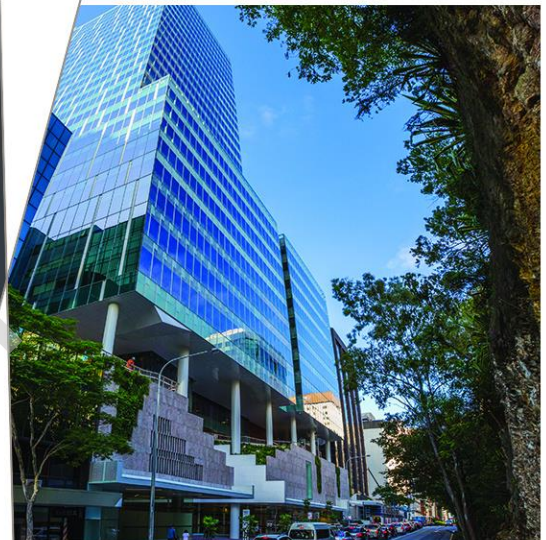


Traffic and Transport Plan

Willoughby Local Centres

80020036



Prepared for
Willoughby City Council

2 December 2019

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Executive Summary

Purpose

Willoughby City Council engaged Cardno to prepare a Traffic and Transport Plan to support the *Willoughby Local Centres Strategy*. The purpose of this study is to assess the existing and future transport networks of each local centre identified for future development within the strategy, and demonstrate how residential and employment growth can be accommodated by the transport networks.

The study includes a high level review of the pedestrian, cycling, public transport and private vehicle networks in the immediate vicinity of each centre, accompanied by SIDRA intersection modelling of the road network. Issues, gaps and deficiencies of the networks are identified and a range of options to address these are considered.

The following centres were assessed, each with a corresponding section in this report:

1. Artarmon;
2. Castlecrag;
3. East Chatswood;
4. High Street;
5. Naremburn;
6. Northbridge;
7. Penshurst Street; and
8. Willoughby South.

Transport vision

The *Willoughby Local Centres Strategy* provides a framework to guide development and growth for each local centre over the next 20 years. The Willoughby Local Government Area (LGA) currently has a population of approximately 78,000 residents and is forecast to reach approximately 91,800 residents in 2036, as well as to accommodate significant increases in employment.

The transport vision for the local centres is to provide walkable, well-connected local centres with high quality active and public transport links to encourage high density development within each centre and accommodate the forecast residential and employment growth. The aim is to facilitate successful people and place experiences within each centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists in alignment with the *Local Centres Strategy*.

The recommendations identified in this study aim to propose improvements to achieve this vision and improve the place experience as well as accommodate additional demand and movement.

Existing conditions

Although the local centres generally have established transport networks, there are numerous issues, challenges and opportunities for improvement, particularly to encourage liveable and vibrant centres in line with the vision of the *Local Centres Strategy*. Some of the key issues include:

- > A lack of pedestrian crossing opportunities and potential for vehicle-pedestrian conflict;
- > Gaps and deficiencies in the cycling network;
- > Insufficient threshold/gateway treatments to support high pedestrian activity environments;
- > Non-compliant kerb ramps and lack of provision for accessibility; and
- > A focus on private vehicles and intersection performance over pedestrian amenity and experience.

The existing conditions of each centre are reviewed and detailed in the corresponding sections of this report.

SIDRA intersection modelling was undertaken to assess the existing performance of the road network at each local centre, and the following issues were identified:

- > **Artarmon:** the intersections of Hampden Road/Brand Street and Hampden Road/Francis Street operate near capacity in most peak periods, generally operating at Level of Service (LoS) D;

- > **Castlecrag:** the intersection of Edinburgh Road/Eastern Valley Way operates at capacity in the AM peak (LoS F), and near capacity in the PM and Saturday peaks (LoS D);
- > **East Chatswood:** the intersection of Victoria Avenue/Penshurst Street operates at capacity in the Saturday peak (LoS F), and near capacity in the PM peak (LoS D);
- > **Penshurst Street:** the intersection at Mowbray Road/Willoughby Road operates near capacity in the PM peak (LoS D); and
- > **Willoughby South:** the intersections of Willoughby Road/Harris Street and Willoughby Road/Julian Street operate at capacity (LoS F) in all peaks.

Other intersections generally operate satisfactorily with spare capacity, and no issues were identified at High Street, Naremburn or Northbridge.

Future conditions

Potential improvement options to address issues identified as part of the existing conditions analysis, as well as to generally improve experience and amenity, were recommended for each local centre. Recommendations were high level and focused on active and sustainable transport, in alignment with the transport vision for the local centres.

Key recommendations were focused on the following:

- > Implementing reduced speed limits and/or shared zones where appropriate to improve safety;
- > Introducing threshold/gateway treatments to promote safe and amenable local centre road networks;
- > Improving compliance and accessibility of pedestrian crossings, footpaths and kerb ramps;
- > Providing bicycle infrastructure to fill gaps, implement continuous and convenient cycling networks and accommodate cycle parking demand;
- > Advocating for Transport for NSW (TfNSW) to review and optimise bus routes and service frequencies;
- > Minor reconfigurations to the road network to improve intersection performance and address safety concerns; and
- > Revising parking restrictions to better serve surrounding land uses and accommodate parking demand without providing additional parking.

Traffic generation of the proposed future developments was estimated in accordance with Roads and Maritime Services' guidelines and used to inform the SIDRA modelling of the future 2036 With Development scenarios. Key findings of the future modelling without any mitigation measures included the following:

- > **Artarmon:** deteriorated performance at the intersections of Brand Street, Francis Road and Broughton Road with Hampden Road, generally operating at LoS F;
- > **Castlecrag:** poor performance of the Edinburgh Road/Eastern Valley Way intersection in line with the 2019 existing base model;
- > **East Chatswood:** deteriorated performance at all intersections, including LoS F at Victoria Avenue/Penshurst Street in the Saturday peak, LoS E at Penshurst Street/Macmahon Street in the PM peak and LoS D at Victoria Avenue/Royal Street in the PM peak;
- > **Naremburn:** minor deterioration of performance at the intersection of Willoughby Road/Merrenburn Avenue to LoS D in the PM peak;
- > **Northbridge:** minor deterioration of performance at the intersections of Sailors Bay Road/Eastern Valley Way to LoS D in the PM and Saturday peaks, as well as Sailors Bay Road/Harden Avenue to LoS D in the PM peak;
- > **Penshurst Street:** deterioration of performance at the intersection of Penshurst Street/Mowbray Road to LoS D in the PM and Saturday peaks, as well as Mowbray Road/Willoughby Road to LoS F in the Saturday peak; and
- > **Willoughby South:** poor performance at the intersection of Willoughby Road/Harris Street in line with the 2019 existing base model, and minor deterioration of performance at the intersection of Willoughby Road/Frenchs Road to LoS D in the Saturday peak.

Although a range of issues were identified, the results should be considered with the following factors:

- > Many issues identified are consistent with the 2019 existing base models, with either consistent performance or a minor deterioration;
- > Background traffic growth was included and is a key driver of future performance compared to the proposed development;
- > Intersection performance at LoS D is acceptable and signifies the intersection operates near capacity, and typically at these intersections all vehicles are able to clear the intersection within one signal cycle;
- > Mitigation measures are expected to improve the performance at some local centres, including Artarmon and Willoughby South; and
- > The local centres assessed are likely situated in the best locations within the LGA for future development as they are well connected to public transport services, and offer a range of services and land uses within walking distance, minimising the potential traffic impact.

Recommendations to address the issues identified, as well as proposed general improvements to the transport networks, are provided in each section of this report.

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Table of Contents

1	Introduction	7
	1.1 Background	7
	1.2 Traffic and Transport Plan purpose	8
2	Strategic context	10
	2.1 Strategies and community plans	10
	2.2 Current travel behaviour	12
	2.3 Proposed land use changes	15
3	Artarmon	16
	3.1 Future transport network review and recommendations	16
4	Castlecrag	25
	4.1 Future transport network review and recommendations	25
5	East Chatswood	33
	5.1 Future transport network review and recommendations	33
6	High Street	42
	6.1 Future transport network review and recommendations	42
7	Naremburn	49
	7.1 Future transport network review and recommendations	49
8	Northbridge	57
	8.1 Future transport network review and recommendations	57
9	Penshurst Street	64
	9.1 Future transport network review and recommendations	64
10	Willoughby South	71
	10.1 Future transport network review and recommendations	71

1 Introduction

1.1 Background

1.1.1 Willoughby Council Local Government Area

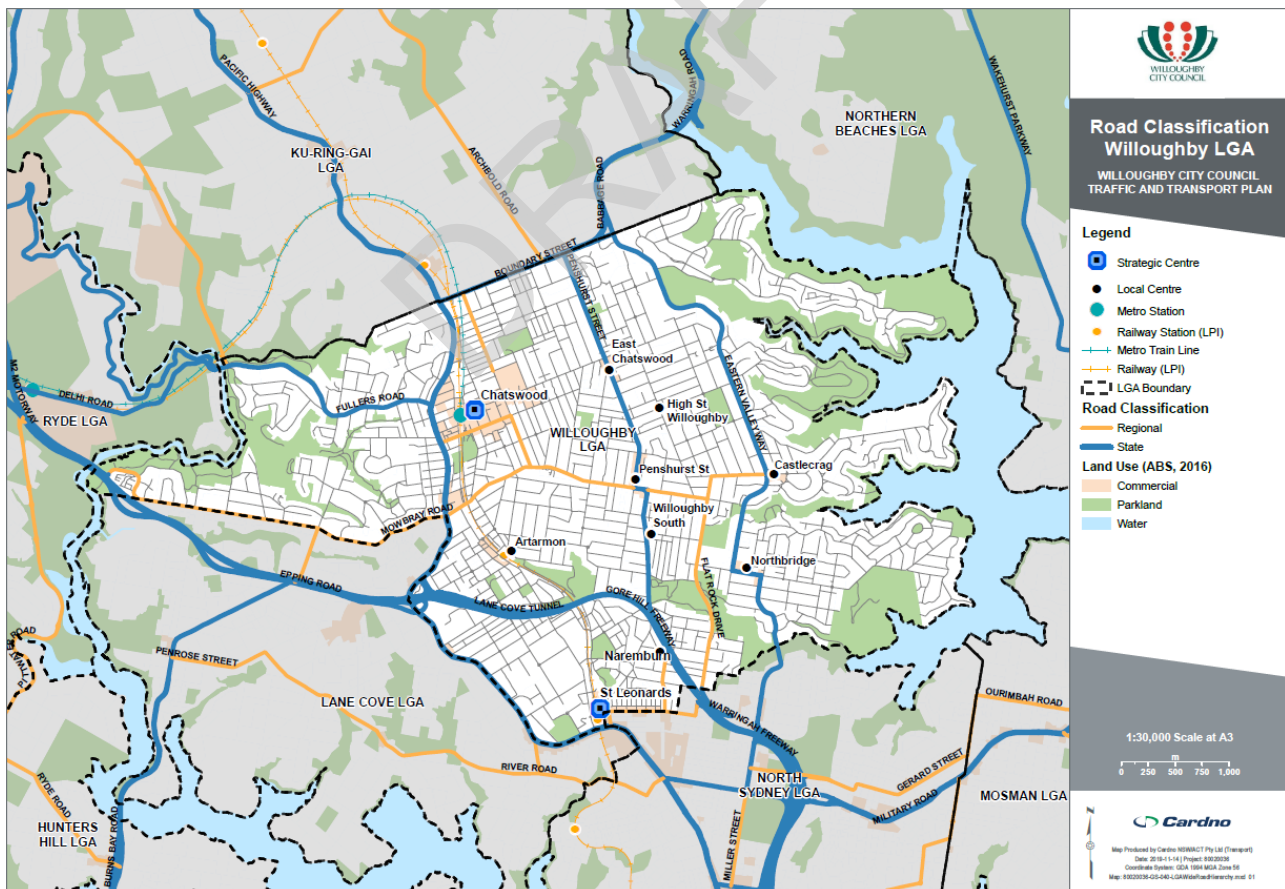
The Willoughby Local Government Area (LGA) is located 8.5 kilometres northwest of the Sydney CBD and covers an area of approximately 23 square kilometres. As of 2018, the region is home to approximately 80,000 people originating from various backgrounds. The region is expected to grow at a steady rate in the coming decades, with a projected population of 91,000 by 2036.

Chatswood and St Leonards operate as the LGA's strategic centres. They drive commercial growth within the region and provide high-density residential housing. Two shopping centres and a shopping district make Chatswood a major retail destination for the Willoughby LGA and the surrounding regions. The LGA also contains eight local centres, each supporting their respective communities with housing, local businesses and amenities.

The Willoughby Council area contains a network of highways and arterial roads. The M1 motorway connects the LGA to destinations in western Sydney and the Sydney CBD. The Pacific Highway functions as the region's main vehicle corridor connecting the LGA with the M1 motorway to the north and providing a route to Sydney's northern suburbs and central coast to the north. The LGA's arterial roads such as Victoria Avenue, Penshurst Street, Mowbray Road and Willoughby Road connect local and strategic centres.

The LGA's state and regional road network is presented in **Figure 1-1**.

Figure 1-1 Willoughby LGA state and regional roads



Public transport services within the LGA include train and bus. There are two train lines, the T1 North Shore line and Western Line, and the Metro Northwest. The T1 line services the local centre of Artarmon, and the strategic centres of Chatswood and St Leonards. The line provides a public transport connection to Sydney's CBD and North Sydney to the south, and Hornsby and the Central Coast to the north. Chatswood operates

as a transport interchange, connecting the LGA with Sydney's north west suburbs via the Sydney Metro Northwest.

1.1.2 Local Centres Strategy

The Willoughby City Council produced the *Draft Willoughby Local Centres Strategy* as a framework to guide future planning controls and public domain improvements for eight local centres identified in the LGA. The draft strategy builds on directions and objectives identified in the *Greater Sydney Region Plan, North District Plan, Willoughby Community Strategic Plan, Willoughby Housing Strategy* and *Willoughby Local Centres and Housing Position Statements*.

The strategy aims to examine the function and character of eight local centres in Willoughby to identify opportunities for growth in residential and employment land uses. It includes a focus on retaining the character of the local centres and promoting thriving, attractive and distinctive neighbourhoods throughout the LGA.

The strategy analyses each local centre and discusses:

- > Local context, character and place;
- > Existing planning controls and land uses;
- > Strengths of the centre;
- > Community feedback on the scenarios identified;
- > Key directions for future development;
- > A vision for the centre;
- > A preferred development scenario;
- > Recommendations for the *Local Environmental Plan (LEP)* and *Development Control Plan (DCP)*;
- > An indicative master plan for the development scenario; and
- > Potential yield of the preferred scenario.

The draft strategy has been used to inform this study and provide guiding principles for the assessment of the transport networks.

1.1.3 Community feedback

A total of 192 submissions were received on the *Draft Local Centres Strategy*, which included a range of concerns relating to the character, identity and scale of the local centres, land uses (particularly inclusion of specific retail uses) and existing traffic and parking issues. The general feedback on traffic and transport related matters was that every local centre is already congested and existing issues needed to be addressed. The community was apprehensive in regards to developing West Chatswood due to congestion issues.

Further detail of community feedback for specific centres is provided later in the report under the relevant local centre.

1.2 Traffic and Transport Plan purpose

The key purpose of the Traffic & Transport Plan is to guide future growth for the local centres and demonstrate how the forecast land uses can be accommodated by the transport networks. The plan will identify and analyse existing traffic and transport issues, assess future potential impacts of the proposals contained in the *Draft Local Centres Strategy* and support development of the *Final Local Centres Strategy*. The plan will include a review of public transport (rail and bus), active transport (bicycles and pedestrians), taxi, ride share services, parking and freight services. The key objectives of the Traffic & Transport Plan include:

- > To establish the traffic and transport objectives, performance indicators and outcomes for each local centre;
- > To establish the current and planned transport system design, operation and capacity in each Local Centre;
- > To identify pedestrian, cycling and traffic management issues in each Local Centre;

- > To recommend actions to provide more efficient and effective traffic and transport arrangements for each Local Centre that will create a healthy, socially cohesive place that meets the current and likely future demands of the community; and
- > To establish measures required to support proposed land use changes foreshadowed in the *Draft Willoughby Local Centres Strategy*.

Safety and amenity will be key focuses of the plan, aligning with the objectives of the *Draft Local Centres Strategy* and allowing future growth to be accommodated without detracting from the character of each local centre to accommodate demand. Consideration of movement and place priorities will be applied to provide for future travel demands while retaining amenable, attractive and activated centres. Active and sustainable transport improvements and initiatives will also be prioritised where possible to promote these travel modes and reduce the need for road space allocated to private vehicles.

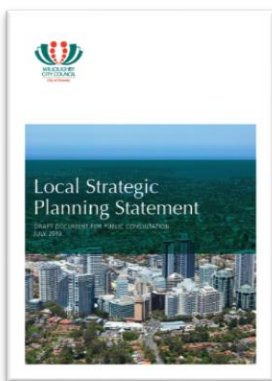
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2 Strategic context

2.1 Strategies and community plans

As well as the *Draft Local Centres Strategy*, there are a number of strategies and community plans that aim to guide future development within the Willoughby LGA and provide direction for traffic and transport considerations.

2.1.1 Local Strategic Planning Statement



The *Draft Willoughby Local Strategic Planning Statement (LSPS)* sets a 20-year vision for land use planning in the Willoughby LGA, including a range of directions, priorities and actions aligning with the Greater Sydney Commission's *Greater Sydney Region Plan* and *North District Plan*. The key themes include a liveable city, productive city, sustainable city and a city that aligns infrastructure with growth. Key directions and Council priorities that relate to traffic and transport include:

- > Enhancing walking and cycling connections;
- > Developing Chatswood's role as a true transport hub for Willoughby and the North Shore; and
- > Connecting Willoughby's network of centres with each other and with Greater Sydney by mass transit.

2.1.2 Local Environmental Plan and Development Control Plan

The *Local Environmental Plan (LEP)* and *Development Control Plan (DCP)* are the key planning instruments guiding development with the Willoughby LGA. The LEP establishes a planning framework for the LGA and provides planning controls to manage development. The plan aims to enable sustainable, socially equitable and economically viable development to manage impacts and risks to the environment. In relation to traffic and transport matters, the LEP aims to:

- > Provide for regional and local transport needs while promoting the use of active and public transport;
- > Provide appropriate levels of car parking in connection with the location of development and managing the demand for ancillary car parking where there is good access to public transport nodes and services; and
- > Provide integrated development design of pedestrian and vehicular access, parking, loading and delivery facilities.



The DCP provides detailed guidelines and environmental controls to guide development within the Willoughby LGA and supports the objectives and planning provisions contained within the LEP. The DCP also aims to encourage the use of active and public transport, as well as providing safe, convenient and efficient movement and accommodation of vehicles.

2.1.3 Community Strategic Plan



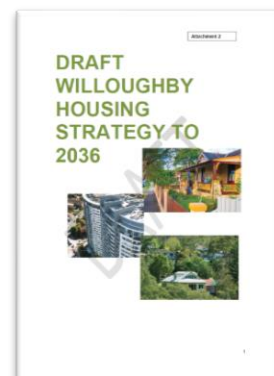
The *Community Strategic Plan (CSP)* identifies the community's aspirations and priorities for the future, and presents a series of outcomes to achieve the overall community vision for Willoughby as a diverse, liveable and prosperous city. Five outcomes are presented and include a city that is green, connected and inclusive, liveable, prosperous and vibrant, and effective and accountable. The outcome of a connected and inclusive city is most relevant for this study and includes the key priorities to:

- > Enhance transport choices and connections throughout the city;
- > Reduce parking and traffic congestion; and
- > Promote accessible services for the community.

A key measure of the connected and inclusive outcome is an increase in the number of journeys to work that do not use a motor vehicle, which aligns with the objectives of the planning framework and LSPS.

2.1.4 Draft Housing Strategy

The *Draft Housing Strategy to 2036* aims to guide the quantity, location and type of future residential development with Willoughby. The strategy indicates that additional residential development should be located close to business and service centres and public transport to promote sustainability. It identifies Chatswood CBD around the commercial core as the key focus due to the significance as a strategic centre and the presence of a train station, however notes that local centres have also been identified for extra dwellings close to services and transport to disperse growth across the LGA. The strategy also provides indicative master plans for the local centres to indicate how development could be achieved.



Feedback on the Housing Strategy included concerns about traffic and parking issues, with mixed sentiment about the proposition to develop local centres. However, most submissions could not say whether increased housing growth could be located in other areas of Willoughby. Chatswood West was proposed as an alternative location and considered as a potential local centre, however this was halted due to congestion concerns of its own.

2.1.5 Street Parking Strategy



The *Street Parking Strategy* provides a framework for efficient and equitable use of street parking in the Willoughby LGA. It uses an evidence-based approach to guide decisions about where and when pricing and time restrictions need to be introduced or adjusted based on surrounding land uses. The strategy notes that on-street parking is important for economic and social wellbeing, but acknowledges that the trend for rising parking demand cannot be sustained and that provision of additional parking will induce traffic into already congested roads. It aims to achieve a balance between supply and demand and encourage mode shift to active and public transport. Key objectives of the strategy include to:

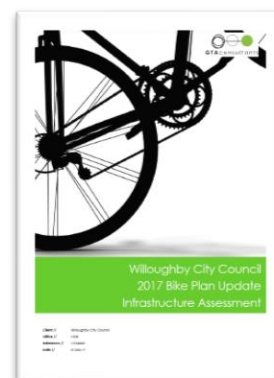
- > Optimise available street space in a fair and transparent manner;
- > Maintain access to local businesses, services and amenities;
- > Balance the needs of residents with those of local workers, businesses, shoppers and commuters through managed travel-demand and mode choice; and
- > Balance the competing interests between parking demand and environmental amenity.

The strategy includes extensive analysis of parking within Willoughby and presents a range of potential solutions to the issues identified. Six strategic directions were proposed to address the issues:

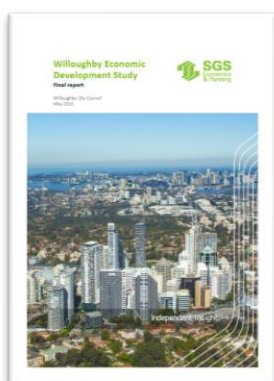
9. Adopt a framework of time and pricing restrictions;
10. Apply parking controls that support the land use context;
11. Develop an integrated transport strategy;
12. Promote car share;
13. Maximise available street and road space for parked cars; and
14. Promote alternative transport choice for non-essential car journeys.

2.1.6 2017 Bike Plan Update Infrastructure Assessment

A bike plan was adopted by Council in 2006, with a review of its implementation undertaken in 2012. This review also identified cycling infrastructure projects required and presented an implementation plan, including a map setting out the existing network and proposed upgrades. The *Willoughby 2017 Bike Plan Update Infrastructure Assessment* provides an audit of existing cycling infrastructure throughout the LGA to determine how the actions identified in 2012 have been implemented, as well as identifying additional projects and re-prioritising all projects. The plan also integrates feedback from the neighbouring LGAs to ensure sufficient inter-LGA connectivity. The update aims to guide investment in cycling infrastructure and support other state and local government policy documents such as the CSP, LEP and Sydney's Cycling Future.



2.1.7 Economic Development Study



The *Willoughby Economic Development Study* was developed to understand the key economic drivers of Willoughby, identify economic trends, analyse the existing economic structure, assess implications economic growth on traffic, transport, environment, community needs and infrastructure, and review planning controls to facilitate opportunities for economic growth. The study examines the strategic centres of Chatswood and St Leonards as well as other centres including the local centres at Artarmon and East Chatswood. The study focuses on supply and demand for industries but identifies some challenges related to traffic and transport such as:

- > Traffic congestion in Chatswood impacting retail business;
- > The rail line posing a barrier for access to the retail core of Chatswood from the Pacific highway; and
- > Expected increases in parking demand associated with future development.

Directions to address the issues include:

- > Facilitating mixed uses in areas other than Chatswood to reduce pressure and congestion;
- > Introducing car parking reforms and innovative parking policies such as shared parking between different land uses;
- > Maintaining but not increasing road network capacity;
- > Reducing parking provision over time to relieve traffic congestion; and
- > Promoting the amenity and public transport offering of Chatswood.

2.2 Current travel behaviour

Existing data sources were analysed to examine current travel patterns within the Willoughby Local Government Area (LGA), including the Household Travel Survey (HTS) and Australian Bureau of Statistics (ABS) Census 2016 data. The HTS is collected by Transport Performance and Analytics (TPA) as part of Transport for NSW (TfNSW) and gathers simple information of key travel statistics over a typical weekday for a sample of respondents, which is extrapolated to estimate travel behaviour for the Greater Sydney region. The ABS Census data is gathered using an enumerative method for all people in Australia on census night, and provides detailed travel information for a much larger sample than the HTS. Both datasets were analysed to extract key information and travel statistics.

2.2.1 Demographics

Key demographic data and statistics for the Willoughby LGA are presented in **Table 2-1** and compared to the Greater Sydney statistics.

Table 2-1 Key travel behaviour statistics

	Willoughby LGA	Sydney GMA
Residential population	74,300 ¹	4,824,000
Households	28,480	1,759,923
Average people per household	2.6	2.7
Area (km ²)	22.4	12,370.0
Population density (people per km ²)	3,317	390
Average vehicles per household	1.4	1.6
Average vehicles per person	0.5	0.5

Source: ABS 2016 Census Data

¹The Estimated Resident Population was approximately 77,900 for 2016, and was estimated to be approximately 80,300 in 2018 (according to .id). The census data shown in the table underestimates the population due to the less than 100% response rate (among other factors), but was used to obtain accurate ratios when combined with vehicle ownership.

The average household in Willoughby owns 1.4 private vehicles, slightly less than the Greater Sydney average, which reflects a slightly lower dependence on cars. The population density of Willoughby is also much greater than the Sydney average (almost 10 times higher).

2.2.2 Mode share

Mode share data was analysed to determine the key Journey to Work travel modes, and the results are presented in **Figure 2-1** and **Figure 2-2**.

Figure 2-1 Mode share for people working in Willoughby

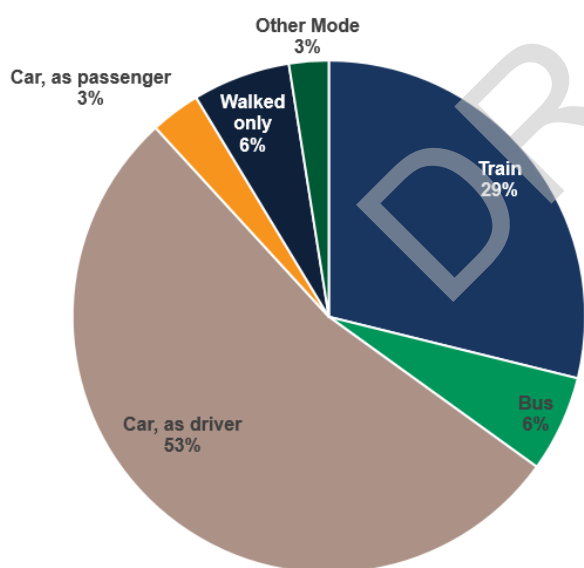
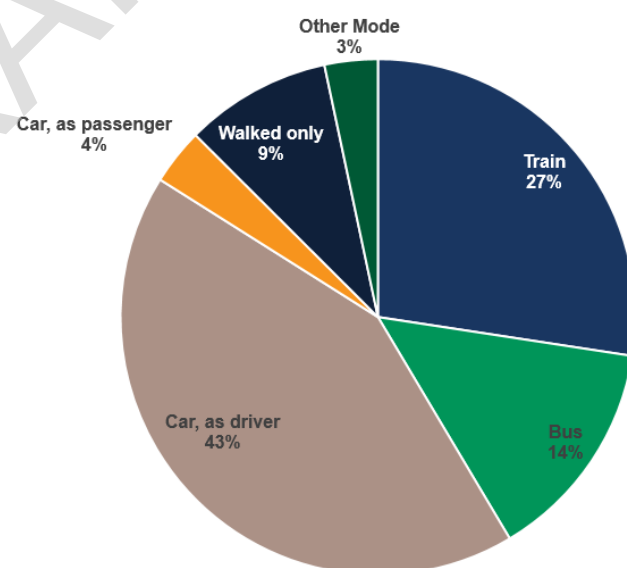


Figure 2-2 Mode share for residents living in Willoughby



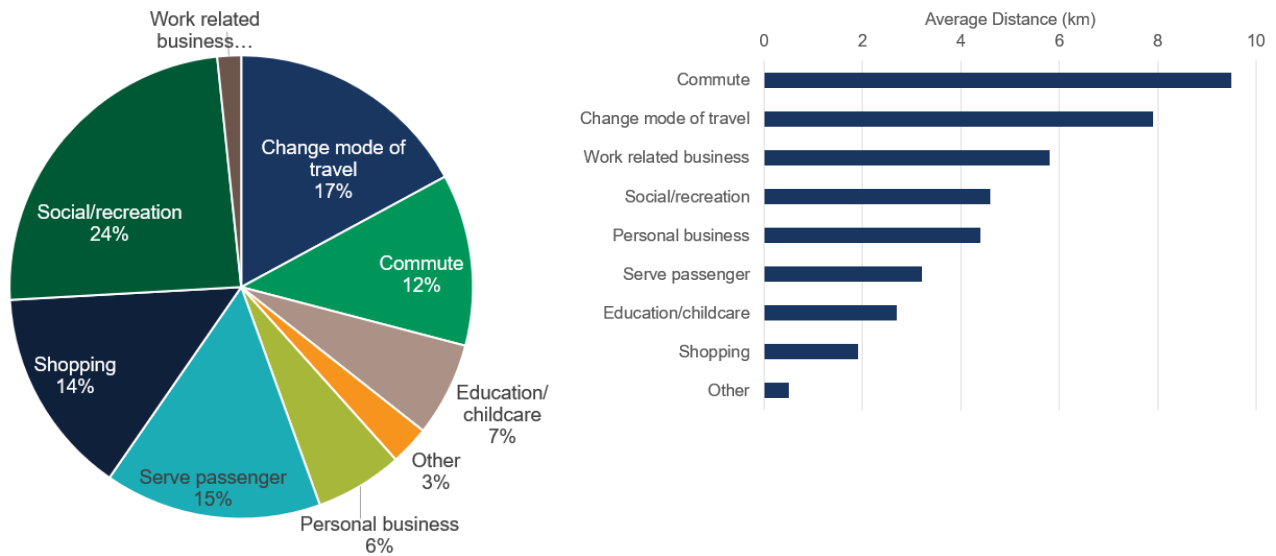
Source: ABS 2016 Census Data

The data indicates that the area is moderately reliant on private vehicles, with approximately half of all trips utilising private cars for travel to work. Approximately 35 – 40% of trips are taken using public transport, especially for residents of Willoughby, reflecting the connectivity of bus and train routes to centres such as North Sydney and the CBD. Active transport represents 10% or less of all trips and may be a result of the limited walking and cycling catchments as well as constraints of the active transport networks.

2.2.3 Trip purpose and travel distance

HTS data was analysed to determine the purpose of trips made, and the results are presented in **Figure 2-3**. Note these are purposes for trips throughout the entire day, and the peak hours are likely to reflect a different mix of trips.

Figure 2-3 Trip purposes and travel distances



Source: HTS 2017/2018 Data

The data shows that trips are undertaken for a wide range of purposes, including recreation (24%), interchanging (17%), taking a passenger (15%), shopping (14%) and commuting (12%), among other purposes. Trip distances were highest for commuters (approx. 9.5km), interchanging and work-related business, while shorter trips were generally associated with shopping or other purposes. This indicates that the immediate catchments of the local centres are likely to attract residents visiting retail and various ancillary land uses (e.g. post offices), which aligns with the community feedback received and the planned direction for the local centres.

2.2.4 Origins and destinations

The top origins and destinations for workers (split by residents in Willoughby and people travelling to Willoughby to work) are presented in Figure 2-4 and Figure 2-5. The results also include mode share to understand the connectivity of travel modes and relationship to origin-destination pairs.

Figure 2-4 Destination of residents in Willoughby

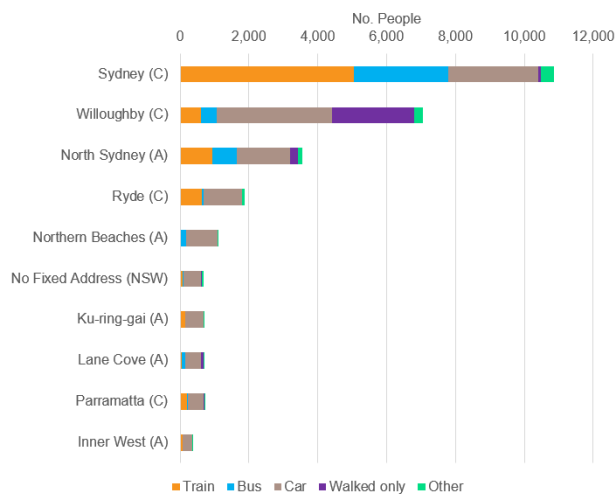
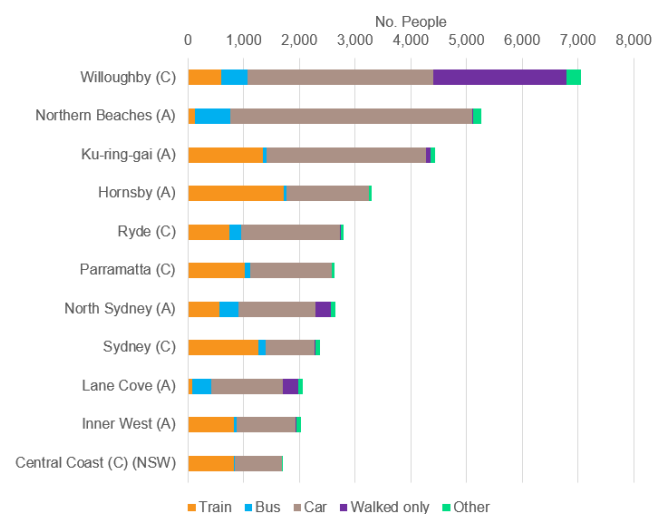


Figure 2-5 Origin of workers in Willoughby



Source: ABS 2016 Census Data

The results show that the top destinations of workplaces for residents of Willoughby are Sydney (inner city), internal trips within Willoughby, and North Sydney. Other trips are generally scattered throughout other

destinations in surrounding suburbs. The top origins for people who travel to Willoughby to work are much more diverse and include internal trips within Willoughby, the northern beaches, Ku-ring-gai, Hornsby, Ryde and various other suburbs throughout the north shore and inner west.

The results also indicate that Willoughby is reasonably well connected to the CBD and North Sydney by public transport, with the majority of trips taken by train and bus. A large portion of internal trips within Willoughby are also taken by walking only. Most other destinations are reliant on private vehicles, particularly for outbound trips. Although some key origins/destination include public transport connections such as railway stations (e.g. Hornsby, Parramatta), many trips are still taken by car, which may reflect the limited ability to interchange and could present an opportunity to improve bus-rail connectivity.

2.2.5 Opal data

Opal data was received from TfNSW and analysed to determine key insights in relation to bus and train trips throughout the LGA. Note that many trips were redacted for privacy reasons, and the magnitude of trips is likely to be underestimated. Some key findings included the following:

- > 11% of bus and train trips within the LGA are internal trips (commencing and finishing within the LGA itself).
- > The remainder of the trips are inbound and outbound trips which are roughly evenly balanced (43% and 46% respectively).
- > Of the interchange trips within the LGA, approximately 20% of trips use buses to access a train station to continue their journey. Another 20% use a train to access a bus service to continue their journey. The remaining 60% interchange between train services at Chatswood station.

2.3 Proposed land use changes

A range of land use changes are proposed including intensification of existing land uses and addition of new land uses, largely composed of shop-top housing as well as various improvements to the public domain. Three possible development scenarios were considered and presented to the community for feedback before a preferred scenario was selected.

Key land use and planning changes under the preferred scenario include:

- > Rezoning, increased Floor Space Ratios (FSRs) and increased height limits to allow higher density land uses;
- > An additional 141,300 sqm GFA of residential land use across all local centres (an uplift of 239%);
- > An additional 30,600 sqm GFA of non-residential land use across all local centre (an uplift of 33%), mostly composed of retail and business use;
- > Provision of new public plazas and green space;
- > Additional through-site links; and
- > Various improvements to the public domain and pedestrian amenity.

Further details of key land use changes for each local centre are provided in the following sections.

3 Artarmon

3.1 Future transport network review and recommendations

3.1.1 Traffic network analysis

3.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Artarmon in accordance with **Table 3-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 3-1 Apartment mix and occupancy - Artarmon

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	33	1.7	55
1 bedroom	14%	47	1.7	77
2 bedroom	60%	200	2.3	457
3 bedroom	16%	53	2.8	149
Total	100%	333	-	738

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 3-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 3-2 Non-residential floor space assumptions - Artarmon

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	153
Hospitality	45%	1 / 20 sqm	458
Office	25%	4.75 / 100 sqm	242
Total	100%	-	852

Therefore, based on these assumptions the Artarmon local centre is expected to accommodate approximately 740 residents and 850 employees.

3.1.1.2 Parking requirements

The required car parking provision for the proposed development at the Artarmon local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 3-3**. The total requirements were rounded down as per the DCP.

Table 3-3 Minimum car parking requirements - Artarmon

Land use	Rate	Proposed development	Spaces required	
Residential (non-adaptable units)	Studio	0.5 / dwelling	33 dwellings	17
	1 bedroom	1 / dwelling	47 dwellings	47
	2 bedroom	1 / dwelling	200 dwellings	200
	3 bedroom	1 / dwelling	53 dwellings	53
	Visitors	0.25 / dwelling	333 dwellings	83
Residential subtotal			399	
Commercial	Retail	36 sqm / space	6103 sqm GFA	171
	Hospitality	107 sqm / space	9154 sqm GFA	85
	Office	110 sqm / space	5086 sqm GFA	46
Commercial subtotal			302	
Development total			701	
	Motorbike parking	1 / 25 car parking spaces	701 spaces	28

Based on these calculations, the proposed development would be required to provide a minimum of 701 car parking spaces (including accessible parking spaces) and 28 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 3-4**.

Table 3-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	333 units	33
Retail	1 / 450m sqm GFA	6103 sqm GFA	14
Hospitality	1 / 450m sqm GFA	9154 sqm GFA	20
Office	1 / 600 sqm GFA	5086 sqm GFA	8
Total			76

The calculations indicate that the proposed development would be required to provide 76 bicycle spaces.

3.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 3-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 3-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	333 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	4,577 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	6,865 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	5,086 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 3-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 3-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	63	50	63
Retail	51	163	42
Hospitality	77	269	514
Office	81	61	0
Total	273	543	619
Existing traffic generation	152	349	394
Net traffic generated	+121	+194	+225

On this basis the proposed development is expected to generate an additional 121 vehicle movements in the AM peak hour, 194 in the PM peak and 225 in the Saturday peak.

3.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 3-7**.

Table 3-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 3-8**.

Table 3-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	11	46	32	14	29	29
Retail	8	8	25	25	6	6
Hospitality	14	9	49	33	78	78
Office	22	2	2	17	0	0
Total (net traffic generated)	55	65	107	87	113	113

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 3-9**.

Table 3-9 Directional assumptions

Direction	In %	Out %
North	35%	45%
East	0%	0%
South	52%	26%
West	14%	29%
Total	100%¹	100%

Source: ABS 2016 Census Data

¹Note totals do not add perfectly due to rounding errors

3.1.1.5 Background traffic

RMS Traffic Volume Viewer count stations were reviewed to understand trends in background traffic throughout the area and included a review of count stations on Eastern Valley Way, Willoughby Road and Penshurst Street. An analysis of the data over a 10-year period from 2009-2019 is presented in **Table 3-10**.

Table 3-10 RMS traffic volume viewer data

Location	AM peak avg. growth ¹	PM peak avg. growth	Saturday peak avg. growth
Eastern Valley Way (south of Sunnyside Cr)	-3%	-3%	-1%
Penshurst Street ² (south of Warrah Ln)	3%	6%	5%
Willoughby Road (south of Small St)	0%	0%	1%

¹Growth is presented as a per annum rate

²The Penshurst Street count station experienced an unusually high spike in 2019, which wasn't reflected in any other year and skewed the growth estimates

Traffic volumes were generally found to be roughly stable or even declining over this period in the AM, PM and Saturday peaks. An exception is the count station at Penshurst Street, which experienced an unusually high spike of northbound traffic in 2019. This growth (+25% from 2018-2019) is not considered sustainable and would already be incorporated into the surveyed intersection counts (undertaken in October 2019), therefore this growth is not expected to continue into the future.

On this basis a growth rate of 0.5% p.a. to 2036 was applied to background traffic through movements to reflect potential future development in areas other than Willoughby utilising these corridors for movement. This growth rate was applied to the following roads:

- > Eastern Valley Way;
- > Penshurst Street;
- > Willoughby Road;
- > Victoria Ave;

- > Mowbray Road; and
- > Hampden Road.

3.1.1.6 Intersection modelling results

Table 3-11 summarises the intersection performance of the Artarmon local centre for the 2036 with 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 3-11 Future intersection performance – Artarmon

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Hampden Road / Brand Street	0.925	41.7	C	0.980	76.9	F	1.093	140.8	F
Hampden Road / Francis Road	0.535	91.6	F	0.661	72.3	F	0.822	102.8	F
Hampden Road Pedestrian Crossing	0.726	9.0	A	0.748	7.6	A	0.791	8.6	A
Hampden Road / Broughton Road	0.819	69.0	E	0.929	81.4	F	0.857	71.9	F
Hampden Road / Jersey Road	0.764	13.1	A	0.885	20.4	B	0.748	13.4	A
Elizabeth Street / Tindale Road	0.056	5.7	A	0.028	5.6	A	0.020	5.5	A

In the 2019 base model, the Hampden Road / Brand Street intersection and Hampden Road / Francis Road intersection operated at LoS D for the PM and Saturday peak periods. With no capacity improvements considered in 2036 and due to the expected increase in demand generated under the full development scenario, the operational performance of these intersections deteriorates to LoS F in the PM and Saturday peak periods. This is due to the expected increase in demand generated on priority roads such as Hampden Road.

Similarly, the intersection operations worsen at Hampden Road / Broughton Road in all peaks when compared to the 2019 base model. In the AM peak period, the intersection performance deteriorates from LoS C in 2019 to LoS E in 2036. In the PM and Saturday peak periods, the intersection performance deteriorates from LoS C in 2019 to LoS F in 2036. The performance of the Hampden Road / Broughton Road intersection in all peak periods in the future year 2036 is driven by the right turning vehicles from the side street (Broughton Road), which are unable to find a sufficient gap on Hampden Road.

The performance of the Hampden Road / Francis Road intersection in all peak periods in the future year 2036 is due to the right turning vehicles from the side street (Francis Road), which are unable to find a sufficient gap on Hampden Road. This issue was also identified in the existing base model. Due to an increase in volumes on Hampden Road, the opportunity for right-turning vehicles from the side streets is decreased as the headways have decreased further when compared to the existing base model.

3.1.2 Active Transport

Walking and cycling needs within the Artarmon local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Artarmon already contains an established footpath network with cycling facilities, however some gaps and deficiencies exist and include:

- > Constrained or non-existent footpaths along Hampden Lane and Hampden Road near the signalised pedestrian crossing;
- > A missing pedestrian crossing at the intersection of Hampden Road/Jersey Street;
- > A lack of threshold/gateway treatments at the road network entries to the local centre, as well as a lack of kerb extensions;

- > The potential for vehicle-pedestrian conflict, particularly as the centre is developed;
- > A lack of dedicated cycleway infrastructure along Hampden Road;
- > Non-compliant kerb ramps; and
- > Poor use of pedestrian fencing.

Recommendations to address these issues are summarised in **Section 3.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

3.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Artarmon is well connected by train to surrounding centres and public transport hubs including Chatswood, North Sydney and Sydney CBD. However, no bus services operate within the local centre during the daytime. The need for bus services is reduced due to the high rail connectivity, but the lack of feeder services to Artarmon station and access to areas not well connected by rail may discourage the use of public transport.

There is also the opportunity to provide on-demand services, which may be a viable measure to complement train services given the lack of bus routes serving the centre.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 3.1.4**.

3.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 3-12** and **Figure 3-1**.

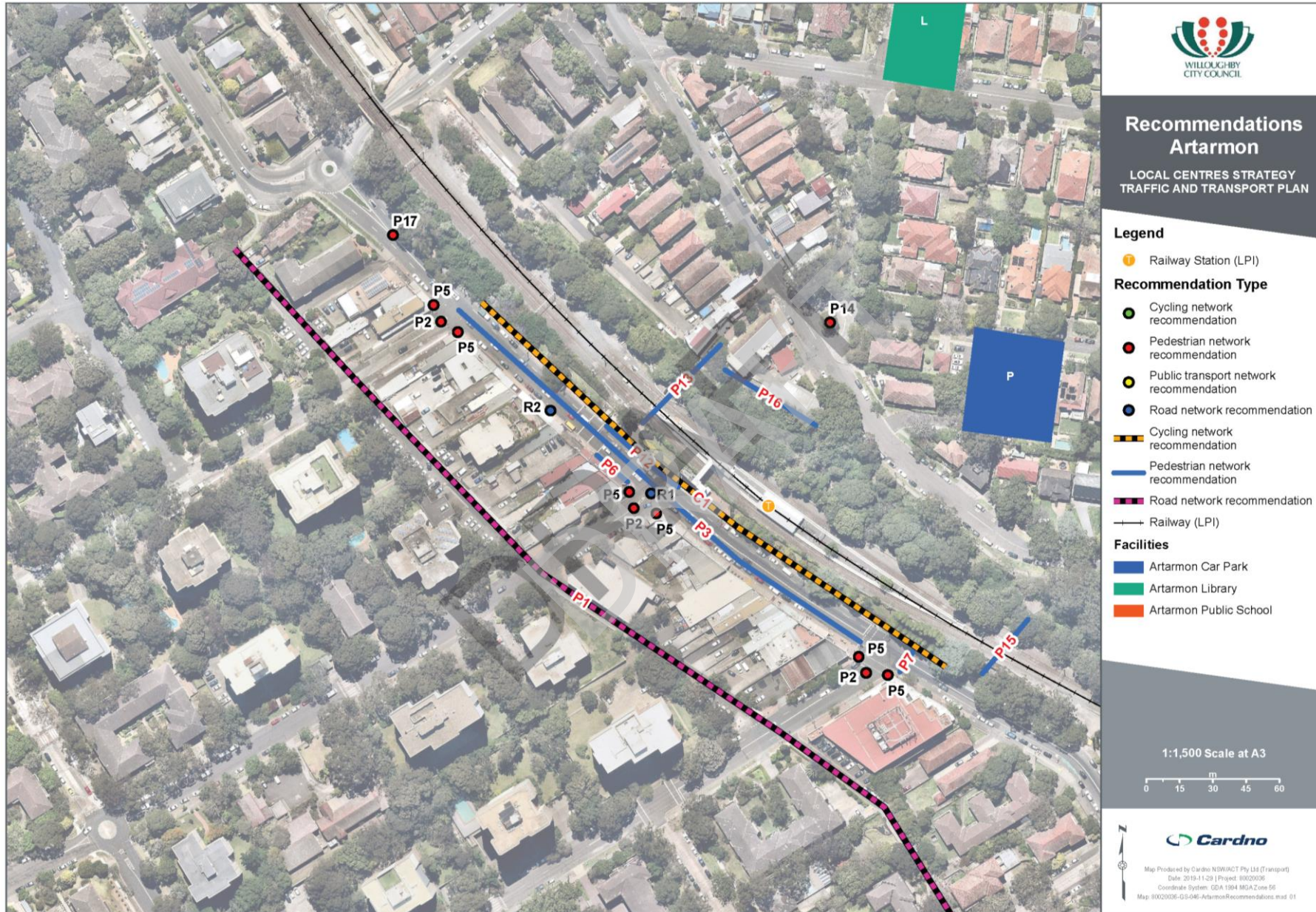
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Table 3-12 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P1	Lack of footpath along Hampden Lane.	Implement a 10 km/h shared zone along the full length of Hampden Lane to improve pedestrian safety.	Shared Zone	580m
P2	Lack of threshold/gateway treatments.	Provide threshold/gateway treatments to improve pedestrian amenity and safety within the centre, including raised pavements and kerb extensions at the intersections of Francis Road, Broughton Road and Jersey Street with Hampden Road.	Pavement treatment	
P3	High pedestrian activity with potential for conflict with vehicles.	Submit a proposal to TfNSW to implement a 40 km/h High Pedestrian Activity Area along Hampden Road between Francis Road and Jersey Street.	Speed limit amendment	
P5	Non-compliant kerb ramps.	Re-align kerb ramps to correct orientations at the intersections of Francis Road, Broughton Road and Jersey Street with Hampden Road and provide Tactile Ground Surface Indicators (TGSIs) for DDA compliance.	Kerb ramp and tactile indicators	2 ramps + 6 sets of tactile indicators
P6	Limited footpath width and accessibility on the southern side of Hampden Road at the signalised crossing.	Provide a kerb extension on the southern side of Hampden Road at the signalised pedestrian crossing to increase circulation and storage space, and ensure the ramp towards Broughton Road is DDA compliant.	Footpath	
P7	Missing pedestrian crossing at the intersection of Jersey Street/ Hampden Road.	Provide a signalised pedestrian crossing on the eastern leg of the Jersey Street/ Hampden Road intersection.	Signalised crossing	
P12	Poor use of pedestrian fencing.	Provide landscaping or other high quality urban design treatments to encourage pedestrians to use formal crossing points and prevent pedestrians from being trapped on the road.	Barrier treatment	
P13	Underpass from Wilkes Avenue to Artarmon station is not DDA compliant.	Investigate the feasibility of a re-grade of the footpath/ramp from Wilkes Avenue to Artarmon station to provide DDA compliance.	Footpath	55m
P14	Narrow footpaths and an informal crossing point on the island at the intersection of Elizabeth Street, Cameron Avenue and Tindale Road.	Remove the redundant east-west footpath leading to an informal crossing point without a kerb ramp. Widen the north-south footpath and install new compliant kerb ramp to direct pedestrians to the pedestrian refuge to the northwest.	Footpath widening, kerb ramp realignment	6m footpath, 1 kerb ramp
P15	Underpass from Hampden Road to Burra Road is poorly lit and may have possible safety concerns.	Provide additional lighting and consider urban design treatments to enhance the underpass and facilitate safe pedestrian movement.	Lighting	
P16	Pedestrian path adjacent to the rail corridor from Elizabeth Street to Wilkes Avenue is poorly lit and without passive surveillance, posing a potential safety risk.	Provide lighting for improved safety and install a footpath to facilitate pedestrian movement.	Lighting and footpath	

No.	Issue	Recommendation	Item	Length / no.
P17	Pedestrians observed crossing informally on Hampden Road near Brand Street.	Install a pedestrian refuge on Hampden Road north of Francis Road to facilitate pedestrian movement from the north west.	Pedestrian refuge	
Bicycle				
C1	Lack of cycleway infrastructure along Hampden Road.	Provide a shared path on the northern side of Hampden Road between Francis Road and Jersey Street, including path widening over the existing vegetation strip.	Shared path signage & linemarking, footpath widening	240m
Public transport				
PT3	No bus services during the daytime.	Advocate for TfNSW to review bus routes and consider providing services which could feed Artarmon Station or service destinations not well connected by rail (e.g. Ryde and other parts of Willoughby).	Bus services	
Road network				
R1	A poor level of service (LoS D) is experienced at the Hampden Road/ Broughton Road intersection.	Ban the right turn from Broughton Road onto Hampden Road to increase performance and reduce safety risks (note that vehicles can turn around at the roundabout at Brand Street).	No Right Turn treatment	
R2	Loading facility on Hampden Road opposite the station loads onto a narrow footpath with stairs.	Relocate the loading zone to a location south of Broughton Road with direct access to a level footpath.	Loading zone relocation	
R20	Overlapping requirements for long-stay parking create a scarcity of parking within the precinct.	Consider the introduction of localised paid parking for long-stay bays in the precinct.	Parking restrictions	
R21	Existing 1/2P free parking is likely too short to support many users on Hampden Road	Increase the 1/2 restriction along Hampden Road to 1P		
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

Figure 3-1 Recommendations map



4 Castlecrag

4.1 Future transport network review and recommendations

4.1.1 Traffic network analysis

4.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Castlecrag in accordance with **Table 4-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 4-1 Apartment mix and occupancy - Castlecrag

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	15	1.7	25
1 bedroom	14%	21	1.7	35
2 bedroom	60%	92	2.3	210
3 bedroom	16%	25	2.8	68
Total	100%	153	-	339

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 4-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 4-2 Non-residential floor space assumptions - Castlecrag

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	40%	1 / 40 sqm	63
Hospitality	40%	1 / 20 sqm	126
Office	20%	4.75 / 100 sqm	60
Total	100%	-	248

Therefore, based on these assumptions the Castlecrag local centre is expected to accommodate approximately 340 residents and 250 employees.

4.1.1.2 Parking requirements

The required car parking provision for the proposed development at the Castlecrag local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 4-3**. The total requirements were rounded down as per the DCP.

Table 4-3 Minimum car parking requirements - Castlecrag

Land use	Rate	Proposed development	Spaces required	
Residential (non-adaptable units)	Studio	0.5 / dwelling	15 dwellings	8
	1 bedroom	1 / dwelling	21 dwellings	21
	2 bedroom	1 / dwelling	92 dwellings	92
	3 bedroom	1 / dwelling	25 dwellings	25
	Visitors	0.25 / dwelling	153 dwellings	38
Residential subtotal			183	
Commercial	Retail	36 sqm / space	2,515 sqm GFA	70
	Hospitality	107 sqm / space	2,515 sqm GFA	23
	Office	110 sqm / space	1,257 sqm GFA	11
Commercial subtotal			105	
Development total			288	
	Motorbike parking	1 / 25 car parking spaces	288 spaces	11

Based on these calculations, the proposed development would be required to provide a minimum of 288 car parking spaces (including accessible parking spaces) and 11 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 4-4**.

Table 4-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	153 units	15
Retail	1 / 450m sqm GFA	2,515 sqm GFA	6
Hospitality	1 / 450m sqm GFA	2,515 sqm GFA	6
Office	1 / 600 sqm GFA	1,257 sqm GFA	2
Total			29

The calculations indicate that the proposed development would be required to provide 29 bicycle spaces.

4.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 4-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 4-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	153 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	1,886 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	1,886 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	943 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 4-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 4-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	29	23	29
Retail	21	67	17
Hospitality	21	74	141
Office	20	15	0
Total	91	179	188
Existing traffic generation	57	126	130
Net traffic generated	+34	+53	+57

On this basis the proposed development is expected to generate an additional 34 vehicle movements in the AM peak hour, 53 in the PM peak and 57 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 46% for residents and 60% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis and for a conservative estimate, a mode share discount of 10% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 36% for residents and 50% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

4.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 4-7**.

Table 4-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 4-8**.

Table 4-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	5	25	13	7	11	16
Retail	3	4	10	14	3	3
Hospitality	4	3	13	12	21	28
Office	5	1	0	5	0	0
Total (net traffic generated)	17	34	36	38	34	48

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 4-9**.

Table 4-9 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

4.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

4.1.1.6 Intersection modelling results

Table 4-10 summarises the intersection performance of the Castlecrag local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 4-10 Future intersection performance – Castlecrag

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Edinburgh Road / Eastern Valley Way	1.354	88.7	F	0.998	55.3	D	0.980	53.4	D
Edinburgh Road / Raeburn Avenue	0.249	10.9	A	0.204	8.7	A	0.209	8.8	A
Edinburgh Road / Rutland Avenue / The Postern	0.619	10.0	A	0.214	10.0	A	0.189	10.1	A

In the 2019 base model, Edinburgh Road / Eastern Valley Way intersection operated unsatisfactorily at LoS F in the AM peak period. With no capacity improvements considered in 2036 and due to the expected increase in demand generated, the operation issue at Edinburgh Road / Eastern Valley Way is expected to remain the same with the unsatisfactory level of service consistent with the 2019 base model. The performance is driven by the vehicle demand on Eastern Valley Way (Southern Approach) and Edinburgh Road (Eastern Approach) that exceed the capacity resulting in residual queues that don't clear every signal cycle. It should be noted that the Edinburgh Road / Eastern Valley Way intersection is already over-saturated (DoS is greater than 1.0) in the 2019 base AM peak period, indicating that the intersection will experience a significant decline in performance with any additional volumes.

Both of the other intersections (Edinburgh Road/ Raeburn Avenue and Rutland Avenue / The Postern) perform at LoS A in the 2036 future year which suggests the intersections will have spare capacity.

4.1.2 Active Transport

Walking and cycling needs within the Castlecrag local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Castlecrag already contains an established footpath network, however some gaps and deficiencies exist and include:

- > Narrow footpaths on Edinburgh Road;
- > Steep grades on The Postern;
- > A lack of threshold/gateway treatments;
- > Long distances between pedestrian crossings;
- > A lack of Tactile Ground Surface Indicators provided;
- > A lack of bike parking within the centre; and
- > Missing bicycle signage & linemarking on Edinburgh Road.

Recommendations to address these issues are summarised in **Section 4.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

4.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Castlecrag is not close to any train stations, however it is well connected by bus services on Eastern Valley Way. These services provide access to surrounding centres and public transport hubs including Chatswood, North Sydney and the Sydney CBD, though there is opportunity to increase the frequency of these services to improve convenience.

There is also the opportunity to provide on-demand services, which may help service the Castlecrag peninsula.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 4.1.4**.

4.1.4 Issues and options

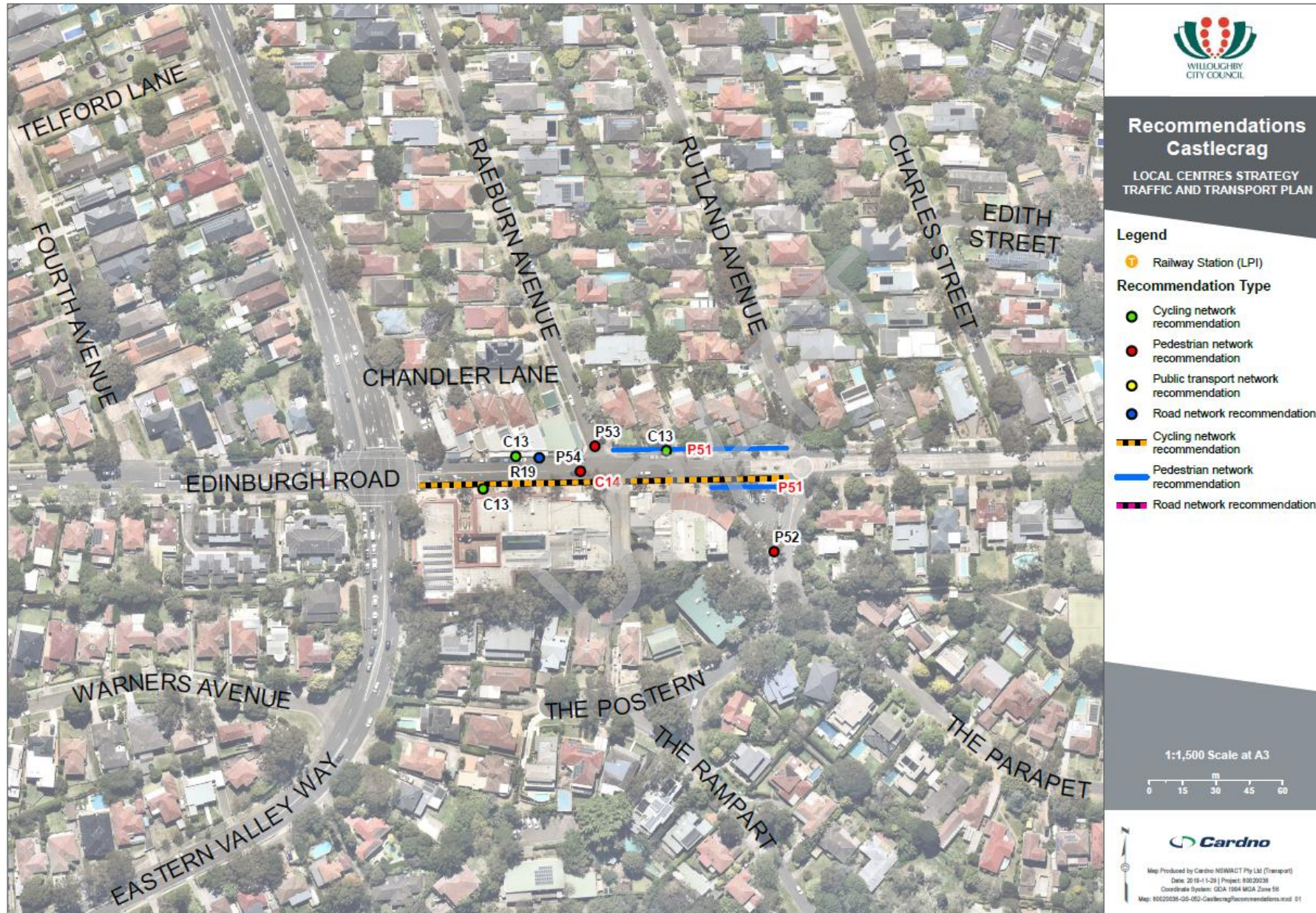
The issues and recommendations for the local centre are summarised in **Table 3-12** and **Figure 3-1**.

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Table 4-11 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P51	Narrow footpaths on Edinburgh Road between Raeburn Avenue and Rutland Street.	Widen the footpath on the northern side of Edinburgh Road between Raeburn Avenue and Rutland Street, and the footpath on the southern side from The Postern 35m to the west.	Footpath	120m
P52	Steep grades on The Postern leading to the retail centre.	Provide an accessible path of travel from The Postern to future development at the Castlecrag retail centre.	Accessible ramp	
P53	Lack of threshold/gateway treatments.	Provide threshold/gateway treatments to improve pedestrian amenity and safety within the centre, including raised pavements and kerb extensions intersection of Raeburn Avenue and Edinburgh Road	Crossing	
P54	Long distance between pedestrian crossings (170 metres) on Edinburgh Road.	Investigate implementation of a pedestrian crossing facility, with consideration of a raised marked pedestrian crossing on Edinburgh Road at the intersection with Raeburn Avenue.	Pedestrian crossing	
P60	Lack of TGSIs at kerb ramps.	TGSIs to be provided for all kerb ramps within the local centre.	TGSIs	
Bicycle				
C13	Lack of bike racks within the centre.	Provide additional bike racks along the north side of Edinburgh Road.	Bike racks	
C14	Missing bike signage on Edinburgh Road.	On-road painted bicycle symbols and signage to be provided on Edinburgh Road in accordance with the Willoughby Bike Plan.	Linemarking & signage	
Public transport				
PT4	Bus services are limited during the daytime.	Advocate for TfNSW to review bus routes and frequencies, with consideration given to providing additional services and increased connectivity to additional destinations.	Bus services	
Road network				
R19	Inadequate signage for local carparks	Improve wayfinding signage to the Quadrant Shopping Village car park on the approach to Castlecrag	Signage	
R22	High pedestrian activity with potential for conflict with vehicles.	Submit a proposal to TfNSW to implement a 40 km/h High Pedestrian Activity Area along Edinburgh Road between Eastern Valley Way and Rutland Avenue.	Speed limit amendment	
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

Figure 4-1 Recommendations map



5 East Chatswood

5.1 Future transport network review and recommendations

5.1.1 Traffic network analysis

5.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at East Chatswood in accordance with Table 5-1, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 5-1 Apartment mix and occupancy – East Chatswood

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	66	1.7	110
1 bedroom	14%	93	1.7	153
2 bedroom	60%	397	2.3	908
3 bedroom	16%	106	2.8	296
Total	100%	662	-	1,467

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 5-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 5-2 Non-residential floor space assumptions – East Chatswood

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	207
Hospitality	40%	1 / 20 sqm	553
Office	30%	4.75 / 100 sqm	394
Total	100%	-	1,154

Therefore, based on these assumptions the East Chatswood local centre is expected to accommodate approximately 1,470 residents and 1,150 employees.

5.1.1.2 Parking requirements

The required car parking provision for the proposed development at the East Chatswood local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 5-3**. The total requirements were rounded down as per the DCP.

Table 5-3 Minimum car parking requirements – East Chatswood

Land use	Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	66 dwellings
	1 bedroom	1 / dwelling	93 dwellings
	2 bedroom	1 / dwelling	397 dwellings
	3 bedroom	1 / dwelling	106 dwellings
	Visitors	0.25 / dwelling	662 dwellings
Residential subtotal			794
Commercial	Retail	36 sqm / space	8,290 sqm GFA
	Hospitality	107 sqm / space	11,053 sqm GFA
	Office	110 sqm / space	8,290 sqm GFA
Commercial subtotal			410
Development total			1,204
	Motorbike parking	1 / 25 car parking spaces	1,204 spaces
			48

Based on these calculations, the proposed development would be required to provide a minimum of 1,204 car parking spaces (including accessible parking spaces) and 48 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 5-4**.

Table 5-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	662 units	66
Retail	1 / 450m sqm GFA	8,290 sqm GFA	18
Hospitality	1 / 450m sqm GFA	11,053 sqm GFA	25
Office	1 / 600 sqm GFA	8,290 sqm GFA	14
Total			123

The calculations indicate that the proposed development would be required to provide 76 bicycle spaces.

5.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 3-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 5-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	662 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	6,217 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	8,290 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	8,290 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 5-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 5-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	126	99	126
Retail	70	222	57
Hospitality	93	325	621
Office	133	99	0
Total	421	746	803
Existing traffic generation	280	551	585
Net traffic generated	+141	+195	+218

On this basis the proposed development is expected to generate an additional 141 vehicle movements in the AM peak hour, 195 in the PM peak and 218 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share., and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 39% for residents and 55% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 10% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 29% for residents and 45% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

5.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 5-7**.

Table 5-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 5-8**.

Table 5-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	16	97	44	29	40	61
Retail	7	11	22	34	6	9
Hospitality	11	11	38	39	61	94
Office	24	4	2	27	0	0
Total (net traffic generated)	57	123	106	129	106	164

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 5-9**.

Table 5-9 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

5.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

5.1.1.6 Intersection modelling results

Table 5-10 summarises the intersection performance of the East Chatswood local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 5-10 Future intersection performance – East Chatswood

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Victoria Avenue / Royal Street / Kooringa Road	0.401	21	B	0.911	50.8	D	0.378	39.6	C
Victoria Avenue / Penshurst Street	1.04	63.3	E	1.036	58.4	E	1.295	140.5	F
Penshurst Street / Macmahon Street / Sydney Street	0.916	7.5	A	1.066	63.4	E	0.913	11.3	A

In the 2019 base model, the Victoria Avenue / Penshurst Street intersection was performing unsatisfactorily at a LoS F in the Saturday peak period. It was noted that delays associated with LoS F were due to the through and right-turning vehicles from Victoria Avenue (western approach), where the demand exceeded the capacity, creating residual queues after each cycle. With no capacity improvements considered in 2036, the existing operation and issue at Victoria Avenue / Penshurst Street intersection worsens. In the AM and PM peak periods, the intersection performance deteriorates from a LoS C and D respectively in 2019 to a LoS E in 2036.

In 2036, the intersection operation worsens at the other two intersections, however, the level of service is consistent with the 2019 base model except in the PM peak period. In 2036 compared to 2019, the Victoria Avenue / Royal Street / Kooringa Road intersection deteriorates to a LoS D from LoS C, the Victoria Avenue / Penshurst Street intersection worsens to LoS E from LoS D and the Penshurst Street / Macmahon Street / Sydney Street intersection worsens to a LoS E from LoS B. This is due to the expected increase in demand generated by the proposed development.

The results from the 2019 base model indicated that the Victoria Avenue / Penshurst Street intersection is over-saturated (DoS is greater than 1.0) in the Saturday peak period but operates satisfactorily in the other peak periods. By 2036, it is expected to be over-saturated across all peak periods. The Penshurst Street / Macmahon Street / Sydney Street intersection reaches a DoS greater than 1.0 in the PM peak period, and in the other peak periods the degree of saturation is above 0.9. Similarly, the Victoria Avenue / Royal Street / Kooringa Road intersection DoS is expected to be above 0.9 in the PM peak period while the degree of saturation remains below 0.9 in the other peak periods.

5.1.2 Active Transport

Walking and cycling needs within the East Chatswood local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

East Chatswood already contains an established footpath network, however there are a range of opportunities for improvement and limited cycling infrastructure. These issues are summarised in xxx, along with recommendations to address them.

Recommendations to address these issues are summarised in **Section 5.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

5.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

East Chatswood is well connected by bus to surrounding centres and public transport hubs including Chatswood, North Sydney and the Sydney CBD. Victoria Avenue and Penshurst Street accommodate a range of services and link to Chatswood station where rail access is provided. Opportunities for improvement are limited but may include additional services and a review of bus routes to optimise connectivity and access.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 5.1.4**.

5.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 5-11** and **Figure 5-1**.

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Table 5-11 Issues and recommendations

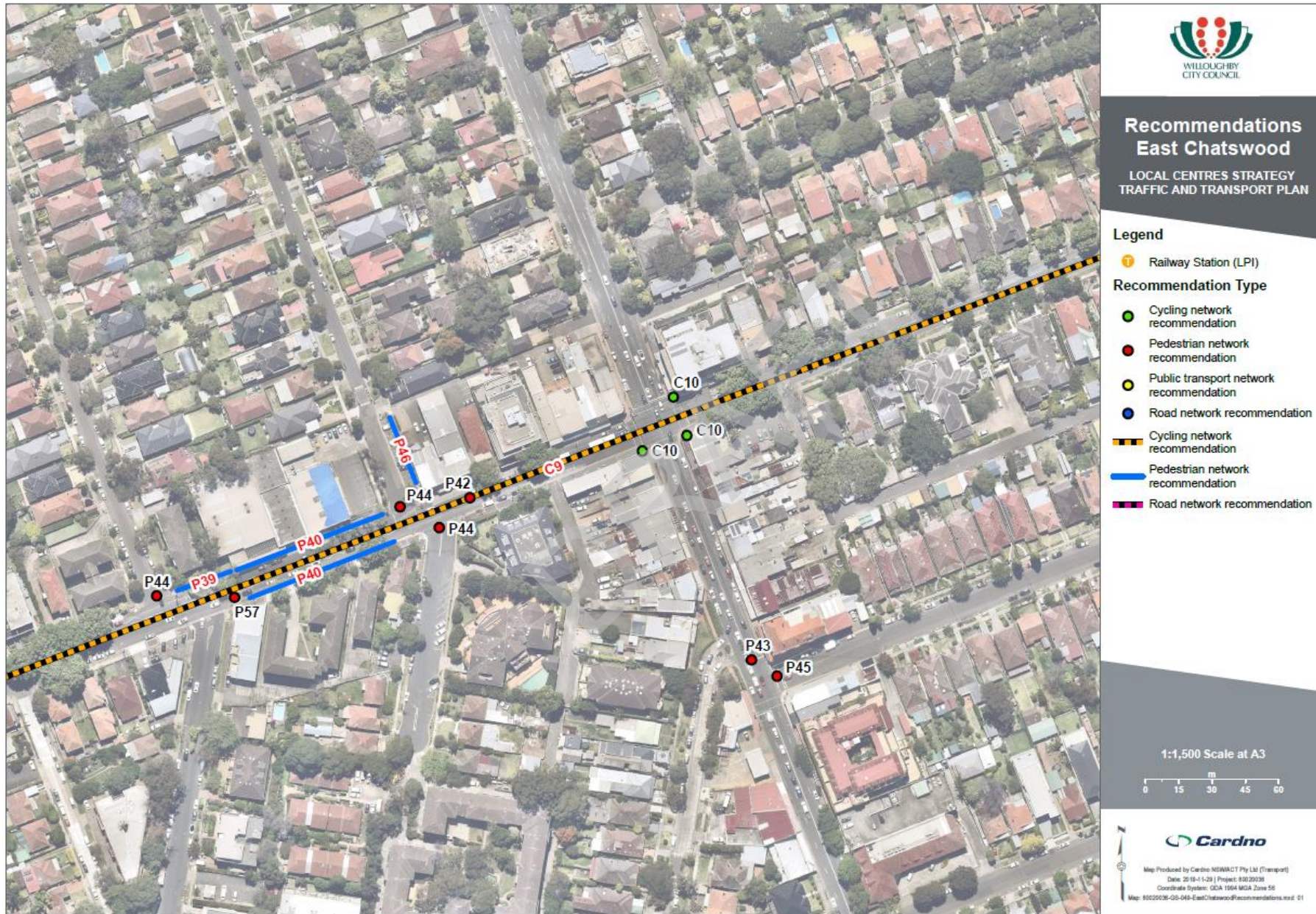
No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P39	Narrow footpath on the northern side of Victoria Avenue between Crick Street and the pedestrian crossing.	Widen the footpath on the northern side of Victoria Avenue between Crick Street and the pedestrian crossing to minimum 2m where possible.	Footpath	30m
P40	Inconsistent paving treatments	Implement the same paving treatment for the north side of the Victoria Avenue as the south side to clearly show that it is a pedestrian priority environment	Footpath	100m
P42	A distance of almost 200 metres between pedestrian crossings on Victoria Avenue.	Investigate implementation of a pedestrian refuge on Victoria Avenue between Kooringa Road and Stirling Lane.	Pedestrian refuge	
P43	Missing pedestrian crossing at the intersection of Penshurst Street with Macmahon Street.	Provide a signalised pedestrian crossing on the northern leg of the Penshurst Street / Macmahon Street intersection.	Signalised pedestrian crossing	
P44	Long pedestrian crossing distances on Kooringa Road, Crick Street and Royal Street at Victoria Avenue and Patrick St at Penshurst Street.	Provide kerb extensions or pedestrian refuges to reduce pedestrian crossing distances and the potential for conflict.	Kerb extensions/ pedestrian refuges	
P45	Incorrect linemarking for the signalised pedestrian crossing on Macmahon Street at Penshurst Street.	Renew pedestrian crossing linemarking with dashed lines in accordance with RMS standards.	Linemarking	
P46	Vehicles encroaching onto the eastern footpath of Royal Street.	Provide wheel stops at the car parking spaces on the eastern side of Royal Street.	Wheel stops	12
P57	Non-compliant pedestrian crossing on Victoria Avenue east of Stanley Street.	Provide kerb extensions at the marked pedestrian crossing to reduce the number of travel lanes crossed from three to two.	Kerb extensions	
Bicycle				
C9	Lack of existing cycling infrastructure within the centre.	Provide a separated cycleway on Victoria Avenue between Havilah Street and High Street in accordance with the Willoughby Bike Plan.	Separated cycleway	760m
C10	Limited bicycle parking available.	Provide bike racks near the corner of Penshurst Street and Victoria Avenue to facilitate future demand from the proposed cycleway on Victoria Avenue.	Bike racks	10
Road network				
R23	Lack of accessible parking within the local centre.	Provide accessible parking spaces within the local centre at convenient locations on Penshurst Street and Victoria Avenue.	Parking	
R24	Existing 1/2P free parking is likely too short to support many of the uses along Penshurst Street, and is difficult to enforce.	Standardise parking along Penshurst Street and Victoria Avenue (within the Centre) to a 1P standard, and introduce 2P parking in other streets within the centre. Parking beyond the centre should be unrestricted.		

All local centres

-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy
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Figure 5-1 Recommendations map



6 High Street

6.1 Future transport network review and recommendations

6.1.1 Traffic network analysis

6.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at High Street in accordance with **Table 6-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 6-1 Apartment mix and occupancy – High Street

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	3	1.7	5
1 bedroom	14%	4	1.7	6
2 bedroom	60%	17	2.3	38
3 bedroom	16%	4	2.8	12
Total	100%	28	-	62

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 6-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 6-2 Non-residential floor space assumptions – High Street

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	50%	1 / 40 sqm	67
Hospitality	40%	1 / 20 sqm	107
Office	10%	4.75 / 100 sqm	26
Total	100%	-	200

Therefore, based on these assumptions the East Chatswood local centre is expected to accommodate approximately 60 residents and 200 employees.

6.1.1.2 Parking requirements

The required car parking provision for the proposed development at the High Street local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 6-3**. The total requirements were rounded down as per the DCP.

Table 6-3 Minimum car parking requirements – High Street

Land use	Rate	Proposed development	Spaces required	
Residential (non-adaptable units)	Studio	0.5 / dwelling	3 dwellings	1
	1 bedroom	1 / dwelling	4 dwellings	4
	2 bedroom	1 / dwelling	17 dwellings	17
	3 bedroom	1 / dwelling	4 dwellings	4
	Visitors	0.25 / dwelling	28 dwellings	7
Residential subtotal			33	
Commercial	Retail	36 sqm / space	2,686 sqm GFA	75
	Hospitality	107 sqm / space	2,149 sqm GFA	20
	Office	110 sqm / space	537 sqm GFA	5
Commercial subtotal			100	
Development total			133	
	Motorbike parking	1 / 25 car parking spaces	133 spaces	5

Based on these calculations, the proposed development would be required to provide a minimum of 133 car parking spaces (including accessible parking spaces) and 5 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 6-4**.

Table 6-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	28 units	3
Retail	1 / 450m sqm GFA	2,686 sqm GFA	6
Hospitality	1 / 450m sqm GFA	2,149 sqm GFA	5
Office	1 / 600 sqm GFA	537 sqm GFA	1
Total			14

The calculations indicate that the proposed development would be required to provide 14 bicycle spaces.

6.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 6-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 6-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	28 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	2,015 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	1,612 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	537 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 6-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 6-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	5	4	5
Retail	23	72	18
Hospitality	18	63	121
Office	9	6	0
Total	54	146	144
Existing traffic generation	37	106	104
Net traffic generated	+18	+40	+40

On this basis the proposed development is expected to generate an additional 18 vehicle movements in the AM peak hour, 40 in the PM peak and 40 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 47% for residents and 59% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 5% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 42% for residents and 54% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

6.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 6-7**.

Table 6-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 6-8**.

Table 6-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	1	8	4	2	4	5
Retail	4	5	13	16	3	4
Hospitality	4	3	13	11	21	27
Office	3	0	0	3	0	0
Total (net traffic generated)	12	16	30	33	28	36

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 6-9**.

Table 6-9 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

6.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

6.1.1.6 Intersection modelling results

Due to the St Thomas' Art and Craft Show coinciding with the Saturday peak period, the modelling for the Saturday peak period could not be undertaken as the behaviour and volumes obtained will not reflect the typical traffic behaviour on High Street.

Table 6-10 summarises the intersection performance of the High Street local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 6-10 Future intersection performance – High Street

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
High Street / Glover Street	0.342	13.9	A	0.361	17.4	B	Special Event		
High Street / Horsley Avenue	0.380	13.0	A	0.336	15	B			
High Street Pedestrian Crossing	0.914	19.1	B	0.800	9.4	A			
High Street / Alexander Avenue	0.363	14.0	A	0.448	18.4	B			
High Street / Forsyth Street	0.352	13.0	A	0.372	15.5	B			
High Street / McClelland Street	0.348	12.7	A	0.442	18.3	B			

In 2036, it is expected that all the intersections will operate at LoS A or B in both the AM and PM peak periods, which indicates satisfactory operation with acceptable delays and spare capacity. This is consistent with the intersection performance in 2019.

The degree of saturation is below 0.9 across all peak periods for all intersections except at the pedestrian crossing between High Street and Alexander Avenue in the AM peak period. It is noted that in the 2019 base model (existing), it was identified that the degree of saturation was greater than 0.9 based on the SIDRA results. It is anticipated that queues will propagate from the unsignalised pedestrian crossing during the AM peak period, similar to the observation noted in the 2019 base model.

6.1.2 Active Transport

Walking and cycling needs within the High Street local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

High Street as a local centre contains wide footpaths along the main shopping strip, however has some opportunities to improve crossing facilities and cycling infrastructure.

Recommendations to address these issues are summarised in **Section 6.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

6.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

High Street offers no public transport services within the centre, however services can be accessed on Penshurst Street via a short walk. Opportunities may include promoting and improving access to these services or amending existing routes to operate on High Street to service the local centre.

There is also the opportunity to provide on-demand services, which may be able to service the local centre in lieu of standard bus services.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 6.1.4**.

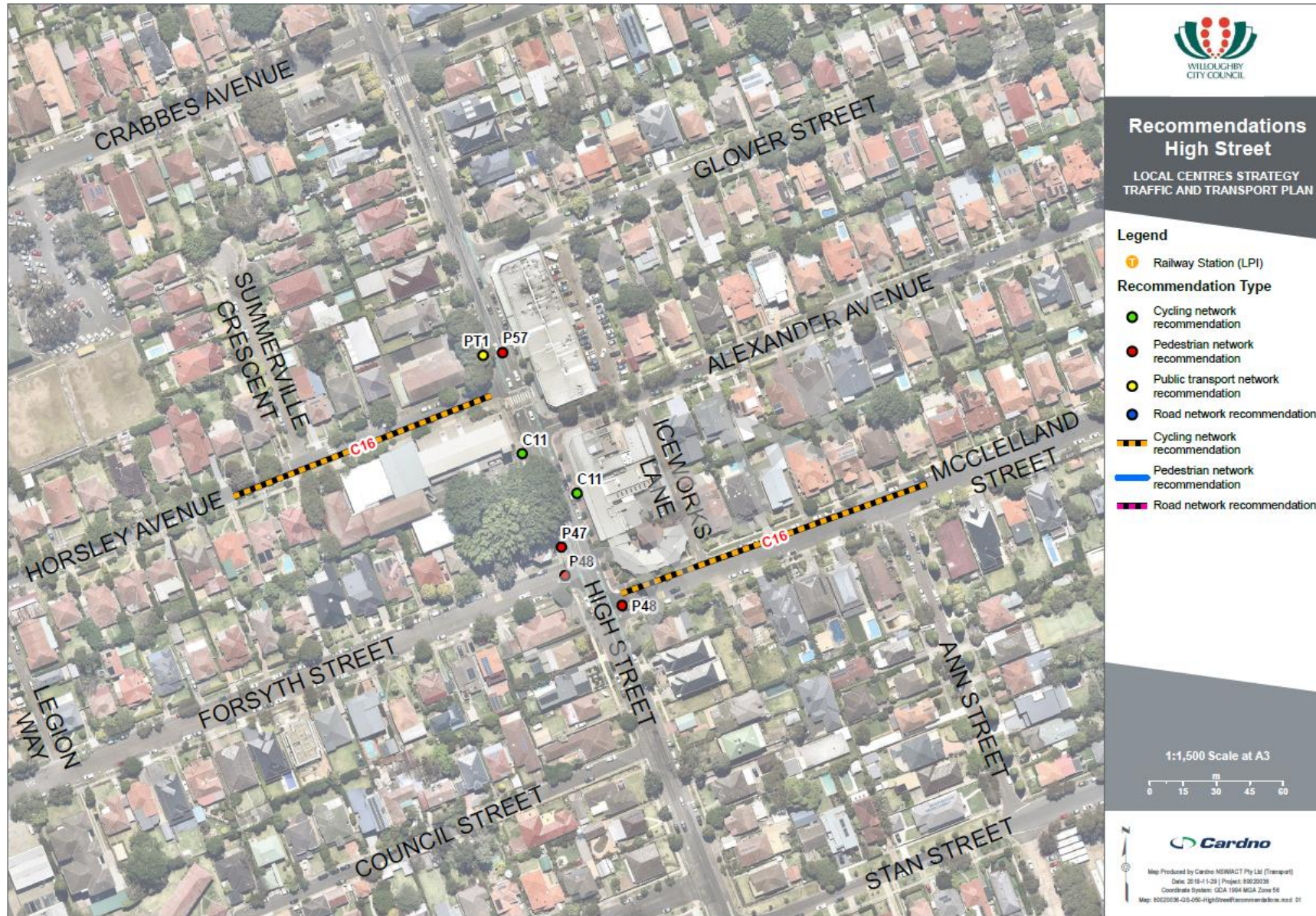
6.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 6-11** and **Figure 6-1**.

Table 6-11 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P47	A pram ramp is present on west side of High Street, adjacent to Forsyth Street, however there is no adjoining pram ramp on the opposite side.	Convert the non-compliant pram ramp into a raised marked pedestrian crossing. It is noted that this will have a parking impact, reducing the number of on-street spaces available.	Pedestrian crossing	
P48	Long crossing distance on McClelland St and Forsyth St.	Provide a pedestrian refuge and/or kerb extensions on McClelland Street and Forsyth Street at High Street to facilitate better pedestrian connectivity in and out of centre.	Pedestrian refuge/ kerb extensions	
P57	Poor alignment of the pedestrian crossing on High Street.	Relocate the existing pedestrian crossing on High Street south of Horsley Avenue to align with future pedestrian arcades/through-site links and improve pedestrian access to the centre.	Pedestrian crossing relocation	
P59	Lack of TGSIs at kerb ramps.	TGSIs to be provided for all kerb ramps within the local centre.	TGSIs	
Bicycle				
C11	Limited bike parking within the local centre.	Install additional bike racks on the eastern side of High Street between Alexander Street and McClelland Street.	Bike racks	
C16	Missing bike signage on sections of cycle routes designated in the Willoughby Bike Plan.	Install signage and line marking on McClelland Street and Horsley Avenue in accordance with the Willoughby Bike Plan.		
Public transport				
PT1	Bus stops are provided strictly for school students however are located approximately 160 metres from the school.	Relocate the northbound bus stop south of Forsyth Street to be located adjacent to the St Thomas Primary School, north of Horsley Avenue.	Bus stop relocation	
PT5	Lack of public transport options in the local centre.	Advocate for TfNSW to review bus routes and consider providing services to operate on High Street, providing access to the centre and connections to destinations such as Chatswood and Sydney CBD.	Bus services	
Road network				
R25	Parking restrictions only cater for short stays	Introduce 1P parking restrictions along Alexander Avenue, McClelland Street and Glover Street (within 100m of High Street), and increase 1/2P duration restrictions along High Street to 1P.	Parking	
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

Figure 6-1 Recommendations map



7 Naremburn

7.1 Future transport network review and recommendations

7.1.1 Traffic network analysis

7.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Naremburn in accordance with **Table 7-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 7-1 Apartment mix and occupancy – Naremburn

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	9	1.7	15
1 bedroom	14%	13	1.7	21
2 bedroom	60%	55	2.3	125
3 bedroom	16%	15	2.8	41
Total	100%	91	-	203

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 7-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 7-2 Non-residential floor space assumptions – Naremburn

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	29
Hospitality	40%	1 / 20 sqm	78
Office	30%	4.75 / 100 sqm	55
Total	100%	-	162

Therefore, based on these assumptions the Naremburn local centre is expected to accommodate approximately 200 residents and 160 employees.

7.1.1.2 Parking requirements

The required car parking provision for the proposed development at the Naremburn local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 7-3**. The total requirements were rounded down as per the DCP.

Table 7-3 Minimum car parking requirements – Naremburn

Land use	Rate	Proposed development	Spaces required	
Residential (non-adaptable units)	Studio	0.5 / dwelling	9 dwellings	5
	1 bedroom	1 / dwelling	13 dwellings	13
	2 bedroom	1 / dwelling	55 dwellings	55
	3 bedroom	1 / dwelling	15 dwellings	15
	Visitors	0.25 / dwelling	91 dwellings	23
Residential subtotal			109	
Commercial	Retail	36 sqm / space	1,167 sqm GFA	33
	Hospitality	107 sqm / space	1,556 sqm GFA	15
	Office	110 sqm / space	1,167 sqm GFA	11
Commercial subtotal			57	
Development total			166	
	Motorbike parking	1 / 25 car parking spaces	166 spaces	6

Based on these calculations, the proposed development would be required to provide a minimum of 166 car parking spaces (including accessible parking spaces) and 6 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 7-4**.

Table 7-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	91 units	9
Retail	1 / 450m sqm GFA	1,167 sqm GFA	3
Hospitality	1 / 450m sqm GFA	1,556 sqm GFA	3
Office	1 / 600 sqm GFA	1,167 sqm GFA	2
Total			17

The calculations indicate that the proposed development would be required to provide 17 bicycle spaces.

7.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 7-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 7-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	91 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	875 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	1,167 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	1,167 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 7-5**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 7-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	17	14	17
Retail	10	31	8
Hospitality	13	46	87
Office	19	14	0
Total	59	105	113
Existing traffic generation	26	53	56
Net traffic generated	+33	+52	+57

On this basis the proposed development is expected to generate an additional 33 vehicle movements in the AM peak hour, 52 in the PM peak and 57 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 36% for residents and 47% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 10% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 36% for residents and 47% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

7.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 7-7**.

Table 7-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 7-8**.

Table 7-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	2	14	7	4	6	9
Retail	2	3	6	9	2	2
Hospitality	3	3	11	10	17	24
Office	7	1	1	7	0	0
Total (net traffic generated)	14	21	24	30	25	35

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 7-9**.

Table 7-9 Directional assumptions

Direction	In %	Out %
North	35%	45%
East	0%	0%
South	52%	26%
West	14%	29%
Total	100%	100%

Source: ABS 2016 Census Data

7.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

7.1.1.6 Intersection modelling results

Table 7-10 summarises the intersection performance of the Naremburn local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 7-10 Future intersection performance – Naremburn

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Gore Hill Freeway	0.582	19.4	B	0.635	26.5	B	0.502	21.9	B
Willoughby Road / Naremburn Car Park Access	0.171	6.3	A	0.234	6.9	A	0.192	6.5	A
Willoughby Road / Rohan Street	0.736	55.3	D	1.334	468.4	F	1.016	194.1	F
Willoughby Road / Merrenburn Avenue	0.673	31.7	C	0.742	44.8	D	0.553	26.8	B

In the 2019 base model, the Willoughby Road / Rohan Street intersection operated unsatisfactorily at LoS F in the PM peak period. With no capacity improvements considered in 2036 and due to the expected increase in demand generated, the intersection performance is expected to be unsatisfactory at LoS F in the PM peak period. In the AM peak period, the intersection performance deteriorates from LoS C in 2019 to a LoS D in 2036 and in the Saturday peak the intersection performance deteriorates from LoS D in 2019 to LoS F in 2036.

The performance of this intersection in all peak periods in the 2036 future year is driven by the left and right turning vehicles from Rohan Street, which are not able to find a sufficient gap to enter Willoughby Road as the queues from the signalised intersection to the north (Willoughby Road / Gore Hill Freeway) extend beyond the Willoughby Road / Rohan Street intersection.

However, these results are not deemed realistic due to the 'Keep Clear' pavement marking on Willoughby Road at Rohan Street. This type of intersection is not accurately modelled in SIDRA, and videos from the intersection surveys revealed that no significant queuing occurred on Rohan Street since vehicles were able to enter the traffic stream due to gaps created by the pavement marking. The intersection performance is therefore deemed satisfactory, since all traffic movements operate sufficiently well in reality.

Furthermore, this observation is consistent with the 2019 base model and is not caused by the proposed development.

7.1.2 Active Transport

Walking and cycling needs within the Naremburn local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Naremburn already contains an established footpath and cycle network, however there is a gap in the cycle network along Willoughby Road and various opportunities to improve the pedestrian network.

Recommendations to address these issues are summarised in **Section 7.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

7.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Naremburn is well connected by bus services along Willoughby Road, providing access to areas including Chatswood, Crows Nest, North Sydney and the Sydney CBD. Opportunities to improve public transport may be limited to increasing the service frequency.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 7.1.4**.

7.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 7-11** and **Figure 7-1**.

Table 7-11 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P19	Lack of threshold/gateway treatments.	Provide raised thresholds/gateway treatments at the intersections of Willoughby Road / Rohan Street and Willoughby Road / Car Park Access, including kerb extensions at Rohan Street.	Kerb extension/ raised threshold/ pavement treatment	2
P20	Non-compliant kerb ramps.	Re-align kerb ramps to correct orientations at the intersections of Willoughby Road / Rohan Street, Glenmore Street / Quiamong Street and Quiamong Street adjacent to the M1.	Kerb ramps	5
P22	Narrow footpaths on Rohan Street.	Widen the footpaths on Rohan Street to a minimum 2m to facilitate future growth and pedestrian activity.	Footpath	75m
P23	Long crossing distance on Rohan Street at Glenmore Street.	Provide kerb extensions to minimise the crossing distance and act as a gateway treatment to slow traffic speeds.	Pedestrian refuge	
P30	Narrow footpaths on Glenmore Street between Rohan Street and Quiamong Street.	Widen the footpaths on Glenmore Street to a minimum 2m to facilitate future growth and pedestrian activity.	Footpath	88m
P61	Lack of Tactile Ground Surface Indicators (TGSIs).	Provide Tactile Ground Surface Indicators at kerb ramps within the local centre for DDA compliance.	TGSIs	11
Bicycle				
C6	Lack of bike hoops within the local centre.	Provide additional bike hoops to encourage cycling as a travel mode and accommodate future development.	Bike hoops	5
C7	Missing bicycle signage and linemarking on designated cycle routes.	Install bicycle signage and painted symbols on Glenmore Street and Faunce Lane to match the designated routes on the Willoughby Bike Plan.	Signage & linemarking	
C17	Lack of a continuous cycleway on Willoughby Road.	Provide a shared path on the eastern side of Willoughby Road between the M1 off ramp and Merrenburn Avenue, including cycle aspects at the signalised intersection of Willoughby Road / M1 Off Ramp and regulatory and wayfinding signage.	Shared path	110m
Road network				
R6	Vehicles encroaching onto the northern footpath on Rohan Street.	Provide wheel stops at the car parking spaces on the northern side of Rohan Street.	Wheel stops	7
R7	Faunce Lane is narrow and leads to a dead end, which is used by vehicles for parking and manoeuvring.	Convert Faunce lane into a 10 km/h shared zone and enforce parking restrictions.	Shared Zone	88m

No.	Issue	Recommendation	Item	Length / no.
R9	High pedestrian activity with potential for conflict with vehicles.	Submit a proposal to TfNSW to implement a 40 km/h High Pedestrian Activity Area along Rohan Street and Quiamong Street.	Speed limit amendment	-
R26	Parking adjacent to Willoughby Road utilising high-value space and creating potential conflict.	Redevelop the Naremburn Shopping Centre car park to relocate car parking to a rear laneway or local streets and reduce conflict potential caused by historic access decisions. Parking could be increased along Rohan Street and Glenmore Street by providing angle parking to compensate for loss of bays, and include streetscape improvements to increase net benefit to businesses.	Parking relocation	-
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

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Figure 7-1 Recommendations map



8 Northbridge

8.1 Future transport network review and recommendations

8.1.1 Traffic network analysis

8.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Northbridge in accordance with **Table 8-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 8-1 Apartment mix and occupancy – Northbridge

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	95	1.7	157
1 bedroom	14%	133	1.7	219
2 bedroom	60%	568	2.3	1,299
3 bedroom	16%	152	2.8	424
Total	100%	947	-	2,099

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 8-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 8-2 Non-residential floor space assumptions – Northbridge

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	30%	1 / 40 sqm	311
Hospitality	30%	1 / 20 sqm	623
Office	40%	4.75 / 100 sqm	789
Total	100%	-	1,722

Therefore, based on these assumptions the Northbridge local centre is expected to accommodate approximately 2,100 residents and 1,720 employees.

8.1.1.2 Parking requirements

The required car parking provision for the proposed development at the Northbridge local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 8-3**. The total requirements were rounded down as per the DCP.

Table 8-3 Minimum car parking requirements – Northbridge

Land use	Rate	Proposed development	Spaces required	
Residential (non-adaptable units)	Studio	0.5 / dwelling	95 dwellings	47
	1 bedroom	1 / dwelling	133 dwellings	133
	2 bedroom	1 / dwelling	568 dwellings	568
	3 bedroom	1 / dwelling	152 dwellings	152
	Visitors	0.25 / dwelling	947 dwellings	237
Residential subtotal			1,136	
Commercial	Retail	36 sqm / space	12,451 sqm GFA	349
	Hospitality	107 sqm / space	12,451 sqm GFA	116
	Office	110 sqm / space	16,602 sqm GFA	151
Commercial subtotal			615	
Development total			1,751	
	Motorbike parking	1 / 25 car parking spaces	1,751 spaces	70

Based on these calculations, the proposed development would be required to provide a minimum of 1,751 car parking spaces (including accessible parking spaces) and 70 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 8-4**.

Table 8-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	947 units	95
Retail	1 / 450m sqm GFA	12,451 sqm GFA	28
Hospitality	1 / 450m sqm GFA	12,451 sqm GFA	28
Office	1 / 600 sqm GFA	16,602 sqm GFA	28
Total			178

The calculations indicate that the proposed development would be required to provide 178 bicycle spaces.

8.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 8-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 8-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	947 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	9,338 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	9,338 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	16,602 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 8-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 8-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	180	142	180
Retail	105	333	85
Hospitality	105	366	699
Office	266	199	0
Total	655	1,041	964
Existing traffic generation	442	769	690
Net traffic generated	+213	+272	+275

On this basis the proposed development is expected to generate an additional 213 vehicle movements in the AM peak hour, 272 in the PM peak and 275 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 44% for residents and 56% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 10% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 44% for residents and 56% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

8.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 8-7**.

Table 8-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 8-8**.

Table 8-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	27	145	75	43	68	91
Retail	12	16	37	50	10	13
Hospitality	14	13	49	44	78	105
Office	54	8	4	54	0	0
Total (net traffic generated)	107	181	166	191	156	208

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 8-9**.

Table 8-9 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

8.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

8.1.1.6 Intersection modelling results

Table 8-10 summarises the intersection performance of the Northbridge local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 8-10 Future intersection performance – Northbridge

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Sailors Bay Road / Eastern Valley Way	0.771	20.1	B	1.121	56.4	D	1.108	46.0	D
Sailors Bay Road / Harden Avenue	0.920	27.2	B	1.004	49.1	D	0.866	19.5	B
Sailors Bay Road / Strathallen Avenue	1.164	41.4	C	1.078	31.2	C	1.066	37.6	C

In the 2019 base model, all the intersections were performing at LoS C or better, indicating that the intersections were operating satisfactorily with acceptable delays and spare capacity.

In 2036, due to the increase in demand on Sailors Bay Road, the intersection performance at the Sailors Bay Road / Eastern Valley Way intersection decreases in the PM and Saturday peak periods, where it deteriorates from LoS B in 2019 to LoS D in 2036.

Similarly, due to the increase in the demand on Sailors Bay Road the intersection performance at Sailors Bay Road/Harden Avenue intersection worsens in the PM peak, from a LoS B in 2019 to LoS D in 2036.

8.1.2 Active Transport

Walking and cycling needs within the Northbridge local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Northbridge already contains an established footpath network, however there is a particular lack of cycling infrastructure and several opportunities to improve pedestrian crossings. Northbridge is heavily focused on Eastern Valley Way – Sailors Bay Road – Strathallen Avenue as a vehicle movement corridor and the environment is therefore constrained.

Recommendations to address these issues are summarised in **Section 8.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

8.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Northbridge is well connected by bus services operating along Eastern Valley Way, providing access to surrounding centres including Chatswood and the Sydney CBD via the Warringah Freeway. Opportunities to improve public transport may include increasing the frequency of services.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 8.1.4**.

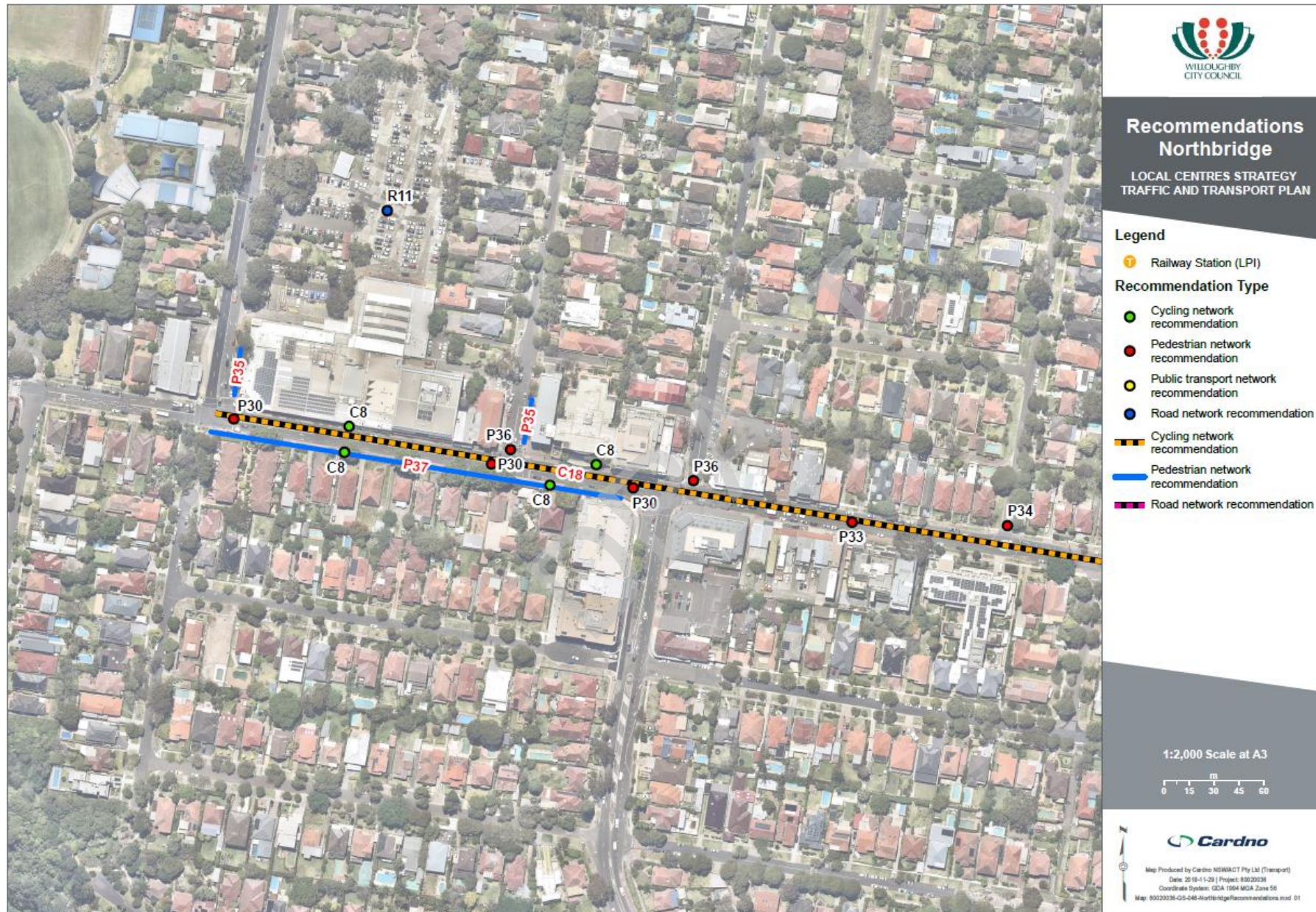
8.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 8-11** and **Figure 8-1**.

Table 8-11 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P30	Missing pedestrian crossings at intersections.	Provide additional pedestrian crossings at the following locations: - Eastern leg of the Eastern Valley Way/Sailors Bay Road intersection; - Western leg of the Sailors Bay Road/Harden Avenue intersection; and - Western leg of the Sailors Bay Road/Strathallen Avenue intersection.	Pedestrian crossings	3
P33	Lack of pedestrian crossings on Sailors Bay Road east of Strathallen Avenue.	Provide a pedestrian crossing facility on Sailors Bay Road between Strathallen Avenue and Euroka Street, with consideration of a marked pedestrian crossing with kerb extensions or a pedestrian refuge.	Pedestrian crossing facility	1
P34	Non-compliant pedestrian refuge at Sailors Bay Road/Euroka Street.	Upgrade the existing pedestrian refuge to a fully compliant pedestrian refuge to facilitate pedestrian movement across Sailors Bay Road.	Pedestrian refuge	1
P35	Narrow footpaths along Eastern Valley Way and Harden Avenue.	Widen the footpaths along the eastern side of Eastern Valley Way and Harden Avenue adjacent to the local centre, to a minimum of 2m.		
P36	Lack of threshold/gateway treatments.	Provide threshold/gateway treatments to improve pedestrian amenity and safety within the centre, including raised pavements and kerb extensions at the intersections of Harden Avenue/Sailors Bay Road and Bellambi Street/Sailors Bay Road.	Kerb extension / raised threshold	2
P62	Non-compliant kerb ramps.	Re-align kerb ramps to correct orientations at the intersections of Sailors Bay Road with Strathallen Avenue and Bellambi Street.	Kerb ramps	4
P63	Lack of Tactile Ground Surface Indicators (TGSIs).	Provide Tactile Ground Surface Indicators at kerb ramps within the local centre for DDA compliance.	TGSIs	14
Bicycle				
C8	Lack of cycleway infrastructure.	Provide an on-road mixed traffic cycle route on Sailors Bay Road between Eastern Valley Way and Namoi Road by implementing painted bicycle symbols.	Painted symbols	-
C18	Lack of cycle parking.	Provide additional cycle parking within the centre to encourage cycling as a travel mode and accommodate future growth.	Cycle parking	10
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

Figure 8-1 Recommendations map



9 Penshurst Street

9.1 Future transport network review and recommendations

9.1.1 Traffic network analysis

9.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Penshurst Street in accordance with **Table 9-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 9-1 Apartment mix and occupancy – Penshurst Street

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	51	1.7	85
1 bedroom	14%	72	1.7	119
2 bedroom	60%	307	2.3	703
3 bedroom	16%	82	2.8	229
Total	100%	512	-	1,135

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 9-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 9-2 Non-residential floor space assumptions – Penshurst Street

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	45%	1 / 40 sqm	172
Hospitality	10%	1 / 20 sqm	77
Office	45%	4.75 / 100 sqm	327
Total	100%	-	576

Therefore, based on these assumptions the Penshurst Street local centre is expected to accommodate approximately 1,140 residents and 580 employees.

9.1.1.2 Parking requirements

The required car parking provision for the proposed development at the Penshurst Street local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 9-3**. The total requirements were rounded down as per the DCP.

Table 9-3 Minimum car parking requirements – Penshurst Street

Land use	Rate	Proposed development	Spaces required	
Residential (non-adaptable units)	Studio	0.5 / dwelling	51 dwellings	26
	1 bedroom	1 / dwelling	72 dwellings	72
	2 bedroom	1 / dwelling	307 dwellings	307
	3 bedroom	1 / dwelling	82 dwellings	82
	Visitors	0.25 / dwelling	512 dwellings	128
Residential subtotal			614	
Commercial	Retail	36 sqm / space	6,886 sqm GFA	193
	Hospitality	107 sqm / space	1,530 sqm GFA	14
	Office	110 sqm / space	6,886 sqm GFA	63
Commercial subtotal			269	
Development total			883	
	Motorbike parking	1 / 25 car parking spaces	883 spaces	35

Based on these calculations, the proposed development would be required to provide a minimum of 883 car parking spaces (including accessible parking spaces) and 35 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 9-4**.

Table 9-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	512 units	51
Retail	1 / 450m sqm GFA	6,886 sqm GFA	15
Hospitality	1 / 450m sqm GFA	1,530 sqm GFA	3
Office	1 / 600 sqm GFA	6,886 sqm GFA	11
Total			81

The calculations indicate that the proposed development would be required to provide 81 bicycle spaces.

9.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TD 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 9-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 9-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	512 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	5,165 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	1,148 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	5,893 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 9-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 9-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	97	77	97
Retail	58	184	47
Hospitality	13	45	86
Office	110	83	0
Total	278	389	230
Existing traffic generation	191	296	150
Net traffic generated	+87	+93	+80

On this basis the proposed development is expected to generate an additional 87 vehicle movements in the AM peak hour, 93 in the PM peak and 80 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 44% for residents and 63% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 5% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 39% for residents and 58% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

9.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 9-7**.

Table 9-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 9-8**.

Table 9-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	16	95	44	28	40	59
Retail	5	8	17	26	4	7
Hospitality	1	1	5	5	8	12
Office	19	3	2	21	0	0
Total (net traffic generated)	41	108	68	80	52	78

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 8-9**.

Table 9-9 Directional assumptions

Direction	In %	Out %
North	6%	28%
East	0%	0%
South	52%	26%
West	42%	46%
Total	100%	100%

Source: ABS 2016 Census Data

9.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

9.1.1.6 Intersection modelling results

Table 9-10 summarises the intersection performance of the Penshurst local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 9-10 Future intersection performance – Penshurst Street

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Penshurst Street / Laurel Street	0.852	11	A	0.836	16.2	B	1.066	28.9	C
Penshurst Street / Oakville Road	1.383	16	B	0.99	25.6	B	0.971	17.3	B
Penshurst Street / Mowbray Road	0.958	40.5	C	1.019	51.3	D	1.041	52.1	D
Mowbray Road / Willoughby Road	1.113	40.2	C	1.14	54.3	D	1.075	98.2	F

In 2036, it is expected that all the intersections will operate at LoS D or better, except in the Saturday peak period where the Mowbray Road / Willoughby Road intersection is expected to operate unsatisfactorily at LoS F. Compared to 2019, there is a notably higher delay incurred PM on Willoughby Road (south approach) for all movements.

The 2019 base model indicated that the Mowbray Road / Willoughby Road intersection is oversaturated (DoS is greater than 1.0) in the PM peak. In 2036, the degree of saturation at all the intersections is oversaturated (DoS is greater than 1) in at least one peak period. This is reflective of the increase in demand which is exceeding the capacity of the intersection. It is noted that the Mowbray Road / Willoughby Road intersection is oversaturated in all peak periods.

9.1.2 Active Transport

Walking and cycling needs within the Penshurst Street local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Penshurst Street contains an established footpath network, although there may be opportunities to improve pedestrian crossings. The centre does not contain cycling facilities. However the Willoughby Bike Plan does not indicate Penshurst Street or Mowbray Road as proposed cycle routes.

Recommendations to address these issues are summarised in **Section 9.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

9.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Penshurst Street is well connected by bus to surrounding centres and public transport hubs including Chatswood, North Sydney and the Sydney CBD. Penshurst Street and Mowbray Road accommodate a range of services and link to Chatswood station where rail access is provided. Opportunities for improvement are limited but may include additional services and a review of bus routes to optimise connectivity and access.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 9.1.4**.

9.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 9-11** and **Figure 9-1**.

Table 9-11 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P49	Missing pedestrian crossing at Penshurst Street/Oakville Road	Provide an additional signalised pedestrian crossing on the northern leg of the intersection at Penshurst Street/Oakville Road.	Signalised pedestrian crossing	1
P50	Lack of pedestrian crossing opportunities across Penshurst Street.	Provide a pedestrian refuge on Penshurst Street between Oakville Road and Mowbray Road.	Pedestrian refuge	1
Bicycle				
C12	Lack of bike parking provision.	Provide bike parking to accommodate demand for cycle parking and encourage cycling as a travel mode.	Bike parking	8
Public transport				
PT2	Lack of a bus shelter on the northern side of Mowbray Road near Penshurst Street.	Provide a bus shelter for the bus stop on the northern side of Mowbray Road immediately west of Penshurst Street (ID: 2068114).	Bus stop shelter	1
Road network				
R13	1/2P parking restrictions likely too short.	Increase 1/2P duration restrictions along Penshurst Street to 1P.	Parking signage	-
R14	Potential non-compliance issues with Kiss and Ride on Oakville Road and Keary Street.	Formalise Kiss & Ride Parking along Oakville Road and Keary Street to improve compliance.	Parking signage	-
R15	Opportunity to make use of underutilised parking at the Laurelbank Function Centre.	Consider a partnership with Laurelbank Function Centre to allow for use of this dormant asset.	Parking management	-
R27	Lack of long-stay parking.	Relax parking controls along Penshurst Street (south of Mowbray Road) or Weld Street to provide sufficient long-stay parking for employees.	Parking signage	-
R28	High number of crashes recorded at the intersection of Penshurst Street/Laurel Street.	Advocate for TfNSW to investigate safety issues at the intersection of Penshurst Street/Laurel Street and explore mitigation measures.	Safety improvements	-
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

Figure 9-1 Recommendations map



10 Willoughby South

10.1 Future transport network review and recommendations

10.1.1 Traffic network analysis

10.1.1.1 Land use assumptions

The *Willoughby Local Centres Strategy* identifies proposed future floor space for residential and non-residential land uses. The residential floor space was assumed to be composed of high-density apartments with yields at Willoughby South in accordance with **Table 10-1**, and assuming an average apartment comprised 66.9 sqm of floor space (based on minimum apartment sizes specified in the *Apartment Design Guide*).

Table 10-1 Apartment mix and occupancy – Willoughby South

Dwelling type	% of mix	No. dwellings	Assumed occupancy rate ¹	No. people
Studio	10%	39	1.7	65
1 bedroom	14%	55	1.7	91
2 bedroom	60%	236	2.3	538
3 bedroom	16%	63	2.8	176
Total	100%	393	-	870

¹Based on ABS 2016 Census Data

The non-residential floor space was assumed to be a mix of retail, hospitality and office space in accordance with **Table 10-2**. The employee densities were adopted from RMS guidelines for office space and typical employee densities for retail and hospitality.

Table 10-2 Non-residential floor space assumptions – Willoughby South

Assumed land use	Proportion of GFA	Employee density	Employees
Retail	35%	1 / 40 sqm	151
Hospitality	25%	1 / 20 sqm	216
Office	40%	4.75 / 100 sqm	329
Total	100%	-	696

Therefore, based on these assumptions the Willoughby South local centre is expected to accommodate approximately 870 residents and 700 employees.

10.1.1.2 Parking requirements

The required car parking provision for the proposed development at the Willoughby South local centre was estimated based on the parking rates provided within the Willoughby DCP, which specifies minimum car parking requirements for various land uses.

Parking rates for the residential areas were based on those specified for 'shop-top housing', which comprises most of the residential development in all local centres, and provides the lowest car parking rates for apartments.

Parking rates for the non-residential uses were based on the relevant rates within the DCP, with a 30% discount factor applied to the retail and hospitality land uses to account for passing trade/linked trips within the local centre. This is a conservative estimate based on a review of RMS surveys for similar land uses. The Willoughby DCP also provides lower car parking rates for certain land uses within railway precincts and major public transport corridors, which applies to residential, office and restaurant land uses. Council provided direction to use the lower rates for all local centres given the proximity to public transport routes.

The minimum car parking requirements are presented in **Table 10-3**. The total requirements were rounded down as per the DCP.

Table 10-3 Minimum car parking requirements – Willoughby South

Land use	Rate	Proposed development	Spaces required
Residential (non-adaptable units)	Studio	0.5 / dwelling	39 dwellings
	1 bedroom	1 / dwelling	55 dwellings
	2 bedroom	1 / dwelling	236 dwellings
	3 bedroom	1 / dwelling	63 dwellings
	Visitors	0.25 / dwelling	393 dwellings
Residential subtotal			471
Commercial	Retail	36 sqm / space	6,052 sqm GFA
	Hospitality	107 sqm / space	4,323 sqm GFA
	Office	110 sqm / space	6,917 sqm GFA
Commercial subtotal			272
Development total			743
	Motorbike parking	1 / 25 car parking spaces	743 spaces
			29

Based on these calculations, the proposed development would be required to provide a minimum of 743 car parking spaces (including accessible parking spaces) and 29 motorbike spaces. These requirements exclude loading bays.

Bicycle parking requirements were also estimated in accordance with the DCP, with the results presented in **Table 10-4**.

Table 10-4 Bicycle parking requirements

Land use	Rate	Proposed development	Spaces required
Residential	1 / 10 units	393 units	39
Retail	1 / 450m sqm GFA	6,052 sqm GFA	13
Hospitality	1 / 450m sqm GFA	4,323 sqm GFA	10
Office	1 / 600 sqm GFA	6,917 sqm GFA	12
Total			74

The calculations indicate that the proposed development would be required to provide 74 bicycle spaces.

10.1.1.3 Trip generation

Future trips expected to be generated by the proposed development were estimated based on the *RMS Guide to Traffic Generating Developments (GTGD)* and the technical direction *TDT 2013/04a Updated Traffic Surveys (TD 2013/04a)*. Traffic generation rates for each land use adopted for each land use are presented in **Table 10-5**, also using the following assumptions:

- > The residential traffic generation rates are well defined in the AM and PM peaks in TD 2013/04a, and the Saturday peak generation rate was estimated based on the survey results for each Sydney Metropolitan Area site analysed as part of this technical direction;
- > Retail traffic generation rates are provided in the GTGD for the PM and Saturday peaks. For the AM peak, it is assumed that employees would arrive comparably with office areas. Retail areas are also assumed to be fast trade;
- > Hospitality areas are assumed to be equivalent to 'specialty shops', which includes uses such as general stores and takeaway food. Traffic generation rates for the PM and Saturday peak are provided in the GTGD, and the rate for the AM peak was assumed to be similar to that of offices;
- > Traffic generation rates for offices are provided in TD 2013/04a for the AM and PM peaks. For the Saturday midday peak, offices were assumed to not generate any trips; and

- > A discount factor of 30% was applied to the retail and hospitality land uses to reflect linked trips (trips with a secondary component, e.g. a resident purchasing a coffee on the way to work), a conservative estimate based on RMS survey results of similar land uses.

Table 10-5 Traffic generation rates

Land use	Proposed development	Traffic generation rate adopted (no. trips)		
		AM peak	PM peak	Saturday peak
Residential	393 units	0.19 / unit	0.15 trips / unit	0.19 trips / unit
Retail	4,539 sqm GLFA	1.12 / 100 sqm GLFA	3.57 / 100 sqm GLFA	0.91 / 100 sqm GLFA
Hospitality	3,242 sqm GLFA	1.12 / 100 sqm GLFA	3.92 / 100 sqm GLFA	7.49 / 100 sqm GLFA
Office	6,917 sqm GFA	1.6 / 100 sqm GFA	1.2 / 100 sqm GFA	Nil

Based on these rates, the estimated number of trips generated by the proposed development are presented in **Table 10-6**, as well as the estimate of existing traffic generated by the current land uses, and the net difference.

Table 10-6 Future traffic generation

Land use	Traffic generation (veh/hr)		
	AM peak	PM peak	Saturday peak
Residential	75	59	75
Retail	51	162	41
Hospitality	36	127	243
Office	111	83	0
Total	272	431	359
Existing traffic generation	198	357	278
Net traffic generated	+74	+74	+80

On this basis the proposed development is expected to generate an additional 74 vehicle movements in the AM peak hour, 74 in the PM peak and 80 in the Saturday peak.

However, the mode share for the sites surveyed by RMS averaged out to approximately 30% for the car driver mode share, and the sites in the Sydney Metropolitan Area included a train station in the surrounding locality. The mode share of the Castlecrag local centre was analysed to determine if the traffic generation rates should be adjusted to reflect a higher car driver mode share given the public transport connectivity and travel behaviour of the area.

The car driver mode share for the surrounding Statistical Area 1s (SA1s) was found to be 39% for residents and 63% for workers. This represents a higher mode share than those surveyed for the RMS traffic generation rates, although the SA1s analysed extended beyond the local centre surrounds and included low density residential areas further from public transport. On this basis, a mode share discount of 5% was applied to account for these factors as well as assumed increases in public transport uptake towards 2036, and mode shares of 34% for residents and 58% for workers was assumed. For a conservative estimate, the traffic generation rates were therefore scaled up to match these mode shares.

10.1.1.4 Trip distribution

Inbound and outbound splits of traffic generated were assumed based on typical proportions used for each land use. The assumptions adopted are presented in **Table 10-7**.

Table 10-7 Inbound / outbound splits

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	20%	80%	70%	30%	50%	50%
Retail	50%	50%	50%	50%	50%	50%
Hospitality	60%	40%	60%	40%	50%	50%
Office	90%	10%	10%	90%	N/A	N/A

These splits were applied to the net traffic generated to determine the inbound and outbound trips presented in **Table 10-8**.

Table 10-8 Inbound and outbound net traffic generated

Land use	AM peak		PM peak		Saturday peak	
	In	Out	In	Out	In	Out
Residential	14	94	38	28	34	59
Retail	2	3	7	11	2	3
Hospitality	2	2	6	7	10	17
Office	8	2	1	10	0	0
Total (net traffic generated)	26	101	51	56	46	78

Journey to Work data was reviewed to determine the likely origins and destinations of residents and workers in the local centre. Directional splits were adopted as presented in **Table 10-9**.

Table 10-9 Directional assumptions

Direction	In %	Out %
North	35%	45%
East	0%	0%
South	52%	26%
West	14%	29%
Total	100%	100%

Source: ABS 2016 Census Data

10.1.1.5 Background traffic

Background traffic volumes were adopted based on the approach outlined in **Section 3.1.1.5**. This included a growth rate of 0.5% p.a. to 2036 applied to background traffic through movements on key corridors to reflect potential future development in areas other than Willoughby.

10.1.1.6 Intersection modelling results

It is noted that in the existing layout, Julian Street allowed traffic to enter and exit. In 2036, it is proposed that Julian Street will be converted to a cul-de-sac.

Table 10-10 summarises the intersection performance of the Willoughby South local centre for the 2036 With 100% Development scenario. A detailed summary of the SIDRA results is provided in **Appendix A**.

Table 10-10 Future intersection performance – Willoughby South

Intersection	AM Peak			PM Peak			SAT Peak		
	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS	DoS	Delay (sec)	LoS
Willoughby Road / Harris Street	2.571	1836.9	F	2.281	1836.8	F	0.844	373.6	F
Willoughby Road / Julian Street	0.457	0	A	0.447	0	A	0.486	0	A
Willoughby Road / Frenchs Road	0.778	10	A	0.841	6	A	1.051	43	D

It is expected that the Willoughby Road / Harris Street intersection will perform unsatisfactorily at LoS F in all peak periods, consistent with the 2019 base model. This is associated with the right turn movement on Harris Street and Penkivil Street, which is identified as the worst-performing movement. Due to an increase in volumes on Willoughby Road, the opportunity for right-turning vehicles from the side streets will decrease as the likelihood of the queue spillback in the downstream of Willoughby Road increases. This inhibits the ability of traffic on the side streets to find safe and suitable gaps as the headways have decreased further in comparison to the existing base model. This is also reflected in the degree of saturation, which exceeds 1.0, indicating that it is oversaturated. The delay is excessive and expected to create safety concerns if no mitigation measures are undertaken.

In 2019, the Willoughby Road / Julian Street intersection was also failing due to the right turning vehicles from Julian Street. It is proposed in the *Willoughby Local Centres Strategy* that Julian Street be converted to a cul-de-sac, hence the intersection will longer operate as an intersection.

In the Saturday peak period, the Willoughby Road / Frenchs Road intersection is expected to operate near capacity at LoS D. This is a deterioration in operation from 2019, from LoS B. In the other peak periods, this intersection will perform satisfactorily at a LoS A.

10.1.2 Active Transport

Walking and cycling needs within the Willoughby South local centre were reviewed to explore the issues and identify potential measures to address these. The aim is to facilitate a successful people and place experience within the centre, encouraging active and sustainable transport and improving priority and safety for pedestrians and cyclists.

Willoughby South already contains an established footpath and cycle network, although some opportunities for improvement may be available to improve crossing opportunities for pedestrians and cycle parking within the centre.

Recommendations to address these issues are summarised in **Section 10.1.4**. A full audit, Pedestrian Access and Mobility Plan or Bike Plan was not undertaken, and the resulting recommendations are high level based on gaps identified and likely requirements due to planned growth.

10.1.3 Public transport

Public transport needs within the centre were also reviewed and considered gaps, service characteristics, connectivity and roadside infrastructure.

Willoughby South is well connected by bus services along Willoughby Road, providing access to areas including Chatswood, Crows Nest, North Sydney and the Sydney CBD. Opportunities to improve public transport may be limited to increasing the service frequency.

Needs for other modes and road users were also considered, with associated recommendations summarised in **Section 10.1.4**.

10.1.4 Issues and options

The issues and recommendations for the local centre are summarised in **Table 10-11** and **Figure 10-1**.

Table 10-11 Issues and recommendations

No.	Issue	Recommendation	Item	Length / no.
Pedestrian				
P55	Narrow footpaths on Julian Street, Harris Street, Penkivil Street and Borlaise Street.	Widen the footpaths on Julian Street, Harris Street, Penkivil Street and the northern side of Borlaise Street to a minimum of 2m.	Footpath	955m
P64	Limited crossing opportunities of Willoughby Road.	Investigate opportunities for additional crossings on Willoughby Road.	Crossings	2
Bicycle				
C15	Lack of bike parking provision.	Provide bike parking to accommodate demand for cycle parking and encourage cycling as a travel mode.	Bike parking	8
C19	Incorrect indication of cycle routes in the Willoughby Bike Plan.	Revise the bike plan maps to indicate the correct cycle route to the west of Willoughby Road as Julian Street - Hector Road - Patton Lane - Zara Road (instead of Penkivil Street).	Bike map	1
Road network				
R29	Poor wayfinding signage to the Borlaise Street car parks.	Improve wayfinding signage to the Borlaise Street car parks from both directions along Willoughby Road.	Parking signage	
R30	Insufficient short-stay parking provision.	Restrict parking to short-stay (2P) on minor roads connecting with Willoughby Road.	Parking signage	
R31	Mixed parking restrictions along Willoughby Road.	Willoughby Road parking should be standardised to allow 1P outside of clearway periods.	Parking signage	
R32	Poor intersection performance at Willoughby Road/Harris Street (LoS F) in all peaks.	Ban the right turn movement from Harris Street into Willoughby Road.	Right turn ban	1
R33	Poor intersection performance at Willoughby Road/Julian Street (LoS F) in all peaks.	Convert Julian Street into a cul-de-sac at Willoughby Road in accordance with the <i>Local Centres Strategy</i> .	Intersection reconfiguration	1
All local centres				
-	Car parking rates in the Willoughby DCP may encourage excessive parking provision for future development.	Review the car parking rates specified in the Willoughby DCP with the intention to reduce the rates and limit parking provided in future development proposals.	Parking policy	

Figure 10-1 Recommendations map

