,029	-17%	-15%	-15%	-15%
		Southbound	727	783	935	560	715	-23%	-9%	-28%	-24%
Belmore Road	South of M5	Northbound	1,445	1,547	1,572	1,470	1,383	2%	-11%	-5%	-12%
		Southbound	1007	1281	1318	894	1113	-11%	-13%	-30%	-16%
Belmore Road	South of Hannans Road	Northbound	1,145	1,082	1,079	1,035	1,034	-10%	-4%	-4%	-4%
		Southbound	639	820	972	685	860	7%	5%	-16%	-12%
M5 Eastbound Exit Ramp	West of Belmore Road	Eastbound	670	850	704	570	650	-15%	-24%	-33%	-8%
M5 Westbound Entry Ramp	West of Belmore Road	Westbound	615	671	712	624	555	1%	-17%	-7%	-22%
M5 Eastbound Entry Ramp	East of Belmore Road	Eastbound	Not built yet	218	214	194	197	-	-10%	-11%	-8%
M5 Westbound Exit Ramp	East of Belmore Road	Westbound	Not built yet	177	193	78	100	-	-44%	-56%	-48%
Hannans Road	East of Belmore Road	Eastbound	638	552	531	369	457	-42%	-17%	-33%	-14%
		Westbound	549	623	682	442	550	-19%	-12%	-29%	-19%

Note: No specified peak hour is documented in the 2017 survey undertaken by a third party company

Table 6.5: Comparison of 2017 and 2021 PM Peak Traffic Volumes

Road	Location	Direction	2017 Survey	2021 REF Forecast		May 2021 Survey		Traffic Change between 2017 and 2021 Survey		Traffic Change between 2021 REF Forecast and 2021 Survey	
				4-5pm	5-6pm	4-5pm	5-6pm	4-5pm	5-6pm	4-5pm	5-6pm
Belmore Road	North of M5	Northbound	726	923	1,032	979	1,005	35%	9%	6%	-3%
		Southbound	1,077	1,313	1,339	991	915	-8%	-30%	-25%	-32%
Belmore Road	South of M5	Northbound	851	1,129	1,073	942	862	11%	-24%	-17%	-20%
		Southbound	1,402	1,715	1,784	1,544	1,484	10%	-13%	-10%	-17%
Belmore Road	South of Hannans Road	Northbound	709	891	828	631	560	-11%	-37%	-29%	-32%
		Southbound	1,031	1,072	1,213	1,010	1,116	-2%	4%	-6%	-8%
M5 Eastbound Exit Ramp	West of Belmore Road	Eastbound	590	689	935	806	778	37%	13%	17%	-17%
M5 Westbound Entry Ramp	West of Belmore Road	Westbound	395	726	658	411	309	4%	-57%	-43%	-53%
M5 Eastbound Entry Ramp	East of Belmore Road	Eastbound	Not built yet	134	139	120	120	-	-10%	-10%	-14%
M5 Westbound Exit Ramp	East of Belmore Road	Westbound	Not built yet	343	190	262	298	-	-13%	-24%	57%
Hannans Road	East of Belmore Road	Eastbound	772	792	869	688	645	-11%	-19%	-13%	-26%
		Westbound	409	401	382	395	459	-3%	14%	-1%	20%

Note: No specified peak hour is documented in the 2017 survey undertaken by a third party company

The traffic volumes presented in Table 6.4 and Table 6.5 indicate the following key findings:

- Traffic volumes have generally reduced since 2017 on the west-facing ramps and Belmore Road in the AM peak period, despite a minor increase in some road sections due to daily variation.
- Traffic volumes have generally reduced since 2017 on most road sections, but with an increase on Belmore Road (at the interchange) and the eastbound exit ramp between 4pm and 5pm, but with a lesser increase between 5pm and 6pm.
- The actual traffic volumes are generally lower than the REF forecast in both AM and PM peak periods, except for Belmore Road northbound (north of M5), eastbound exit ramp and westbound exit ramp in the PM peak period.
- The traffic counts do not show large volume of traffic using the east facing ramps since the 2017 survey.
- The traffic volumes in 2017 and 2021, and the comparison with SCATS counts do not show a clear or strong change in traffic profile in Belmore Road since 2017 that the demand modelling is based on. The opening of east facing ramps on M5 has provided a new access route for traffic heading and arriving from east.

Traffic increases on Belmore Road and the ramps has been considered in a sensitivity test in Aimsun modelling for the ultimate assessment (year 2041). This is presented in Appendix C. The sensitivity test concluded that additional traffic on the M5 ramps and Belmore Road is not expected to have tangible traffic impacts and would not affect the infrastructure requirements identified later in Section 6.9.5 and Section 11.4.

6.4 On-Street Car Parking

A review of existing on-street parking facilities within the Study Area indicated that on-street parking demand on roads is typically low to medium, with approximately 500 unrestricted parking spaces being available along Washington Avenue, Roosevelt Avenue, Truman Avenue and Belmore Avenue.

6.5 Road Safety

Crash history for the local area surrounding the Study Area has been obtained from Transport for NSW to assess the road crash history within the vicinity of the site. This data covers the most recent five-year period (1 January 2015 to 31 December 2019) recorded along the following roads:

- Belmore Road between Canterbury Road and Eldon Street
- Hannans Road between Belmore Road and Broadarrow Road
- Broadarrow Road between Hannans Road and King Georges Road
- Canterbury Road between Rose Street and Draper Avenue

- Wiggs Road between Moxon Road and Belmore Road
- Thurlow Street between Belmore Road and Erskine Street
- King Georges Road between Pallamana Parade and Tooronga Terrace
- All local streets in the Riverwood area bounded by Kentucky Road/Washington Avenue to the north, Belmore Road to the east, Coleridge Street to the south and Mary Street/Union Street to the west. Refer to the diagram on the right below.

The locations and severity of the crash data for the five-year period are shown in Table 6.6 and Figure 6.7.

Key findings from the crash data analysis are shown as follows:

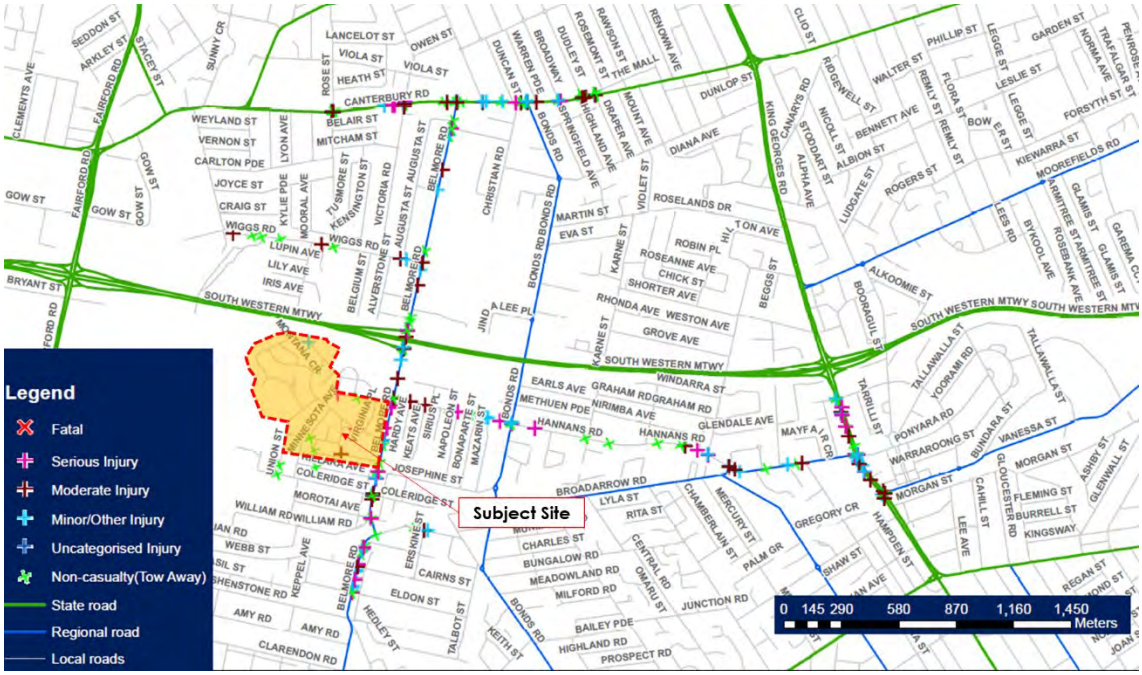
- No fatalities were recorded during the five-year period
- Approximately 55 percent of crashes resulted in an injury
- Approximately 62 percent of crashes occurred during daylight hours
- Approximately 15 percent of crashes occurred in wet weather conditions.

Table 6.6: Road Crashes within Riverwood Estate SSP and Surrounding Area

Road/Street	Number of Crashes
Augusta Street	1
Belmore Road	93
Bonds Road	8
Broadarrow Road	11
Canterbury Road	91
Coleridge Street	1
Cullens Road	1
Dudley Road	1
Erskine Street	1
Florida Crescent	2
Hannans Road	20
Kentucky Road	1
Killara Avenue	1
King Georges Road	43

Minnesota Avenue	1
Moxon Road	1
New Hampshire Street	1
Roosevelt Avenue	3
The Mall	1
Thurlow Street	2
Union Street	1
Victoria Road	2
Washington Avenue	1
Wiggs Road	5
TOTAL	**293**

Figure 6.7: Crash Map (1 January 2015 to 31 December 2019)



Source: TfNSW

There were 24 crashes that involved pedestrians and all resulted in injury, 10 of which occurred along Belmore Road at the following locations.

- Belmore Road north of the M5 interchange: 1 crash (at intersection)
- Belmore Road between the M5 interchange and Riverwood station: 4 crashes at intersections and one at a mid-block location

- Belmore Road between Riverwood station and shopping centre: 3 crashes at intersections and one at a mid-block location.

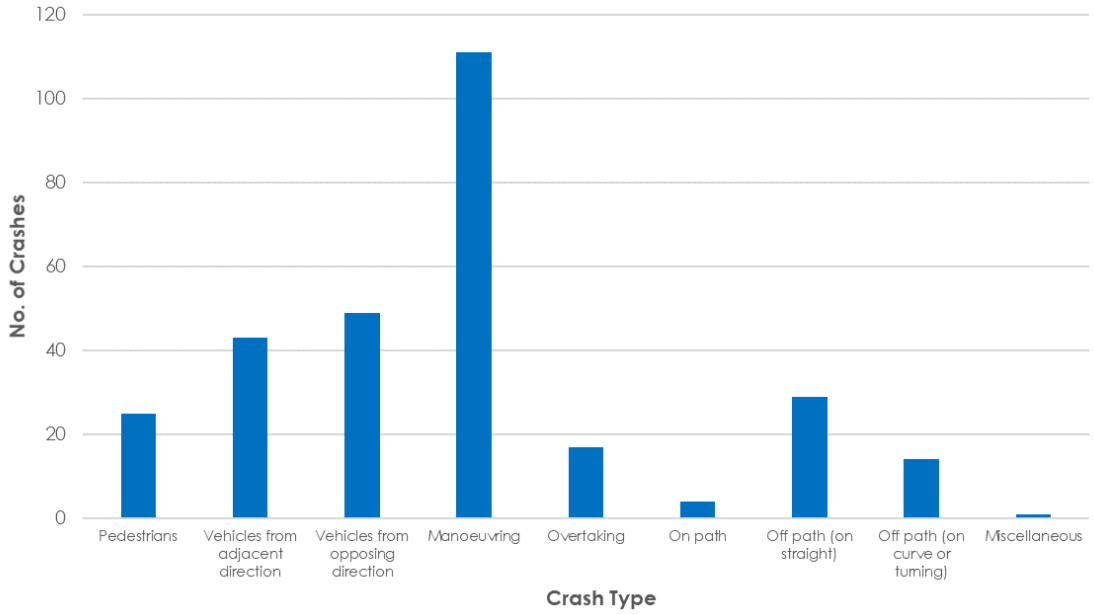
There were three crashes involved cyclists and both resulted in injury, of which two occurred on Belmore Road at the following locations:

- Belmore Road- Josephine Street intersection: 1 crash where the cyclist was hit by a vehicle turning right
- Belmore Road (between Cairns Street and Eldon Street): 1 crash where the cyclist was hit by a vehicle's door.

Out of the total 293 crashes, there were a high proportion of rear-end (69 or 24%), opposing vehicle (49 or 17%), and off-carriageway into object (36 or 12%) crashes. Incidents involving vehicles from opposite directions are of high occurrence, particularly right-turning vehicles conflicting with through vehicles (36 or 12%).

Figure 6.8 outlines the number and type of different crashes that have occurred within the Study Area and surrounding areas over the last five years.

Figure 6.8: Crash Occurrence by Type



6.6 Proposed Internal Road Network

6.6.1 Overview of Changes

The existing road network within the Study Area will be upgraded as part of the development proposal to meet the Movement and Place objectives. The local streets will be upgraded,

and new streets will be provided to create a robust street network to provide an integrated and balanced approach to movement, place-making and streetscaping design.

The proposed internal network has been designed to improve traffic movements within the site with better connectivity, and also allocate space to encourage walking and cycling by providing clear hierarchy of streets and shared paths that link to key destinations such as Riverwood Train Station, Riverwood Public School, commercial area and community facilities. The pedestrian and cyclist facilities are further discussed in Section 8.3.

The proposed internal road network will include the following upgrade works to facilitate vehicle movements:

- Widening and extension of Roosevelt Avenue to serve as the major access to the site and to provide direct connection to Salt Pan Creek Reserve
- Widening of local streets such as Kentucky Street, Union Street and Hunter Street to improve traffic flow
- Provision of new traffic signals at the Belmore Road and Roosevelt Avenue intersection
- Provision of new roundabout at Roosevelt Avenue, Washington Avenue and Kentucky Road intersection
- Extension of Truman Avenue to provide direct connection between Belmore Road and Riverwood Public School
- Removal of dead-end streets
- Provision of new north-south local streets

Roads internal to the site are generally undivided local streets except for Roosevelt Avenue.

The proposed internal road layout is shown in Figure 6.9.

Figure 6.9: Proposed Street Network

Source: Architectus

6.6.2 Assessment of Internal Streets

The internal road network has been redesigned to overcome the existing constrained layout to improve accessibility and circulation. The advantage is that it would not attract through traffic as it abuts the M5 motorway to the north and Salt Pan Creek Reserve to the west. As such, the proposed development would serve as a precinct based on its intended function.

The future role and function of the local streets within the Study Area are to provide two primary functions:

- Movement: the ability to travel between places
- Place: the ability to access origins and destinations of travel.

Under the Movement and Place framework, Washington Avenue and Roosevelt Avenue located within the Study Area would serve as places for people and provide access to the supermarket and shops where significant activity takes place. Emphasis would be given to the Place function on these streets whilst providing for vehicle movement to access into and out of the Study Area via the Belmore Road- Roosevelt Avenue intersection.

Roosevelt Avenue would provide a 30m road reserve as a designated route for delivery vehicles to the mixed-use centre that has been designed to accommodate a 12.5m long heavy rigid vehicle. Refer to Section 6.6.3 for the proposed cross sections.

Other internal roads are primarily in a lower hierarchy with an emphasis on the Place function to provide access to the residential area, with good connectivity within the local streets and accessibility to public transport services. Local streets would provide 18m or 16.7m road reserve to accommodate two-way traffic with kerbside parking and footpath on both sides of the street.

There are also local streets with a 15.7m road reserve to accommodate one-way traffic with kerbside parking and footpath on both sides of the street.

A 20m wide pedestrianised Community Greenway would be created to connect local residents with the primary school and Salt Pan Creek Reserve. This open space is where residents meet and play and no vehicles are permitted.

Outside of the Study Area, Belmore Road is the vibrant street along the mixed-use centre frontage while carrying local and through traffic to the wider road network such as the M5 motorway, Canterbury Road and King Georges Road.

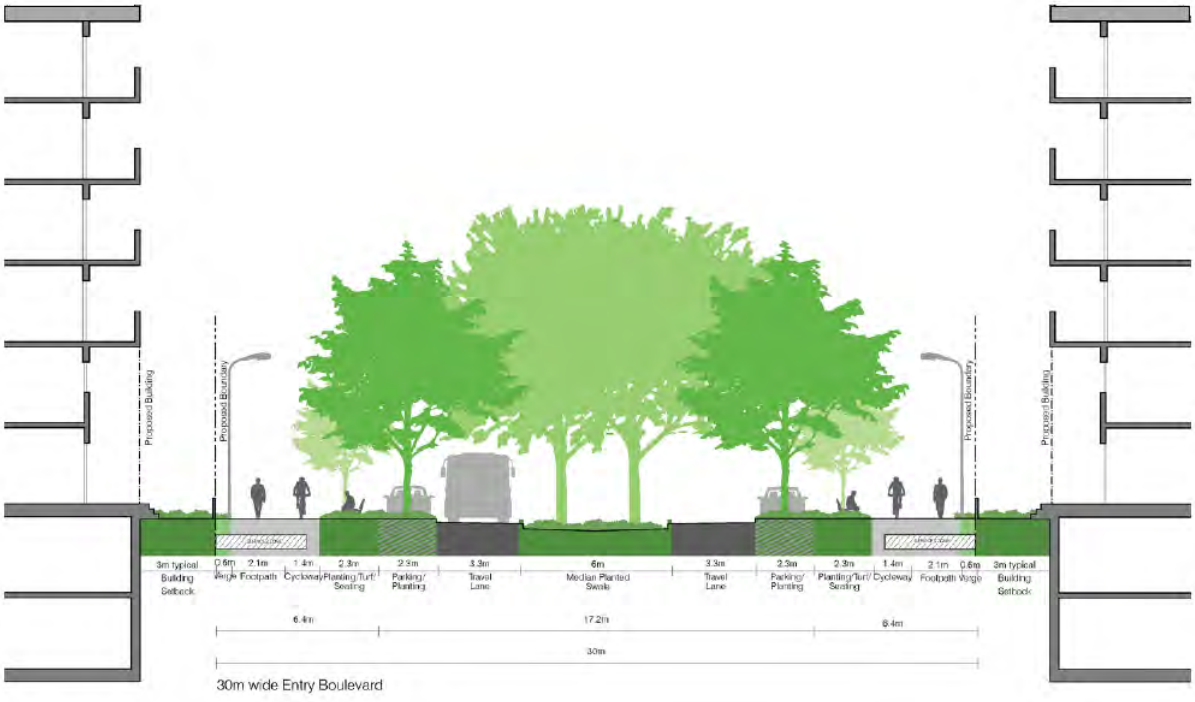
6.6.3 Cross Section of Internal Roads

The cross section of the internal roads has considered Movement and Place objectives considering the needs of all users on the roads and footpath including pedestrians, cyclists, private vehicles and public transport, as well as people spending time in these places.

Roosevelt Avenue serves as the main collector road of the Study Area and is configured as a 30m wide boulevard as shown in Figure 6.10 with the following key features:

- 0.6m verge on both sides
- 3.5m shared path on both sides
- 2.3m planting/ turf / seating on both sides
- 2.3m indented on-street parking on both sides
- 3.3m travel lane on each direction
- 6m median planted swale

Figure 6.10: Proposed Road Section – Roosevelt Avenue



Source: Architectus

Local streets with a central median are generally provided with a 18m wide carriageway as shown in Figure 6.11, with the following key features:

- 3.3m travel lanes
- 2.1m indented on-street parking or planting
- 2m footpath
- 0.6m verge
- 2m rain garden median

Figure 6.11: Proposed Road Section – Local Street

Source: Architectus

Local streets without a central median generally have a 16.7m wide carriageway as shown in Figure 6.12, with the following key features:

- 3.25m travel lanes
- 2.3m indented on-street parking or planting
- 2.2m footpath
- 0.6m verge

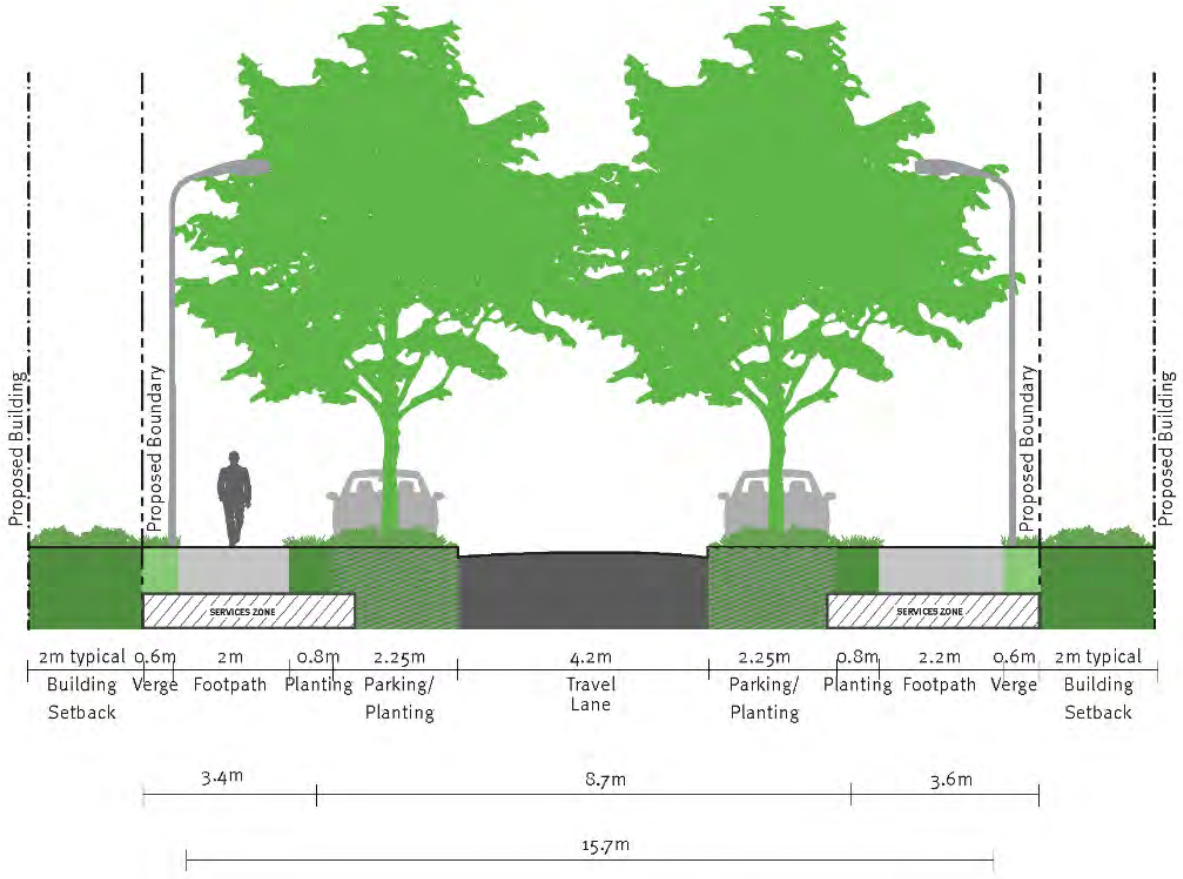
Figure 6.12: Proposed Road Section – Local Street

Source: Architectus

One-way streets are provided with a 15.7m wide carriageway as shown in Figure 6.13 with the following key features:

- 4.2m travel lane
- 2.25m indented on-street parking or planting
- 0.8m planting strip
- 2.0m/2.2m footpath
- 0.6m verge

Figure 6.13: Proposed Road Section – One-Way Street



Source: Architectus

6.7 Traffic Modelling Overview

6.7.1 Assessment Scenarios

The following scenarios have been considered to assess potential traffic impact of the proposed development on the surrounding road network:

- Scenario 1: Existing Base Case – this scenario included baseline traffic based on existing traffic with no development traffic

- Scenario 2: Future Base Case – this scenario considered background traffic growth (Appendix B) on the future year without development traffic
- Scenario 3: Future Year with Development – this scenario included background traffic growth (Appendix B) with additional traffic associated with the proposed development and impact of the proposed infrastructure improvement works

The above future scenarios have been assessed for Years 2031 and 2041.

6.7.2 Aimsun Microsimulation Modelling

Jacobs developed a microscopic Aimsun model for the suburb of Riverwood on behalf of DPIE in 2017. The model was used to support the preparation of a transport and traffic study and the development of a Land Use and Infrastructure Strategy (LUIS) for the Riverwood Priority precinct.

The model included the Riverwood Estate SSP as well as a small commercial centre located around Riverwood Train Station. The model was reviewed and approved by the Roads and Maritime (currently TfNSW). The model was also used for Test of Adequacy assessment associated with the earlier Planning Proposal submission in 2017.

As part of this current Planning Proposal, Jacobs updated the Aimsun model to reflect the reduction in design yield in the master plan and updated the background traffic growth based on the Strategic Transport Model (STM) cordon matrices provided by TfNSW on 12 January 2021 (Appendix B) taking into consideration the planned and committed development in the surrounding area (Appendix C).

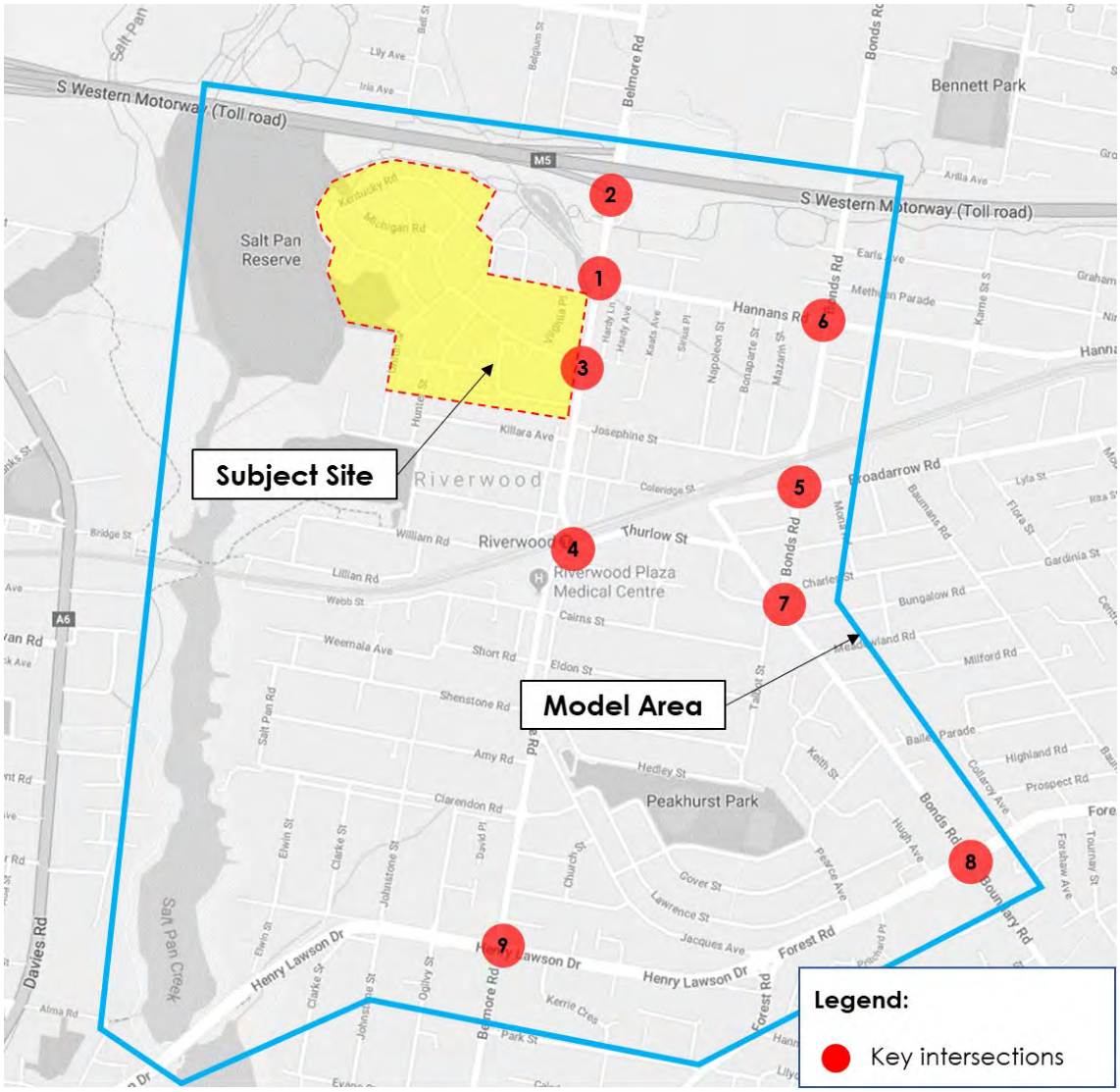
The model assessed the impacts of the Riverwood Estate SSP and determined the required upgrades to maintain an acceptable level of service of the road network.

The model captures the morning (6am to 10am) and evening (3pm to 7pm) peak periods and extends to the study area shown in Figure 6.14. Key intersections that have been assessed to determine the need for any road upgrades include:

1. Belmore Road – Hannans Road
2. Belmore Road – M5
3. Belmore Road – Roosevelt Avenue – Washington Avenue
4. Belmore Road – Thurlow Street
5. Bonds Road – Broadarrow Road
6. Bonds Road – Hannans Road
7. Bonds Road – Romily Street
8. Forest Road – Boundary Road – Bonds Road
9. Henry Lawson Drive – Belmore Road

The 'Traffic Works and Apportionment Report' prepared by Jacobs discussing the traffic modelling methodology and results is shown in Appendix C.

Figure 6.14: Aimsun Model Study Area



Source: Google Maps Australia

Note: The King Georges Road and Broadarrow Road and Canterbury Road and Belmore Road are located outside the Aimsun model area but have been assessed separately in SIDRA modelling.

The future traffic volumes have been forecasted based on the following information:

- Removal of existing traffic generation associated with the dwellings to be demolished.
- Inclusion of potential traffic generation associated with SSP development for residential, retail and childcare centre based on the staging plan provided by LAHC and trip rates as discussed in Section 6.9.3.
- Background traffic growth and distribution of development traffic based on TfNSW current STM, which uses the current common planning assumptions for the NSW Government and represents a pre-Covid-19 pandemic view of the future.

- Jacobs advised that the background traffic and traffic distribution in the WRTM model has been reviewed and accepted by TfNSW. The development, calibration and validation of the model are documented in the Riverwood Land Use and Infrastructure Strategy – Traffic and Transport Assessment – Calibration and Validation Report (July 2017).
- Directional distributions of trips to and from the Study Area for Year 2031 and Year 2041 are presented in Table 6.7 and Table 6.8, respectively.

Table 6.7: 2031 Trip Distribution Based on STM

Primary Access Point To/From the Proposed Development	AM Peak		PM Peak	
	Inbound	Outbound	Inbound	Outbound
South Western Motorway/M5 (west of development)	4%	5%	4%	5%
Belmore Road (north of development)	34%	43%	35%	38%
Bonds Road (north of development)	4%	4%	6%	6%
South Western Motorway/M5 (east of development)	<1%	<1%	<1%	<1%
Hannans Road	24%	25%	24%	20%
Broadarrow Road	1%	<1%	1%	1%
Meadowland Road	<1%	<1%	<1%	<1%
Forest Road (east of development)	1%	1%	1%	<1%
Boundary Road	2%	2%	2%	2%
Forest Road (south of development)	<1%	<1%	<1%	1%
Belmore Road (south of development)	2%	1%	2%	2%
Henry Lawson Drive	11%	4%	6%	7%

Table 6.8: 2041 Trip Distribution Based on STM

Primary Access Point To/From the Proposed Development	AM Peak		PM Peak	
	Inbound	Outbound	Inbound	Outbound
South Western Motorway/M5 (west of development)	7%	6%	6%	6%
Belmore Road (north of development)	35%	39%	35%	37%
Bonds Road (north of development)	4%	6%	6%	6%
South Western Motorway/M5 (east of development)	<1%	<1%	<1%	<1%
Hannans Road	22%	25%	24%	20%
Broadarrow Road	1%	<1%	1%	1%
Meadowland Road	<1%	<1%	<1%	<1%
Forest Road (east of development)	<1%	2%	1%	1%
Boundary Road	2%	2%	2%	2%
Forest Road (south of development)	<1%	<1%	<1%	1%
Belmore Road (south of development)	2%	1%	2%	2%
Henry Lawson Drive	10%	4%	5%	6%

Table 6.7 and Table 6.8 indicate that most of the site related traffic travel to/from the site via Belmore Road north of site (35% to 39%), Hannans Road (20% to 25%), Henry Lawson Drive (4% to 10%), and M5 Motorway west of Belmore Road (6% to 7%). The forecasted low usage of the M5 Motorway is likely because it is a tollway.

The remaining trips assigned to various other roads, with a small proportion of trips assigned to travel across the rail line. There are three crossing opportunities available across the rail line, namely:

- Belmore Road – Thurlow Street intersection
- Bonds Road south of Bonds Road – Josephine Street intersection, and
- Underbridge link road connecting Lilian Road and Webb Street.

6.7.3 SIDRA Intersection Modelling

Intersection capacity analysis has been undertaken by TTPP using SIDRA Intersection 8 modelling software to ascertain the intersection performance of the following intersections outside the extent of the Aimsun traffic model:

- Canterbury Road – Belmore Road
- King Georges Road – Broadarrow Road.

Future traffic volumes for Years 2031, Year 2036 and 2041 have been estimated based on a combination of the following information:

- Background traffic growth rates based on TfNSW STM cordon matrices (Appendix B)
- Existing traffic share at key intersections based on the traffic survey data
- Review of Environmental Factors, Belmore Road Ramps, Roads and Maritime Services (November 2017)
- Distribution of development traffic based on directional split of background traffic

It is noted that the intersection of King Georges Road-Broadarrow Road has recently been upgraded (Year 2020) as part of the Gateway to the South – Pinch Point Program. As such, the SIDRA models of future years adopted the upgraded configuration of King Georges Road-Broadarrow Road.

6.7.4 Intersection Level of Service

The performance of subject intersections surrounding the Riverwood Estate SSP has been assessed based on the criteria defined by TfNSW, as presented in Table 6.9.

At signalised intersections, the average delay is the volume weighted average of all movements. For roundabouts and priority (give way and stop sign) controlled intersections, the average delay relates to the worst movement.

Table 6.9: Roads and Maritime Level of Service Criteria

Level of Service (LoS)	Average Delay per vehicle (secs/veh)	Traffic Signals, Roundabout	Give Way & Stop Sign
A	Less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity, accident study required
E	57 to 70	At capacity; at signals incidents would cause excessive delays. Roundabouts require other control mode	At capacity, requires other control mode.
F	Greater than 70	Unsatisfactory with excessive queuing	Unsatisfactory with excessive queuing; requires other control mode

In order to determine the intersection and road improvement works required to accommodate the proposed development in the modelling scenarios, the future intersection performance with proposed upgrade works should meet the following criteria:

- Intersections that currently perform at Level of Service D or better to maintain this operation

- Intersections that currently perform worse than Level of Service D not to exceed existing average delays

6.8 Existing Intersection Performance

Table 6.10 provides a summary of traffic modelling results for the existing Year 2017 scenario undertaken by Jacobs for the suburb of Riverwood on behalf of DPIE in 2017.

As discussed in Section 6.3.3, the opening of east facing ramps of the M5 interchange in 2017 has altered traffic patterns with generally less traffic on Belmore Road, the M5 ramps and Hannans Road in the AM peak, whilst a mix of changes on these roads in the PM peak. Generally, the traffic increase around the M5 interchange is less than the REF prediction.

Table 6.10: Year 2017 Existing Intersection Performance

Intersection	AM Peak		PM Peak	
	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	25	B	20	B
Belmore Road – M5	14	A	14	A
Belmore Road – Roosevelt Ave	24	B	43	C
Belmore Road – Thurlow Street	39	C	28	B
Bonds Road – Broadarrow Road	106	F	11	A
Bonds Road – Hannans Road	32	C	31	C
Bonds Road – Romilly Street	10	A	14	A
Forest Road – Boundary Rd – Bonds Road	106	F	102	F
Henry Lawson Drive – Belmore Road	24	B	42	C
Canterbury Road – Belmore Road	38	C	17	B
King Georges Road – Broadarrow Road	54	D	42	C

Based on above results, the assessed intersections currently operate at acceptable levels of service, except the Forest Road- Boundary Road- Bonds Road intersection which currently operates at LoS F during the morning and evening peak periods, and intersection of Bonds Road and Broadarrow Road which operates at LoS F during the morning peak.

It is also noted that King Georges Road-Broadarrow Road is operating at capacity with LoS D during the morning peak period.

6.9 Future Intersection Performance

6.9.1 Existing Development Traffic Generation

Based on the staging plan presented in Table 4.1, approximately 1,000 medium-density dwellings will be demolished in stages to accommodate the proposed development.

Trips generated by the site has been estimated by the total number of vehicles accessing the site into and out of Belmore Road via Washington Avenue and Roosevelt Avenue. However, not all the surveyed turning traffic volumes at these intersections in 2017 are related to those dwellings to be demolished. It was assumed that the dwellings to be demolished contributed about 40% of the surveyed traffic at these intersections in order to derive the trip rates of those dwellings to be demolished. The remaining 60% contributed to traffic associated with the land uses to remain, such as Washington Park estate and Riverwood Public School etc.

As such, the trip rates have been assessed based on a conservative assumption that 40% of the traffic traversing these intersections are associated with the existing dwellings which are to be demolished for the development. On this basis, the existing site traffic generation has been estimated based on traffic movements recorded at these intersections based on the surveys undertaken on Thursday 9 February 2017 on Saturday 11 February 2017.

Table 6.11: Existing Site Traffic Generation

Peak Hour	Traffic Volumes (vehicle/hour)			Distribution (%)		Trip Rate (veh/unit)
	In	Out	Two-Way	In	Out	
Weekday AM peak	128	205	333	38%	62%	0.12
Weekday PM peak	218	165	383	57%	43%	0.14
Saturday peak	140	191	331	42%	58%	0.12

To determine the net impact of the proposed development, the existing traffic volumes generated by the dwellings to be demolished are to be deducted sequentially as the development progresses throughout the stages. The trip rates shown in Table 6.11 have been applied to the number of dwellings that will be demolished. A summary of the traffic volumes to be deducted is presented in Table 6.12. Demolition of 1,081 dwellings would ultimately deduct 133 trips in the AM peak, 153 trips in the PM peak and 132 trips in the Saturday peak.

Table 6.12: Traffic Generation Deduction during Peak Hours

Ultimate Number of Dwellings to be Demolished	Traffic Volumes to be Deducted (vehicle/hour)		
	AM	PM	Saturday
1,081	133	153	132

The traffic volumes shown in Table 6.12 have been deducted based on the existing directional distribution.

The remaining traffic volumes at the Belmore Road intersections with Washington Avenue and Roosevelt Avenue would be sufficient to cover the traffic generation associated with Washington Park and Riverwood Public School:

- AM peak hour: 200 vehicle trips which could cover Washington Park 126 vehicle trips (refer to Table 6.13) and school 71 vehicle trips (based on a rate of 0.67 trips/student and enrolment of 106 students).
- PM peak hour: 230 vehicle trips which could cover Washington Park 155 vehicle trips (refer to Table 6.13) and school 56 vehicle trips (based on a rate of 0.53 trips/student and enrolment of 106 students).
- Saturday peak hour: survey was not undertaken on Saturday at Washington Park for this traffic assessment.

This is considered conservative because the existing traffic volume at the Belmore Road and Truman Avenue intersection was not reduced in the traffic assessment but in reality Truman Avenue is a common travel route to/from Riverwood Public School.

6.9.2 Washington Park Development (Benchmark Site)

Washington Park is a residential area located immediately adjacent to the subject site, with a housing mix comprising of social and private housing. Due to the similar housing mix and accessibility to public transport services, Washington Park has been selected as a suitable site for establishing traffic generation rates for benchmarking purposes.

Roads and Maritime (currently TfNSW) has approved the use of Washington Park as a benchmark site. Whilst the identification of a second benchmark site would have been beneficial, no other sites are deemed more suitable than Washington Park due to its similar site characteristics with the subject site. Therefore, only one benchmark site has been adopted in this assessment, and this approach has been agreed by the Roads and Maritime (currently TfNSW) during the consultation process. Refer to Appendix A for the approval.

Traffic surveys have been conducted at Washington Park development to count all vehicle and pedestrian movements in and out of the residential buildings for the establishment of traffic generation rates for the social and market units separately. The derived rates would be compared with the rates set out in the Roads and Maritime Guide to Traffic Generating Developments (Guide).

The traffic surveys were undertaken by TTPP on Tuesday, 22 May 2018 at the following residential buildings within Washington Park (refer to Figure 6.15):

- Building 1: 70 Kentucky Road, 1 Vermont Crescent, 4-6 Vermont Crescent – 192 market units

- Building 2: 7 Washington Avenue – 197 market units
- Building 3: 9 Washington Avenue – 123 social housing units
- Building 4: 72-76 Kentucky Road – 218 market units
- Building 5: 11 Washington Avenue – 27 social housing units, 68 market units

Classified vehicle counts and car occupancy surveys were undertaken at building driveways from 6:30am to 9:30am and from 4pm to 7pm, whereas pedestrian movements were counted at all site entrances from 6:30am to 9:30am.

A questionnaire survey was also conducted at pedestrian access points where residents were interviewed to answer pre-set questions on travel modes of the current trip.

Figure 6.15: Washington Park Survey Locations

Map source: Nearmap

6.9.2.1 Survey Results

The traffic surveys provided the following information:

- Classified vehicle counts and car occupancy at building driveways
- Pedestrian counts at building entrances
- Questionnaire survey conducted at the building entrances to record residents' mode choice of the current trip.

The driveway count results are summarised in Table 6.13 and Table 6.14.

Table 6.13: Washington Park Peak Hour Vehicle Survey Results

Building	Number of Dwellings		Peak Hour Volume (Vehicles Per Hour)					
			AM Peak Hour			PM Peak Hour		
	Market	Social	In	Out	Two-Way	In	Out	Two-Way
1	192	0	6	32	38	32	19	51
2	197	0	9	36	45	28	21	49
3	0	123	1	7	8	5	3	8
4	218	0	5	21	26	22	11	33
5	68	27	1	8	9	11	3	14
Washington Park Overall	**675**	**150**	**22**	**104**	**126**	**98**	**57**	**155**

Notes:

(1) Overall site peak hour is from 8:15am to 9:15am and from 6pm to 7pm. Peak hour trips for Building 3 are based on the building peak hour (i.e., from 7:15am to 8:15am and from 5:45pm to 6:45pm).

(2) The survey data associated with Building 5 does not segregate the results for the market and social housing, thereby survey results from Building 5 has been excluded in the assessment.

Table 6.14: Washington Park Traffic Count Survey Summary (Three-Hour Period)

Direction	In (veh/hr)			Out (veh/hr)			Two-Way (veh/hr)
Time Period	Light	Heavies	Total	Light	Heavies	Total	Total
6:30 to 7:30	12	0	12	89	0	89	**101**
7:30 to 8:30	12	0	12	100	1	101	**113**
8:30 to 9:30	29	0	29	77	0	77	**106**
AM Total	**53**	**0**	**53**	**266**	**1**	**267**	**320**
16:00 to 17:00	71	0	71	38	0	38	**109**
17:00 to 18:00	94	1	95	36	0	36	**131**
18:00 to 19:00	96	0	96	58	0	58	**154**
PM Total	**261**	**1**	**262**	**132**	**0**	**132**	**394**

TTPP notes that the hourly traffic presented in Table 6.14 differs from the overall peak hour traffic shown in Table 6.13. Morning peak period was recorded from 8:15am to 9:15am. As for the evening peak period, there is a slight discrepancy between the values presented in the two tables since peak hour trips for Building 3 are based on the building peak hour (i.e., 5:45pm to 6:45pm) and not on the overall site peak hour (i.e., 6pm to 7pm).

Table 6.15: Washington Park Vehicle Occupancy Survey Results (AM Peak)

Building	Peak Hour Volume											
	In				Out				Total			
	Drivers	Passengers	Motorbikes	Cycles	Drivers	Passengers	Motorbikes	Cycles	Drivers	Passengers	Motorbikes	Cycles
1	6	0	0	0	32	16	1	0	38	16	1	0
2	9	0	0	0	34	19	0	0	43	19	0	0
3	1	0	0	0	7	0	0	1	8	0	0	1
4	5	1	0	0	21	4	0	0	26	5	0	0
5	1	0	0	0	9	2	0	0	10	2	0	0
Washington Park Overall	**22**	**1**	**0**	**0**	**103**	**41**	**1**	**1**	**125**	**42**	**1**	**1**
Overall Car Occupancy Rate	**1.05**				**1.41**				**1.34**			

Table 6.16: Washington Park Vehicle Occupancy Survey Results (PM Peak)

Building	Peak Hour Volume											
	In				Out				Total			
	Drivers	Passengers	Motorbikes	Cycles	Drivers	Passengers	Motorbikes	Cycles	Drivers	Passengers	Motorbikes	Cycles
1	32	11	0	0	19	10	0	0	51	21	0	0
2	28	12	0	0	21	3	0	0	49	15	0	0
3	5	0	0	0	3	1	0	0	8	1	0	0
4	22	11	0	0	12	7	0	0	34	18	0	0
5	11	2	0	0	3	0	0	0	14	2	0	0
Washington Park Overall	**98**	**36**	**0**	**0**	**58**	**21**	**0**	**0**	**156**	**57**	**0**	**0**
Overall Car Occupancy Rate	**1.37**				**1.36**				**1.37**			

The pedestrian movement counts recorded a total of 245 pedestrian movements into and out of the residential buildings. The questionnaire survey recorded a total of 118 respondents who completed the interview questions. A summary of the existing travel mode share of Washington Park is presented in Table 6.17.

Table 6.17: Washington Park Interview Survey Results

Mode of Travel	Mode Share					
	Market (Buildings 1, 2, 4)		Social (Building 3)		Washington Park Overall (Buildings 1-5)	
	Sample	%	Sample	%	Sample	%
Driver (parked on street)	9	10%	2	9%	12	10%
Passenger (picked-up or dropped off outside building)	7	8%	0	0%	7	19%
Bus	17	17%	5	22%	22	6%
Train	38	41%	7	30%	45	38%
Walk	22	24%	9	39%	32	27%
Total	**93**	**100%**	**23**	**100%**	**118**	**100%**

Table 6.18 presents the existing mode share of Washington Park. Sample counts of drivers, car passengers and cyclists counted in the vehicle occupancy survey have been added to the total counts.

Table 6.18: Washington Park Mode Split

Mode of Travel	Market (Buildings 1, 2, 4) Peak Hour Pedestrian Count: 149		Social (Building 3) Peak Hour Pedestrian Count: 44		Washington Park Overall (Buildings 1-5) Peak Hour Pedestrian Count: 245	
	Count	%	Count	%	Count	%
Driver	121	40%	12	23%	150	35%
Passenger	60	20%	0	0%	66	16%
Bus	27	9%	10	18%	46	11%
Train	61	20%	13	25%	93	22%
Walk	35	11%	17	32%	66	16%
Cycle	0	0%	1	2%	1	0%
Total	**304**	**100%**	**53**	**100%**	**422**	**100%**

Based on the above table, about 60% of the market housing residents travel via car (i.e., drivers and passengers) from/to their destinations. This suggests that majority of the market housing residents are private car users, which is consistent with the overall Washington Park development travel mode choice with 51% of residents travelling via car.

This observation is contrary to the results gathered from social housing developments where most of the residents (32%) walk to their destinations. This is followed by train users which correspond to 25% of the total residents. The survey results suggest that private car use is not the most popular travel mode among social housing residents.

6.9.2.2 Washington Park Survey Results Analysis

The traffic survey established the following benchmark factors for comparison with the rates to be developed using the first principles approach (refer to Section 6.9.2.3):

- AM and PM peak hour traffic generation rates for market and social housings
- AM peak mode share

Results of the driveway counts and interview surveys have been analysed to determine the peak hour traffic generation of the subject site for market or social housings.

It is noted that interview surveys were conducted in the morning only because the evening mode share is expected to be similar to that recorded in the morning.

A summary of the trip generation rates estimated from the surveys is presented in Table 6.19. The highest number of combined trips (i.e., total vehicle counts from all buildings) of Washington Park development were recorded from 8:15am to 9:15am and from 6pm to 7pm. The trip generation of social housing is based on the trips recorded during the peak hour of Building 3 which occurred between 7:15am and 8:15am and between 5:45pm and 6:45pm.

Table 6.19: Washington Park Benchmark Traffic Generation Rates (vehicle trips/hour/unit)

Development Type	Number of Dwellings	Two-Way Peak Hour Trips		Benchmark Peak Hour Trip Generation Rates	
		AM Peak (8:15am-9:15am & 7:15am-8:15am)	PM Peak (6pm-7pm & 5:45pm-6:45pm)	AM Peak (8:15am-9:15am & 7:15am-8:15am)	PM Peak (6pm-7pm & 5:45pm-6:45pm)
Market	675	123	151	0.18	0.22
Social	150	12	12	0.08	0.08
Washington Park Overall	**825**	**151**	**186**	**0.18**	**0.23**

Note: Building 5 is excluded in identifying trips by housing type since there is no breakdown of market and social housing generated traffic

The benchmark site generates 0.18 and 0.23 vehicle trips per unit during the morning and evening peak hours, respectively. Trips generated by market units resulted in higher rates than the overall rates which resulted in 0.18 vehicle trips per unit during the morning peak and 0.22 vehicle trips per unit during the evening peak. Conversely, social housing vehicle trip rate is determined to be 0.08 trips per unit in both peak periods, significantly lower than the trip rates of the market dwellings.

6.9.2.3 *First Principles Approach*

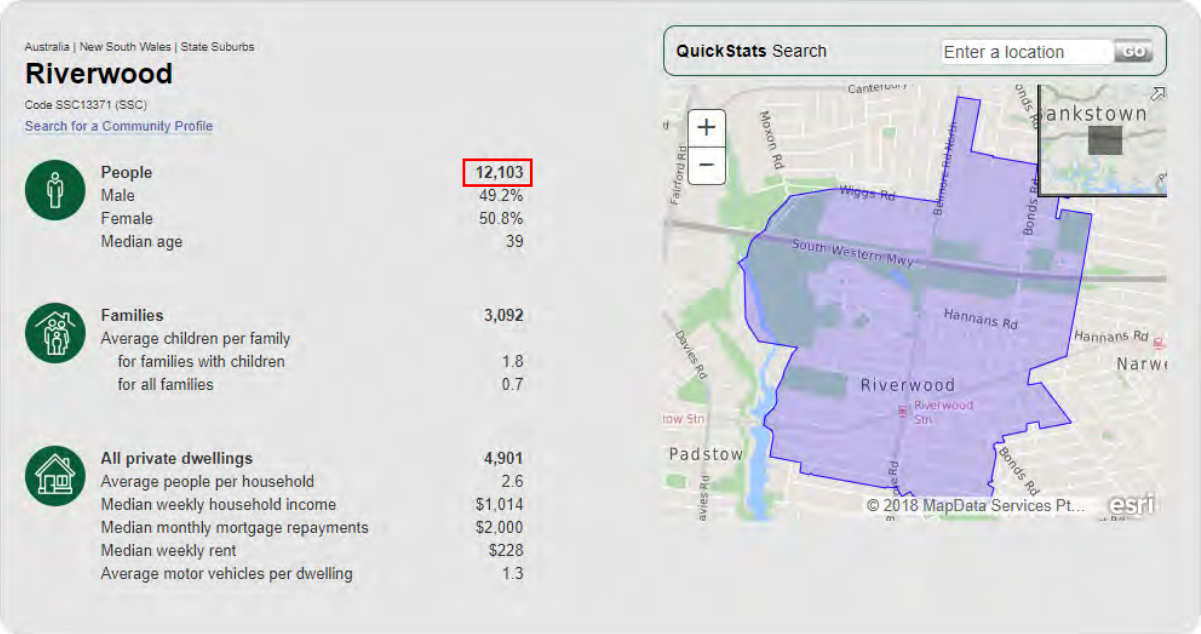
6.9.2.3.1 TfNSW Comments

TfNSW considered that the subject site is not within easy walking distance of Riverwood Station which is not a major transport interchange such as Chatswood and Parramatta that provide high frequency bus and rail connections. TfNSW had requested a higher rate be tested considering the high degree of car-based mode identified in the questionnaire survey at Washington Park, as documented in Appendix A. Subsequently, the adjusted higher rates have been approved by TfNSW for the purpose of this assessment.

6.9.2.3.2 Adjustment Factor to Benchmark Traffic Generation Rates

In response to TfNSW comments, TTPP undertook an alternative approach to derive traffic generation rates of the Washington Park development based on Census data (Figure 6.16 and Figure 6.17), and subsequently compared with the surveyed benchmark traffic generation rates (Table 6.19).

Figure 6.16: Riverwood Suburb Demographics (2016)



Reference: 2016 Census QuickStats (Australian Bureau of Statistics)

Figure 6.17: Riverwood Suburb Methods of Travel to Work (2016)

Travel to work, top responses *Employed people aged 15 years and over*	Riverwood	%	New South Wales	%	Australia	%
Car, as driver	2,195	47.0	1,953,399	57.8	6,574,571	61.5
Train	1,173	25.1	252,786	7.5	488,012	4.6
Car, as passenger	199	4.3	144,820	4.3	489,922	4.6
Train, bus	149	3.2	60,155	1.8	104,122	1.0
Walked only	107	2.3	130,957	3.9	370,427	3.5
People who travelled to work by public transport	1,515	32.4	540,215	16.0	1,225,668	11.5
People who travelled to work by car as driver or passenger	2,486	53.1	2,182,854	64.6	7,305,271	68.4

In Riverwood (State Suburbs), on the day of the Census, the most common methods of travel to work for employed people were: Car, as driver 47.0%, Train 25.1% and Car, as passenger 4.3%. Other common responses were Train, bus 3.2% and Walked only 2.3%. On the day, 32.4% of employed people used public transport (train, bus, ferry, tram/light rail) as at least one of their methods of travel to work and 53.1% used car (either as driver or as passenger).

Reference: 2016 Census QuickStats (Australian Bureau of Statistics)

Based on the latest 2016 Census data, 18% of the population in the suburb of Riverwood drive to work (2,195 drivers out of 12,103 total population). By applying the same ratio to the Washington Park development, it is estimated that a total of **386** people drive to work (i.e., 825 dwellings x 2.6 average household size x 18%).

Based on the traffic survey results presented in Table 6.14, there are **320** vehicles recorded during the morning survey period (6:30am to 9:30am) and **394** vehicles during the afternoon survey (4pm to 7pm).

This suggests that the first principles figures are 20% higher than the actual traffic counts in the morning period (**320** vehicles compared to **386** vehicles) and almost the same in the evening period (**394** versus **386**), as shown in Table 6.14.

6.9.2.3.3 Household Travel Survey Data

Consideration has also been given to Household Travel Survey (HTS) for all trip purposes, such as work, education, social and recreation etc. The 2016 HTS data for statistical Area Level 3 (SA3 11903 – Hurstville) indicates 38% people in this SA3 drive for any trip purposes during anytime on an average weekday, as opposed to the above 18% driving for work trips that are more likely to occur during the commuter peak periods.

Applying the rate of 38% driving on the 825 existing dwellings with an average household size of 2.6, this produces 815 vehicles which are way more than the surveyed traffic volumes at Washington Park, being 320 and 394 vehicles in the 3-hour AM and PM peak periods respectively.

6.9.2.3.4 Adjusted Traffic Generation Rates

In order to address TfNSW comments, TTPP adopted the 2016 data for Methods of Travel to Work and concluded that an adjustment of 20% to the benchmark traffic generation rates

was necessary to match with the suburb JTW data to enable a conservative traffic generation derived based upon the Census data.

The trip rates as shown in Table 6.20 have been adopted in estimating the future traffic generation of Riverwood Estate SSP. The TfNSW rates for high density residential developments in sub-regional centres are shown in Table 6.20 for comparison.

Table 6.20: Adjusted Washington Park Trip Generation Rate (for Riverwood Estate SSP)

Development Type	Benchmark Trip Generation Rate (vehicle trips/unit)		Adjusted Trip Generation Rate (vehicle trips/unit)		TfNSW Trip Rate (vehicle trips/unit)	
	Morning Peak	Evening Peak	Morning Peak	Evening Peak	Morning Peak	Evening Peak
Market	0.18	0.22	0.26	0.29	-	-
Social	0.08	0.08	0.13	0.12	-	-
Overall	0.18	0.23	0.23	0.27	0.29	0.29

The above proposed trip rates had been reviewed by Roads and Maritime (currently TfNSW) which subsequently approved these trip rates on 1 August 2018 as the rates are closely aligned with the recommended rates in the TfNSW research on other sites with similar characteristics. Refer to Appendix A for the approval.

As such, the benchmark rates have been augmented in estimating the residential trip generation of the proposed development. This is further discussed in Section 6.9.3.1.

6.9.3 Proposed Development Traffic Generation

6.9.3.1 Trip Rates of Residential Development

As discussed in Section 6.9.2, TTPP has carried out traffic surveys at Washington Park located adjacent to the subject development. The site has been identified as a benchmark site as it is located adjacent to the subject site and contains a mix of market and social housing.

TTPP has applied adjustments on the trip generation rates obtained from survey results based on the first principles method. Roads and Maritime (currently TfNSW) have agreed on the following proposed rates to be applied on the residential developments. It has been assumed that trip rates during Saturday peak hour would be in-line with the higher weekday trip rate, as demonstrated in the intersection counts undertaken 2017.

- Market housing:
  - Morning peak: 0.26 vehicle trips per unit
  - Evening peak: 0.29 vehicle trips per unit
  - Saturday peak: 0.29 vehicle trips per unit
- Social housing:

- Morning peak: 0.13 vehicle trips per unit
- Evening peak: 0.12 vehicle trips per unit
- Saturday peak: 0.13 vehicle trips per unit

6.9.3.2 Trip Rates of Retail Development

Trip generation rates for retail development have been sourced from Roads and Maritime Services' *Trip Generation Surveys – NSW Small Suburban Shopping Centres* report (November 2018). The following rates have been used based on the average trip rates from surveyed sites in Sydney Metropolitan Area with GLFA ranging from 4,000m^2 to 6,000m^2:

- 6.97 vehicle trips per 100m^2 GLFA during the morning peak hour
- 9.87 vehicle trips per 100m^2 GLFA during the afternoon peak hour
- 10.37 vehicle trips per 100m^2 GLFA during Saturday peak hour

It has been assumed that the GLFA is 75% of the GFA in accordance with the RMS Guide.

6.9.3.3 Trip Rates of Childcare Centre

TfNSW *Validation Trip Generation Surveys Child Care Centres Analysis Report* (September 2015) includes trip generation rates obtained from 14 surveyed childcare sites (12 sites in Sydney metropolitan areas, 2 sites in regional areas). The following trip rates have been adopted in this assessment which have been based on the average trip rates of Sydney sites:

- 6.17 vehicle trips per 100m^2 GFA during the morning peak hour
- 4.99 vehicle trips per 100m^2 GFA during the afternoon peak hour

It is also assumed that the childcare will not be operational during weekends. As such, trip generation during Saturday peak period is estimated to be nil.

6.9.3.4 Trip Rates of Library

TfNSW does not provide a trip rate for libraries. Research into the DCP parking rates of libraries was undertaken at various Council DCPs in order to provide an indication of the likely trip generation. Canterbury Bankstown DCP does not provide such information.

The DCP parking rates of other Council DCPs are shown as follows:

- Shellharbour DCP: 1 space / 50m^2
- Cumberland DCP: 1 space / 10m^2 or 1 space/ 6 seats whichever is greater
- Dubbo DCP: 1 space / 20m^2 of public area
- Fairfield DCP: 1 space / 5m^2

An average of the above parking rates is one space per 32.5m² GFA, equating to 16 parking spaces for the library with a 500m² GFA. Assuming a typical turnover rate of 1 hour for visitors, traffic generation is estimated to be 16 vehicle trips per hour during the typical opening hours between 10am and 7pm.

On this basis, the following traffic generation has been estimated for the inbound and outbound traffic to/from the library:

- 32 vehicle trips during the morning peak hour
- 32 vehicle trips during the Saturday peak hour.

6.9.3.5 Traffic Generation Summary

For trips generated by the residential uses, it has been assumed that 20% of trips would be inbound and 80% of trips would be outbound in the weekday morning peak hour, and these would be reversed in the evening peak period. For Saturday peak period, it has been assumed that 50% of the residential trips would be inbound and 50% would be outbound.

For trips generated by retail use and community facilities, it has been assumed that 50% of the trips would be inbound and 50% of trips would be outbound during peak hours.

Traffic generation of the development has been estimated based on three main development stages (i.e., year 2031, 2036, and 2041).

As mentioned in Section 4.1, LAHC advised a minor change in the development yield. A comparison of the traffic generation is shown in Table 6.21.

Table 6.21: Difference in Traffic Generation in the Original and Revised Scheme

Scheme	Land Use	Indicative Yield	Trip Generation Rate			Weekday AM Peak Trips (veh/hr)	Weekday PM Peak Trips (veh/hr)	Saturday Peak Trips (veh/hr)
			Weekday AM	Weekday PM	Saturday			
Original	Market	2,889 dwellings	0.26 trips per unit	0.29 trips per unit	0.29 trips per unit	751	838	838
	Social	1,037 dwellings	0.13 trips per unit	0.12 trips per unit	0.13 trips per unit	135	124	135
	Retail	4,793m² GFA	6.97 trips per 100m² GLFA	9.87 trips per 100m² GLFA	10.37 trips per 100m² GLFA	251	355	373
	Childcare Centre	970m² GFA	6.17 trips per 100m² GFA (1)	4.99 trips per 100m² GFA (1)	-	45	36	0
	Total					**1,181**	**1,353**	**1,345**
Revised	Market	2,889 dwellings	0.26 trips per unit	0.29 trips per unit	0.29 trips per unit	751	838	838
	Social	1,037 dwellings	0.13 trips per unit	0.12 trips per unit	0.13 trips per unit	135	124	135

	Childcare Centre	420m² GFA (60 place)	6.17 trips per 100m² GFA (1)	4.99 trips per 100m² GFA (1)	-	19	16	0
	Retail	3,130m² GFA	6.97 trips per 100m² GLFA	9.87 trips per 100m² GLFA	10.37 trips per 100m² GLFA	164	232	243
	Library	500 m² GFA	Based on average DCP parking rate (2)			Negligible	32	32
	Community Centre	150 People within 600m² (3)	First-principles approach (4)			28	28	28
	Cultural use	38 People within 150m² (3)				7	7	7
	Total					**1,104**	**1,277**	**1,283**
Difference from the original Scheme						**Reduction of 77**	**Reduction of 77**	**Reduction of 63**

Notes:
1. Assume 75% external trips and 25% internal trips for childcare centre. Applied TfNSW trip rates.
2. Based on the average DCP parking rate from the various DCPs for libraries.
3. Assume community centre and cultural use with a density of 1 person per 4m².
4. Assume 75% external and 25% internal trips for community centre and cultural use. Of the 75% external trips, half of which involve driving with a car occupancy 2 persons per vehicle, and another half would arrive to the site by active and public transport

Table 6.21 indicate the revised scheme would generate less traffic with a reduction of 63 to 77 vehicles trips in the peak hours, and hence would not trigger a need to revise the traffic model. On this basis, this traffic and transport assessment focuses on the earlier scheme due to the minor change in traffic generation between schemes.

Estimates of the peak hour traffic generation for the proposed development are provided in Table 6.22 to Table 6.24 based on the earlier scheme. It has been assumed that retail, childcare centre and community centre are expected to attract customers/visitors both from within the development and outside of the development, with 75% of trips arriving from the external road network and 25% arriving from within the development via internal road network.

Table 6.22: Riverwood Estate SSP Traffic Generation Potential (2031)

Land Use	Indicative Yield	Trip Generation Rate			Weekday AM Peak Trips (veh/hr)		Weekday PM Peak Trips (veh/hr)		Saturday Peak Trips (veh/hr)	
		Weekday AM	Weekday PM	Saturday	In	Out	In	Out	In	Out
Market	497 dwellings	0.26 trips per unit	0.29 trips per unit	0.29 trips per unit	26	103	115	29	72	72
Social	213 dwellings	0.13 trips per unit	0.12 trips per unit	0.13 trips per unit	6	22	20	5	14	14
Retail	4,793m² GFA	6.97 trips per 100m² GLFA	9.87 trips per 100m² GLFA	10.37 trips per 100m² GLFA	125	125	177	177	186	186
Community (Childcare)	0m² GFA (not built yet)	6.17 trips per 100m² GFA	4.99 trips per 100m² GFA	-	0	0	0	0	0	0
Total					**157**	**251**	**313**	**211**	**272**	**272**

Note: Indicative yield adopted for analytical purposes but subject to change as the project progresses.

Table 6.23: Riverwood Estate SSP Traffic Generation Potential (2031+2036 cumulatively)

Land Use	Indicative Yield	Trip Generation Rate			Weekday AM Peak Trips (veh/hr)		Weekday PM Peak Trips (veh/hr)		Saturday Peak Trips (veh/hr)	
		Weekday AM	Weekday PM	Saturday	In	Out	In	Out	In	Out
Market	2,091 dwellings	0.26 trips per unit	0.29 trips per unit	0.29 trips per unit	109	435	485	121	303	303
Social	695 dwellings	0.13 trips per unit	0.12 trips per unit	0.13 trips per unit	18	72	67	17	45	45
Retail	4,793m² GFA	6.97 trips per 100m² GLFA	9.87 trips per 100m² GLFA	10.37 trips per 100m² GLFA	125	125	177	177	186	186
Community (Childcare)	970m² GFA	6.17 trips per 100m² GFA	4.99 trips per 100m² GFA	-	22	22	18	18	0	0
Total					**275**	**655**	**747**	**333**	**535**	**535**

Note: Indicative yield adopted for analytical purposes but subject to change as the project progresses.

Table 6.24: Riverwood Estate SSP Traffic Generation Potential (2031+2036+2041 cumulatively)

Land Use	Indicative Yield	Trip Generation Rate			Weekday AM Peak Trips (veh/hr)		Weekday PM Peak Trips (veh/hr)		Saturday Peak Trips (veh/hr)	
		Weekday AM	Weekday PM	Saturday	In	Out	In	Out	In	Out
Market	2,889 dwellings	0.26 trips per unit	0.29 trips per unit	0.29 trips per unit	150	601	670	168	419	419
Social	1,037 dwellings	0.13 trips per unit	0.12 trips per unit	0.13 trips per unit	27	108	100	25	67	67
Retail	4,793m² GFA	6.97 trips per 100m² GLFA	9.87 trips per 100m² GLFA	10.37 trips per 100m² GLFA	125	125	177	177	186	186
Community (Childcare)	970m² GFA	6.17 trips per 100m² GFA	4.99 trips per 100m² GFA	-	22	22	18	18	0	0
Total					**325**	**856**	**965**	**388**	**673**	**673**

Note: Indicative yield adopted for analytical purposes but subject to change as the project progresses.

6.9.4 Network Capacity Analysis

Results of the Aimsun and SIDRA traffic modelling results are presented in Sections 6.9.4.1 to 6.9.4.3. The proposed intersection improvement works that were applied in Scenario 3 modelling is further discussed in Section 11.4.

The Movement objectives set in Section 5.6.2 require key intersections to be achieve a target level of service in the future assessment years and where required, an intersection redesign would be considered to maximise capacity in order to accommodate the future background traffic growth, other major projects and additional traffic associated with the proposed development.

The following target level of service has been set as a trigger for intersection upgrade works based on the forecast traffic demand associated with the development:

- intersections that currently perform at Level of Service D or better to maintain this operation
- intersections that currently perform worse than Level of Service D not to exceed existing average delays

6.9.4.1 Year 2031 Road Network Performance (Interim Year)

Results of the traffic modelling for the Year 2031 scenario are presented in Table 6.25 and Table 6.26.

Table 6.25: Year 2031 AM Peak Intersection Performance

Intersection	Upgrade works?	S1. 2017 Existing Performance		S2a. 2031 Without Development (w/o Improvements)		S2b. 2031 Without Development (with Improvements)		S3a. 2031 With Development (w/o Improvements)		S3b. 2031 With Development (with Improvements)	
		Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	Yes	25	B	26	B	29	C	27	B	31	C
Belmore Road – M5	No	14	A	16	B	18	B	15	A	18	B
Belmore Road – Roosevelt Ave	No	24	B	48	D	16	B	33	C	13	A
Belmore Road – Thurlow Street	No	39	C	42	C	32	C	43	C	27	B
Bonds Road – Broadarrow Road	Yes	106	F	43	C	43	C	50	D	54	D
Bonds Road – Hannans Road	No (banning parking on Hannans Road only)	32	C	32	C	34	C	32	C	47	D
Bonds Road – Romilly Street	Yes	10	A	13	A	38	C	20	B	52	D
Forest Road – Boundary Rd – Bonds Road	Yes	106	F	125	F	42	C	117	F	43	D
Henry Lawson Drive – Belmore Road	No	24	B	27	B	28	B	28	B	27	B
Canterbury Road – Belmore Road	No	38	C	21	B	21	B	29	C	29	C
King Georges Road – Broadarrow Road	No	54	D	65	E	65	E	74	F	74	F

Table 6.26: Year 2031 PM Peak Intersection Performance

Intersection	Upgrade works?	S1. 2017 Existing Performance		S2a. 2031 Without Development (w/o Improvements)		S2b. 2031 Without Development (with Improvements)		S3a. 2031 With Development (w/o Improvements)		S3b. 2031 With Development (with Improvements)	
		Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	Yes	20	B	24	B	24	B	26	B	25	B
Belmore Road – M5	No	14	A	15	A	17	B	14	A	17	B
Belmore Road – Roosevelt Ave	No	43	C	13	A	8	A	10	A	10	A
Belmore Road – Thurlow Street	No	28	B	32	C	27	B	31	C	30	C
Bonds Road – Broadarrow Road	Yes	11	A	11	A	36	C	12	A	55	D
Bonds Road – Hannans Road	No (banning parking on Hannans Road only)	31	C	31	C	45	D	31	C	34	C
Bonds Road – Romilly Street	Yes	14	A	13	A	33	C	18	B	37	C
Forest Road – Boundary Rd – Bonds Road	Yes	102	F	158	F	48	D	155	F	44	D
Henry Lawson Drive – Belmore Road	No	42	C	42	C	41	C	41	C	45	D
Canterbury Road – Belmore Road	No	17	B	31	C	31	C	37	C	37	C
King Georges Road – Broadarrow Road	No	42	C	101	F	101	F	107	F	107	F

Traffic modelling results indicate that by Year 2031, infrastructure upgrades will be required to accommodate the future demand. Otherwise, the intersection of Forest Road-Boundary Road-Bonds Road will experience an unacceptable level of delay on both peak periods, with or without the Riverwood Estate SSP development traffic.

The intersection of King Georges Road-Broadarrow Road will also operate at LoS E or F in Year 2031, even without the additional development traffic. Further upgrade works would be required which would necessitate additional land acquisition to increase intersection capacity in order to accommodate the traffic demands.

It is noted that this intersection has been recently upgraded in 2020 as part of the Gateway to the South Pinch Point Program and that there is not enough road reserve in the area to accommodate any additional lanes. As such, no further improvements have been recommended at this intersection.

Scenario 2b and 3b modelling results show that the proposed Year 2031 road network upgrades applied on the model can achieve satisfactory levels of service. The proposed upgrade works would be required to accommodate the future background growth and Riverwood Estate SSP development traffic in Year 2031.

Details of the proposed infrastructure upgrades are further discussed in Section 11.4.

The modelling result indicate the Belmore Road- Roosevelt Avenue intersection could be retained at its existing layout; however, it is recommended to bring forward the signalisation to year 2031 to provide a recognised gateway intersection on Belmore Road to the proposed development to meet the Movement objective set in Section 5.6.2. Refer to Table 6.27 and Table 6.28 for the intersection performance under signalisation for the full development in year 2041. Further modelling is presented in Appendix E with and without a right turn bay on Belmore Road.

6.9.4.2 Year 2041 Road Network Performance (Full Development)

A summary of existing and Year 2041 intersection performance of subject intersections is presented in Table 6.27 and Table 6.28.

Table 6.27: Year 2041 AM Peak Intersection Performance

Intersection	Upgrade works?	S1. 2017 Existing Performance		S2a. 2041 Without Development (w/o Improvements)		S2b. 2041 Without Development (with Improvements)		S3a. 2041 With Development (w/o Improvements)		S3b. 2041 With Development (with Improvements)	
		Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	Yes	25	B	36	C	31	C	76	F	36	C
Belmore Road – M5	No	14	A	17	B	18	B	17	B	19	B
Belmore Road – Roosevelt Ave	Yes	24	B	41	C	20	B	27	B	20	B
Belmore Road – Thurlow Street	No	39	C	45	D	28	B	48	D	43	C
Bonds Road – Broadarrow Road	Yes	106	F	46	D	45	D	97	F	56	D
Bonds Road – Hannans Road	Yes	32	C	33	C	43	D	38	C	47	D
Bonds Road – Romilly Street	Yes	10	A	15	A	36	C	27	B	41	C
Forest Road – Boundary Rd – Bonds Road	Yes	106	F	137	F	49	D	139	F	56	D
Henry Lawson Drive – Belmore Road	No	24	B	31	C	29	B	30	C	34	C
Canterbury Road – Belmore Road	Yes	38	C	37	C	29	C	67	E	55	D
King Georges Road – Broadarrow Road	No	54	D	146	F	146	F	157	F	157	F

Table 6.28: Year 2041 PM Peak Intersection Performance

Intersection	Upgrade works?	S1. 2017 Existing Performance		S2a. 2041 Without Development (w/o Improvements)		S2b. 2041 Without Development (with Improvements)		S3a. 2041 With Development (w/o Improvements)		S3b. 2041 With Development (with Improvements)	
		Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	Yes	20	B	27	B	25	B	48	D	27	B
Belmore Road – M5	No	14	A	16	B	20	B	20	B	19	B
Belmore Road – Roosevelt Ave	Yes	43	C	13	A	19	B	61	E	21	B
Belmore Road – Thurlow Street	No	28	B	29	B	29	C	52	D	30	C
Bonds Road – Broadarrow Road	Yes	11	A	20	B	52	D	21	B	34	C
Bonds Road – Hannans Road	Yes	31	C	33	C	42	C	37	C	49	D
Bonds Road – Romilly Street	Yes	14	A	16	B	38	C	13	A	41	C
Forest Road – Boundary Rd – Bonds Rd	Yes	102	F	160	F	49	D	156	F	53	D
Henry Lawson Drive – Belmore Road	No	42	C	48	D	47	D	58	E	56	D
Canterbury Road – Belmore Road	Yes	17	B	67	E	43	D	98	F	56	D
King Georges Road – Broadarrow Road	No	42	C	161	F	161	F	169	F	169	F

The modelled results indicate that with the proposed intersection upgrades, all assessed intersections could achieve the desired standard of service, with the exception of King Georges Road-Broadarrow Road intersection.

As discussed in Section 6.9.4.1, King Georges Road-Broadarrow Road intersection has recently been upgraded and there is limited road reserve available to facilitate any further upgrade works.

The proposed works that would be required to support the development traffic and background growth in Year 2041 is further discussed in Section 11.4.

Further modelling is presented in Appendix E with and without a right turn bay on Belmore Road. For the right turn bay option, storage lengths of 88m and 55m have been assessed to compare the intersection performance. It was concluded that a right turn bay on the northern approach for a length of approximately 55m would enable a "back to back" right turn bay for the Belmore Road- Hannans Road intersection and minimise further adjustment to the property boundary of the Study Area on the west side of Belmore Road.

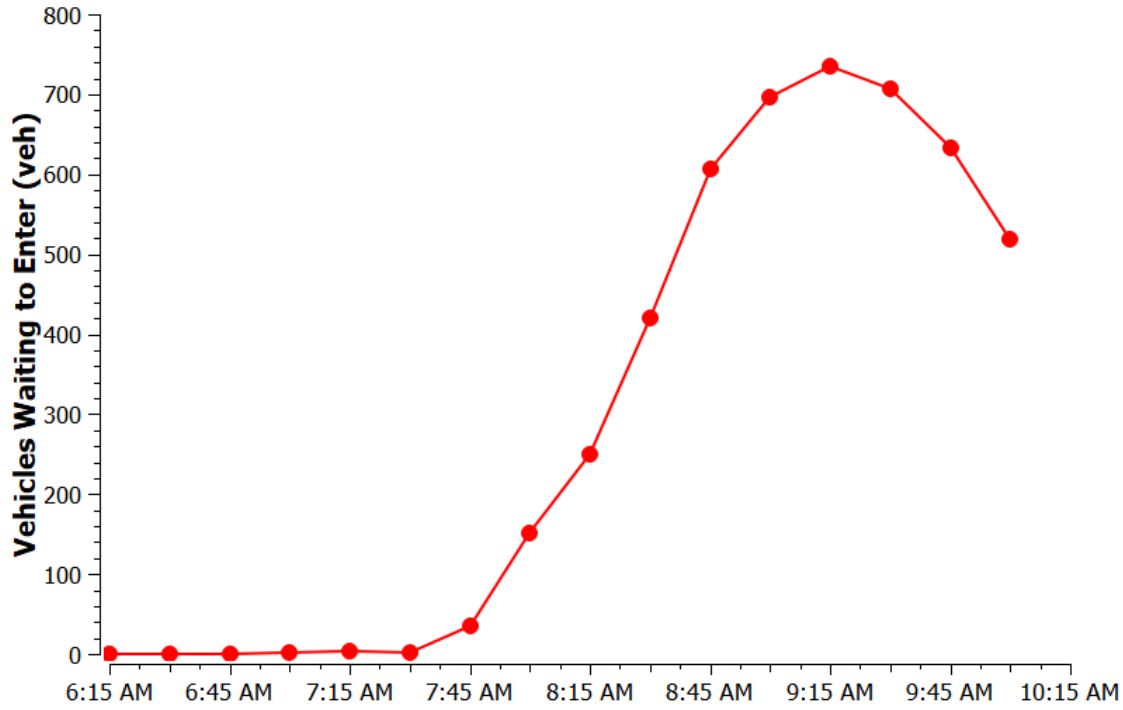
On the other hand, a further review into the modelling results indicate that some intersections in Year 2041 scenarios (without upgrade) with the higher forecast demand appear to produce better network outcomes when compared to Year 2031. This is due to the network gridlock in these model runs, with over 500 and 2,400 vehicles still waiting to enter the network at the end of the morning and evening simulation periods respectively.

Vehicles are not able to enter the network in particular on Boundary Road and Forest Road south during the morning peak, and on Boundary Road and Forest Road east during the evening peak. This is due to extensive queues originating from the following intersections:

- Most critically, Bonds Road / Forest Road / Boundary Road in both AM and PM peaks
- In the PM peak, secondary contributions from Belmore Road and Hannans Road, Belmore Road and Thurlow Street, and Bonds Road and Hannans Road

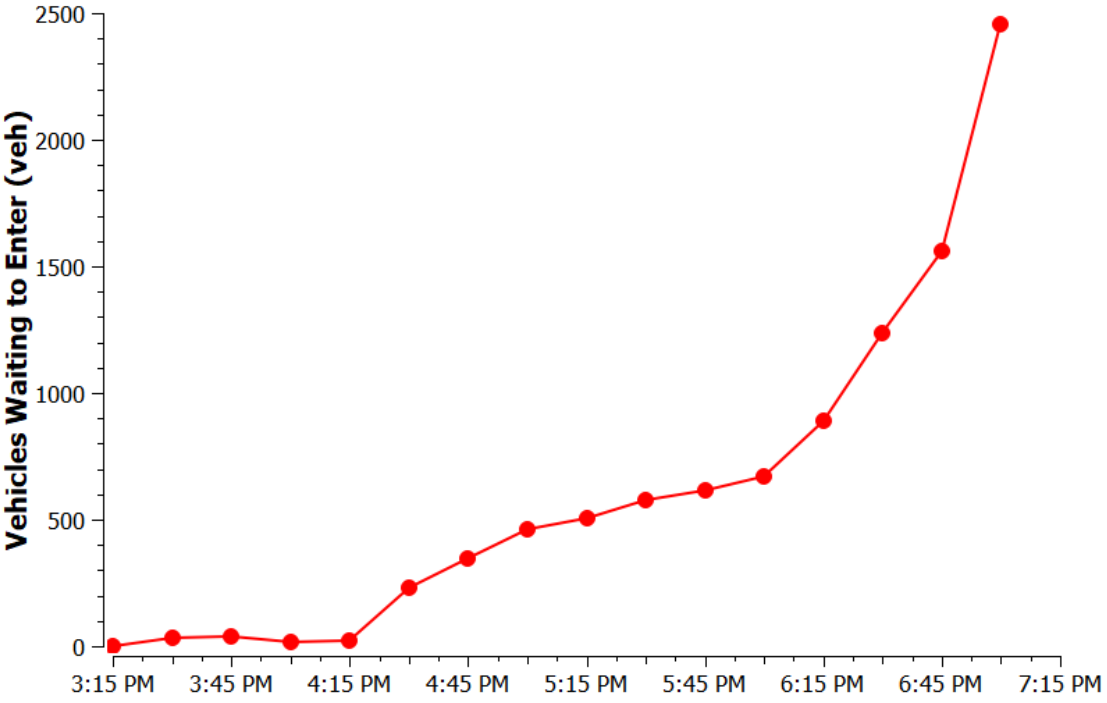
Graphs of vehicles blocked from entering the Year 2041 network (without upgrades) are presented in Figure 6.18 and Figure 6.19.

Figure 6.18: Blocked Traffic in Year 2041 Aimsun Model – AM Peak (Without Developments)



Source: Jacobs

Figure 6.19: Blocked Traffic in Year 2041 Aimsun Model – PM Peak (Without Developments)



Source: Jacobs

6.9.4.3 Year 2036 Road Network Performance (Interim Year)

The Aimsun traffic model was undertaken to estimate the volumes and assess intersection performance for Year 2031 and 2041 only. TTPP has provided indicative performance of the assessed intersections for Year 2036, by inferring the results that are available for Year 2031 and Year 2041. Table 6.29 shows the peak hour traffic generation comparison between Years 2031, 2036 and 2041.

Table 6.29: Traffic Generation Comparison Between Years 2031, 2036 and 2041

Year	Development Traffic Generation	
	AM Peak	PM Peak
2031	407	524
2036	929	1,081
2041	1,182	1,353

The intersection performance for Year 2036 has been calculated pro rata based on the delays from Year 2031 and Year 2041 Aimsun models, and the difference between the traffic generation estimates.

On this basis, indicative intersection performance for Year 2031 has been estimated and shown in Table 6.30 for the AM Peak hour and Table 6.31 for the PM peak hour.

Table 6.30: Year 2036 AM Peak Intersection Performance (LoS)

Intersection	Upgrade works?	S1. 2017 Existing Performance		S2a. 2036 Without Development (w/o Improvements)		S2b. 2036 Without Development (with Improvements)		S3a. 2036 With Development (w/o Improvements)		S3b. 2036 With Development (with Improvements)	
		Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	Yes	25	B	33	C	30	C	60	E	34	C
Belmore Road – M5	No	14	A	17	B	18	B	16	B	19	B
Belmore Road – Roosevelt Ave	Yes	24	B	43	D	19	B	29	B	18	B
Belmore Road – Thurlow Street	No	39	C	44	D	29	C	46	D	38	C
Bonds Road – Broadarrow Road	Yes	106	F	45	D	44	D	82	F	55	D
Bonds Road – Hannans Road	Yes	32	C	33	C	40	C	36	C	47	D
Bonds Road – Romilly Street	Yes	10	A	14	A	37	C	25	B	45	D
Forest Road – Boundary Rd – Bonds Road	Yes	106	F	133	F	47	D	132	F	52	D
Henry Lawson Drive – Belmore Road	No	24	B	30	C	29	B	29	C	32	C
Canterbury Road – Belmore Road	Yes	38	C	25	B	22	B	45	D	37	C
King Georges Road – Broadarrow Road	No	54	D	106	F	106	F	115	F	115	F

Table 6.31: Year 2036 PM Peak Estimated Intersection Performance (LoS)

Intersection	Upgrade works?	S1. 2017 Existing Performance		S2a. 2036 Without Development (w/o Improvements)		S2b. 2036 Without Development (with Improvements)		S3a. 2036 With Development (w/o Improvements)		S3b. 2036 With Development (with Improvements)	
		Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS	Ave Delay (s)	LoS
Belmore Road – Hannans Road	Yes	20	B	26	B	25	B	41	C	26	B
Belmore Road – M5	No	14	A	16	B	19	B	18	B	18	B
Belmore Road – Roosevelt Ave	Yes	43	D	13	A	15	B	44	D	17	B
Belmore Road – Thurlow Street	No	28	B	30	C	28	B	45	D	30	C
Bonds Road – Broadarrow Road	Yes	11	A	17	B	47	D	18	B	41	C
Bonds Road – Hannans Road	Yes	31	C	32	C	43	C	35	C	44	D
Bonds Road – Romilly Street	Yes	14	A	15	B	36	C	15	A	40	C
Forest Road – Boundary Rd – Bonds Rd	Yes	102	F	159	F	49	D	156	F	50	D
Henry Lawson Drive – Belmore Road	No	42	C	46	D	45	D	52	D	52	D
Canterbury Road – Belmore Road	Yes	17	B	41	C	39	C	63	E	53	D
King Georges Road – Broadarrow Road	No	42	C	145	F	145	F	156	F	156	F

Based on the above indicative results, it is expected that the assessed intersections would operate acceptably in Year 2036 with the proposed upgrades in place, except for the King Georges Road-Broadarrow Road intersection in both peak periods.

The results also indicate that a number of intersections will experience LoS D in Year 2036 without the upgrade works, with the exception of Belmore Road-Hannans Road and Bonds Road-Broadarrow Road intersection which are expected to operate at LoS E/F in the morning peak period. This indicates that the likely trigger point for intersection upgrade would occur at some time between Year 2031 and Year 2036. As discussed earlier in Section 6.9.4 consideration should be given to acquiring land to provide additional intersection capacity to accommodate the future traffic demands.

6.9.5 Impacts of Upgrades

As shown in Table 6.25 to Table 6.31, intersection upgrade works would be required to accommodate the future background growth and development traffic. However, it is noted that some of the intersections will perform unsatisfactorily in Year 2031 and Year 2041, even without the additional traffic associated with the development.

Table 6.32 provides a summary of the intersections that will experience high levels of delays due to background growth and the additional traffic generated by the development based on the earlier scheme as discussed in Section 6.9.3.5.

Table 6.32: Impact of Upgrades

Scenario	Intersections Operating Unsatisfactorily without Improvements	Increase in Dwellings (Riverwood Estate SSP)
2017 Existing Performance	• Bonds Road – Broadarrow Road • Forest Road – Boundary Road – Bonds Road	N/A
2031 Without Development	• Forest Road – Boundary Road – Bonds Road • King Georges Road – Broadarrow Road	N/A
2031 With Development	• Same as 2031 without Development	710 dwellings 4,793 m² retail use
2036 Without Development (inferred based on 2031 and 2041 results)	• Same as 2031 without Development	N/A
2036 With Development (inferred based on 2031 and 2041 results)	• Same as 2031 without Development • Belmore Road – Hannans Road • Bonds Road – Broadarrow Road • Canterbury Road – Belmore Road	2,786 dwellings 4,793 m² retail use 970 m² community use
2041 Without Development	• Same as 2031 without Development	N/A
2041 With Development	• Same as 2041 without Development • Belmore Road – Hannans Road • Belmore Road – Roosevelt Ave (refer to Table 11.1 to bring forward the signalisation to provide a recognised gateway intersection on Belmore Road to the	3,925 dwellings 4,793 m² retail use 970 m² community use

Scenario	Intersections Operating Unsatisfactorily without Improvements	Increase in Dwellings (Riverwood Estate SSP)
	proposed development. Appendix E indicate a 55m right turn bay on Belmore Road would be appropriate to form a "back to back" right turn bay with the Belmore Road- Hannans Road intersection • Bonds Road – Broadarrow Road • Henry Lawson Drive – Belmore Road Canterbury Road – Belmore Road	

6.9.6 Assessment of Washington Avenue-Roosevelt Avenue Intersection

The proposed masterplan includes realignment and upgrade of Washington Avenue and Roosevelt Avenue as discussed in Section 6.6. TTPP has assessed the future utilisation of the intersection to determine an appropriate control of this major cross-intersection within the site as shown in Figure 6.20.

Figure 6.20: Washington Avenue-Roosevelt Avenue Intersection

To estimate traffic volumes that will travel through this intersection, it is assumed that only trips associated with Stage 4 and non-LAHC developments will use the intersection based on its location.

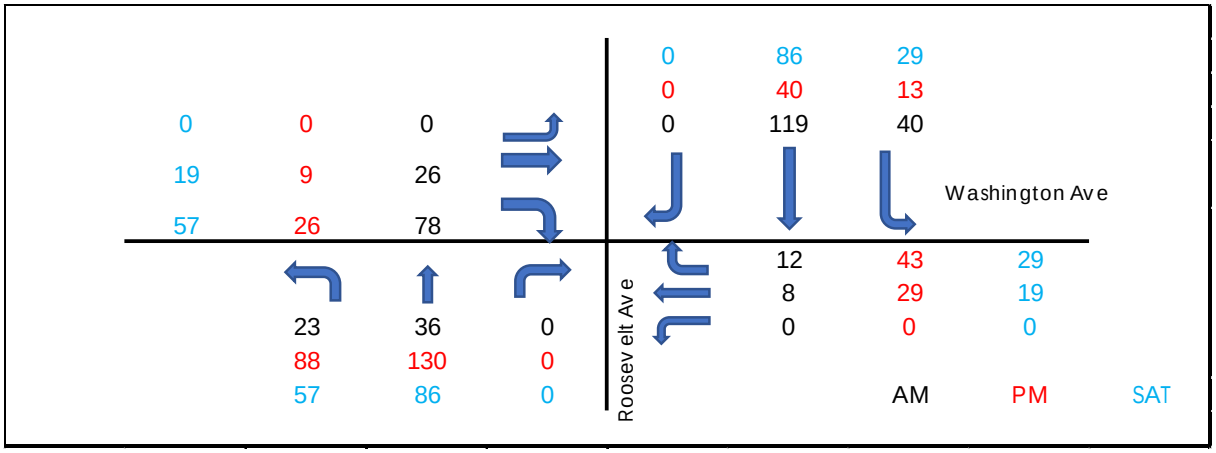
In addition, the following assumptions have been made:

- Trips associated with Stage 4 developments will travel to/from Roosevelt Avenue north leg

- Trips associated with non-LAHC developments will travel to/from Washington Avenue west leg
- Retail and childcare trips that will be generated by residents within Stage 4 and non-LAHC lands are distributed based on the proportion of number of dwellings on these locations versus total dwellings of overall Riverwood Estate SSP (i.e., 24% of total dwellings are within Stage 4, 12% of total dwellings are within non-LAHC land).
- 25% of trips will travel to/from Belmore Road via Washington Avenue to travel
- 75% of trips will travel to/from Belmore Road via Roosevelt Avenue and Truman Avenue

Figure 6.21 presents the estimated future traffic volumes at this intersection.

Figure 6.21: Washington Avenue-Roosevelt Avenue Future Peak Traffic Volumes (Year 2041)



TfNSW's *Traffic Signal Design* sets out the following warrants for signalised intersections:

- Traffic demand: For each of four one-hour periods of an average day:
  - The major road flow exceeds 600 vehicles/hour in each direction: and
  - The minor road flow exceeds 200 vehicles/hour in each direction.

As shown in Figure 6.21, the highest volume is 218 vehicles/hour travelling from Roosevelt Avenue south approach and therefore would not meet the TfNSW warrant for installing traffic signals. Given it is a four-way intersection, a roundabout would be more suitable control at this location, as shown in the master plan accordingly.

Table 6.33 presents the results of SIDRA analysis of Washington Avenue-Roosevelt Avenue under a single lane roundabout configuration. It is noted that the layout of the intersection is not yet known at this stage. As such, geometric configuration of the SIDRA model has been based on existing surrounding roundabouts.

Table 6.33: Washington Avenue-Roosevelt Avenue Year 2041 Intersection Performance

Peak Hour	Ave Delay (s)	LoS
AM Peak	8	A
PM Peak	8	A
Saturday Peak	8	A

Based on the above, the future roundabout at Washington Avenue-Roosevelt Avenue will perform satisfactorily as a single lane roundabout.

7 Existing and Future Travel Behaviour

Residential Development

The travel mode preference of Riverwood Estate SSP residents has been estimated based on the existing person trip generation rate and travel mode share of Washington Park development as discussed in Section 6.9.2, except for the number of car drivers and passengers.

The following average peak hour person trip rates have been calculated based on Washington Park pedestrian count results:

- Market housing: 0.25 person trips per dwelling
- Social housing: 0.36 person trips per dwelling
- Overall: 0.30 person trips per dwelling

The estimated person trip rates have been distributed to public transport and active transport users.

Mode share splits of residential trips have been calculated based on the following assumptions:

- The estimated number of car drivers generated by the existing site is based on the morning peak trip generation presented in Table 6.12 multiplied by assumed outbound proportion of 80% (i.e., 160 car drivers)
- The estimated number of car drivers in the future is based on the morning peak outbound residential trip generation presented in Table 6.22 to Table 6.24.
- The number of car passengers is calculated based on the average car occupancy rate of morning peak outbound trips obtained from Washington Park survey (i.e., 1.41 persons per car).
- Total number of non-car trips has been calculated using the person trip rates obtained from Washington Park survey.
- The non-car trips have been distributed pro-rata to bus, train, walk and cycle modes based on splits from Washington Park.
- For estimating the existing trips, the person trip rate and mode split of overall Washington Park has been used whilst for the future trips, the distinct trip rates for Washington Park market and social housing are used.

This resulted in different mode shares when compared with what were recorded in Washington Park development.

Retail Development

Travel behaviour of retail staff and visitors has been based on the following assumed parameters and trip data presented in Roads and Maritime *Trip Generation and Parking Demand Surveys of Shopping Centre* (September 2011). Survey data collected at a site located in close proximity to the Riverwood Estate SSP Study Area has been used as reference.

Assumptions adopted in this assessment are shown as follow:

- 6.65 person trips per 100m^2 GLFA
- GLFA = 75% of GFA
- 5% of people will travel by train

Childcare Centre

For the purpose of estimating the future trips generated by the Childcare Centre, the following assumptions have been made:

- 91% of people will travelling to/from the childcare centre will drive based on average data obtained from *Roads and Maritime Child Care Centres Analysis Report (2015)*
- The remaining 9% has been distributed to bus, train and walk based on existing JTW data
- 2.0 vehicle occupancy which translates to one parent driving with one child (i.e., 46% driver mode share and 46% passenger mode share)
- Bus, train and walk trips are calculated pro-rata based on estimated peak hour vehicle trip generation (i.e., 45 vehicle trips)

The existing and target mode share of Riverwood Estate SSP is summarised in Table 7.1 to Table 7.4. Notably, the number of residential car trips in the peak direction match with those shown earlier in Table 6.22 to Table 6.24. The development yield is based on the earlier scheme as discussed in Section 6.9.3.5.

Table 7.1: Existing Travel Mode Share

Mode of Travel	1,019 dwellings	
	%	Trips
Driver	30%	160
Passenger	12%	66
Bus	13%	69
Train	26%	137
Walk	19%	100
Cycle	0%	0
Total	**100%**	**531**

Note: Estimated number of car drivers are based on the morning peak trip estimates presented in Table 6.12 multiplied by assumed outbound split of 80%. Trips from other modes are based on the person trip rates and mode share from overall Washington Park development.

Table 7.2: Future Travel Mode Share Target (Year 2031)

Mode of Travel	Market		Social		Retail		Childcare Centre	
	497 dwellings		213 dwellings		3,595 m² GLFA		-	
	%	Trips	%	Trips	%	Trips	%	Trips
Driver	39%	103	21%	22	78%	186	46%	0
Passenger	16%	42	8%	9	7%	17	46%	0
Bus	10%	27	17%	18	5%	12	1%	0
Train	23%	60	23%	25	4%	10	7%	0
Walk	13%	35	30%	32	1%	2	0%	0
Cycle	0%	0	2%	2	5%	12	0%	0
Total	**100%**	**267**	**100%**	**107**	**100%**	**239**	**100%**	**0**

Note: Estimated number of car drivers are based on the morning peak outbound trip estimates presented in Table 6.22 to Table 6.24. Trips from other modes are based on the person trip rates and mode share from Washington Park development.

Table 7.3: Future Travel Mode Share Target (Year 2031+2036)

Mode of Travel	Market		Social		Retail		Childcare Centre	
	2,091 dwellings		695 dwellings		3,595 m² GLFA		970 m² GFA	
	%	Trips	%	Trips	%	Trips	%	Trips
Driver	39%	435	21%	72	78%	186	46%	45
Passenger	16%	178	8%	30	7%	17	46%	45
Bus	10%	113	16%	58	5%	12	1%	1
Train	22%	253	23%	81	4%	10	7%	7
Walk	13%	147	30%	104	1%	2	0%	0
Cycle	0%	0	2%	6	5%	12	0%	0
Total	**100%**	**1,127**	**100%**	**350**	**100%**	**239**	**100%**	**99**

Note: Estimated number of car drivers are based on the morning peak outbound trip estimates presented in Table 6.22 to Table 6.24. Trips from other modes are based on the person trip rates and mode share from Washington Park development.

Table 7.4: Future Travel Mode Share Target (Year 2031+2036+2041)

Mode of Travel	Market		Social		Retail		Childcare Centre	
	2,889 dwellings		1,037 dwellings		3,595 m² GLFA		970 m² GFA	
	%	Trips	%	Trips	%	Trips	%	Trips
Driver	39%	601	21%	108	78%	186	46%	45
Passenger	16%	246	8%	44	7%	17	46%	45
Bus	10%	157	16%	86	5%	12	1%	1
Train	22%	350	23%	121	4%	10	7%	7
Walk	13%	203	30%	155	1%	2	0%	0
Cycle	0%	0	2%	9	5%	12	0%	0
Total	**100%**	**1,557**	**100%**	**523**	**100%**	**239**	**100%**	**99**

Note: Estimated number of car drivers are based on the morning peak outbound trip estimates presented in Table 6.22 to Table 6.24. Trips from other modes are based on the person trip rates and mode share from Washington Park development

Table 7.2 to Table 7.4 indicate that the estimated car driver percentage of the future residents is 1%-2% lower than what was obtained from Washington Park survey.

In response to the transport vision and strategy set in Section 5.6.5, an indicative Green travel plan (GTP) presented in Section 11.5 recommends measures to encourage modal shift away from car use that could be applied to achieve the target for active and public transport.

It is noted that a modal shift between 3%-5% is typically considered to be a significant achievement, based on knowledge on local and international GTPs, and advice from experts in Land Environment Court proceedings.

However, due to the close similarity of the proposed development and Washington Park, it is highly likely that there would be no significant difference between the travel behaviour of future residents and those of living in Washington Park. It is noted that majority of the trips that will be generated by the site would be made by work trips to/from place of work which are not within walking/cycling distance from the site (based on 2016 Census data). As such, the proposed improvements on walking and cycling infrastructure within the site would have minimal impact. On this basis, a 1%-2% shift away from car use is considered realistic.

Notwithstanding, further reduction in private vehicle reliance could be expected due to integral land use planning. Future residents could shop/work in the proposed retail shops instead of travelling outside the site in this mixed use development, thus reducing external car trips.

8 Walking and Cycling

8.1 Existing Walking Facilities

Good pedestrian connectivity is provided in the Study Area. Local streets are generally provided with pedestrian footpaths on both sides of the road, except for Hunter Street where wide verges are available on both sides of the road as informal pathway for pedestrians. This existing pedestrian network within the Study Area provide connection to key destinations in the local area including Riverwood Train Station, Belmore Road retail strip, Riverwood Public School and Riverwood Community Centre.

Pedestrian crossing facilities are located every 100m to 230m along Belmore Road between Hannans Road and the town centre located on the south side of Riverwood Train Station:

- Belmore Road and Hannans Road intersection (signalised pedestrian crossings)
- North of Roosevelt Avenue (pedestrian refuge)
- South of Roosevelt Avenue (pedestrian refuge)
- South of Killara Avenue (mid-block signalised pedestrian crossing)
- North of Morotai Avenue (pedestrian refuge)
- Belmore Road and Thurlow Street intersection (signalised pedestrian crossings)
- Belmore Road, Webb Street and Cairns Street intersection (signalised pedestrian crossings).

Various raised pedestrian crossings have been installed on Washington Avenue, Michigan Road, Roosevelt Road, Kentucky Road and Union Street within the subject site.

Pedestrians generally used the pedestrian signals to cross Belmore Road to access the bus stops located either side of the road. There was one instance observed during the site visit where pedestrians jaywalked across Belmore Road to get to the bus stop. Bus stops along Belmore Road are located near pedestrian crossing facilities such as signals or refuge islands to improve pedestrian safety.

8.2 Existing Cycling Facilities

Washington Avenue and Union Street within the site are identified cycle routes as per City of Canterbury Bankstown Cycleway Plan. These cycling routes are provided as shared on-road facilities which extend from Riverwood to Narwee and Roselands. The bicycle pavement markings were faded from observations along the cycleways.

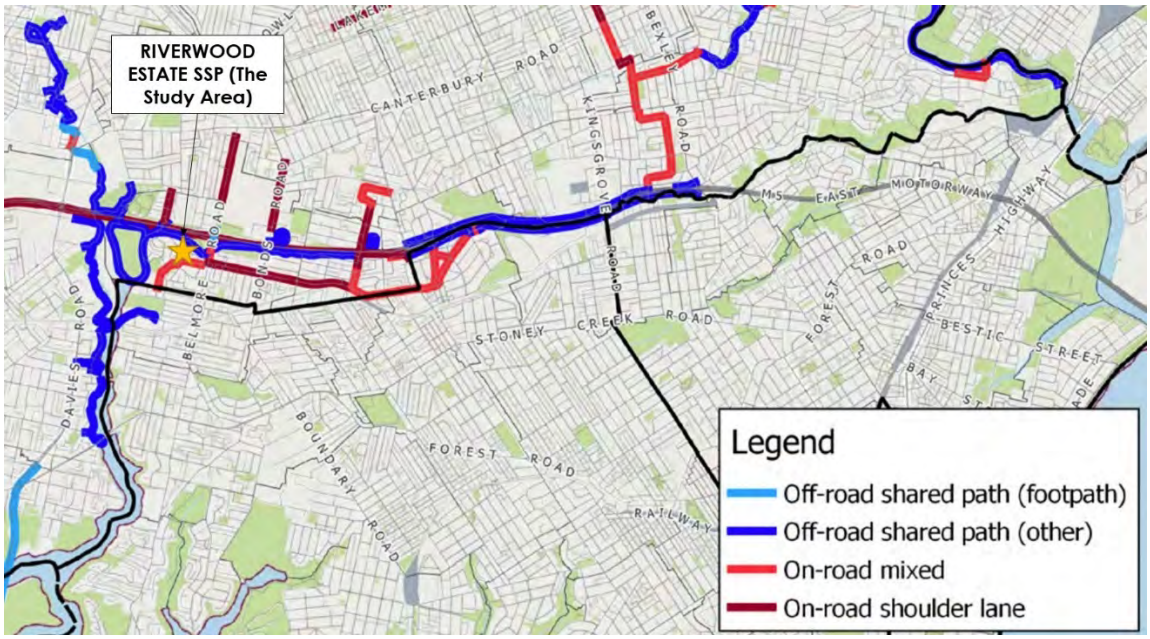
Existing and planned cycleways within the site vicinity are shown in Figure 8.1.

Figure 8.1: City of Canterbury Cycleway Plan

Reference: City of Canterbury Cycleway Plan

Canterbury-Bankstown Council's Draft Active Transport Action Plan 2020-2030 shows an updated version of the existing cycleways in Figure 8.2. It indicates an additional on-road shoulder lane on Belmore Road between Canterbury Road and Wiggs Road. However, this action plan does not include any changes in the cycleway facilities in proximity of the subject development.

Figure 8.2: Location of Existing Cycleways



Reference: Draft Active Transport Action Plan 2020-2030 published by Canterbury-Bankstown Council (December 2020)

8.3 Future Walking and Cycling Infrastructure

The proposed development will provide integrated cycling and walking connectivity within the Study Area to meet the Movement and Place objectives as set in Section 5.6 for the people who live, work and spend time in the proposed development. Walking and cycling are space efficient modes internal to the proposed development.

The master plan aims to improve active transport network within the site and its connection with external network to enhance local movement, encourage short trips by active travel modes and reduce reliance on private vehicles for local trips.

Cycle paths will be established along Roosevelt Avenue and Washington Avenue as shown in the cross sections in Section 6.6.3 and Figure 8.3. Shared paths will also be provided in the local streets for good connectivity within the Study Area and the external network via the existing facilities along the M5 Motorway, Hannans Road, Riverwood Wetlands and YMCA pathways.

A cycle path is suggested on Belmore Road. This will be subject to further detailed discussions with TfNSW, Canterbury-Bankstown and Georges River Councils to ensure safety and connectivity can be achieved.

The proposed walking and cycling infrastructure also aim to accommodate the future additional travel demand as discussed in Section 7. Based on Table 7.4, the full development would result in a total of 360 walking trips and 21 cycling trips. This translates to a net addition of 294 walking trips and 20 cycling trips as compared with the existing site.

Figure 8.3 shows the proposed walking and cycling connections, subject to detailed design at a later stage.

Figure 8.3: Proposed Walking and Cycling Network

Source: Architectus

A pedestrian only zone is proposed along the east-west running Community Greenway which will provide a through connection between Roosevelt Park and Riverwood Public School.

The footpath network aims to cater for people with a disability, older people and pram users as the proposed path width exceeds the minimum Austroads requirement of 1.8m for two wheelchairs to pass each other. The proposed walking and cycling paths within the subject site are configured as follows and shown in Section 6.6.3:

- footpath: 2m to 2.2m width
- shared path: 2.5m to 3.5m width

The provision of the bicycle facilities within the site would meet the Movement and Place objective to encourage short trips by bicycle and reduce reliance on private vehicles for local trips to the surrounding points of interest such as Belmore Road bus corridor, Riverwood Public School, community facilities and leisure areas such as Riverwood wetlands etc.

9 Public Transport

9.1 Existing Public Transport Facilities

Figure 9.1 shows the site's proximity to existing bus stops and train station.

Figure 9.1: Public Transport Map

Source: Google Maps Australia

Figure 9.2 shows the pedestrian walking time which is typically within 15 minutes to Riverwood Train Station.

Figure 9.2: Walking Time to Riverwood Train Station

Source: Targomo

9.1.1 Train Services

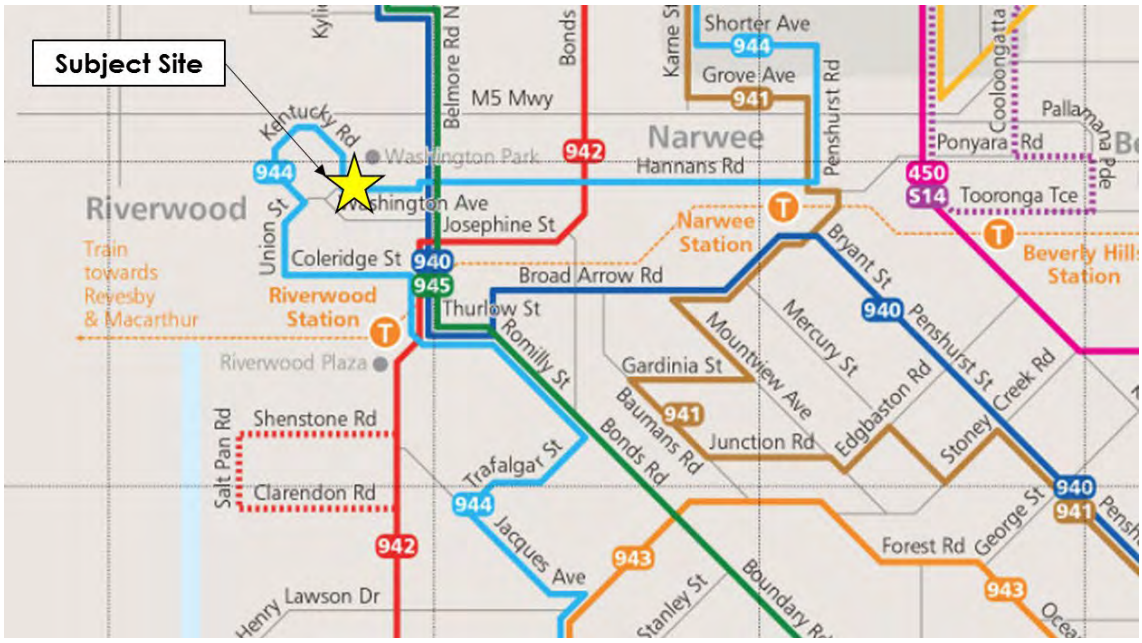
The proposed development is located within a reasonable walking distance to Riverwood Train Station. The closest point of the proposed development is located some 350m from Riverwood Train Station, while the furthest point is some 1,100m from Riverwood Train Station.

Riverwood Station is served by T8 Airport and South Line which provides frequent services between Sydney CBD, Macarthur and International and Domestic Airports. Frequency of the train services vary between 3 and 12 minutes during the peak periods, with up to seven trains per hour during the morning peak period.

9.1.2 Bus Services

The subject site is served by three bus routes operated by Punchbowl Bus Company. The existing bus services surrounding the proposed site is shown in Figure 9.3.

Figure 9.3: Existing Bus Network



Reference: Public Bus Company

Bus stops servicing Routes 940 and 945 are located along Belmore Road near the intersections with Washington Avenue and Roosevelt Avenue. Bus stops serving Route 944 are located on Washington Avenue, Roosevelt Avenue, Kentucky Road and Union Street within the Precinct.

Table 9.1 provides a summary of existing bus routes and service frequencies.

Table 9.1: Existing Bus Services

Bus Route	Average Frequency		
	Weekday Peak	Weekday Off-Peak	Saturday, Sunday and Public Holidays
940 Hurstville to Bankstown via Riverwood and vice versa	30 minutes	30 minutes	1 hour
944 Bankstown to Mortdale via Peakhurst Heights and vice versa	30 minutes	30 minutes	1 hour
945 Hurstville to Bankstown via Mortdale and vice versa	15 minutes	30 minutes	30 minutes

Reference: TfNSW

9.2 Proposed Public Transport Facilities

In order to meet the Movement and Place objectives, access to bus stops will be improved to connect people to these places via the improved footpath and re-routing the existing Bus Route 944. This would enable better integration of bus services within the Study Area by improving coverage and accessibility to serve the local community and the mixed-use centre.

The modification will involve a minor re-route with a switch from Washington Avenue to Roosevelt Avenue to enable all developments within 200m of a bus stop, subject to consultation with TfNSW and bus service provider. The re-route and bus stop locations are shown in Figure 9.4. Minor widening of existing local streets, such as Kentucky Road, Union Street and Truman Avenue, to facilitate improved traffic flow as compared with the existing conditions with narrow roads.

Location of bus stops are also to be reviewed by TfNSW and bus service provider. Bus infrastructure should be in accordance with relevant planning and design guidelines such as TfNSW *State Transit Bus Infrastructure Guide*. As a guide, bus stops should generally be spaced at 200m to 400m intervals. The number of bus stops should also be provided at a practical minimum to reduce journey times and passenger delays.

The geometry of the streets for the bus route would be suitable for turning, stopping sight distance and parking requirements of buses.

Figure 9.4: Proposed Bus Route 944

Source: Architectus

9.3 Impact on Bus Services

Based on Table 7.4, when the proposed development is fully operational it would generate a total of 256 bus users. This would result to a net increase of 189 bus users from the existing development.

Bus occupancy data has been obtained from Transport for NSW collected on Thursday, 20 February 2020 to understand existing capacities of buses arriving at the following bus stops within the immediate vicinity of the site during typical conditions (i.e., pre-COVID):

- Washington Avenue at Virginia Place (Bus Route 944) – Stop ID: 2210207
- Belmore Road opposite Washington Avenue (Bus Routes 940 and 945) – Stop ID 221044
- Belmore Road at Washington Avenue (Bus Routes 940 and 945) – Stop ID 2210267

A review of the bus occupancy survey during the peak period on a typical weekday (i.e., 7am to 9am and 5pm to 7pm) indicates that the existing bus stops within the site vicinity currently operates well within the available seating capacity. All of the bus routes servicing these stops currently operates with not more than 20% of the seating capacity occupied, based on the existing demand which would however reduce due to the demolition of the existing dwellings within the Study Area. On this basis, the future background patronage growth is expected to be even out as existing residents would move out of the Study Area.

Buses servicing the site vicinity have typical capacity of 60 to 82 seats. Assuming that 20% of the buses are occupied upon reaching the site a total of eight buses run during the peak hour based on existing bus service frequency, there will be a spare capacity of approximately 240 seats. This suggests that buses will be almost at full occupancy with an addition of 189 bus users generated by the development.

As mentioned in Section 9.2, the existing Bus Route 944 would be modified to better accommodate the subject development, Riverwood Public School and move through the precinct via Union Street, Kentucky Road and Roosevelt Avenue. Additional bus passengers associated with the development are expected to impose impacts on the existing bus services. Additional bus demand would significantly reduce the capacity for users outside the site as buses would be almost full when departing from the Study Area.

It is suggested that additional bus services should be provided to accommodate the future level of patronage, subject to consultation and approval from Transport for NSW and Punchbowl Bus Company (or other bus company operating the route in the future).

Georges River Council Draft Transport Strategy Report (2021) makes mention that it is important to link the T4 Eastern Suburbs and Illawarra line with the T8 Airport and South train line to accommodate for the Study Area and the Riverwood local centre. An option for this linkage may be the Parramatta/ Bankstown to Hurstville/ Kogarah rapid bus link that supports the efficiency and reliability of passenger journeys between Parramatta to Bankstown and

Hurstville and improve 30 minute access to Greater Parramatta by enabling customers to use rapid, high frequency buses, as opposed to lower frequency suburban services.

In a recent discussion, TfNSW gave in-principle support to the proposed re-routing of Bus Service 944. In addition, TfNSW suggested looping Bus Service 940 or 945 into the internal roads which will be further investigated at a later stage.

Provision of bus services will be subject to further detailed discussions with TfNSW, Canterbury Bankstown and Georges River Councils at a later stage.

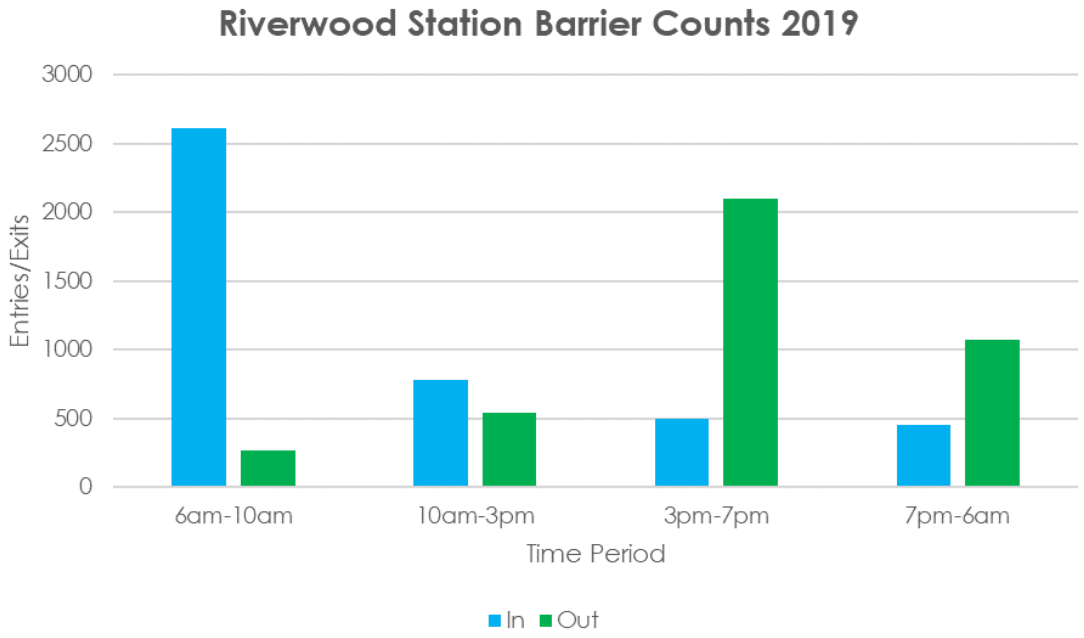
9.4 Impact on Train Services

The subject site is located within 350m to 1.1km radius from Riverwood Train Station. This station is serviced by T8 Airport and South Line (formerly T2 Airport, Inner West & South Line).

Based on the 2019 Station Barrier Counts collected by Transport for NSW (TfNSW) at Riverwood Station, a total of 8,320 people travelled to/from Riverwood Station through the day (i.e., 4,480 in and 3,980 out). A total of 2,610 entries were recorded during the morning period (6am-10am) and 2,100 exits during the afternoon period (3pm-7pm).

A summary of the 2019 station barrier counts is provided in Figure 9.5.

Figure 9.5: Summary of 2019 Station Barrier Counts at Riverwood Station



Further to this, the TfNSW train load data collected at Riverwood Station on 28 February 2019 has been obtained to understand existing capacity of train services at this station.

Graphical presentations of the train load information on are presented in Figure 9.6 and Figure 9.7.

Figure 9.6: Riverwood Station Train Load Surveys – February 2019 (to Sydney CBD)

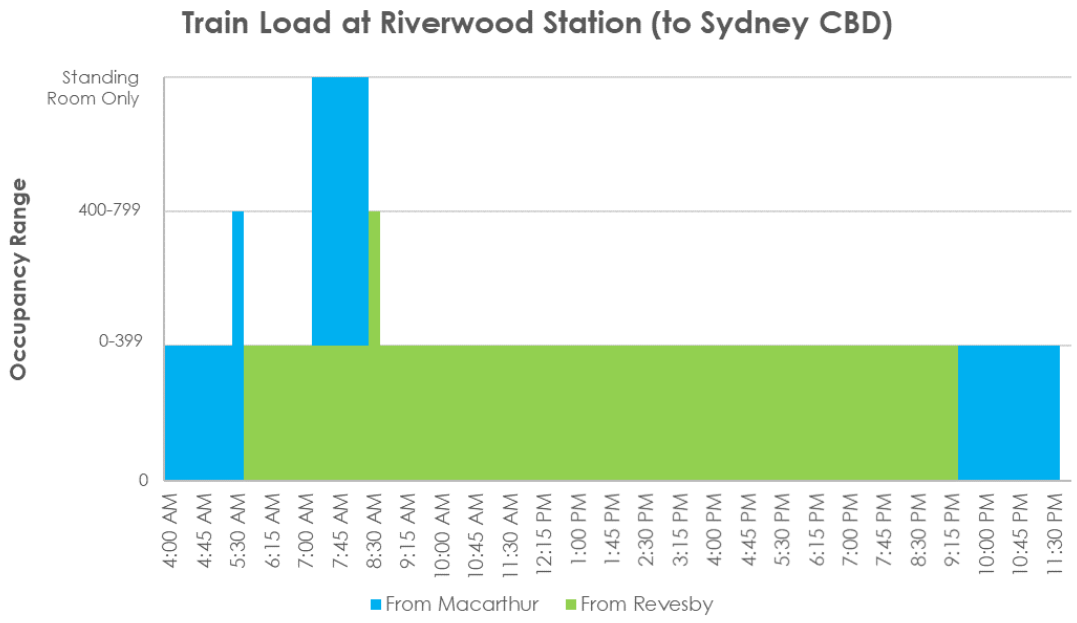
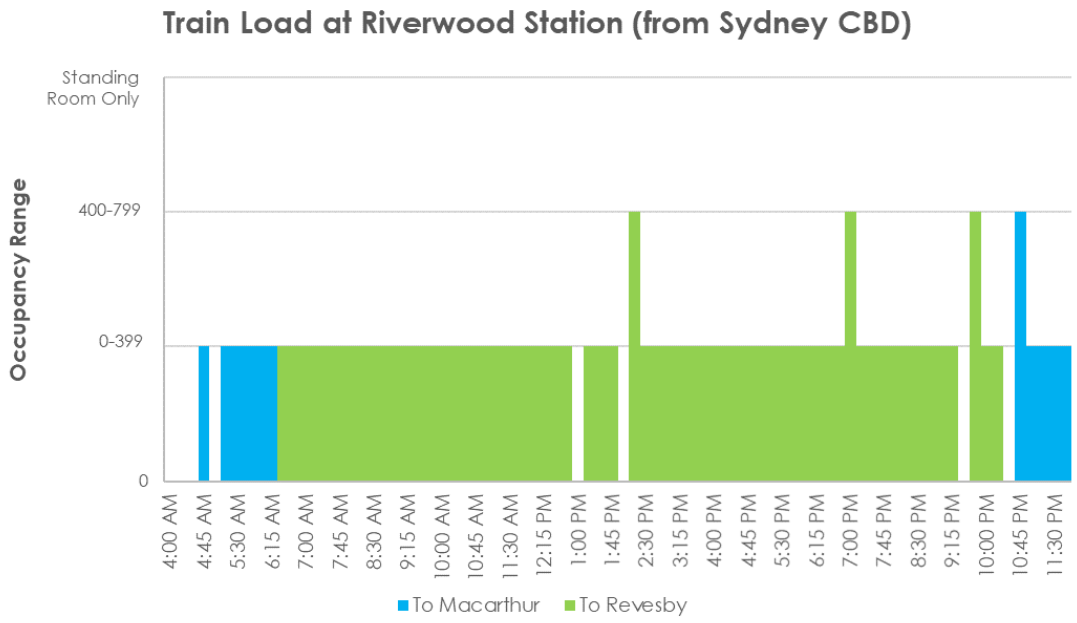


Figure 9.7: Riverwood Station Train Load Surveys – February 2019 (from Sydney CBD)



These existing patronage levels are expected to reduce due to the demolition of the existing dwellings within the Study Area. On this basis, the future background patronage growth is expected to be even out as existing residents would move out of the Study Area.

Based on Table 7.4, it is anticipated that a total of 488 Riverwood Estate SSP residents/staff will travel via train during the peak period. The existing site is estimated to be currently generating 134 train trips. This would result to a net increase of 354 train users.

This corresponds to about 14% of the total train passengers travelling from Riverwood Station during the morning survey period. This increase in train patronage can be considered significant.

Further to this, Figure 9.7 indicates that even without the additional demand associated with the future development, T8 line trains travelling to Sydney CBD during the morning peak experience heavy loadings with occupancy exceeding the nominal train capacity (i.e., standing room only). As such, any increase in demand for rail services would most likely further exacerbate existing rail line deficiencies.

However, the State Government is investing heavily in the Rail Future with North West, Sydney City and South West Metros as well as significant line duplication on the rail network.

This is anticipated to release rail capacity of many lines as commuters find more efficient ways to reach their destination. The rail network upgrades are expected to relive existing deficiencies in the network, as well as to support future demand and growth.

In a recent discussion, TfNSW advised that frequency of train services is expected to improve to 10 minutes within five years. More frequent train services would better accommodate the future patronage demand in the rail network.

10 Parking and Loading Facilities

10.1 Proposed Parking Provision

It is anticipated that off-street parking for residential tenants and visitors will be accommodated in basement levels. Underground basement parking will also be required for future retail uses along Belmore Road with driveway access located within the internal roads.

Driveway access to basement parking areas and garbage collection will not be permitted along Roosevelt Avenue, Belmore Road and key east-west streets to minimise conflict between vehicles and pedestrians. Wherever possible, basement entries will be located on the north-south minor local streets.

On-street car parking will also be provided on all streets. On-street parking will be indented and will be provided in between street trees. This is important for visitor parking, retail, and activating streets.

Access to parking and servicing facilities are to be provided in accordance with the proposed design guidelines for the Riverwood Estate SSP.

10.2 Car Parking Requirement

The Movement objective set in Section 5.6.2 for internal road network includes parking provision to meet relevant statutory requirements for local residents and the mixed-use centre.

Parking requirements for the proposed development have been assessed based on the rates set out in Canterbury Development Control Plan (DCP) 2012, TfNSW Guide to Traffic Generating Developments (Guide) 2002, Apartment Design Guide (ADG) 2015, and State Environmental Planning Policy (Affordable Rental Housing) (ARHSEPP) 2009.

For market housing located within 800m of the train station, car parking rates are in accordance with ADG. For areas further than 800m from Riverwood Train Station, car parking rates set out in Section B1.3.1 of the DCP are applied.

Parking requirements for social housing have been calculated in accordance with the requirements set out in SEPP for social housing by LAHC.

Car parking rates for retail and childcare centres are in accordance with the DCP rates.

For the community use of the site, in the absence of a parking rate for libraries and community centres in Bankstown Canterbury DCP, TTPP has undertaken research on DCP parking rates of other Council DCPs, namely:

- Shellharbour DCP: 1 space / 50m^2
- Cumberland DCP: 1 space / 10m^2 or 1 space/ 6 seats whichever is greater
- Dubbo DCP: 1 space / 20m^2 of public area
- Fairfield DCP: 1 space / 5m^2

An average of the above parking rates is one space per 32.5m^2 GFA has been adopted in the parking assessment for library, community centre and cultural use.

The following assumptions have been adopted in estimating the bedroom mix for market housing units:

- Studio/1 bedroom: 25%
- 2 bedroom: 65%
- 3 bedroom: 10%

The following assumptions have been adopted in estimating the bedroom mix for social housing units:

- studio: 10%
- 1 bedroom: 40%
- 2 bedroom: 45%
- 3 bedroom: 5%

A summary of indicative car parking requirements for the proposed development is shown in Table 10.1 based on the revised scheme described in Section 4.1.

Table 10.1: Car Parking Requirement

Land Use	Size	Source	Parking Rate	Car Parking Requirement
Market Housing				
Within 800m of train station				
Studio / 1-bedroom	531 units	ADG	0.6 spaces per unit	318
2-bedroom	1,380 units		0.9 spaces per unit	1,242
3-bedroom	212 units		1.4 spaces per unit	297
Visitor	2,122 units		1 space per 5 units	424
Outside 800m of train station				
Studio / 1-bedroom	192 units		1 space per unit	192
2-bedroom	498 units		1.2 spaces per unit	598
3-bedroom	77 units		2 spaces per unit	153
Visitor	766 units		1 space per 5 units	153
Social Housing				
Studio	104 units		0.4 spaces per unit	41
1-bedroom	415 units		0.4 spaces per unit	166
2-bedroom	466 units		0.5 spaces per unit	233
3-bedroom	52 units		1 space per unit	52
Retail (B2 Zone – Accessible Centre)	3,130 m^2 GFA		1 space per 22m^2 GFA	142
Childcare centre	420m^2 GFA (60 place)		1 car space per 4 children and 2 additional car spaces for the exclusive use of any associated dwelling (Staff number unknown at this stage)	15
Library	500 m^2 GFA		1 space per 32m^2 GFA (average rate of other DCPs)	15
Community Centre and Cultural Use	650 m^2 GFA		1 space per 32m^2 GFA (average rate of other DCPs)	20
TOTAL				**4,062**

Table 10.1 shows that the indicative minimum parking requirement for the Riverwood Estate SSP is approximately 4,062 car parking spaces.

Retail parking should be distributed to staff and visitor parking as follows:

- visitors: 80% of parking spaces (114 spaces)

- staff: 20% of parking spaces (28 spaces)

Notably, parking requirements should be reassessed during the Development Application stage of each development and establishment to determine the actual parking requirement. Parking provision of the proposed development will comply with the DCP and ARHSEPP requirements.

Off-street car parking facilities should be designed in accordance with AS2890.1:2004 Parking Facilities – Off-Street Parking and relevant DCP design standards.

On-street parking spaces are to be provided based on the requirements set out in AS2890.5:2020 and Council standards. Driveways for access and egress movements are to be designed based on AS2890.1:2004.

10.3 Justification of the Use of Statutory Parking Rates

As discussed in Section 5.6.1, the Movement and Place vision and strategy are to provide on-site parking spaces in accordance with relevant statutory guidelines.

A parking assessment has been undertaken in Table 10.1 based on the statutory rates in accordance with Canterbury Development Control Plan (DCP) 2012, TfNSW Guide to Traffic Generating Developments (Guide) 2002, Apartment Design Guide (ADG) 2015, and State Environmental Planning Policy (Affordable Rental Housing) (SEPP) 2009.

The Riverwood Estate SSP with a mixed of market and social housing dwellings is expected to demonstrate different characters in car ownership, which is reflective in the lower SEPP parking rates in social housing as compared with market housing. Table 10.1 indicates a total provision of 3,869 parking spaces for 3,927 market and social housing dwellings, which is equivalent to 0.99 spaces per dwelling. A breakdown is shown as follows for different housing types:

- Market housing dwellings (within 800m of train station): 1.08 spaces per dwelling based on ADG parking rates
- Market housing dwellings (outside 800m of train station): 1.43 spaces per dwelling based on DCP parking rates
- Social housing dwellings: 0.50 spaces per dwelling based on SEPP parking rates
- **Average: 0.99 spaces per dwelling for all housing types**

The above breakdown indicates the parking provision is less in market housing dwellings which are located closer to the train station to encourage the use of public transport, while social housing has lowest parking provision based on the SEPP requirement.

Based on the car ownership data in the 2016 Census, approximately 38% of households in Riverwood had access to two or more motor vehicles, compared to 46% in Greater Sydney. As an average, each household had 1.3 vehicles in Riverwood.

On this basis, the provision of 0.99 spaces per dwelling (as an average) in the Riverwood Estate SSP is less than the car ownership of 1.3 vehicles per household in Riverwood. This justifies the use of the DCP and SEPP statutory rates is lower than the car ownership in the wider Riverwood based on Census 2016, without oversupplying parking spaces in the Study Area. This is in response with the Movement and Place objectives set out in Section 5.6.2 with the use of relevant statutory parking guidelines whilst implementing measures to minimise parking demand within the Study Area. Refer to Section 11.2 for the recommended measures to minimise parking demand from the statutory requirements.

10.4 Accessible Parking Requirement

It is noted that the number of adaptable units are not yet known at this stage. Notwithstanding, Council DCP requires one accessible parking space to be provided for every adaptable residential dwelling.

For retail use, the following accessible parking rates apply for development containing 10 or more spaces:

- staff: 1 accessible space per 50 parking spaces
- visitors:
  - with less than 500 car parking spaces: 1 space per 50 parking spaces
  - with more than 500 car parking spaces: 1 space per 100 parking spaces

Based on the above and the estimated car parking requirement of 142 spaces, the proposed retail development would require a total of four accessible parking spaces, comprising one accessible space for staff use and three accessible spaces for visitor use.

Childcare developments are classified as Class 9 buildings as per Building Code of Australia. Council requires the accessible parking on Class 9 buildings with more than 10 parking spaces to be provided at a rate of one accessible parking space for every 25 parking spaces.

Parking facilities for disabled should be provided in accordance with AS2890.6:2009 Parking Facilities: Off-street Parking for People with Disabilities and relevant DCP design requirements.

10.5 Bicycle Parking

Bicycle parking requirement for the Study Area has been calculated using the minimum parking rates set out in the Council DCP. For libraries and community centres, the bicycle parking rate is based on NSW Government Planning Guideline for Walking and Cycling.

The required bicycle parking provision is summarised in Table 10.2

Table 10.2: Bicycle Parking Requirement

Land Use	Size	Parking Rate	Bicycle Parking Requirement
Residential	3,925 units		
• Resident		1 space per 5 dwellings	785
• Visitor		1 space per 10 dwellings	393
Retail	3,130 m^2 GFA		
• Staff		1 space per 300 m^2 GFA	10
• Visitor		1 space per 500 m^2 GFA over 1,000 m^2 GFA	4
Childcare Centre			
• Staff	To be determined	1 space per 4 staff	To be determined
Library and Community Centre			
• Staff	To be determined	3-5% of staff number	To be determined
• Visitor	To be determined	5-10% of staff number	To be determined

Reference: Canterbury DCP and NSW Government Planning Guideline for Walking and Cycling

The residential and retail uses of the proposed development are required to provide a minimum of 1,192 bicycle parking spaces to meet the DCP requirements.

The bicycle parking requirements for the childcare centre, library and community centre have not been included as the number of staff is not yet determined at this stage.

10.6 Motorcycle Parking

The DCP does not require the provision of motorcycle parking spaces in residential developments nor retail area.

10.7 Servicing and Freight Requirements

The design of the movement network ensures that service and freight vehicles can enter and exit the Study Area appropriately. These vehicles could include delivery vehicles and waste vehicles which are required to service the Study Area.

The DCP states that service bay requirement will be determined based on the merits of individual development proposals.

As a guide, it is recommended that access to loading bays should not be provided along major roads (i.e., Belmore Road, Washington Avenue and Roosevelt Avenue) if possible and should be located far from intersections.

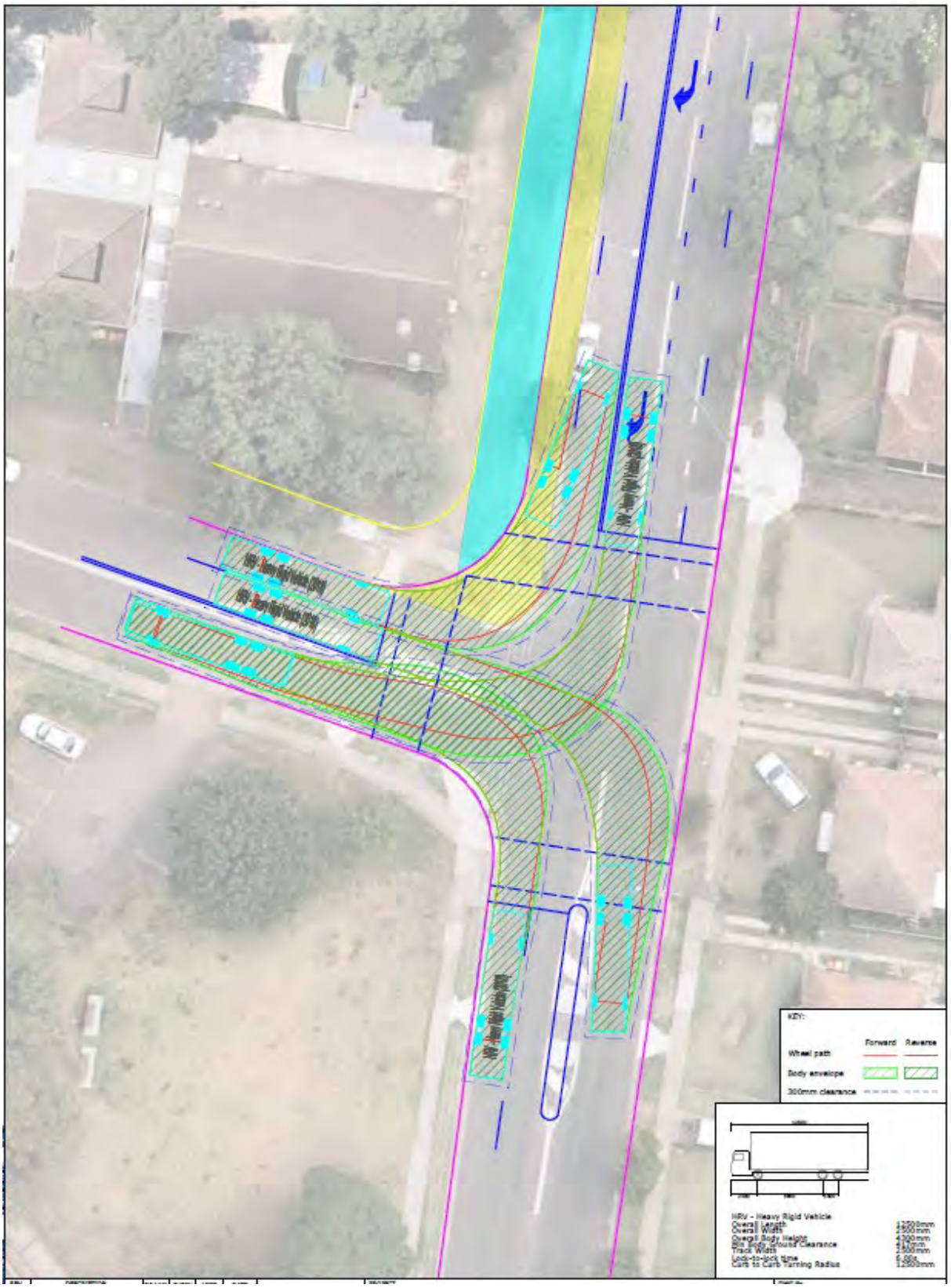
Council's Waste Management Guide for New Developments (Waste Management Guide) states that where kerbside collection is not operationally feasible for residential apartment buildings, waste collection vehicles will be required to enter the property. A waste collection vehicle loading area is to be included in the plans and should be within 10m of the bin storage area. Access to the nominated waste collection area is to be designed using a 12.5m heavy rigid vehicle (HRV). HRV must be able to enter and exit the site in a forward direction.

Waste Management Guide also requires commercial developments to be serviced by a private waste collection service or Council's trade waste service on site on ground level. Similarly, waste collection area and access are to be designed such that a 12.5m heavy rigid vehicle could enter and exit the site in a forward direction.

Internal roads accommodating waste collection would have a minimum carriageway width of 6.5m (2-way) which is suitable to accommodate waste collection vehicles. Detailed design will ensure sufficient clearance is provided for access to the waste storage areas in each building. According to TfNSW Combined Higher Mass Limits and Restricted Vehicle Map, 19m B-doubles and larger vehicles are not permitted along Belmore Road. As such, trucks servicing the site should be limited to 12.5m long heavy rigid vehicle. Loading and servicing facilities and driveways will be designed in accordance with AS2890.2:2018 at a later stage.

Roosevelt Avenue will be designed to provide sufficient clearance to accommodate delivery vehicles to the loading dock of the retail mixed use centre. A swept path assessment has been undertaken in Figure 10.1 for the largest vehicle (12.5m long vehicle) accessing and exiting the Belmore Road- Roosevelt Avenue intersection with localised widening required to provide sufficient clearance to the turning vehicle's swept path. Furthermore, Roosevelt Avenue will be widened for a 30m road reserve enabling additional space to accommodate turning swept paths. Figure 10.1 will be updated when the detailed road design is available for Roosevelt Avenue at a later stage.

Figure 10.1: Swept Path of Delivery Vehicle at the Belmore Road- Roosevelt Avenue Intersection



11 Transport Strategies

Having considered the existing and proposed traffic and transport conditions, a transport action plan is provided as follows in this section:

- enhancement of the active and public transport provision in and around the Study Area
- reduction of parking demand in addition to the statutory parking requirements
- key design elements of internal road design to be designed in the detailed design
- recommended infrastructure works and strategic costs on the external road network
- travel demand management.

11.1 Active and Public Transport

A re-cap of the following active and public transport measures is to enhance the Place and Movement functions:

- provide shared use path for safe pedestrian and cyclist access within the Study Area and to connect with Belmore Road and Riverwood Train Station to promote more walking and cycling in shorter trips
- provide signalised pedestrian crossings at intersection of Belmore Road – Roosevelt Avenue to provide a safe crossing location on Belmore Road
- re-route the existing Bus Route 944 to ensure residents are located within 200m of a bus stop
- seek to negotiate to increase the frequency of bus services to once every 15 minutes during peak periods.

11.2 Reduction of Parking Demand

In order to minimise parking demand that may reach beyond the statutory requirement, the following measures are recommended:

- Prepare a green travel plan in the DA stage as an initiative to reduce car dependency and encourage the use of public transport, cycling and walking by improving the development access and connectivity. Refer to Section 11.5 for details.
- Promote provision of car share spaces to reduce car ownership. Car share space could replace some parking spaces (e.g., 1 car space can be provided in place of 10 car parking spaces).
- Implement parking restrictions on streets within site to discourage residents owning multiple cars and parking outside the buildings. As such, long term parking along internal roads will be minimised and on-street parking would be more suited for visitor use only.

The objectives set out in the Movement and Place objectives in Section 5.6.2 would be satisfied by the use of relevant statutory parking guidelines whilst implementing measures to minimise parking demand within the Study Area.

11.3 Internal Road Design

The following key elements will be incorporated into the detail design at a later stage:

- Local streets to provide a minimum 6.5m width between kerbs to enable sufficient turning circle for the waste collection and servicing vehicles.
- Loading and servicing facilities and driveways will be designed in accordance with AS2890.2:2018.
- The internal roads identified as bus routes will be designed suitable for turning, stopping sight distance and parking requirements of buses in accordance with State Transit Bus Infrastructure Guide.
- At intersections, turning vehicles are accommodated using Austroads Design Vehicles and Turning Templates to enable turns to be made in a single forward movement.
- Shared use path is to be provided in accordance with the Austroads requirements in terms of path width, clearances, crossfall, grade, sight distance, surface treatment and intersection treatment etc.
- On-street parking spaces are to be designed to meet the minimum dimensional requirements in accordance with AS2890.5.

11.4 Infrastructure Improvement Works in External Road Network

11.4.1 Movement Objectives

In order to meet the Movement objectives set out in Section 5.6.6, intersection performance has been assessed to identify the extent of the improvement works required at the key intersections to level of service D in order to support the background growth and development traffic. Consideration has been given to constraints including downstream capacity, structural constraints (such as bridge, retaining walls and existing structures) and land acquisition to minimise the impacts on these constraints.

As discussed in the Movement objectives, a recognised entry point to the Study Area would be provided on Belmore Road with a turning lane to facilitate the right turning movement into the Study Area, which would minimise interruption to the through movements on Belmore Road.

Two options have therefore been developed for Belmore Road as follows:

- Belmore Road Option 1

- Retention of the existing centre line on Belmore Road.
- Belmore Road bridge widening above the open channel south of Hannans Road.
- No right turn bay on Belmore Road southbound to Roosevelt Avenue.

▪ Belmore Road Option 2

- Relocation of the existing centre line to the west on Belmore Road.
- Belmore Road bridge widening above the open channel south of Hannans Road.
- Right turn bay on Belmore Road southbound to Roosevelt Avenue.

11.4.2 Recommended Intersection Upgrade Measures

A summary of the proposed intersection and road improvement works to accommodate the proposed Riverwood Estate SSP development and background traffic growth is presented in Table 11.1.

Table 11.1: Proposed Infrastructure Improvement Works

Location	Works Required in 2031	Works Required in 2041
Belmore Road – Hannans Road – Washington Avenue	**Option 1 (retention of the existing Belmore Road centreline)** • Widen southern approach (including culvert bridge) to allow for 2 through lanes and one right turn lane • Widen northern approach to 3 lanes for 100m • Widen the eastern approach to provide additional 75m right turn lane • Turn Washington Avenue to left in, left out (priority control) • Ban right turn onto Hannans Road from Washington Avenue • Move pedestrian crossing from south of Hannans Rd to south of Washington Avenue • Remove parking on both sides of Belmore Road **Option 2 (relocation of the existing Belmore Road centreline to further west)** • Widen southern approach (including culvert bridge) to allow for 2 through lanes and one right turn lane • Widen northern approach to 3 lanes for 100m • Widen the eastern approach to provide additional 75m right turn lane • Turn Washington Avenue to left in, left out (priority control) • Ban right turn onto Hannans Road from Washington Avenue • Move pedestrian crossing from south of Hannans Rd to south of Washington Avenue • Realign footpath on the west side of Belmore Road • Remove parking on both sides of Belmore Road	• As per 2031
Belmore Road – Roosevelt Avenue	• No upgrade works required by year 2031 based on the modelling results, but suggested to bring the upgrade forward as this is a gateway intersection to the Study Area	**Option 1 (no right turn bay on Belmore Road)** • Upgrade to traffic signals • Ban parking on Roosevelt Avenue from Virginia Place to Belmore Road in the eastbound direction • Ban parking on Belmore Road from Truman Avenue to Washington Avenue in both directions **Option 2 (with right turn bay on Belmore Road)**

Location	Works Required in 2031	Works Required in 2041
		• Widen the intersection to accommodate design vehicle's turning path • Provide a 55m right turn bay on Belmore Road southbound • Realign footpath on the west side of Belmore Road • Ban parking on Roosevelt Avenue from Virginia Place to Belmore Road in the eastbound direction • Ban parking on Belmore Road from Truman Avenue to Washington Avenue in both directions
Bonds Road – Hannans Road	• Ban parking on Hannans Road from Bonds Road to Mazarin Street in the eastbound direction	• As per 2031 • Widen intersection to provide a 50m eastbound right turn lane and two westbound approach and departure lanes
Bonds Road – Broadarrow Road	• Upgrade to traffic signals • Provide right turn bays on all approaches (50m on the northern and eastern approaches, 25m on the southern and western approaches)	• As per 2031
Bonds Road – Romilly Street	• Upgrade to traffic signals • Square up the staggered intersections to form a cross intersection to better accommodate the design vehicle's turning path • Relocate the existing utility poles at the northern corner at the intersection • Provide right turn bays on Romilly Street, Talbot Street, and Bonds Road southern approach • Provide left turn bay on Bonds Road northern approach • Remove pedestrian refuge on Bonds Road as signalised crossing is provided further north at the intersection with Romilly Street • Provide traffic islands on Talbot Street to prevent the right turn movements into and out of Larkhill Avenue, and the right turn weaving movement from Larkhill Avenue to the right turn lane on Talbot Street	• As per 2031

Location	Works Required in 2031	Works Required in 2041
Bonds Road – Forest Road – Boundary Road	• Widen south-eastern approach to provide right turn lane • Widen north-western approach to provide right turn lane flare of 25m • Extend right turn bay on the south-western approach to Hugh Avenue • Extend right turn bay on the north-eastern approach by 50m	• As per 2031 • Extend right turn flare on north-western approach by 50m (total 75m)
Canterbury Road – Belmore Road	• Extend No Stopping Zone on Belmore Road to 90m	• As per 2031 • Additional 20m kerbside left turn lane on Canterbury Road east approach

Source: Jacobs and Orion

Based on the above table, most of the upgrade works required by 2031 are also sufficient to accommodate the forecasted 2041 traffic volumes, with the exception of the following intersections where additional upgrades are not required until Year 2041:

- Bonds Road – Hannans Road (provision of a right turn bay and two westbound lanes)
- Belmore Road – Roosevelt Road (however recommend upgrading to signalisation by year 2031 to provide a gateway intersection to the proposed development)
- Canterbury Road – Belmore Road (provision of a left turn lane)

Results presented in Section 6.9.4 also indicate that the intersection of King Georges Road – Broadarrow Road will operate at LoS E or F in the future years, regardless of the development traffic. It is noted that this intersection has been recently upgraded in 2020 as part of the Gateway to the South Pinch Point Program and that there is not enough road reserve in the area to accommodate any additional lanes. As such, opportunities for further improvements at this intersection is limited.

11.4.3 Traffic Apportionment

An assessment of the apportionment of the required infrastructure improvement works required to support the proposed development and background growth has been undertaken by Jacobs.

As the philosophy behind the identification of infrastructure requirements was based on existing delays and levels of service, the demand for the upgrade is taken as arising from the difference between the higher demand 2041 scenario (i.e. with the project) and the existing intersection demand. The relative contribution of the project to this demand is taken to be the difference between the "with" and "without" project scenarios for 2041. This captures both the direct impact of development traffic and indirect effects from background traffic changing routing decisions.

The calculation has been done for the peak AM and PM hour (8-9 AM and 4:45-5:45 PM) reflecting an overall package of upgrades driven by the critical hour.

Thus for example an intersection with a total AM peak hour flow of 5,000 vehicles in the base year, 6,000 vehicles in 2041 with background growth only, and 6,500 vehicles in 2041 with background growth plus the Riverwood Estate SSP development, with PM peak hour flows of 6,000, 7,000 and 7,500 vehicles respectively, would be calculated to have a project apportionment of 33% (500+500 / 1500+1500).

11.4.3.1 Apportionment Involving Belmore Road Option 1 and other Intersections

A summary of the apportionment assessment for the relevant intersections is presented in Table 11.2 with the Belmore Road Option 1 Design. This also involves widening of Belmore Road over the culvert south of Hannans Road.

Table 11.2: Traffic Apportionment based upon 2041 Traffic Volumes (with Belmore Road Option 1 Design)

Location	Background Apportionment %	Development Apportionment %
Belmore Road – Hannans Road – Washington Avenue (Option 1)	80%	20%
Belmore Road – Roosevelt Avenue (Option 1)	44%	56%
Bonds Road – Hannans Road	44%	56%
Bonds Road – Broadarrow Road	79%	21%
Bonds Road – Romilly Street	10%	90%
Bonds Road – Forest Road – Boundary Road	93%	7%
Canterbury Road – Belmore Road	82%	18%

Source: Jacobs and TTPP

The Regional Infrastructure Contribution (RIC) is a recently introduced mechanism to collect contributions from development to help fund State and regional infrastructure such as transport infrastructure, state or regional roads etc.

The RIC is a charge that will apply to new residential development in Greater Sydney. The proposed RIC Framework will assist in the acceleration of the delivery of priority growth infrastructure. The base regional infrastructure contribution is forecast to levy, on average, $793 million per annum.

The RIC SEPP is proposed to commence on 1 July 2022. To minimise the potential for adverse impacts on current development supply, and in light of ongoing impacts of the COVID-19 pandemic, the RIC would be phased-in to allow industry stakeholders, councils and consent authorities to adapt to the new charge.

It is anticipated that the proposed payment of the RIC would address the off-site traffic impacts on the State and Regional Roads.

11.4.3.2 Apportionment Involving Belmore Road Option 2 and other Intersections

A summary of the apportionment assessment for the relevant intersections is presented in Table 11.3 with the Belmore Road Option 2 Design. This also involves widening of Belmore Road over the culvert south of Hannans Road.

Table 11.3: Traffic Apportionment based upon 2041 Traffic Volumes (with Belmore Road Option 2 Design)

Location	Background Apportionment %	Development Apportionment %
Belmore Road – Hannans Road – Washington Avenue (Option 2)	80%	20%
Belmore Road – Roosevelt Avenue (Option 2)	44%	56%
Bonds Road – Hannans Road	44%	56%
Bonds Road – Broadarrow Road	79%	21%
Bonds Road – Romilly Street	10%	90%
Bonds Road – Forest Road – Boundary Road	93%	7%
Canterbury Road – Belmore Road	82%	18%

Source: Jacobs and TTPP

It is anticipated that the proposed payment of the RIC would address the off-site traffic impacts on the State and Regional Roads.

11.5 Travel Demand Management / Green Travel Plan

11.5.1 What is a Green Travel Plan (GTP)?

The key role of a Green Travel Plan (GTP) is to bring about better transport arrangements to manage travel demands, particularly promoting more sustainable modes of travel modes which have a low environmental impact, such as active transport modes (e.g., walking, cycling, public transport) and better management of car use.

Active transport presents a number of interrelated benefits including:

- Improved health benefits
- Reduced traffic congestion, noise and air pollution caused by cars
- Greater social connections within communities
- Cost savings to economy and individual.

As part of the DPIE requirements, a Travel Plan is to be prepared for the proposed development to promote sustainable travel. This GTP would be prepared to mainly target residents and retail staff of the proposed development with the intention to improve health and wellbeing of residents and retail staff, as well as to decrease their car dependency.

It is however noted that the GTP works hand in hand with the proposed active and public transport provision to meet the Movement and Place objectives in promoting more walking and cycling in short trips and public transport usage for longer trips, rather than a back-up in

case an intersection was unable to be upgraded. GTP strategies have been proven at a number of other sites to increase active travel modes.

This section provides a framework for the implementation of such travel plan, noting that the full travel plan document will be provided at a later stage.

11.5.2 Objectives and Strategies

A GTP is a package of coordinated strategies and measures to promote a range of sustainable travel choices, whilst reducing the reliance on private car usage, particularly single occupancy car trips.

It is envisaged that the GTP for the site would relate to the following principal areas of action:

- **Public Transport** – increase public transport use of residents and retail staff by development targeted information to increase knowledge and aware of surrounding public transport facilities. This information could be provided in community and residential building noticeboards, staff area in retail establishments, and website and/or social media account of the proposed development.
- **Cycling and walking** – increase cycling and walking activities of residents and retail staff by providing high quality walking and cycling paths, and bicycle parking facilities in residential developments, retail establishments and community spaces. End-of-trip facilities such as change rooms and shower areas should be made available for retail staff. Regular audits/inspections of the facilities would be conducted to ensure that the facilities are accessible and working order.
- **Development access and connectivity** – improve active transport access and connectivity from outside and within the Study Area by developing a Transport Access Guide (TAG) to detail local walking, cycling and public transport routes. This TAG would be disseminated to new apartment tenants and retail staff and will be posted on community noticeboards and online platforms.
- **Car sharing scheme** – car share allows residents or businesses to use a shared vehicle fleet to reduce the number of parking spaces required to be provided in new developments. This would give residents an option not to buy a second car (or even not to own a car at all) but rent one on an hourly basis to reduce operating costs.
- **Community involvement** – influence greater uptake of active transport by conducting community consultations or workshops to explore opportunities and/or constrains to increase active transport to/from and within the development. Coordination with Riverwood Public School would be organised to decrease private car use of Riverwood Estate SSP residents travelling to and from the school.

11.5.3 Review and Monitoring

Whilst there is no standard methodology for monitoring of travel plans, it is recommended that the plan be monitored on a regular basis to ensure that the desired benefits are

achieved or otherwise, suitable measures be implemented to reduce private car usage particularly single car occupancy trips.

At this early stage, it is not possible to identify what specific measures may be required to reach the desired outcomes of the travel plan as this would be dependent upon the particular circumstances at the time.

Thus, it is recommended that the travel plan be monitored on a regular basis (e.g., yearly, half occupancy or full occupancy) through travel surveys, or similar. Travel surveys would show how residents, staff and visitors travel to/from the site and assist to identify whether the proposed initiatives and measures outlined in the GTP are effective or are required to be replaced or modified to ensure that the best outcomes are achieved.

Regular consultation would also be beneficial to help understand people's reasons for travelling the way they do and help identify any potential barriers to change their travel behaviours. In order to ensure successful implementation of the travel plan, a Travel Plan Coordinator (TPC), should be appointed to oversee the measures and resultant impacts of the travel plan.

12 Construction Traffic Management Plan Framework

12.1 Construction Activity

The redevelopment of the Riverwood Estate SSP will primarily involve the following key tasks:

- Demolition of existing residential dwellings
- Excavation and site establishment
- Building structure construction
- Façade and internal fittings
- Public domain and landscaping works.

The extent of the work site shall generally be wholly contained within the site boundary, with minimal impact on the surrounding road network and residential accesses.

A detailed Construction Traffic Management Plan would be prepared prior to the commencement of the construction activities. However, a preliminary review of construction traffic management requirements is set out below.

12.2 Work Hours

It is proposed that works be only undertaken during the approved hours consistent with any relevant consent conditions. At this stage, the proposed development has not been approved, however, it is expected there will be a consent condition stipulating similar work hours to the following:

- 7:00am – 6:00pm, Monday to Friday
- 8:00am – 1:00pm, Saturday
- no work to be undertaken on Sundays or public holidays.

In addition, any works outside the above work hours (as amended by the relevant consent conditions) will be subject to a separate application to DPIE or Council.

12.3 Construction Vehicle Types

Construction vehicles likely to be generated by the proposed construction activities include:

- Semi-trailer trucks for use during demolition and excavation works,
- Heavy rigid vehicles and concrete truck mixers for structural and finishing works, and
- Small rigid vehicles, vans and couriers for smaller deliveries as required.

The traffic generated by construction activities on the site is not known at this stage, however construction traffic generation is expected to be minimal and have a negligible impact on existing traffic conditions.

12.4 Construction Vehicle Routes

Construction vehicles generally have origins and destinations throughout Sydney, with an extensive network of roads made available for such trips.

To minimise the impact of construction traffic on local streets, dedicated construction routes will be developed to provide the shortest distances to/from the arterial road network. These will be detailed in the detailed construction traffic management plan.

12.5 Parking

It is envisaged that construction workers may park on local streets surrounding the site. The removal of the existing dwellings mean that the existing on-street parking demand will be reduced accordingly, therefore workers would not impose an adverse parking impact on the road network. However, the appointed site supervisor will encourage workers to travel to/from the site via public transport. Further details to parking for construction workers will be confirmed in the detailed construction traffic management plan.

A tool drop-off and storage facility will be provided within the site. This will allow construction workers to drop off and store their tools, allowing them to use public transport to travel to and from the site.

12.6 Traffic Control Plan

Notwithstanding the likely limited impacts of construction on traffic operation of the surrounding network, Traffic Control Plans (TCPs) will likely need to be prepared by and submitted to the TfNSW and Canterbury Bankstown Council to appropriately manage the use of the designated construction routes.

The TCP should also outline how potential construction vehicle manoeuvres could be accommodated in and out of the construction site.

12.7 Construction Traffic Management Plan

A Construction Traffic Management Plan would be prepared and submitted to either Canterbury Bankstown Council or DPIE for approval, following engagement with TfNSW and before construction commences at the site. The Plan will provide further details on the construction activities and their impacts, if any.

13 Consultation with TfNSW

Consultation with TfNSW was undertaken on 8 February 2022. A summary of the discussion outcome is provided as follows:

- TfNSW suggested consolidation of some of the proposed bus stops to ensure buses are not delayed by too many stops.
- TfNSW gave in-principle support of the proposed re-routing of Bus Service 944. In addition, consideration should be given to looping Bus Service 940 or 945 into the internal roads.
- Walkability to bus stops and especially the train station should be a priority to ensure good quality access to public transport.
- In-principle support of the provision of a right turn bay on Belmore Road to Roosevelt Avenue to improve bus movements into and out of Belmore Road. It provides an opportunity to remove the dog-leg movement at the Belmore Road intersections with Washington Avenue and Hannans Road in the existing Bus Service 944.
- Frequency of train services is expected to improve to 10 minutes in five years.

The first three items will be considered in the detailed design at a later stage.

14 Consultation with Canterbury-Bankstown Council

Consultation with Canterbury-Bankstown Council was undertaken on 8 March 2022. A summary of the discussion outcome is provided as follows:

- The existing "dog-leg" movement between Washington Avenue and Hannans Road is to be minimised. This could be achieved by installation of a raised concrete median between the through lane and right turn lane on the Belmore Road approach to the Hannans Road intersection.
- Council supports keeping Washington Avenue open to maintain vehicle accessibility and to reduce burden on other access roads and to minimise traffic movements on local roads within the site.
- Council does not support an on-road cycleway on Belmore Road for road safety reasons. Consideration could be given to an off-road cycleway or a cycleway on less trafficked roads, noting possible land acquisition into the subject site may be required to enable compliant cycleway width to be provided.
- Council sought clarification on three sets of traffic generation rates in relation to the existing dwellings to be demolished, Washington Park survey, and the proposed development based on TfNSW approved traffic generation rates.
- Council advised that the Washington Park traffic was not included in the 2017 survey (i.e. still under construction) but considered the traffic volume would be minor in comparison to the large scheme of the development traffic.

15 Summary and Conclusions

The Transport Planning Partnership (TTPP) undertook a traffic and transport assessment on behalf of LAHC to assess the impacts of the proposed mixed-use development known as Riverwood Estate State Significant Precinct (SSP). The development essentially involves demolition of the existing housing and construction of a mixed-use development.

TTPP and a consultant team have worked with LAHC to prepare a master plan for the redevelopment of the site that will replace the existing dwellings, provide for additional private dwellings, new streets and parks and community uses. The redevelopment will include:

- Approximately 3,900 new dwellings, ranging between 3 and 12 storeys.
- Extensive areas of integrated open space and five new parks, including two large new local open spaces Roosevelt Park and the Community Greenway.
- A mixed-use precinct, with approximately 4,000m^2 of non-residential floorspace, for local shops, cafés and services; and new community spaces, including a new multi-purpose community hub co-located with new open space, located close to Riverwood Public School.

Jacobs developed a microscopic Aimsun model for the suburb of Riverwood which was reviewed and approved by Roads and Maritime Services (currently TfNSW). As part of this study, Jacobs was commissioned by LAHC to assess the impacts of the proposed development and the upgrades to maintain an acceptable level of service using the Aimsun model.

Key findings in this traffic and transport assessment include:

- Traffic surveys have been conducted at Washington Park development as a benchmark for trip generation rates and travel mode share. The derived rates have been increased to better reflect the driving characteristics shown in Census Data 2016.
- The proposed development is estimated to generate approximately 1,182 trips in the morning peak hour and 1,353 trips in the evening peak hour when it is fully operational (Year 2041).
- In Year 2031, intersection upgrade works would be required at a number of key intersections to accommodate the future traffic associated with the proposed development and background growth.
- Additional upgrade works will be required at the intersections of Belmore Road – Roosevelt Avenue, Bonds Road – Hannans Road and Canterbury Road – Belmore Road in Year 2041.
- The intersection of King Georges Road – Broadarrow Road will operate at LoS E or F in the future years, even without the additional development traffic. It is noted that this

intersection has been recently upgraded in 2020 as part of the Gateway to the South Pinch Point Program and that there is not enough road reserve in the area to accommodate any additional lanes.

- It is anticipated that the proposed development would require 4,062 car parking spaces.
- The provision of additional bus and train services would need to be explored to support future growth within the catchment areas. Georges River Council Draft Transport Strategy Report (2021) makes mention of rapid bus services to accommodate for the Study Area and the Riverwood local centre via the possible Parramatta/ Bankstown to Hurstville/ Kogarah rapid bus link
- A cycle path is suggested on Belmore Road. This will be subject to further detailed discussions with TfNSW, Canterbury Bankstown and Georges River Councils to ensure safety and connectivity can be achieved.

Overall, it is concluded that proposed residential development can generally be accommodated with the infrastructure upgrade works at key intersections in Year 2031 and Year 2041, subject to consultation with relevant stakeholders and additional public transport services to be provided.

Appendix A

Roads and Maritime Services (TfNSW) Email – Approved Trip Generation Rates

Doris Lee

Subject: FW: Riverwood SSP traffic update

From: Nigel Macdonald <Nigel.Macdonald@facs.nsw.gov.au>
Sent: Thursday, 2 August 2018 12:57 PM
To: Ken Hollyoak <Ken.Hollyoak@ttpp.net.au>
Cc: Doris Lee <Doris.Lee@ttpp.net.au>; Lalaine Malaluan <lalaine.malaluan@ttpp.net.au>
Subject: FW: Riverwood SSP traffic update

Ken

Please see email below from Billy Yung of TfNSW.

Per the email, you have the ok to run the model.

Look forward to the results.

Regards

Nigel Macdonald |Development Director
NSW Land and Housing Corporation | Department of Family and Community Services
Communities Plus Program
A: Level 5, 219-241 Cleveland Street, Strawberry Hills NSW 2012
PO Box 10 Strawberry Hills 2012
E: nigel.macdonald@facs.nsw.gov.au
P: (02) 9374 3656
M: 0419 510 500

From: Yung, Billy [mailto:Billy.Yung@transport.nsw.gov.au]
Sent: Wednesday, 1 August 2018 1:22 PM
To: Holly Patrick
Cc: HALL James C; Nigel Macdonald; Ozinga, Mark; Bocman, Haggai
Subject: RE: Riverwood SSP traffic update

Hi Holly

Further to your earlier conversation with James, please see below our response in regards to the additional information provided by TTPP.

Roads and Maritime Services and TfNSW had reviewed the revised trip rates as proposed by TTPP and would accept the revised trip rates (i.e. 0.26 for private housing in the AM peak) as it aligns closely to our recommended rate adopted for other sites with similar characteristics (i.e. 0.29 for AM peak). The consultant should adopt the revised trip rates for private housing to test out the worst case scenario (i.e. maximum private housing yields).

Trust the above could help to proceed forward their subsequent exercise.

Many thanks,
Billy

Billy Yung
Senior Transport Planner | Land Use Planning & Development

Freight, Strategy & Planning
Transport for NSW

T 02 8265 9932 | **M** 0481 905 670 | **E** Billy.Yung@transport.nsw.gov.au
Level 4, 241 O'Riordan Street, Mascot NSW 2020

From: Ken Hollyoak [mailto:Ken.Hollyoak@ttpp.net.au]
Sent: Wednesday, 18 July 2018 9:03 AM
To: Holly Patrick
Cc: Yung, Billy; HALL James C; Nigel Macdonald; Doris Lee; Lalaine Malaluan
Subject: FW: Riverwood SSP traffic update

Hi Holly

We have reviewed the TfNSW/RMS comments in relation to the above. I have copied Billy Yung and James Hall into this email but, as I'm in leave in WA, I don't have any of the other contact addresses in the original email so I am requesting that Billy and James will distribute to their relevant colleagues.

As stated by TFNSW, TTPP carried out counts (video and on the ground) at Washington Park. We think it is the most appropriate site being as it is located very close to the subject site and contains a similar mix of market and social housing. Indeed it is anticipated that the residents will have similar travel patterns.

I note the comment that RMS has recently completed surveys of high density residential developments above 800m of heavy rail and the survey had identified a higher trip rate (i.e. average 0.28) trips per unit for Sub-Metropolitan Site in the AM peak. However, the RMS sites will all have their site specific characteristics as does Riverwood/Washington Park,

In response to the questions, there was a small error on the issued data in respect that it didn't accurately reflect off site / on street parking in the neighbourhood. We did consider this in the surveys and picked it up in the interview surveys but the calculation did erroneously omit this. The amended trip generation rates are below.

Original Suggested traffic Generation			Amended traffic generation		
	AM Peak	PM Peak		AM Peak	PM Peak
Total	0.15	0.19	Total	0.18	0.23
Market	0.18	0.22	Market	0.20	0.25
SHUs	0.07	0.07	SHUs	0.10	0.10

I also note the comment about

- The share for car based mode is high for market housing but the corresponding trip rate obtained from the survey is low.
- Any interpretation in regards to high degree of car-based mode and low trip rate for market housing? Can the mode share data be verified against the trip rate obtained from the survey, i.e. using first principles with assumptions on household density, car occupancy, person trips in peak hour, etc.?

This is a reasonable comment so we have had a more detailed look at this. The following census data etc has been examined.

Travel to work, top responses *Employed people aged 15 years and over*	Riverwood	%	New South Wales	%	Australia	%
Car, as driver	2,195	47.0	1,953,399	57.8	6,574,571	61.5
Train	1,173	25.1	252,786	7.5	488,012	4.6
Car, as passenger	199	4.3	144,820	4.3	489,922	4.6
Train, bus	149	3.2	60,155	1.8	104,122	1.0
Walked only	107	2.3	130,957	3.9	370,427	3.5
People who travelled to work by public transport	1,515	32.4	540,215	16.0	1,225,668	11.5
People who travelled to work by car as driver or passenger	2,486	53.1	2,182,854	64.6	7,305,271	68.4

In Riverwood (State Suburbs), on the day of the Census, the most common methods of travel to work for employed people were: Car, as driver 47.0%, Train 25.1% and Car, as passenger 4.3%. Other common responses were Train, bus 3.2% and Walked only 2.3%. On the day, 32.4% of employed people used public transport (train, bus, ferry, tram/light rail) as at least one of their methods of travel to work and 53.1% used car (either as driver or as passenger).

2016 Census QuickStats

For the Riverwood suburb:

- car trips to work / total population = 2195 / 12103 = 18% of total population drive to work

For Washington Park:

- 18% of total population drive to work = 2145 x 18% = 386 people (both social and market) who drive to work

(Note the 2145 population comes from average people per household = 2.6, number of dwellings in Washington Park = 825, therefore population = 825 x 2.6 = 2,145)

There are **320** vehicles (53 in, 267 out) recorded during the morning survey period (6:30am-9:30am) and **394** vehicles during the afternoon survey (4pm-7pm)..

Direction	IN			OUT			TWO-WAY	
Time Period	Lights	Heavies	Total	Lights	Heavies	Total	Total	%
6:30 to 7:30	12	0	12	89	0	89	101	32%
7:30 to 8:30	12	0	12	100	1	101	113	35%
8:30 to 9:30	29	0	29	77	0	77	106	33%
Total	53	0	53	266	1	267	320	100%
16:00 to 17:00	71	0	71	38	0	38	109	28%
17:00 to 18:00	94	1	95	36	0	36	131	33%
18:00 to 19:00	96	0	96	58	0	58	154	39%
Total	261	1	262	132	0	132	394	100%

This suggests that the first principles figure is 20% higher than the actual traffic counts in the AM peak (320 versus 386) and almost the same in the PM peak (394 versus 386).

There are 825 existing dwellings at Washington Park of which 191 are social and 634 are market. If we use the "recorded" trips rates suggested above, the calculated peak hour traffic is higher than the total recorded traffic count in the busiest hour

	No of dwellings	AM trip rate	PM trip rate	AM Trips	PM Trips
Social Housing	191	0.10	0.10	19	19
Market Housing	634	0.20	0.25	127	159
				146	**178**

- 113 recorded in traffic count in the AM count vs 146 calculated
- 154 recorded in the PM traffic count vs 178 calculated

The theoretical trip rates are on average 29% higher in the AM and 16% higher than the recorded trip rates in the PM peak.

We have therefore increased the recorded trip generation rates by these factors and would suggest the following trip rates would be appropriate for the modelling,

	AM Peak	PM Peak
Total	0.23	0.27
Market	0.26	0.29
SHUs	0.13	0.12

I will await TfNSW/RMS confirmation that these rates are acceptable before I commence the modelling.

Kind Regards

Ken Hollyoak

Director

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a: Suite 402, 22 Atchison Street, St Leonards NSW 2065

w: www.ttpp.net.au e: Ken.Hollyoak@ttpp.net.au

ttpp transport planning

From: Yung, Billy
Sent: Thursday, 28 June 2018 9:33 AM
To: Papadopoulos, Christina; Ozinga, Mark; HALL James C
Cc: Bocman, Haggai; ZAPANTA Tricia T
Subject: RE: Riverwood SSP traffic update

Hi Christina

As we spoke yesterday, please see below my consolidated comment for your coordination with DP&E. **James**, please feel free to supplement in case I missed out any of your points.

Items noted from TTPP's report:

- TTPP carried out survey (videos of driveway) at Washington Park in May 2018, which is the same site where GTA undertook survey in December 2017.
- The TTPP survey identified trip generations by different housing types i.e. market and social/affordable.
- TTPP had carried out a questionnaire survey to obtain mode share data. The share for car based mode is high for market housing but the corresponding trip rate obtained from the survey is low.

Comments on the report:

- Any observation being made on site in regards to on-street residential parking in the neighbourhood? Does the trip generation survey factor in on-street demand for residential parking?
- Any interpretation in regards to high degree of car-based mode and low trip rate for market housing? Can the mode share data be verified against the trip rate obtained from the survey, i.e. using first principle with assumptions on household density, car occupancy, person trips in peak hour, etc.?

Recommendation:

The subject site is note within easy walking distance of Riverwood Station and this Station is not considered a major transport interchange (i.e. Chatswood, Parramatta) providing high frequency bus and rail connections. RMS has recently completed survey on high density residential developments not within easy walking distance for heavy rail and the survey had identified a higher trip rate i.e. average 0.29 trips per unit for Sub-Metropolitan Site in the AM peak. It is recommended that a higher rate should be tested for the market dwellings having considered the high degree of car-based mode identified in the questionnaire survey.

Many thanks,

Billy Yung
Senior Transport Planner
Freight, Strategy & Planning
Transport for NSW

T 02 8265 9932 | **M** 0481 905 670 | **E** Billy.Yung@transport.nsw.gov.au
Level 4, 241 O'Riordan Street, Mascot NSW 2020

Appendix B

TfNSW Email – STM Cordon Matrix for Future Background Traffic Growth

Doris Lee

From: Donna Liu <Donna.Liu@transport.nsw.gov.au>
Sent: Tuesday, 12 January 2021 10:21 AM
To: Mansour, Miliss
Cc: Malcolm Bradley; Doris Lee
Subject: RE: Riverwood - Subarea for STM
Attachments: Sent_12Jan2020.zip; Riverwood_subarea_gates.pdf; TPA_Fact Sheet_STM Assumptions v3.8.pdf; TPATF_840-Riverwood_Subarea_Demand_v1.xlsx

Hi Miliss and Doris,

Please find the attached your request summary spreadsheet, zip folder(includes all the subarea matrices for all the model year requested). The cordon gate map and STM v3.8 fact sheet are re-sent here again for a complete response. Each model year has two data files - one for each time period. The naming convention is:

- AM: List_mf921_etc_byZone_with_constrMtx_**<model year>**_std.rep;
- PM: List_mf931_etc_byZone_with_constrMtx_**<model year>**_std.rep;

In each file, there are six columns namely origin, destination, car driver trips, LCV trips, rigid truck trips and articulated truck trips. All the demand is in pcu and represents 2hr demand. The factor used to convert pcu to veh for the four classes is 1.0, 1.2, 2.0 and 4.0.

As mentioned before, STM is not an validated traffic model and has weakness in small area forecasting. It is recommended to calibrate and validate base year demand based on observed data and apply the growth derived from the data provided for your future demand.

Please do not hesitate to contact us if you have any question.

Kind regards
Donna

From: Mansour, Miliss [mailto:Miliss.Mansour@jacobs.com]
Sent: Monday, 4 January 2021 8:08 PM
To: Donna Liu <Donna.Liu@transport.nsw.gov.au>
Cc: Malcolm Bradley <Malcolm.Bradley@transport.nsw.gov.au>; Doris Lee <Doris.Lee@ttpp.net.au>
Subject: RE: Riverwood - Subarea for STM

Hi Donna,
There are more cordon zones in the new matrices that you provided us which I assume is due to the STM network having changed.

Could you please provide a cordon zone map (an updated version of the attached pdf) so that we can update the Aimsun zone equivalence?

Regards

Miliss Mansour (CPEng)| Jacobs | Technical Leader - Transport Modelling
M:+61 (0) 406 492 086
177 Pacific Highway, North Sydney NSW 2060 Australia

From: Donna Liu <Donna.Liu@transport.nsw.gov.au>
Sent: Thursday, December 24, 2020 12:24 PM
To: Doris Lee <Doris.Lee@ttpp.net.au>
Cc: Mansour, Miliss <Miliss.Mansour@jacobs.com>; Malcolm Bradley <Malcolm.Bradley@transport.nsw.gov.au>
Subject: [EXTERNAL] RE: Riverwood - Subarea for STM

Hi Doris,

As discussed, attached is the subarea matrix from STM(v3.8) 2031 and 2016 standard model. This is just to assist you to get your process started. Sorry, I only managed to get these two done. The rest will be provided after the holiday.

This version of STM adopts TZP19 land use which is the latest available land use dataset. As you may already know, STM is not an validated traffic model and not good at small area forecasting. Therefore, we do recommend to calibrate and validate your base year traffic model based on observed data and use the growth derived from the data provided for your future demand. FYI, the STM assumption fact sheet is also attached.

In each file, there are six columns, namely origin, destination, car driver, lcv, rigid truck and articulated truck demand. All the demand is in pcu and represents 2hr volumes. The factor to convert pcu to veh is 1.0,1.2,2.0 and 4.0.

Please let me know if you have any question.

Merry Christmas and Happy New Year!

Cheers
Donna

From: Doris Lee [mailto:Doris.Lee@ttpp.net.au]
Sent: Monday, 14 December 2020 5:26 PM
To: TPA <TPA@transport.nsw.gov.au>
Cc: Mansour, Miliss <Miliss.Mansour@jacobs.com>
Subject: RE: Riverwood - Subarea for STM

Hi TPA

We are assisting LAHC to update a traffic model in the Riverwood area for a proposed residential development, and would like to request the STM sub-area demand matrices for the following years:

- The latest validated base year that TPA has ready
- 2026
- 2036

The STM sub-area demand matrices are required for AM and PM peak periods, for light vehicles and heavy vehicles separately.

Sub-area is shown in the attached shapefile.

Thanks in advance.

Doris Lee

Associate
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a: Suite 402, 22 Atchison Street, St Leonards NSW 2065
w: www.ttpp.net.au e: Doris.Lee@ttpp.net.au

Appendix C

Riverwood Estate Development – Traffic Work and Apportionment (Jacobs)

Riverwood Estate Traffic Modelling

Traffic Work and Apportionment

| 4.1

14 February 2022

The Transport Planning Partnership Pty Ltd

Riverwood Estate Traffic Modelling

Project No:	IA195800
Document Title:	Traffic Work and Apportionment
Document No.:	
Revision:	4.1
Date:	14 February 2022
Client Name:	The Transport Planning Partnership Pty Ltd
Client No:	17.0000302200.1207-0133
Project Manager:	Miliss Mansour
Author:	Dibyojyoti Saha
File Name:	20210414 Riverwood Estate - Traffic Works and Apportionment Revised Report(Feb 2022)

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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
Rev 1	26/02/2021	Draft Report	D. Saha	J. Patterson	J. Patterson	M. Mansour
Rev 2	04/03/2021	Updated Draft Report	D. Saha	J. Patterson	J. Patterson	M. Mansour
Rev 3	14/04/2021	Editorial update to Section 2 & 3.2				M. Mansour
Rev 4	31/01/2022	Editorial update to Section 2 & 6			M. Mansour	
Rev 4.1	14/02/2022	Editorial update to Section 7.1& 7.2			M. Mansour	

Contents

1. Introduction

This technical report summarises the findings of recent traffic modelling undertaken by Jacobs Group (Australia) Pty Ltd for the Transport Planning Partnership Pty Ltd (TTPP). This work has been carried out to update the previously identified list of road network improvements required to support the planned development of the Riverwood Estate as well as background traffic growth.

This work follows on from similar investigations in 2018, which examined infrastructure needs in 2026 and 2036. The technical note *Riverwood Estate Development – Traffic and Transport – Traffic Work and Apportionment* (November 5, 2018) refers.

The current investigations have updated the modelling to include revised development yields and schedules, as well as updated background traffic growth. Analysis years of 2031 (interim) and 2041 (ultimate) have been adopted to better suit current development expectations. Background growth is now based on cordon matrices provided by Transport for New South Wales (TfNSW) from the current Strategic Transport Model (STM version 3.8), which uses the current common planning assumptions for the NSW Government and represents a pre-Covid-19 pandemic view of the future[1].

An apportionment of the infrastructure provision associated with the identified works has also been provided, based on the share of traffic volumes for both the Riverwood Estate and the background growth at each location. This apportionment has been based on total modelled traffic volumes intersection with identified upgrade needs.

[1] TPA Information Sheet October 2020, *Strategic Travel Model Assumptions*, provided by TfNSW 12/01/2021 with the cordon matrices for this study

2. Proposed Land Use

Traffic modelling of the future 2031 and 2041 scenario considers the development associated with the Land and Housing Corporation's (LAHC) proposed Riverwood Estate and the background traffic growth in the Riverwood study area (refer to Figure 3-1.).

The yield of the proposed Riverwood Estate development was calculated by The Transport Planning Partnership Pty Ltd (TTPP) based on information provided by LAHC.

By 2041 a net yield of dwellings was applied, based on:

- Demolition of 994 existing dwellings
- Construction and occupation of approximately 3,900 dwellings.

A summary of future dwellings and their timings is shown in Table 2.1. These numbers have been updated based on LAHC advice (Jan 2022) for consistency with Section 4.1 and 6.9.3.5 of the main report. Due to small changes in the number of dwellings, re-modelling is not deemed necessary. The timing of the non-residential works assumed for 2031 and 2041 is summarised below.

- Modelling year 2031 non-residential land use assumption:
  - Commercial use: 4,793 sqm
- Modelling year 2041 non-residential land use assumption:
  - Commercial use: 4,793 sqm
  - Community use: 970 sqm

As shown in Table 2.1, the trip generation within the Riverwood study area also includes 470 dwellings assumed to be constructed by others, in addition to the LAHC yield listed above, based on TTPP advice.

The subsequent network upgrades detailed in Section 6 have been determined following the assessment of future performance against the mandated network performance requirement outlined in Section 3.6

Table 2.1: Riverwood LAHC dwellling assumptions and staging of works (excludes community and commercial)

Assumed Modelling Year		Source: TTPP, 2021				
2031	2041	Stage	No. existing dwellings (demolition)	Begin (demolitions)	No. future dwellings	End (unit completion)
Yes	Yes	1	-185	2026	710	2030
Demolition only	Yes	2	-236	2029	999	2035
	Yes	3	-308	2031	910	2038
No	Yes	4	-290	2034	836	2043
No	Yes	Non LAHC Land	-	-	445	2035

Notes: Updated based on LAHC advice (Jan 2022)
Future dwelling numbers rounded to 3,900

3. Traffic Modelling

This section outlines the approach taken for modelling the traffic generation from the development sites in the study area and the impacts that this traffic will have on the surrounding road network. It also details the process undertaken to determine the intersection and road improvements that will be required to accommodate the traffic generated by the proposed development. Jacobs have used the Riverwood microsimulation traffic model to examine the road network performance including intersection Level of Service, delay and queuing. The details of this traffic assessment are presented below

3.1. Aimsun Traffic modelling

The Riverwood Aimsun traffic model has been developed for the purposes of assessing the impacts of development in the Riverwood Estate. The model the covers the morning (6am to 10am) and evening (3pm to 7pm) peak periods and extends to cover the geographic area shown in Figure 3-1.

The development, calibration and validation of the model are documented in the *Riverwood Land Use and Infrastructure Strategy – Traffic and Transport Assessment – Calibration and Validation Report* (July 2017).

Modelling has been carried out using Aimsun version 8.2.3.

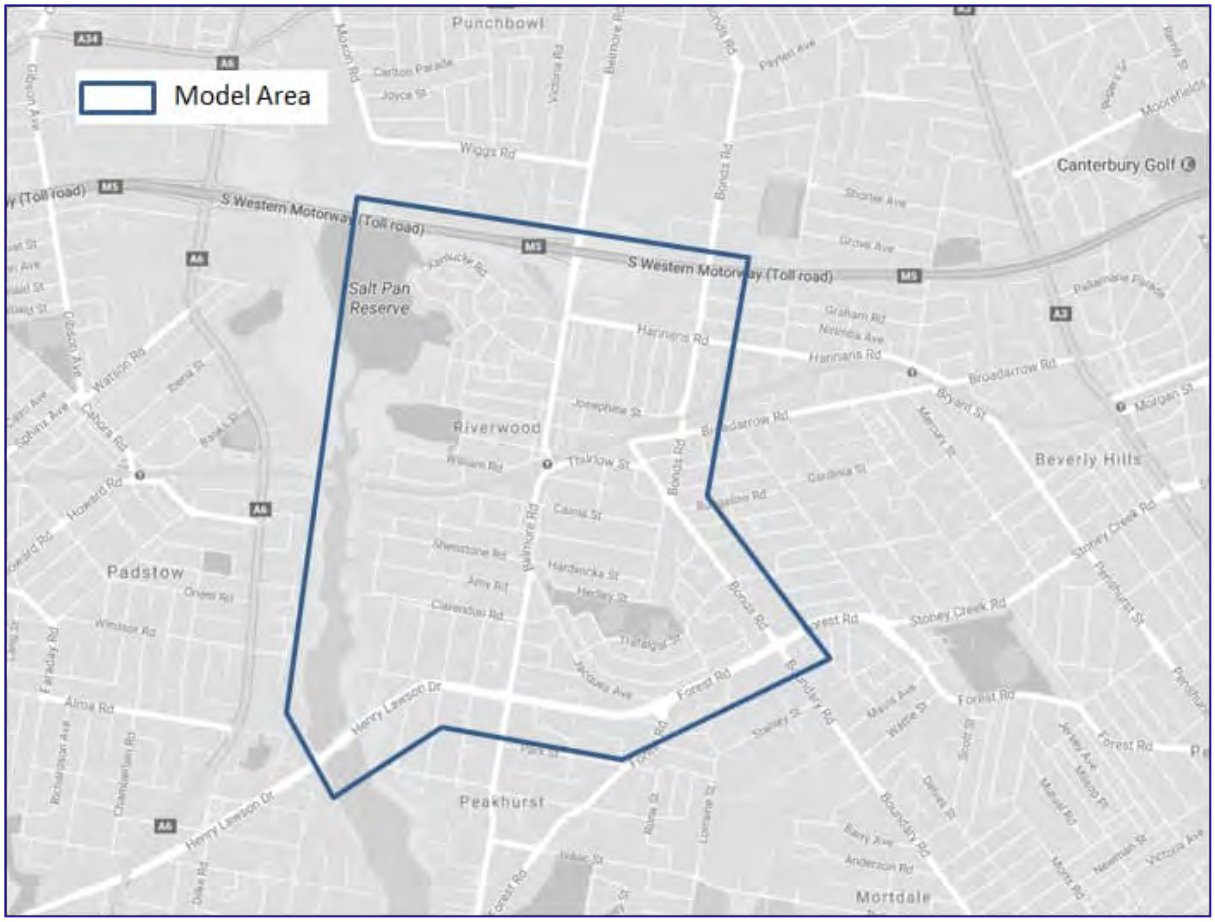

Figure 3-1: Riverwood traffic model extents

Source: Google Maps

3.2. Background traffic growth

Background traffic growth in the Aimsun model is based on cordon matrices from the STM, provided by TfNSW on 12 January 2021.

This latest version of Sydney Travel Model (STM 3.8) uses the 'Travel Zone Projections 2019' (TZP19) land use data set. As stated in the *Strategic Travel Model Assumptions* TPA Information Sheet (October 2020), this uses the current common planning assumptions for the NSW Government and represents a pre-Covid-19 pandemic view of the future. Appendix B of the TTPP Traffic Impact Assessment includes a copy of correspondence with TfNSW concerning the data received.

The resulting growth in the modelled period Aimsun demand matrices is summarised in Table 3.1.

Table 3.1: Background Traffic Growth

Total Vehicle Demand	2017	2031	2041	Growth 2017 - 2031	Growth 2017 - 2041
AM Peak	57,700	63,400	66,600	**9.7 %**	**14.0 %**
PM Peak	67,100	72,600	75,700	**9.6 %**	**13.5 %**

Compared to the future year background demands from the 2018 work, some changes in flow patterns are observed in the updated forecasts. In particular, comparing the previous and new interim (2026 and 2031) and ultimate (2036 and 2041) demands indicates:

- The largest traffic increases occur in through traffic along M5 in the counter peak direction, especially in the AM peak.
- The additional five years of growth also results in higher demands between Henry Lawson Drive and Belmore Road South (in both directions), and in the PM peak, higher demands between Henry Lawson Drive and Forest Road East (in both directions).
- Despite the later timeframes, the newer forecasts indicate lower AM peak traffic flows from Henry Lawson Drive to other destinations, and from Forest Road westbound, as well as lower demands to Bonds Road north and Belmore Road north.
- The newer forecasts also indicate lower PM peak demands between Henry Lawson Drive and Belmore Road north (in both directions).

The STM cordons provided do not indicate any usage of the new east facing ramps on the M5 at the Belmore Road interchange. A sensitivity test has been carried out reassigning traffic to these ramps, using the ramp catchments from the previous (2018) modelling. The results indicate no change in the infrastructure requirements identified in this report. The sensitivity test methodology and results are described in Appendix C.

3.3. Traffic generation

Future traffic growth within the Riverwood Estate has been based on an hourly peak morning and evening trip generation supplied by The Transport Planning Partnership Pty Ltd (TTPP).

In order to determine the impact of additional traffic generated by the background growth and the Riverwood Estate development, the additional trips resulting from the additional dwellings have been applied to the forecast 2031and 2041 background traffic demand supplied by NSW Roads and Maritime from STM model as discussed above.

3.4. Trip distribution

Directional distribution of traffic growth from within the Riverwood Estate has been based on the trip distribution derived from the STM cordons. A summary of the 2031 and 2041 trip distribution to/from Riverwood Estate is provided in Table 3.2 and Table 3.3 respectively.

Table 3.2: 2031 trip distribution to/from proposed development based on STM

Primary access point to (inbound) and from (outbound) proposed development	Morning Peak		Evening Peak	
	Inbound	Outbound	Inbound	Outbound
South Western Motorway/M5 (west of development)	4%	5%	4%	5%
Belmore Road (north of development)	34%	43%	35%	38%
Bonds Road (north of development)	4%	4%	6%	6%
South Western Motorway/M5 (east of development)	<1%	<1%	<1%	<1%
Hannans Road	24%	25%	24%	20%
Broad Arrow Road	1%	<1%	1%	1%
Meadowland Road	<1%	<1%	<1%	<1%
Forest Road (east of development)	1%	1%	1%	<1%
Boundary Road	2%	2%	2%	2%
Forest Road (south of development)	<1%	<1%	<1%	1%
Belmore Road (south of development)	2%	1%	2%	2%
Henry Lawson Drive	11%	4%	6%	7%

Table 3.3: 2041 trip distribution to/from proposed development based on STM

Primary access point to (inbound) and from (outbound) proposed development	Morning Peak		Evening Peak	
	Inbound	Outbound	Inbound	Outbound
South Western Motorway/M5 (west of development)	7%	6%	6%	6%
Belmore Road (north of development)	35%	39%	35%	37%
Bonds Road (north of development)	4%	6%	6%	6%
South Western Motorway/M5 (east of development)	<1%	<1%	<1%	<1%
Hannans Road	22%	25%	24%	20%
Broad Arrow Road	1%	<1%	1%	1%
Meadowland Road	<1%	<1%	<1%	<1%
Forest Road (east of development)	<1%	2%	1%	1%
Boundary Road	2%	2%	2%	2%
Forest Road (south of development)	<1%	<1%	<1%	1%
Belmore Road (south of development)	2%	1%	2%	2%
Henry Lawson Drive	10%	4%	5%	6%

3.5. Road Network Assumptions

The recently completed east facing ramps at the Belmore Road / M5 interchange and the eastbound off ramp upgrade (compared to the 2017 base year model) are included in all future scenarios, although the modelling has been done with the previous anticipated layout. All other road network upgrades identified in this report have been determined through the traffic modelling process.

For the current work, initial interim and ultimate year Aimsun networks have been taken from the 2018 investigations. Traffic signal phase times have been adjusted to better match the updated flow patterns, and the network performance has been checked to confirm whether the previously identified upgrades are adequate, or any further improvements would be required (whether expanding treatments in those locations or improving other locations). The final upgraded intersection performance statistics have not significantly improved, with Levels of Service equal to or worse than previously identified, indicating that the same locations still require treatment.

3.6. Desired Standard of Service

The functional performance of intersections surrounding the Riverwood Estate has been assessed on the basis of Level of Service. Level of Service for intersection is based on:

- Average delay of all movements for signalised intersections
- Average delay of the worst movement (or approach) for roundabouts, give way and stop signs.

A summary of the intersection Level of Service, as defined by NSW Roads and Maritime Services is provided in Table 3.4.

Table 3.4 : Level of Service criteria for intersections

Level of Service	Average Delay per Vehicle (sec)	Traffic Signals. Roundabouts	Give way & Stop Signs
A	<14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 to 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity & accident study required
E	57 to 70	At capacity, incidents would cause excessive delays at signals Roundabouts require other control modes	At capacity, requires other control mode
F	>70	Over Capacity; unstable operation	Over capacity; unstable operation.

Source: RTA Guide to Traffic Generating Developments (2002)

To assess the requirements for upgrade works surrounding the Riverwood Estate, the performance of the road network under the forecast traffic demand associated with the development has been assessed according to the same criteria as the 2018 work, namely:

- Intersections that currently perform at Level of Service D or better to maintain this operation
- Intersections that currently perform worse than Level of Service D not to exceed existing average delays

These criteria apply to both morning and evening peak hours.

Where possible, the recommendation of upgrade works has considered constraints including downstream capacity, structural constraints (such as bridge, retaining walls and existing structures) and land acquisition and sought to minimise the impacts on these constraints.

4. 2031 Road Network Performance (Interim Year)

A summary of existing and 2031 intersection performance of the key intersections in the Riverwood area with and without the proposed development is shown in Table 4.1 and Table 4.2.

Table 4.1: Morning peak intersection performance (existing versus 2031)

Location	Existing performance		Future 2031 performance			
			Background growth only		Background growth + Riverwood Estate	
	Average Delay (sec)	LoS	Average Delay (sec)	LoS	Average Delay (sec)	LoS
Belmore Road/Hannans Road	25	B	29	C	31	C
Belmore Road/M5	14	A	18	B	18	B
Belmore Road/Roosevelt Avenue	24	B	16	B	13	A
Belmore Road/Thurlow Street	39	C	32	C	27	B
Bonds Road/Broad Arrow Road	106	F	43	C	54	D
Bonds Road/Hannans Road	32	C	34	C	47	D
Bonds Road/Romilly Street	10	A	38	C	52	D
Forest Road/Boundary Road/Bonds Road	106	F	42	C	43	D
Henry Lawson Drive/Belmore Road	24	B	28	B	27	B

Table 4.2: Evening peak intersection performance (existing versus 2031)

Location	Existing performance		Future 2031 performance			
			Background growth only		Background growth + Riverwood Estate	
	Average Delay	LoS	Average Delay	LoS	Average Delay	LoS
Belmore Road/Hannans Road	20	B	24	B	25	B
Belmore Road/M5	14	A	17	B	17	B
Belmore Road/Roosevelt Avenue	43	C	8	A	10	A
Belmore Road/Thurlow Street	28	B	27	B	30	C
Bonds Road/Broad Arrow Road	11	A	36	C	55	D
Bonds Road/Hannans Road	31	C	45	D	34	C
Bonds Road/Romilly Street	14	A	33	C	37	C
Forest Road/Boundary Road/Bonds Road	102	F	48	D	44	D
Henry Lawson Drive/Belmore Road	42	C	41	C	45	D

The modelled intersection performance shows that with the proposed 2031 network upgrades all the intersections can achieve the desired standard of service. The proposed works that would be required to support the Riverwood Estate development and background growth in 2031 is further discussed in Section 6.

5. 2041 Road Network Performance (Ultimate Year)

A summary of existing and 2041 intersection performance of the key intersections in the Riverwood area with and without the proposed development is shown in Table 5.1 and Table 5.2.

Table 5.1: Morning peak intersection performance (existing versus 2041)

Location	Existing performance		Future 2041 performance			
			Background growth only		Background growth + Riverwood Estate	
	Average Delay (sec)	LoS	Average Delay (sec)	LoS	Average Delay (sec)	LoS
Belmore Road/Hannans Road	25	B	31	C	36	C
Belmore Road/M5	14	A	18	B	19	B
Belmore Road/Roosevelt Avenue	24	B	20	B	20	B
Belmore Road/Thurlow Street	39	C	28	B	43	C
Bonds Road/Broad Arrow Road	106	F	45	D	56	D
Bonds Road/Hannans Road	32	C	43	D	47	D
Bonds Road/Romilly Street	10	A	36	C	41	C
Forest Road/Boundary Road/Bonds Road	106	F	49	D	56	D
Henry Lawson Drive/Belmore Road	24	B	29	B	34	C

Table 5.2: Evening peak intersection performance (existing versus 2041)

Location	Existing performance		Future 2041 performance			
			Background growth only		Background growth + Riverwood Estate	
	Average Delay	LoS	Average Delay	LoS	Average Delay	LoS
Belmore Road/Hannans Road	20	B	25	B	27	B
Belmore Road/M5	14	A	20	B	19	B
Belmore Road/Roosevelt Avenue	43	C	19	B	21	B
Belmore Road/Thurlow Street	28	B	29	C	30	C
Bonds Road/Broad Arrow Road	11	A	52	D	34	C
Bonds Road/Hannans Road	31	C	42	C	49	D
Bonds Road/Romilly Street	14	A	38	C	41	C
Forest Road/Boundary Road/Bonds Road	102	F	49	D	53	D
Henry Lawson Drive/Belmore Road	42	C	47	D	56	D

The modelled intersection performance shows that with the proposed network upgrades all the intersections in 2041 can achieve the desired standard of service.

As noted in Section 3.5, the ultimate year Aimsun network was initially based on the ultimate upgraded network identified in 2018, with signal timing adjustments to improve performance. The only location at which this was not sufficient to meet the target performance criteria was the Forest Road / Boundary Road / Bonds Road intersection. It was found that increasing the length of the proposed right turn lane on Bonds Road to approximately 75 m would allow the performance criteria to be met. However, this may require land acquisition.

If the previously identified intersection layout were adopted, with a 25 m right turn pocket on Bonds Road, modelling indicates that including the Riverwood Estate volumes, in the AM peak the average delay would be 65 seconds, with LOS E. This includes LOS F on the southern approach (78 seconds delay). In the PM peak, the performance criteria would be met, with an average delay of 56 seconds and LOS D (62 seconds and LOS D on the northern approach).

The proposed works that would be required to support the Riverwood Estate development and background growth in 2041 is further discussed in Section 6.

6. Summary of Works

A summary of the proposed works required to support the Riverwood Estate development and background growth in 2031and 2041 is provided in Table 6.1. Plots of intersection works are provided in Appendix A. Additional modelling and option testing was undertaken for the intersection of Belmore Road/Roosevelt Avenue to accommodate a right turn bay in the southbound direction of Belmore Road to Roosevelt Avenue - Option 2. Jacobs report dated 8 July 2021 provides the results of this assessment.

Most of the works required for 2031 are sufficient to also support forecast 2041 traffic volumes, with the exception of:

- Belmore Rd/Roosevelt Rd intersection upgrade
- Bonds Rd/Hannans Rd intersection upgrade

Additional works would be required at these locations to support further growth in traffic volumes from 2031 to 2041.

In most cases, the 'Interim' and 'Ultimate' network improvements identified in the 2018 work met performance targets with the updated demands, with only signal timing refinements needed to accommodate the changed flow patterns.

The only exception was at Bonds Road / Forest Road / Boundary Road. For that intersection, the previous study indicated an average delay of 60 seconds and Level of Service E in the AM peak, for the 2036 scenario with Riverwood Estate. The updated 2041 demands indicated with the previous layout. It was found that extending the right turn bay on the north-western approach by a further 50 m (total 75 m) would allow the LOS threshold to be achieved, and this is reflected in the current 'Ultimate' modelling. However, as noted in Section 5, this may require land acquisition, so its priority and timing would need further consideration.

Table 6.1 : Summary of required works for LAHC site

ID	Location	Works required	Works required in 2031	Works required in 2041
1[1]	Belmore Rd/Hannans Rd/Washington Ave	Intersection upgrade	• Widen southern approach to allow for 2 through lanes and one right turn lane • Widen northern approach to 3 lanes for 100m • Widen the eastern approach to provide additional 75m right turn lane • Turn Washington Ave to left in left out • Ban right turn onto Hannans Rd from Washington Ave • Move pedestrian crossing from south of Hannans Rd to south of Washington Ave	▪ As per 2031
2[1]	Belmore Rd/Roosevelt Ave	Intersection upgrade	▪ No upgrade works required	• Upgrade to traffic signals • Ban parking on Roosevelt Ave from Washington Ave to Belmore Rd in the eastbound direction ▪ Ban parking on Belmore Rd from Truman Ave to Washington Ave in both directions
3[1]	Bonds Rd/Hannans Rd	Intersection upgrade	• Ban parking on Hannans Road from Bonds Road to Mazarin Street in the eastbound direction	▪ As per 2031 ▪ Widen western approach to provide additional 50m right turn only lane

ID	Location	Works required	Works required in 2031	Works required in 2041
4	Bonds Rd/Broad Arrow Rd	Intersection upgrade	• Upgrade to traffic signals • Provide right turn bays on all approaches (50m on the northern and eastern approaches, 25m on the southern and western approaches)	▪ As per 2031
5	Bonds Rd/Romilly St	Intersection upgrade	• Upgrade to traffic signals • Provide right turn bays on Romilly St, Talbot St, and Bonds Road southern approach • Provide left turn bay on Bonds Road northern approach • Turn Larkhill Avenue to left in/left[2]	▪ As per 2031
6	Bonds Rd/Forest Rd/Boundary Rd	Intersection upgrade	• Widen south-eastern approach to provide right turn lane • Widen north-western approach to provide right turn lane flare of 25 m • Ban parking on Bonds Rd for 270m prior to Forest Rd • Move bus stop TSN221020 ('Forest Rd at Bonds Rd') 45m further east along Forest Rd (this was implemented in late 2018, with the stop now called 'Forest Rd at Collaroy Ave') • Extend right turn bay on the south-western approach to Hugh Ave • Extend right turn bay on the north-eastern approach by 50m	▪ Extended right turn flare on north-western approach by 50m – (total 75m)

1. Belmore Road Option 1. Option 2 involves provision of a right turn bay in Belmore Road into Roosevelt Avenue
2. Left in/out arrangement based on advice from LAHC to avoid property impact

7. Apportionment

7.1. Nexus between Proposed Development and Background Demand

An assessment of the apportionment of the required road network upgrades required to support the proposed development and the background growth is provided in Table 7.1. This apportionment has been based on the volumes of traffic for the ultimate 2041 year from each development using each of the intersections identified for upgrade works.

For comparative purposes the future intersection performance of the road network without the proposed upgrades ('Do Minimum') is provided in Appendix B. In these scenarios, as the forecast demand exceeds capacity at a number of key locations, the models are unable to converge on a stable result. This results in network gridlock and vehicles experiences unrealistic levels of delays.

For the 2041 'Do Minimum' network with background growth and development demand the model is unable to release all of the traffic demand into the network, with over 500 and 2400 vehicles still waiting to enter the network at the end of the morning and evening simulation periods respectively.

In the AM peak the traffic unable to enter the network is concentrated on Boundary Road and (once the right turn at Henry Lawson Drive is blocked by downstream queueing) on Forest Road south. In the PM peak it is primarily on Forest Road east and on Boundary Road.

This is due to extensive queues originating from the following intersections:

- Most critically, Bonds Road / Forest Road / Boundary Road
- In the PM peak, secondary contributions from Belmore Road and Hannans Road, Belmore Road and Thurlow Street, and Bonds Road and Hannans Road

These results indicate that the forecast demand generated by background growth exceeds the available road capacity and any direct comparisons with individual intersection performance between these models should not be made other than to validate the need for proposed network upgrades.

7.2. Apportionment philosophy

In order to inform the nexus between the proposed development and infrastructure required to support forecast traffic growth, a philosophy for determining the contribution to required road works in the study area has been developed. The key elements of this philosophy are as follows:

- Assess the existing performance of intersections. This sets the desired standards of service, as noted in Section 3.6.
- Assign background growth traffic and proposed development traffic to the network to determine the works required to support each component of traffic growth.

For upgrades that serve both background growth and the proposed development, determine the apportionment based on the proportion of total traffic volumes.

7.3. Summary of Apportiontment for 2041 traffic volumes

The proposed road infrastructure works to be provided to meet the demands generated by both background growth and the proposed development site are listed in Table 7.1 below. The respective locations of the proposed road network upgrades are shown in Appendix A.

Table 7.1 : Summary of road network upgrades and apportionment

ID	Location	Works description	Background apportionment	Development apportionment
6	Forest Rd/Boundary Rd/Bonds Rd	Intersection upgrade	93%	7%
3	Bonds Rd/Hannans Rd	Intersection Upgrade	44%	56%
1	Belmore Rd/Hannans Rd	Intersection upgrade	80%	20%
7	Belmore Rd/M5	Intersection upgrade	59%	41%
4	Bonds Rd/Broad Arrow Rd	Intersection upgrade	79%	21%
5	Bonds Rd/Romilly St	Intersection upgrade	10%	90%
2	Belmore Rd/Roosevelt Ave	Intersection Upgrade	44%	56%

Appendix A. Intersection upgrade plots

Figure A-1 : Belmore Road/Hannans Road/Washington Avenue (2031 and 2041)

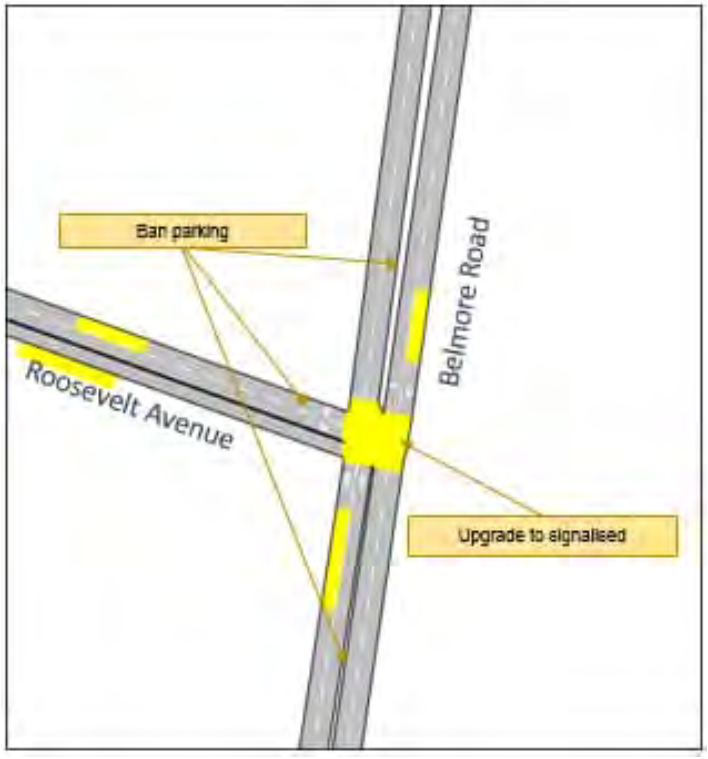

Figure A-2 : Belmore Road/Roosevelt Avenue (2041)

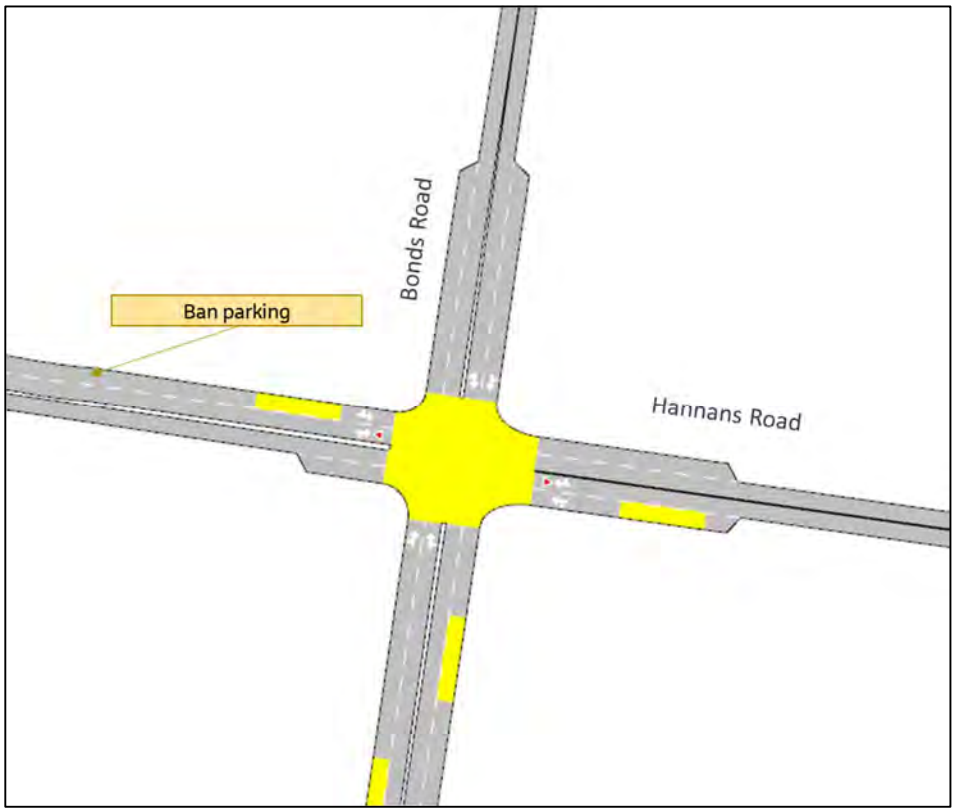

Figure A-3 : Bonds Road/Hannans Road (2031)

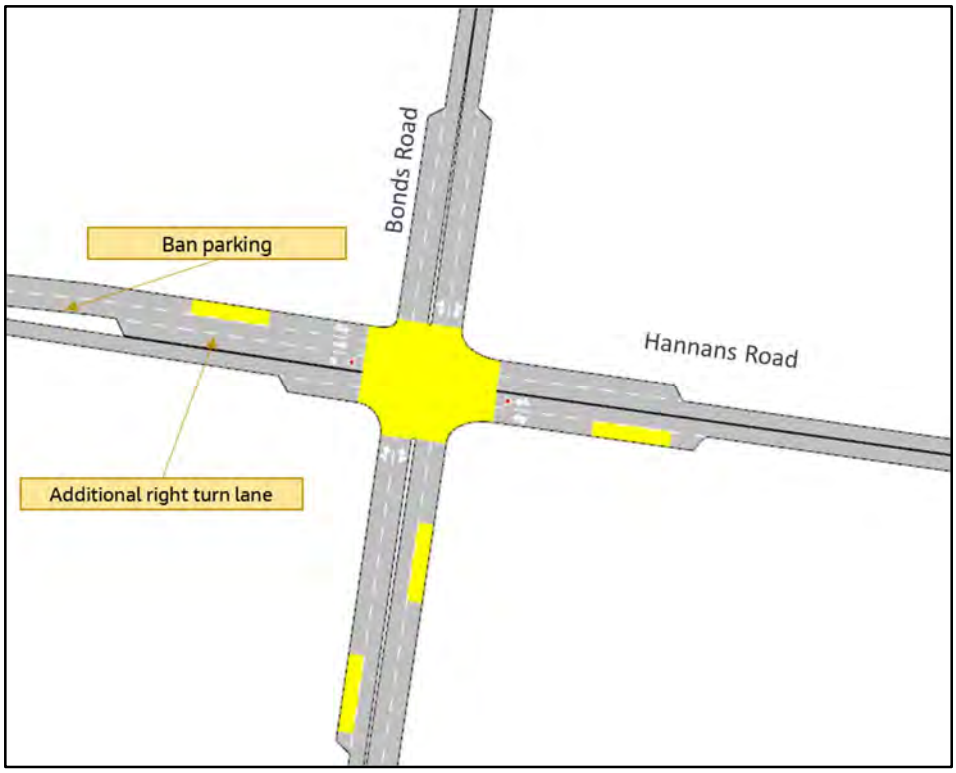

Figure A-4 : Bonds Road/Hannans Road (2041)

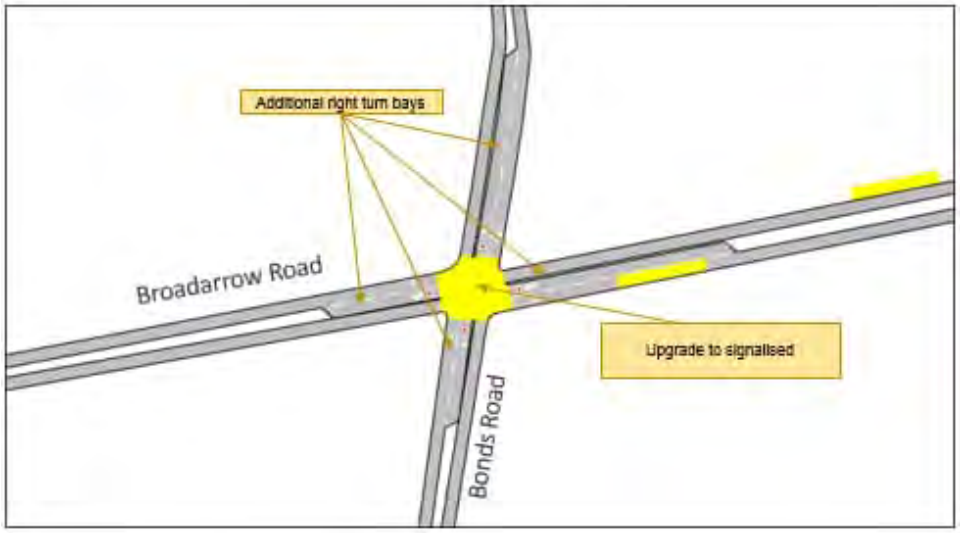

Figure A-5 : Bonds Road/Broad Arrow Street (2031 and 2041)

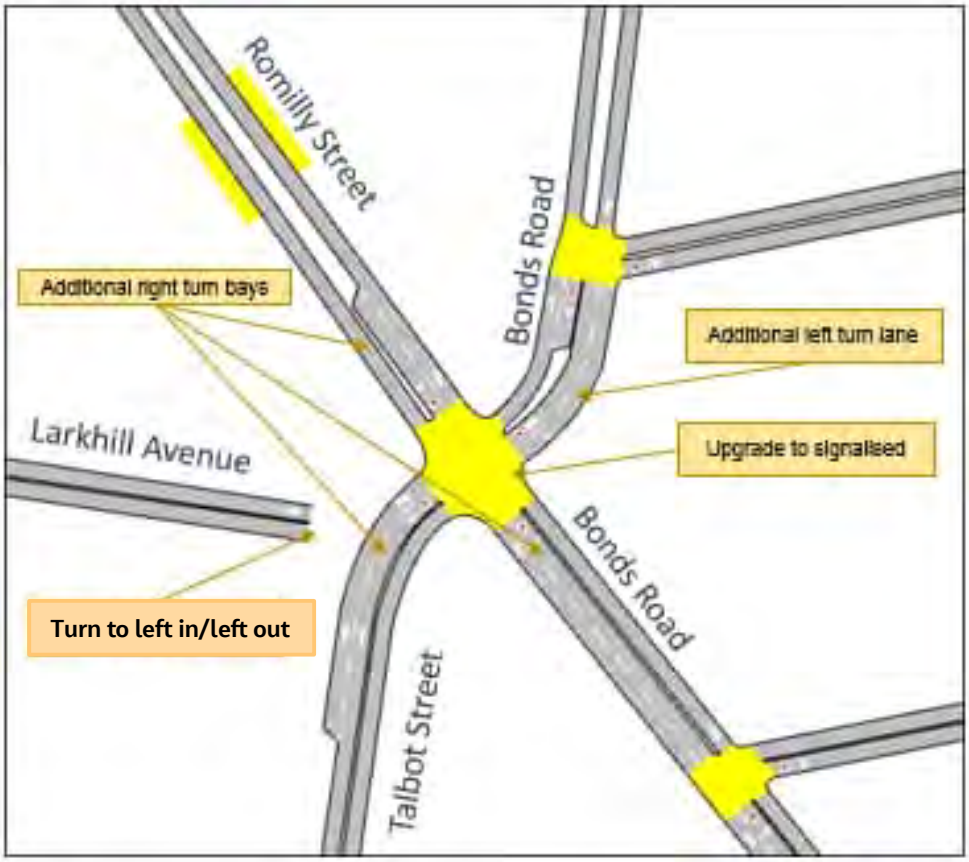

Figure A-6 : Bonds Road/Romilly Street (2031 and 2041)

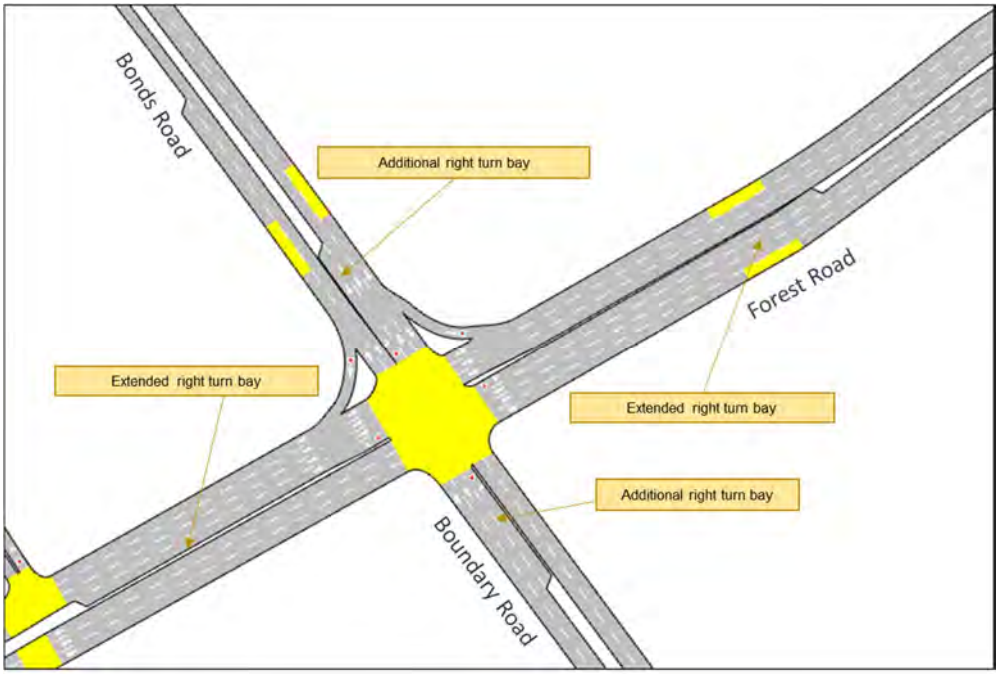

Figure A-7 : Bonds Road/Forest Road/Boundary Road (2031)

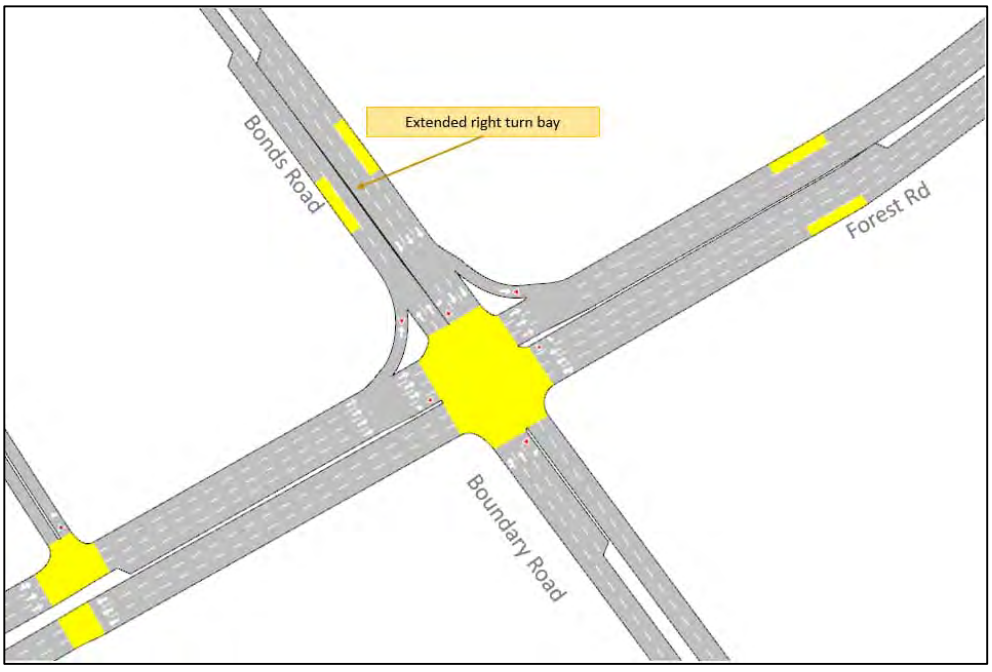

Figure A-8 : Bonds Road/Forest Road/Boundary Road (2041)

Appendix B. Without upgrades ('Do Minimum') road network performance

Note, some intersections in 2041 with the higher forecast demand appear to produce better network outcomes when compared to 2031. This is due to the network gridlock in these model runs as described in Section 7.1.

As such any direct comparisons with individual intersection performance between these models should not be made other than to validate the need for proposed network upgrades documented in the main body of this report.

Maximum network density plots and graphs of vehicles blocked from entering the network are also presented to illustrate the performance issues in the do minimum scenarios.

Table B.1: 2031 morning peak intersection performance (without upgrades 'Do Minimum' network)

Location	2031 without upgrades ('Do Minimum') road network			
	Background growth only		Background growth + Riverwood Estate	
	Average Delay	LoS	Average Delay	LoS
Belmore Road/Hannans Road	26	B	27	B
Belmore Road/M5	16	B	15	A
Belmore Road/Roosevelt Avenue	48	D	33	C
Belmore Road/Thurlow Street	42	C	43	C
Bonds Road/Broad Arrow Road	43	C	50	D
Bonds Road/Hannans Road	32	C	32	C
Bonds Road/Romilly Street	13	A	20	B
Forest Road/Boundary Road/Bonds Road	125	F	117	F
Henry Lawson Drive/Belmore Road	27	B	28	B

Table B.2: 2031 evening peak intersection performance (without upgrades 'Do Minimum' network)

Location	2031 without upgrades ('Do Minimum') road network			
	Background growth only		Background growth + Riverwood Estate	
	Average Delay	LoS	Average Delay	LoS
Belmore Road/Hannans Road	24	B	26	B
Belmore Road/M5	15	A	14	A
Belmore Road/Roosevelt Avenue	13	A	10	A
Belmore Road/Thurlow Street	32	C	31	C
Bonds Road/Broad Arrow Road	11	A	12	A
Bonds Road/Hannans Road	31	C	31	C
Bonds Road/Romilly Street	13	A	18	B
Forest Road/Boundary Road/Bonds Road	158	F	155	F
Henry Lawson Drive/Belmore Road	42	C	41	C

Table B.3: 2041 morning peak intersection performance (without upgrades 'Do Minimum' network)

Location	2041 without upgrades ('Do Minimum') road network			
	Background growth only		Background growth + Riverwood Estate	
	Average Delay	LoS	Average Delay	LoS
Belmore Road/Hannans Road	36	C	76	F
Belmore Road/M5	17	B	17	B
Belmore Road/Roosevelt Avenue	41	C	27	B
Belmore Road/Thurlow Street	45	D	48	D
Bonds Road/Broad Arrow Road	46	D	97	F
Bonds Road/Hannans Road	33	C	38	C
Bonds Road/Romilly Street	15	A	27	B
Forest Road/Boundary Road/Bonds Road	137	F	139	F
Henry Lawson Drive/Belmore Road	31	C	30	C

Table B.4: 2041 evening peak intersection performance (without upgrades 'Do Minimum' network)

Location	2041 without upgrades ('Do Minimum') road network			
	Background growth only		Background growth + Riverwood Estate	
	Average Delay	LoS	Average Delay	LoS
Belmore Road/Hannans Road	27	B	48	D
Belmore Road/M5	16	B	20	B
Belmore Road/Roosevelt Avenue	13	A	61	E
Belmore Road/Thurlow Street	29	B	52	D
Bonds Road/Broad Arrow Road	20	B	21	B
Bonds Road/Hannans Road	33	C	37	C
Bonds Road/Romilly Street	16	B	13	A
Forest Road/Boundary Road/Bonds Road	160	F	156	F
Henry Lawson Drive/Belmore Road	48	D	58	E

Figure B.1: Maximum density plot – 2041 AM peak, background growth + Riverwood Estate, Do Minimum network

Figure B.2: Maximum density plot – 2041 PM peak, background growth + Riverwood Estate, Do Minimum network

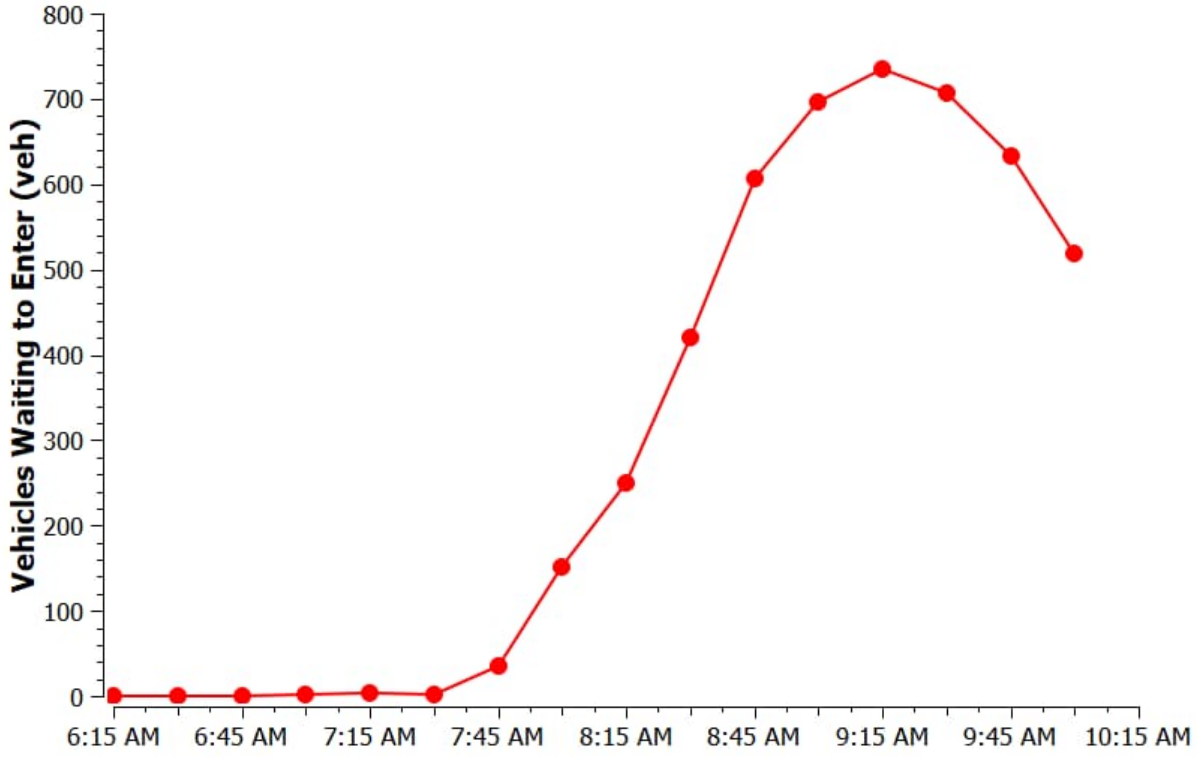

Figure B.3: Blocked traffic – 2041 AM peak, background growth + Riverwood Estate, Do Minimum network

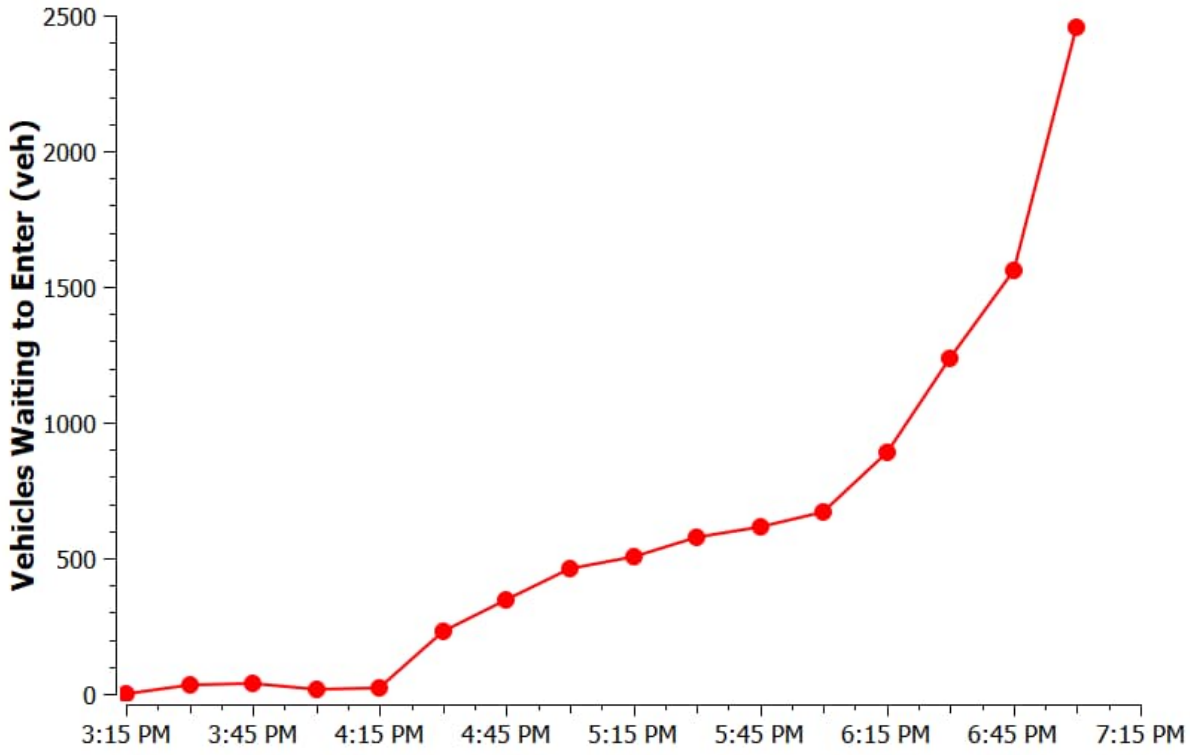

Figure B.4: Blocked traffic – 2041 PM peak, background growth + Riverwood Estate, Do Minimum network

Appendix C. M5 Eastern Ramps sensitivity test

As noted in Section 3.2, the cordon matrices provided by TfNSW from the STM model did not indicate any usage of the eastern ramps of the M5 / Belmore Road interchange.

The modelling carried out in 2018 indicated that the usage of these ramps was relatively low, particularly compared to the west facing ramps. However, a sensitivity test has been carried out to explore whether usage of these ramps is likely to affect the infrastructure needs identified in Section 6.

The sensitivity test has been carried out for a 2041 background growth plus Riverwood development demand level, using the ultimate road network as in Section 5.

The sensitivity test shifted demand from competing northbound and eastbound routes to the M5 eastern ramps, drawing on the ultimate year network background plus project demand modelling from 2018.

C.1 Test methodology

The process followed to adjust the 2041 demand matrices was:

- Run path analysis on each ramp (eastbound on ramp and westbound off ramp), for AM and PM, in the previous model, to identify the source zones for the traffic using them.
- For each source zone, identify the percentage of trips between that zone and each of the northern and eastern externals in both the previous and updated AM and PM ultimate demands.
- Both northern and eastern alternatives are included as Bonds Road and Belmore Road connect to Canterbury Road which is a potential inbound route. The most direct alternative parallel to the M5, Hannans Road, carries less of this traffic in the peak direction in the newer cordons, and only slightly more in the counter peak direction, suggesting it does not offer a simple substitution for the ramp traffic.
- Trips to be shifted to the M5E are taken off only the competing routes which have increased in importance for that source zone (attract a higher percentage of the north and east external trip ends for that zone) compared to the previous modelling which included these ramps. Trips between the source zone and northern and eastern externals which have decreased in importance for that source in the updated demands have not been changed for this sensitivity test.
- The reduction in demand between each source zone and the affected northern and eastern externals is proportional to the increase in importance of the external. Thus for example if external A carries 20% more of the total north/eastbound traffic from a particular source zone than in the previous ultimate demand, while external B carries 10% more and external C carries 10% less, twice as much traffic will be shifted away from external B than external A, while traffic to external C will not be changed.
- The shifts are calculated to make the M5 ramps carry the same proportion of north/east bound traffic for each source zone as they did in the previous (2018) modelling.
- Traffic between the source zones and the eastern M5 is added to each time interval matrix.
- Traffic between the source zones and the competing routes is reduced by multiplying the cell value for all time intervals by the appropriate factor for the shifts described above.
- The changes are applied only to car matrices, as the previous modelling showed negligible use of these ramps by heavy vehicles (only one truck eastbound in the AM modelled period and one westbound in the PM, with no heavy trucks).

The resulting demand matrices have been run in the 2041 Ultimate Year network, with signal timings adjusted to improve performance with the changed flow patterns.

No changes have been made to the layout of the upgraded intersections.

C.2 Test results

A summary of the performance of the key intersections in the sensitivity test case, compared to the existing conditions (base year) model and the results from Section 5, is shown in Table C.1 and Table C.2 below.

Table C.1: Morning peak intersection performance, ultimate year – standard vs sensitivity test results

Location	Existing performance		Future 2041 performance			
			STM Cordon Scenario		M5 East Ramps Sensitivity Test	
	Average Delay (sec)	LoS	Average Delay (sec)	LoS	Average Delay (sec)	LoS
Belmore Road/ Hannans Road	25	B	36	C	33	C
Belmore Road/ M5	14	A	19	B	17	B
Belmore Road/ Roosevelt Avenue	24	B	20	B	27	B
Belmore Road/ Thurlow Street	39	C	43	C	44	D
Bonds Road/ Broadarrow Road	106	F	56	D	46	D
Bonds Road/ Hannans Road	32	C	47	D	50	D
Bonds Road/ Romilly Street	10	A	41	C	43	D
Forest Road/ Boundary Road/ Bonds Road	106	F	56	D	45	D
Henry Lawson Drive/ Belmore Road	24	B	34	C	39	C

Table C.2: Evening peak intersection performance, ultimate year – standard vs sensitivity test results

Location	Existing performance		Future 2041 performance			
			STM Cordon Scenario		M5 East Ramps Sensitivity Test	
	Average Delay (sec)	LoS	Average Delay (sec)	LoS	Average Delay (sec)	LoS
Belmore Road/ Hannans Road	20	B	27	B	29	B
Belmore Road/ M5	14	A	19	B	19	B
Belmore Road/ Roosevelt Avenue	43	C	21	B	19	B
Belmore Road/ Thurlow Street	28	B	30	C	30	C
Bonds Road/ Broadarrow Road	11	A	34	C	37	C
Bonds Road/ Hannans Road	31	C	49	D	46	D
Bonds Road/ Romilly Street	14	A	41	C	35	C
Forest Road/ Boundary Road/ Bonds Road	102	F	53	D	48	D
Henry Lawson Drive/ Belmore Road	42	C	56	D	51	D

The results indicate similar levels of performance at all intersections in the two cases. There are some small changes in average delay, but no intersections show an improvement in Level of Service in the sensitivity test case, and all remain within the performance targets.

C.3 Conclusions

The sensitivity test results indicate that the impact of the M5 eastern ramps at the Belmore Road interchange is not expected to affect the infrastructure requirements identified in Section 6. All intersections perform to the standard identified in Section 3.6, and none improve sufficiently compared to the Section 5 results to reduce the identified upgrades.

In particular, the extra 50m extension to the right turn lane on Bonds Road approaching Forest Road (for a total of 75m storage), which was the only change identified in the updated modelling compared to the 2018 recommendations, would still be required.

Overall, the M5 Eastern Ramps sensitivity test results support the upgrades identified in Section 6.

Appendix D

Traffic Volume Flow Plots (Jacobs)

Riverwood Future Model with Proposed Upgrades
Traffic Volume Flow Plots (veh/h)

2041 LAHC (background growth and Proposed development) - M5E Ramps Sensitivity Test
Peak morning (8-9am)

Riverwood Future Model with Proposed Upgrades
Traffic Volume Flow Plots (veh/h)

2041 LAHC (background growth and Proposed development) - M5E Ramps Sensitivity Test
Peak evening (5-6am)

Appendix E

Additional Modelling for a Right Turn Bay on Belmore Road at the Roosevelt Avenue intersection

Riverwood Estate Traffic Modelling

Belmore Rd N/Roosevelt Ave Intersection Option Test

| 2

13 July 2021

The Transport Planning Partnership Pty Ltd

Riverwood Estate Traffic Modelling

Project No:	IA195800
Document Title:	Belmore Rd N/Roosevelt Ave Intersection
Document No.:	
Revision:	2
Date:	13 July 2021
Client Name:	The Transport Planning Partnership Pty Ltd
Client No:	
Project Manager:	Miliss Mansour
Author:	Atanu Das
File Name:	20210707 Riverwood Estate -Roosevelt Avenue_Belmore Road Junction Option Test Report_V2.2

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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
Rev 1	07/07/2021	Roosevelt Avenue_Belmore Road Junction Option Test	A. Das	A. Das	M. Mansour	M. Mansour
Rev 2	13/07/2021	Right turn lane into Roosevelt Ave		M. Mansour		

Contents

1. Introduction

This technical report outlines the findings of a recent investigation undertaken by Jacobs Group (Australia) Pty Ltd to assess a proposal to signalise the intersection of Roosevelt Avenue/Belmore Road and advice whether a right turn short lane in Belmore Road north is required and its length to avoid long queues and adversely impacting the nearby intersections.

1.1. Background

Currently there are queues in Belmore Road North that extend back to Hannans Road from this intersection. SIDRA and Aimsun platforms have been used to determine optimal signal timing and intersection layout operating under traffic signal control and future flows. Figure 1-1 provides a basic layout of the intersection for the purpose of further development.

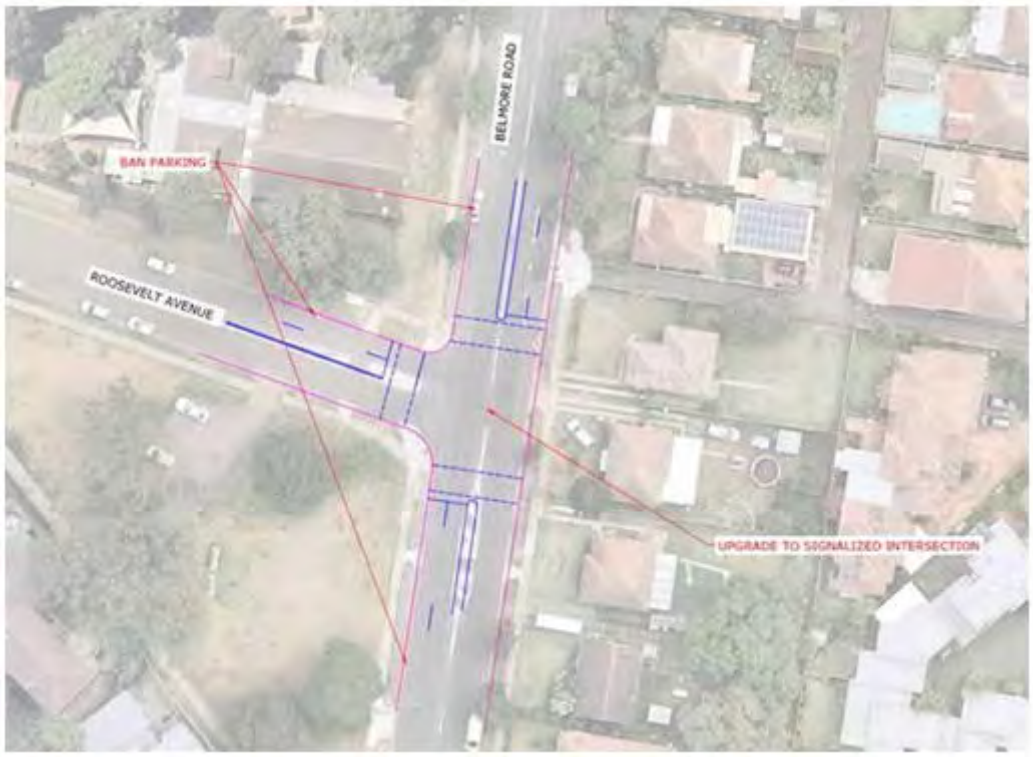

Figure 1-1: Indicative Belmore Road and Roosevelt Avenue intersection layout

LAHC has requested a high level advice in relation to indicative length of the right turn bay and a preferred intersection layout for their discussion with stakeholders. If a right turn lane is deemed necessary, realignment of Belmore Road to the west, rather than to the east is considered preferrable to accommodate the extra lane.

2. Traffic Modelling

This section outlines the modelling approach, inputs and options details that were developed.

2.1. Modelling Methodology

SIDRA and AIMSUN modelling tools were used for the assessment. Table 2.1 outlines the inputs and outputs derived from each model.

Table 2.1: Summary of SIDRA and AIMSUN Modelling purpose, inputs and performance measures

	SIDRA	AIMSUN
Purpose	▪ Testing of various geometric layouts ▪ Optimising signal plan and signal timing	▪ Existing Aimsun model was used to test the wider network performances ▪ Used to estimate average delay and comparing with existing test model (without considering north right turn lane) ▪ Visualise the queue to understand site specific problems and simulated density
Input	▪ Layout - based on drawings and google map ▪ Demand – Peak hour demands extracted from 2041 project upgraded demand (including full Riverwood development trips) ▪ Signal Plan – Based on demand (vehicular and pedestrian) and optimised using SIDRA	▪ Layout - based on existing model and SIDRA layout for the intersection ▪ Demand – 2041 project upgraded demand (including full Riverwood development trips) ▪ Signal Plan – based on SIDRA
Performance measures	▪ Average delay ▪ Queue length ▪ Degree of saturation	▪ Average delay (extracted from Aimsun through sub-paths) ▪ Simulated density (using Aimsun view mode to visualise vehicles density)

The first step involved developing SIDRA scenarios to determine signal timings and different intersection option layouts. This was followed by testing the existing/preferred option in Aimsun using the basic inputs from the SIDRA models. The combined use of SIDRA and Aimsun helped to optimise the intersection and understand the wider network impacts.

2.2. General Assumptions

Below is an outline of assumptions that were adopted during this study.

- 2041 demand flows with full Riverwood development traffic
- Cycle time of 120 seconds to remain consistent with nearby signalised intersections.
- Inclusion of pedestrian crossing movements and assumption of 100 ped/hr on each leg in the AM and PM with all pedestrian phases called in at every cycle
- Inclusion of 5 sec late start of green for Roosevelt Avenue phase for safe crossing of pedestrians
- Right turn filter on the northern right turn lane permitted

2.3. SIDRA Modelling Options

SIDRA scenarios were developed for the options shown below. Three scenarios for the AM and 2 scenarios for PM peak hours were tested. As Belmore North arm has existing Clearway parking restriction between 3-7pm on weekdays, Option 1 and option 2 are the same in the PM model.

Table 2.2 shows the details of each option.

Table 2.2: Summary of proposed options for Belmore Road and Roosevelt Avenue

Approach	Option 1	Option 2	Option 3
Belmore Road North (northbound)	▪ One through traffic lane and ▪ 55 m traffic lane for straight and left turn movement	▪ Same as option 1	▪ Two continuous traffic lanes (no parking allowed)
Belmore Road North (southbound)	▪ One shared traffic lane (straight and right turn) and ▪ One short lane for through movement. Retain kerb side parking and bus zone in AM peak as per existing	▪ Two traffic lanes, comprising one through and one dedicated short right turn lane	▪ Two traffic lanes and right turn flare lane
Roosevelt Avenue	▪ Two traffic lanes	Same as option 1	▪ Same as option 1
Pedestrian Crossing	▪ All three arms	▪ Same as option 1	▪ Same as option 1

The layout of the three options are illustrated in Figure 2-1.

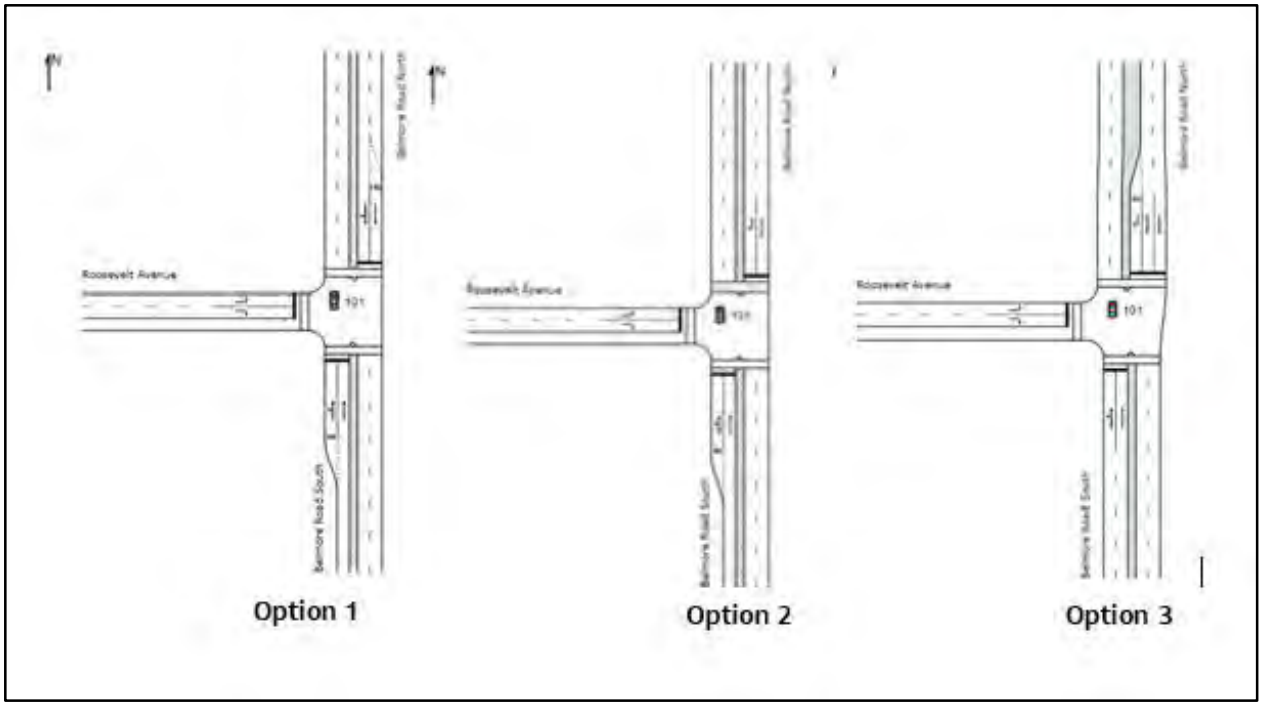

Figure 2-1: SIDRA Modelling Options Layouts

The adopted phasing is shown in Figure 2-2

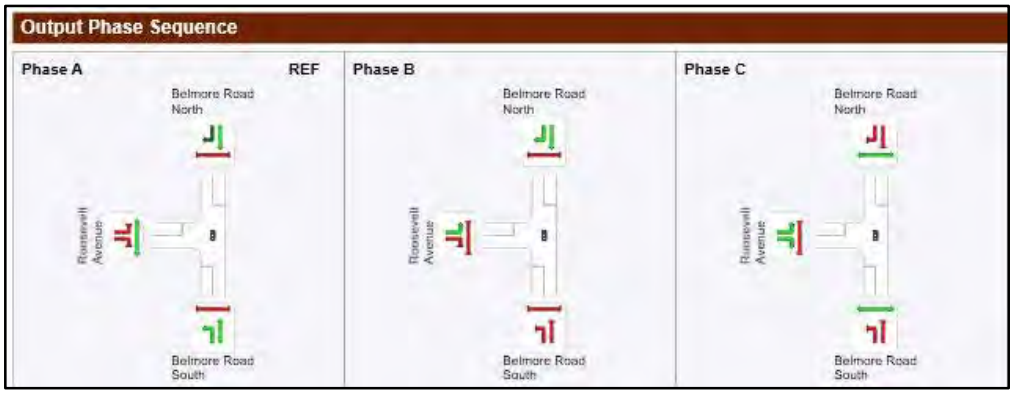

Figure 2-2: Proposed Signal Plan AM and PM Peaks Belmore Road N / Roosevelt Avenue

2.4. Performance Indicators

The assessment of the intersection was undertaken using the criteria outlined in Table 2.3. This criterion was used for assessment of SIDRA and AIMSUN modelling outcomes.

The average vehicle delay was considered in the assessment of signalised intersections for all movements and is expressed in seconds per vehicle. It is generally accepted that the target Level of Service (LoS) for intersection performance should be D or better. However, when assessing intersection performance for parts of the road network that already experience substantial congestion over the course of the day or with future demand, achieving Level of Service D or better may not represent good value for money, or not be physically possible within the constraints of the project.

Table 2.3: Level of Service (LoS) criteria for intersections

LoS	Average delay per vehicle (seconds / vehicle)	Traffic signals and roundabouts
A	Less than 15	Good operation
B	15 to 28	Good with acceptable delays and spare capacity
C	29 to 42	Satisfactory
D	43 to 56	Operating near capacity
E	57 to 70	At capacity, at signals, incidents will cause delays Roundabouts require other control mode
F	Over 70	Extra capacity required

Source: Roads and Traffic Authority (2002) Guide to Traffic Generating Developments

With traffic signals, delays per approach are equalised subject to any overriding requirements of signal co-ordination as well as to variations within individual movements.

The performance of the road network under the forecast traffic demand associated with the development has been assessed according to the same criteria as the 2018 Riverwood work, namely:

- Intersection(s) that currently perform at Level of Service D or better to maintain this operation
- Intersection(s) that currently perform worse than Level of Service D not to exceed existing average delays

These criteria apply to both morning and evening peak hours.

2.5. SIDRA Modelling Outputs and Discussion

The results of SIDRA modelling are summarised in Table 2.4 and Table 2.5.

Table 2.4: AM peak result summary Belmore Road / Roosevelt Avenue

Approach	Turn/ Approach	Option 1			Option 2			Option 3		
		Average Delay (sec)	LOS	95% Back of Queue (m)	Average Delay (sec)	LOS	95% Back of Queue (m)	Average Delay (sec)	LOS	95% Back of Queue (m)
Belmore Road (South approach)	Left	923	F	1385	51	D	240	33	C	188
	Through	918	F	1385	45	D	240	27	C	188
	Approach	**918**	**F**	**1385**	**45**	**D**	**240**	**27**	**C**	**188**
Belmore Road N (North approach)	Through	754	F	2666	12	B	292	8	A	90
	Right	763	F	2666	38	D	87	39	D	82
	Approach	**755**	**F**	**2666**	**17**	**B**	**292**	**13**	**B**	**88**
Roosevelt Avenue	Left	18	B	23	36	D	36	30	C	32
	Right	55	E	17	55	E	17	54	D	17
	Approach	**28**	**C**	**23**	**41**	**D**	**36**	**37**	**D**	**32**
Intersection	ALL	779	F	2666	31	C	292	21	C	188

Table 2.5: PM peak result summary Belmore Road / Roosevelt Avenue

Approach	Turn/ Approach	Option 1			Option 2			Option 3		
		Average Delay (sec)	LOS	95% Back of Queue (m)	Average Delay (sec)	LOS	95% Back of Queue (m)	Average Delay (sec)	LOS	95% Back of Queue (m)
Belmore Road South	Left	46	D	95	46	D	95	46	D	95
	Through	40	D	95	40	D	95	40	D	95
	Approach	**40**	**D**	**95**	**40**	**D**	**95**	**40**	D	**95**
Belmore Road North	Through	10	B	231	10	B	231	7	A	78
	Right	22	C	87	22	C	87	23	C	88
	Approach	**14**	**B**	**231**	**14**	**B**	**231**	**12**	**B**	**88**
Roosevelt Avenue	Left	18	B	42	18	B	42	18	B	42
	Right	54	D	5	54	D	5	53	D	5
	Approach	**20**	**B**	**42**	**20**	**B**	**42**	**20**	**B**	**42**
Intersection	ALL	21	C	231	21	C	231	19	B	95

Below are a number of observations with regard to the modelling results:

- Option 1 performs poorly particularly the northern approach in terms of average delay and long queues in both peaks. This is due to a single through lane being available for the southbound traffic i.e. existing network. The queue lengths extend to the nearby Belmore Road /Hannans Road intersection. Option 1 has insufficient capacity to accommodate the demand.
- In option 2, the parking is banned on the northern approach, with all the other geometric inputs remaining same as existing. This results in overall improvement in junction LOS to C, however, this configuration still shows long queues on both south and north approaches. This would cause spillback to other approach intersections i.e. Belmore Road /Hannan Road intersection.
- Option 3 includes a right turn lane and parking ban to increase approach capacities and queuing space. It addresses the above issues requiring approximately 88 metres length on the northern approach and full parking ban on the southern approach to Truman Avenue. The Southern approach in the AM peak experiences 188m queuing that extends to Killara Avenue. Note that the intersections between Belmore Road /Roosevelt Avenue and Belmore Road/Killara Avenue are all unsignalised.

2.5.1. Assessment of Required Right Turn Bay

The results reported from Sidra assessment indicates a 95th percentile back of queue of 82m in AM and 88m in the PM peak. A 95th percentile back of queue represents queues that will only be exceeded 5% of the times. For example, with a signal cycle time of 120sec i.e. 30 cycles/hr the queue may be exceeded approximately 1-2 cycles in the hour.

It is noted that a right turn bay of 88m in length is likely to be problematic to provide due to limited length available in Belmore Road North to also accommodate a right turn storage lane at Hannans Road planned as part of road network improvements for Riverwood Estate. The two turning bays will be back to back as shown in Figure 2-3 so a long right turn bay at Roosevelt Avenue would result in a shorter storage bay at Hannan Road.

A number of scenarios were therefore tested to identify an optimal right turn bay length that would still be able to operate satisfactorily. The average back of queue length is approximately 54m in PM peak. Option 3A was therefore developed to assess the feasibility of providing a 55m right turn length. Table 2.6 presents key outcomes of the assessment.

Table 2.6: Option3A AM and PM Peaks Result Summary

Approach	Turn/ Approach	AM Peak					PM Peak				
		DoS	Average Delay (sec)	LOS	Average Back of Queue (m)	95% Back of Queue (m)	DoS	Average Delay (sec)	LOS	Average Back of Queue (m)	95% Back of Queue (m)
Belmore Rd (southern (approach)	Left	0.67	27	C	115	188	0.50	46	D	58	95
	Through	0.67	27	C	115	188	0.50	40	D	58	95
	Approach		27	C				40	D		
Belmore Road North (northern approach)	Through	0.4	8	A	55	88	0.36	7	A	48	78
	Right	0.49	39	D	49	82	0.40	23	C	54	88
	Approach		13	B				12	B		
Roosevelt Avenue	Left	0.17	30	C	20	32	0.21	18	B	26	42
	Right	0.17	54	D	10	17	0.05	53	D	3	5
	Approach		37	D				20	B		
Intersection	ALL		21	C				19	B		

*DoS: denotes Degree of saturation

The assessment shows that with a right turn length of 55m, there is no change in operation of the intersection in terms of average delays or impact on the capacity of the two southbound through lanes as evident from average delay and degree of saturations of the approach. This is because there is no short lane effect on capacity to cause an increase in delay or degree of saturation i.e. there is no saturation flow losses due to short lane of length 88m or 55m. Some short lane effect occurs only when the lane length is reduced to below 50m but even then, the effect is small.

As the operation of the intersection would not be affected in terms average delay and lane capacities, there is little benefit in extending this bay to accommodate an "ideal" 95th percentile back of queue when such length would be at the expense of having a shorter distance to accommodate a right turn bay at Hannans Road. Hannans Road is a higher order road in terms of its functional hierarchy in the road network and higher traffic volumes when compared to Roosevelt Avenue which would serve as an access road to the precinct west of Belmore Road North once signalised. A right turn bay of 55m would accommodate 8 vehicles during a signal cycle.

For the purpose of discussions with TfNSW, it is recommended that the design of two intersections including their operations be concurrently covered so that the proposal can be evaluated in the context of site constraints and optimal outcomes for both intersections.

Figure 2-3: Proposed Geometric Layout for Belmore Road North

2.6. AIMSUN Traffic Modelling

Aimsun Model was used to test the above. The model considers background traffic growth and forecast Riverwood Estate development traffic for the year 2041.

Three options were modelled, option 2 and option 3 by taking inputs (layout and signal plans) from the SIDRA models.

In the AM period, the southbound movement is critical and long queues are observed if no right turn bay is provided. The queue extends to Belmore Road N/M5 interchange. The performance is improved under option 3 and option 3A after inclusion of a right turn lane.

A summary comparison of results for option 2, option 3 and option 3A is shown in Table 2.7 and Table 2.8.

Table 2.7 : Level of Service AM Peak Belmore Road / Roosevelt Avenue

Intersection Name	Approach	Approach Delay (sec)	Level of Service	Approach Delay (sec)	Level of Service	Approach Delay (sec)	Level of Service
	Without Flare (option 2)			After Upgraded with 88 m flare (option 3)		After Upgraded with 55 m flare (option 3A)	
Belmore Road/Roosevelt Avenue	N	30.19	C	9.20	A	9.37	A
Belmore Road/Roosevelt Avenue	S	24.31	B	28.60	B	27.52	B
Belmore Road/Roosevelt Avenue	W	21.65	B	22.25	B	21.96	B
Belmore Road/Roosevelt Avenue	Average	27	B	18.54	B	18.19	B

Table 2.8 : Level of Service PM Peak Belmore Road / Roosevelt Avenue

Intersection Name	Approach	Approach Delay (sec)	Level of Service	Approach Delay (sec)	Level of Service	Approach Delay (sec)	Level of Service
	Without Flare (option 2)			After Upgraded with 88 m flare (option 3)		After Upgraded with 55 m flare (option 3A)	
Belmore Road/Roosevelt Avenue	N	9.95	A	9.26	A	25.34	B
Belmore Road/Roosevelt Avenue	S	40.85	C	44.40	D	46.63	D
Belmore Road/Roosevelt Avenue	W	21.39	B	12.78	A	12.52	A
Belmore Road/Roosevelt Avenue	Average	19	B	17.24	B	28.53	B

2.7. Wider network Impacts

Overall, the average delays are similar between option 2 (without the right turn lane) and option 3 (with a right turn lane). The inclusion of a right turn lane and removal of parking to accommodate 2 through lanes reduces the queue length on this approach which in their absence backs to the Hannans Road and M5 interchanges.

Aimsun results show that the average delay and density are similar in the wider network between option 3 and option 3A as presents in Table 2.7, Table 2.8 and Appendix A. The plots of simulated densities of option 2, option 3 and option 3A are also shown in Appendix A.

3. Conclusion

The following road network improvements could be considered by 2041:

- A right turn bay on the northern approach for a length of approximately 55m. Note that this length is less than ideal 88m to accommodate the 95th percentile back of the queue but it is considered less problematic in terms of its impact on the adjacent properties on the western side of Belmore Road North and a future right turn bay at Hannans Road intersection.
- Ban parking in Belmore Road North as below:
  i. Northbound direction: In both AM and PM peaks up to the next intersection (Truman Avenue)
  ii. Southbound direction: in AM peak up to Hannans Road intersection. Note parking is already banned in the PM peak due to existing Clearway restriction.
  iii. Eastbound direction: In both AM and PM peaks for a distance of 45m toward Virginia Place

The proposed layout was tested through Aimsun modelling to confirm that this layout provides sufficient capacity in the wider network. Figure 3-1 presents the layout of the intersection.

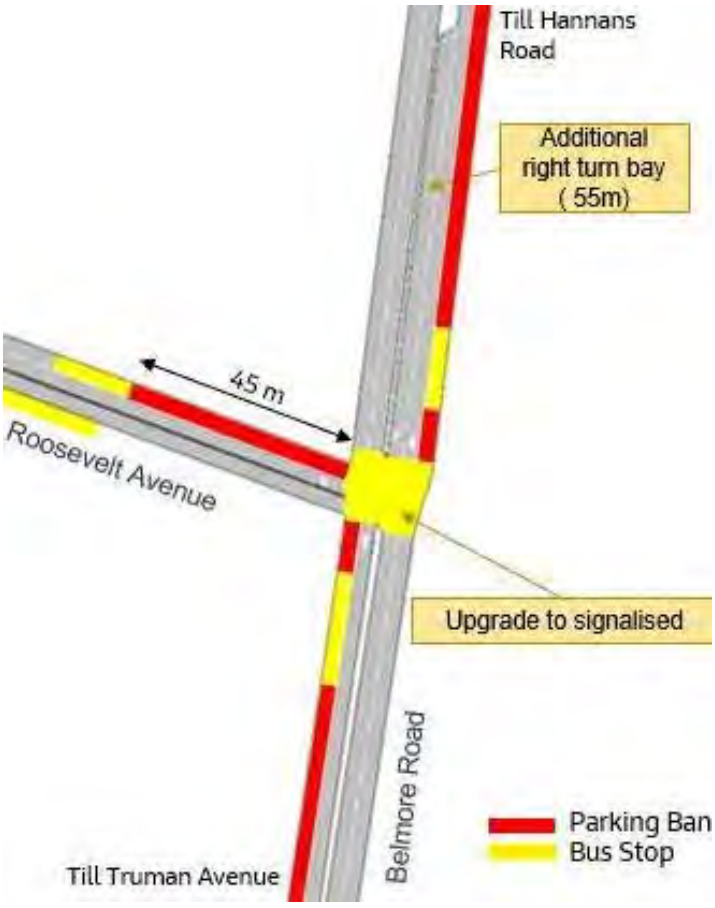

Figure 3-1: Proposed Intersection Layout Belmore Road / Roosevelt Avenue

Appendix A. Aimsun Density Plots

The traffic simulation operations were observed while the models were running. Visual checks confirmed the models were able to simulate vehicle operation and interactions at an acceptable level. Visual checks were also carried out on congestion patterns shown by simulated density, as illustrated below figures.

Simulated density is measured in vehicles per kilometre and is an indication of the level of congestion that exists on each section of road. Green colours represent low simulated density, orange / yellow colours represent medium simulated density and red/deep read represent high simulated density. These patterns were compared to Google Traffic to confirm that the model identifies congestion in the appropriate areas and concentrations.

Color	Simulated Desity (veh/Km)
	0-20.00
	20.00 - 40.00
	40.00 - 60.00
	60.00 - 80.00
	80.00 - 100.00
	100.00 -120.00
	120.00 -inf

Simulated density plots of AM Models

Simulated density plots of PM Models

Appendix F

Aimsun Modelling Output

Without Flare (option 2)

Subpath	TCS Number	TCS Name	TCS No. (no direction)	TCS or US	Intersection Name	Approach	Approach Delay (sec) *AM Peak (8AM-9AM)*	Approach LoS *AM Peak (8AM-9AM)*	Approach Vol (veh) *AM Peak (8AM-9AM)*	Total Delay (veh.sec) *AM Peak (8AM-9AM)*	Reference	AM Signalised Delay	AM Unsignalised Delay	AM Intersection Volume	AM Intersection Delay AM	AM Approach LoS
40508659	US 3101N	US 3101N	3101	TCS	Belmore Road/Roosevelt Avenue	N	30.19	C	1195.0	36077	Belmore Road/Roosevelt Avenue	27	30	2494	27	B
40508660	US 3101S	US 3101S	3101	TCS	Belmore Road/Roosevelt Avenue	S	24.31	B	1132.0	27514	Belmore Road/Roosevelt Avenue					
40508661	US 3101W	US 3101W	3101	TCS	Belmore Road/Roosevelt Avenue	W	21.65	B	167.0	3615	Belmore Road/Roosevelt Avenue					

Subpath	TCS Number	TCS Name	TCS No. (no direction)	TCS or US	Intersection Name	Approach	Approach Delay (sec) *PM Peak (5PM-6PM)*	Approach LoS *PM Peak (5PM-6PM)*	Approach Vol (veh) *PM Peak (5PM-6PM)*	Total Delay (veh.sec) *PM Peak (5PM-6PM)*	Reference	PM Signalised Delay	PM Unsignalised Delay	PM Intersection Volume	PM Intersection Delay PM	PM Approach LoS
40508659	US 3101N	US 3101N	3101	TCS	Belmore Road/Roosevelt Avenue	N	9.95	A	1291.0	12840	Belmore Road/Roosevelt Avenue	19	41	2000	19	B
40508660	US 3101S	US 3101S	3101	TCS	Belmore Road/Roosevelt Avenue	S	40.85	C	476.0	19443	Belmore Road/Roosevelt Avenue					
40508661	US 3101W	US 3101W	3101	TCS	Belmore Road/Roosevelt Avenue	W	21.39	B	233.0	4983	Belmore Road/Roosevelt Avenue					

After Upgraded with 90 m flare (option 3)

Subpath	TCS Number	TCS Name	TCS No. (no direction)	TCS or US	Intersection Name	Approach	Approach Delay (sec) *AM Peak (8AM-9AM)*	Approach LoS *AM Peak (8AM-9AM)*	Approach Vol (veh) *AM Peak (8AM-9AM)*	Total Delay (veh.sec) *AM Peak (8AM-9AM)*	Reference	AM Signalised Delay	AM Unsignalised Delay	AM Intersection Volume	Intersection Delay AM	AM Approach LoS
40508659	US 3101N	US 3101N	3101	TCS	Belmore Road/Roosevelt Avenue	N	9.20	A	1260.0	11591	Belmore Road/Roosevelt Avenue	19	29	2522	19	B
40508660	US 3101S	US 3101S	3101	TCS	Belmore Road/Roosevelt Avenue	S	28.60	B	1115.0	31891	Belmore Road/Roosevelt Avenue					
40508661	US 3101W	US 3101W	3101	TCS	Belmore Road/Roosevelt Avenue	W	22.25	B	147.0	3271	Belmore Road/Roosevelt Avenue					

Subpath	TCS Number	TCS Name	TCS No. (no direction)	TCS or US	Intersection Name	Approach	Approach Delay (sec) *PM Peak (5PM-6PM)*	Approach LoS *PM Peak (5PM-6PM)*	Approach Vol (veh) *PM Peak (5PM-6PM)*	Total Delay (veh.sec) *PM Peak (5PM-6PM)*	Reference	PM Signalised Delay	PM Unsignalised Delay	PM Intersection Volume	Intersection Delay PM	PM Approach LoS
40508659	US 3101N	US 3101N	3101	TCS	Belmore Road/Roosevelt Avenue	N	9.26	A	1404.0	13001	Belmore Road/Roosevelt Avenue	17	44	2119	17	B
40508660	US 3101S	US 3101S	3101	TCS	Belmore Road/Roosevelt Avenue	S	44.40	D	455.0	20203	Belmore Road/Roosevelt Avenue					
40508661	US 3101W	US 3101W	3101	TCS	Belmore Road/Roosevelt Avenue	W	12.78	A	260.0	3322	Belmore Road/Roosevelt Avenue					

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