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**Major Cycle Routes in Christchurch:
Conflicts in Local Situations and Proposed Design-based Solutions**

A Dissertation
submitted in partial fulfilment
of the requirements for the Degree of
Master of Landscape Architecture

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by
Di Wang

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Abstract of a Dissertation submitted in partial fulfilment of the requirements for the Degree of Master of Landscape Architecture.

Abstract

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by

Di Wang

The Christchurch City Council is currently developing a network of 13 major cycle routes, which link residential neighbourhoods, businesses, parks, schools and popular recreational destinations across Christchurch. As of February 2018, the network of cycle routes has been fully planned but only partially completed. Drawing on relevant literature, planning documents and real site situations, this study identifies local conflicts that have arisen during and after the planning and implementation phases. International design recommendations, exemplar, and Christchurch design guidelines are reviewed as references for solutions. The overall aim of this study is to propose design-based solutions to mitigate existing conflicts and to remove barriers to full implementation in the future.

Keywords: Christchurch, major cycle routes, conflicts, implementation, design-based solutions

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Chapter 1: Introduction

“Our choice of whether to walk, cycle, drive or take public transport is influenced by the urban form and functioning of the transport network, which in turn impacts on our environment” (Christchurch Transport Strategic Plan, 2012, p. 10). The design of cities and urban transportation networks influences travellers’ decisions, which in turn has an impact on the environment and people’s well-being. According to the *Christchurch Transport Strategic Plan 2012–2042* (2012), a well-linked transport system is significant to people’s quality of life and the cohesion of communities. The overall vision of the plan is to “keep Christchurch moving forward by providing transport choices to connect people and places” (Christchurch Transport Strategic Plan 2012–2042, 2012, p. 12).

Christchurch intends to develop an efficient and integrated transport system that provides accessible travel choices. Such a system efficiently links commercial centres and communities by providing a safe, healthy, affordable and sustainable transport network. To achieve the vision, four major goals have been put forward. They are: 1) to improve access and transport choices; 2) to create safe, healthy and liveable communities; 3) to support economic vitality; and 4) to create opportunities for environmental enhancements (Christchurch Transport Strategic Plan 2012–2042, 2012, p. 7). In terms of improving access and choice of transport, part of this goal is to create opportunities for easier cycling by developing a better cycling network (Christchurch Transport Strategic Plan 2012–2042, 2012, p. 13).

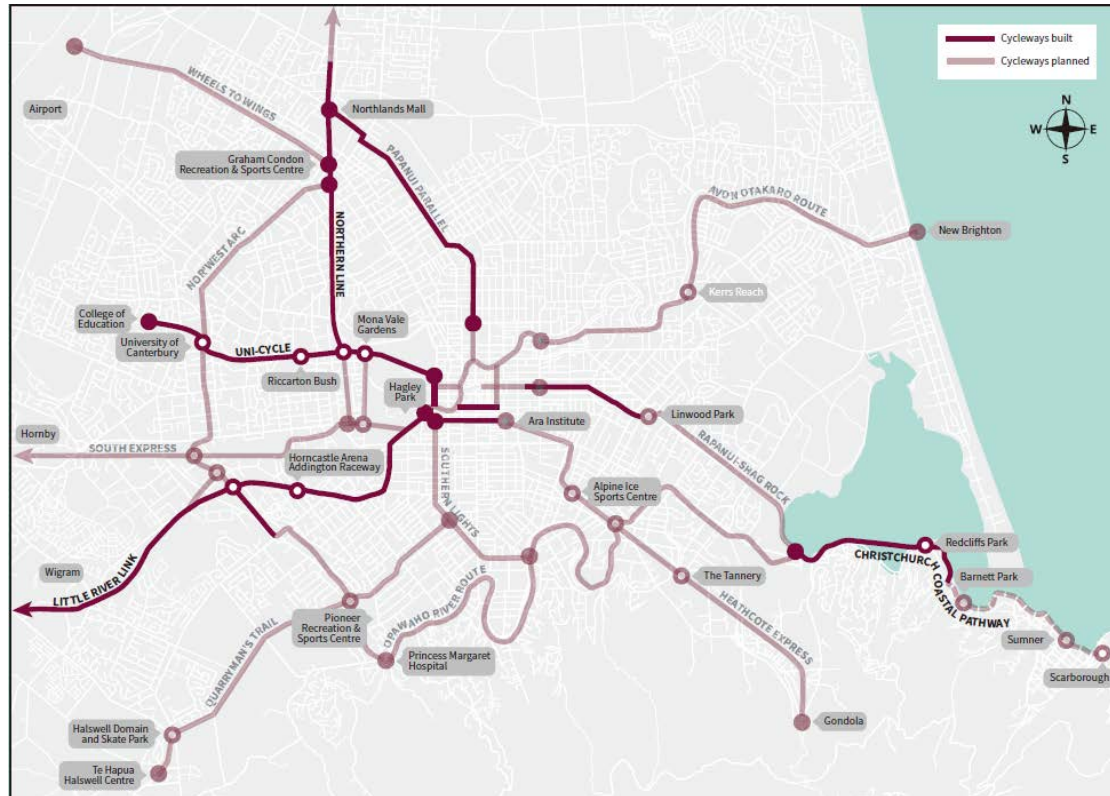


Figure 1-1. Latest map of Christchurch MCR network (Christchurch cycle map, 2018).

Note. The dark purplish red lines show the built Major Cycle Routes.

The Christchurch City Council is currently developing a network of 13 major cycle routes (MCRs), which link residential neighbourhoods, businesses, parks, schools and popular recreational destinations across Christchurch (Figure 1-1). The current study examines reported conflicts around the design and implementation of MCRs in Christchurch. The goal of the study is to propose design-based solutions that mitigate conflicts. It raises the following three research questions.

1. What are the conflicts and barriers inherent in the MCR planning and implementaton process?
2. How can these barriers to implementation be removed during the design phase?
3. What additional cycleway design ideas, concepts or models can be applied in broader Christchurch situations?

To address these questions, the study is structured into five major sections: methods, literature review, analysis and results, discussion and conclusion. First, in the methods section, research methodology is explained. In Chapter 3, I review publicly available, previously published academic and grey literature. Literature is grouped according to themes I identified as: 1) the benefits of cycling in the urban environment; 2) cycling and safety; 3) cycle-friendly route designs and methods of cycling; and 4) policies and design guidelines for cycleways in Christchurch. At the end of Chapter 3, design exemplars are presented to provide a reference for indicating design-based solutions. In Chapter 4, local Christchurch news articles (sourced from <https://www.stuff.co.nz/the-press/>) are investigated to identify conflicts specific to local cycleways. In addition, I analyse conflicts and barriers reported in these articles, perform a site analysis at each identified conflict area (known as a “hot spot”), and analyse related local planning documents generated before and after consultation with key stakeholders. Then, I share results in relation to the analyses. Most importantly, in Chapter 5, I discuss design proposals with the idea of improving conflict situations, or hot spots. In addition, I discuss design ideas which can be considered in long-term development of urban cycleways. In Chapter 6, I summarize all design proposals and ideas in the context of broader Christchurch situations, together with restraints, reflections and future vision of the study.

Chapter 2: Research Methods

Research data used in the current study include primary sources, such as site analyses and informal interviews. Data also include secondary sources: international academic literature; local media articles; international design guides and exemplars; and Christchurch City design policies, guidelines and planning documents. Data and documents were comprehensively analysed with regard to conflicts that pose barriers to the planning, design, implementation and use of the major cycleways both in New Zealand and overseas. Based on the analysis, I developed novel designs to solve Christchurch City's MCR issues. My goal was to mitigate conflicts by introducing new designs, which the local council may consider as they improve cycleways in the future.

I pursued my research aim by following five stages, or steps.

- First, I performed an analysis of academic literature and international design guides, and compared these with local design guides for cycleways. I sought evidence to show why cycling should be promoted and what elements are important to the design of cycleways. I separated the literature into five major themes: 1) cycling and safety; 2) benefits of cycling in an urban environment; 3) cycle-friendly designs and methods of cycling; 4) policies and design guidelines for cycleways in Christchurch; and 5) international design exemplars.

I arrange the literature under above categories because of following three reasons.

- 1) The most important requirement of cycling is safety. This should be considered in all cycleway designs.

- 2) To achieve cycling related goals listed in Christchurch Transport Strategic Plan, it is necessary to promote cycling and to present benefits of cycling in urban environment.
 - 3) In relation to my research topic, information about cycle-friendly design, guidelines for cycleways in Christchurch and international cycleway design exemplars is needed to shape my design-based solutions.
- Second, I identified the main hot spots (conflict areas) for Christchurch City's MCRs. To find out about conflicts and barriers, I accessed five recent news articles (sourced from <https://www.stuff.co.nz/the-press/>) and analysed them to better understand the issues. My article selection process was made by following two steps.
 - 1) I performed a search on the topic of conflicts caused by MCRs, Christchurch.
 - 2) I identified articles that clearly reported the conflicts or concerns raised by local people before and during implementation of MCRs.

I made this process because of following two reasons.

- 1) Although there might be more unreported conflicts or concerns, I could not analyse them as the major topic due to lack of clear evidence.
- 2) I could only select limited articles to analyse due to the scope of this study.

- Third, I conducted two site surveys (September 22, 2017 & December 15, 2017). I took current site photos in December 15, 2017. To identify which hot spots are qualified for additional analysis, I analysed information collected in my site surveys. The selection was made based on following two standards.

- 1) Conflicts reported in previous articles can be observed in constructed MCRs during my site surveys.
- 2) Design is the only or the best choice for resolving conflicts reported in previous articles.

Then, I conducted a thorough site analysis of four selected conflict areas - 969 Colombo Street, 5/63 Rutland Street, 49 Rutland Street, and 96 Trafalgar Street, Christchurch, and focused on design solutions in relation to identified conflicts. Previous site images (images captured before the year 2017) were downloaded from Google Earth and Google Maps.

- Fourth, I performed an analysis of the planning document of Papanui Parallel and the four most recent, detailed planning updates describing the four major hot spots. I examined planning documents containing information on goals, predictions, proposed designs and current progress on building MCRs. Both pre- and post-consultation planning documents were compared to identify what changes were made after consultation with stakeholders, and whether any issues at hot spots were resolved. All planning documents were sourced directly from the Christchurch City Council.
- Finally, I came up with design-based solutions. I developed ideas and put forward design proposals to mitigate conflicts in identified hot spots. In addition, I provided additional design ideas in relation to long-term situations.

Chapter 3: Literature Review

Based on the research topic and methods, I reviewed academic literature from international sources to broaden the discussion beyond the New Zealand context, and from local manuals to specify the guideline within the Christchurch background. I also discussed two international cycleway design exemplars to indicate design-based solutions.

In the part 'cycle-friendly designs and methods of cycling', I refer to the book *Non-motorised Transport System: Design of Walkway and Cycleway* published in Chinese by Guangxi Normal University Press. Ceccon & Zampieri (2016) were invited as the authors to study and to summarize key design suggestions based on 27 international design guidelines. Yanfei (2016) translated them into Chinese. During my research, I found many similar suggestion, rules, standards and examples in these international design guidelines. However, as the book has been translated into Chinese, I cannot cite every sentence accurately in original guidelines. Strictly speaking, I cannot include them in my reference list. Thus, I decide to cite all information with the secondary source: Ceccon and Zampieri.

3.1. Cycling and Safety

Cyclists' safety concerns need to be addressed up front if urban populations are to realise the various benefits of cycling. The most concerning issue for cyclists' safety is the danger from motorised traffic. The issue has a negative impact on both health benefits and the wider social and environmental benefits of active transport. Thus, improving cycling safety is a significant step to increasing the number of cyclists (Pucher & Buehler, 2014).

Improving the safety of cyclists is a multi-dimensional task. It can be related to policy making, urban planning and detailed design-based solutions. According to

current data from Australia, the number of injuries per cyclist decrease as cycling is promoted more (Robinson, 2005). “If the number of people cycling doubles, the risk per kilometre falls by about 34%; conversely, if cycling halves, the risk per kilometre will be about 52% higher” (Robinson, 2005, p. 47). Based on Peter Lyndon Jacobsen’s study, the chance of a motorist colliding with a cyclist or pedestrian is likely to reduce when there are more cyclists and pedestrians. The probability declines with approximately -0.6 power of the number of cyclists and pedestrians. For example, “the risk of colliding while walking in a community with twice as much walking can reduce to 66%” (Jacobsen 2003). Therefore, urban policies that help increase the numbers of cyclists and pedestrians seems to be positive to the safety of cycling and walking (Jacobsen 2003). In addition, legal requirements such as compulsory helmet legislation should be retained (Robinson, 2005).

In the context of urban planning, issues abound when dealing with cycle route planning. For example, creating non-continuous cycleways can influence safety and route efficiency. Non-continuous cycleways occur mainly around road intersections and shared paths. When cycling on a non-continuous or shared route, cyclists have to face more conflicts with pedestrians and vehicles. A more systematic and sustainable planning method should be explored to solve this pervasive issue (Wen, 2015).

A range of detailed design solutions from around the world has been put forward to address such issues. Lusk et al. (2011) have compared different designs to examine overall safety. The authors conducted their study in Montreal, Canada, a city with a longstanding network of cycle tracks. The objective was to compare injury rates of bicycle riders on cycle tracks versus injuries to cyclists using common streets. Based on their data, the authors argued that most people preferred a dedicated cycleway separated from motorised traffic, and that the injury risk of riding bicycles on well-designed cycle tracks was less than risks associated with riding bicycles along streets

shared with vehicles (Lusk et al., 2011). Thus, it appears that promoting designs for dedicated cycle tracks would benefit cycling safety everywhere around the world.

3.2. The Benefits of Cycling in Urban Environments

People realise many benefits from cycling for business and recreation. Pucher and Buehler (2014) have stated that the benefits of cycling outweigh general concerns, which include the traffic risks and the cost of required infrastructure (such as cycleways). According to the *Christchurch Transport Strategic Plan 2012–2042* (2012),

the benefits are improved health and wellbeing by promoting more physical activity; reduced traffic congestion and energy cost; a decreased demand to build new roads; reduced parking issues and related costs; more equitable transportation choice; increased community resilience and social interaction. (p. 31)

The above described benefits will eventually contribute to longevity and quality of life. These benefits are discussed in the next four subsections: health benefits, environmental benefits, economic benefits and social benefits.

3.2.1. The health benefits of cycling. Health can be improved through appropriate physical activity. Evidence shows that moderate physical activity of between 30 minutes and an hour per day can generate many health benefits. Benefits mainly include risk reduction of obesity and high blood pressure, prevention of chronic disease, and psychosocial improvements, such as mental relaxation (Pucher & Buehler, 2014). Cycling can be a good choice of physical activity. In the Netherlands, cycling occupied the highest total time spent by adults on physical activity (Pucher & Buehler, 2014). Many positive relationships between moderate cycling and health benefits have been identified. In fact, most “...current public health efforts...promote cycling as an important contributor to improving population health” (Oja et al., 2011, p. 508).

Population-based studies in different countries provide evidence for the direct health benefits of cycling. For instance, a study conducted in Copenhagen, Denmark showed that, as a common physical activity, cycling to work can reduce the risk of mortality (Andersen et al., 2000). In fact, cycling has improved the metabolic health of elderly men in the Netherlands (Caspersen et al., 1991). Another study performed in the US argued that moderate cycling helps reduce the possibility of weight gain for women (Lusk et al., 2010). Regarding psychosocial improvement, UK guidelines for depression management suggest that physical activity such as cycling can contribute to the treatment of mild to moderate depression (The National Institute for Health and Care Excellence [NICE], 2009). Two US studies reported that physical activity including walking and cycling can improve cognitive function and memory, and reduce the risk of Alzheimer's disease (Angevaren et al., 2008; Scarmeas et al., 2009).

3.2.2. The environmental benefits of cycling. Vehicles are the main sources of air and noise pollution in many cities. Pollutants and noise generated by vehicles have adverse effects on the environment, then causing illnesses; for instance, people can suffer from cardiovascular and respiratory diseases, insomnia, stress-related disorders and hearing damage (Buis & Wittink, 2000; Dora & Phillips, 2000). By decreasing vehicle use and increasing active modes of transportation including cycling, air pollution, noise and greenhouse gas emissions can be significantly decreased (Pucher & Buehler, 2014). Data generated in a study conducted by Liu and Zhang (2013) indicated that, in contrast with vehicle-based traffic, cycling produces zero carbon emissions. The authors concluded that cycling should be further promoted in urban areas due to its advantages in protecting the environment (Liu & Zhang, 2013). Another study in the US suggested that less dependence on vehicles and more promotion of cycling for short trips in urban areas would result in significantly reduced carbon emissions in that country (Grabow et al., 2012).

3.2.3. The economic benefits of cycling. Reducing vehicle use and promoting cycling in urban areas can also generate indirect economic benefits. In Australia, for example, the estimated costs for treating cardiovascular and respiratory disease caused by air pollution were between AUD0.4 and 1.2 billion in the year 2000 (Bureau of Transport and Regional Economics, 2005). Furthermore, a complementary study in the US estimated that “making 50% of short trips by bicycle would yield savings of approximately USD3.8 billion per year from avoided mortality and reduced health care costs” (Grabow et al., 2012, p. 68). These authors also estimated that “the combined benefits of improved air quality and physical fitness would exceed USD8 billion per year” (Grabow et al., 2012, p. 68).

3.2.4. The social benefits of cycling. Cycling can provide social benefits by generating social interactions. Social interactions and connectedness brought by recreational and transportation cycling was highly valued (Pucher & Buehler, 2014). Researchers have suggested that social interactions can be improved by providing human-scale urban environments that encourage more cycling and walking, which leads to more social interactions. This change contributes to an increased sense of community attachment, a feeling of liveability and a general sense of amenity (Litman & Doherty, 2009). In contrast, an urban environment with more vehicle-based traffic reduces street-based activities and social interactions among people (Pucher & Buehler, 2014). Thus, by promoting cycling as a regular physical activity, social interactions and a cohesive sense of community can also be improved in urban environments.

3.3. Cycle-friendly Designs

In an urban environment, when people find that cycling is not merely convenient, safe and enjoyable, but can shorten their journey, they are more inclined to choose cycling for transport (Ceccon & Zampieri, 2016). Therefore, if it is possible to design cycleways that are fully compliant with local safety regulations, and that are more convenient and more enjoyable to use, then the number of cyclists may increase, and

the benefits to health and the environment may also be reflected. Safety compliance, convenience and enjoyment factors are all important when creating better, usable designs for urban cycleways (Ceccon & Zampieri, 2016).

3.3.1. Designs for safety. Safe cycleways can ensure the safety of cyclists by reducing conflicts between cyclists and other road users. According to Ceccon & Zampieri (2016), the safety of cycling is affected by the speed and traffic flow of motor vehicles; therefore, under normal conditions, separating cycleways and motorways can make cycling safer. Common isolation designs include fences, painted lines, kerbs, planted areas and raised platforms. Under different road situations, different design methods are recommended. Moreover, the design of good road intersections, the installation of street and cycleway lighting and the strategic placement of directional signs also contribute to improved safety in busy urban environments (Ceccon & Zampieri, 2016).

3.3.2. Designs for convenience. Based on suggestions from Ceccon & Zampieri (2016), urban cycleways should be designed to be relatively direct and to avoid detours, so that cycleways can be accessed easily and so that parking is ample at all access and start points. Such design features save time and effort, thus attracting more users. Detours, wasting time or parking inconveniences may force users to choose other cycling routes, or simply to give up cycling altogether. Therefore, when designing cycleways, it is necessary to ensure their continuity so that they easily reach the desired destination, such as the central business district, where many people work. In addition, clear signs, a unified set of road rules and a single set of design standards also contribute to ensure and enhance the convenience of cycling (Ceccon & Zampieri, 2016).

3.3.3. Designs for comfort. The comfort of cycling is especially important for cyclists. Too steep a slope, unsmooth road surfaces or poor choice of pavement materials may reduce cycling comfort significantly (Ceccon & Zampieri, 2016).

Therefore, cycleways should be designed to be relatively flat, slip-resistant, clean, smooth and to have gentle gradients, where possible. When conditions permit, designers should take into account the effects of sun exposure, rain and wind on cyclists; such considerations can yield site-specific, targeted designs, which include features to combat discomfort, such as hedges and shelterbelts to create shade and wind barriers (Ceccon & Zampieri, 2016).

3.3.4. Designs for aesthetics. Cycleways can interact with the surrounding environment and increase the general attractiveness of the streetscape. Researchers suggest that in the urban environment, cycleway designs should be a part of the big-picture design of wider public spaces, which is in line with most New Zealand local council requirements for landscape planning. A scenic or highly aesthetic route improves the overall cycling experience (Ceccon & Zampieri, 2016).

3.3.5. Methods of Cycling: Design for different use. According to Ceccon & Zampieri (2016), cyclists can be divided into four user groups: 1) those cycling between adjacent areas; 2) fast commute cyclists; 3) short-distance recreational cyclists; and 4) long-distance travelling cyclists. Different cycling purposes require different cycleway designs. However, in some cases, a cycleway can be a multi-purpose experience, suiting both leisure and business, and short- and long-distance users (Ceccon & Zampieri, 2016). Based on the scope of this study, I only focus on design suggestions for the first two user groups. This is determined by major uses and conflicts identified in Chapter 4.

Cycling between adjacent areas. Cycling between adjacent areas mainly refers to short-distance commutes between nearby places. For instance, cyclists may pedal from home to nearby private properties, local schools or local shops. Therefore, the design and service facilities of cycleways catering to this user group should meet the needs of the local community (Ceccon & Zampieri, 2016). Due to the relatively short distances short-distance cyclists travel, cycleways catering to them may be used

more by more children or beginners, so special attention should be paid to ensure the safety of less experienced riders, especially their safety around busy road junctions, crowded shops and multi-vehicle-use areas, such as schools. When cycling, safety-conscious users prefer high-security isolation, high-comfort road surfaces and clear signage. Therefore, design of cycle routes catering for short-distance cyclists should prioritise these features (Ceccon & Zampieri, 2016).

Short commutes. Fast commuting means riders want to take only a short time to reach their destination. Their routes are along the major cycleways, and the commuting user group are usually teenagers and adults travelling between work and home. Most of these cyclists value the quickness of cycleways. Thus, these users prefer high-quality road surfaces, direct and continuous routes and intersection designs that minimise conflicts with vehicles (Ceccon & Zampieri, 2016).

3.4. Christchurch Cycle Design Guidelines

Several important Christchurch City policies serve as references in designing cycleways to minimise conflict areas. City guidelines recommend that the cycle path should be wide enough to allow two cyclists to pass one another, approximately 1.8 m–2 m for a single lane (Christchurch Cycle Design Guidelines, 2013, p. 24). Cycle paths separated from the road, dedicated cycle lanes that are part of the road, shared footpaths or cycleways on the berm could be considered on busier residential streets where traffic volumes and speeds cannot be reduced (Christchurch Cycle Design Guidelines, 2013, p. 28) (Figure 3-1).

Guidelines recommend that on urban streets with heavy traffic and dense crossing points or urban development, two-way separated cycle paths can be designed on one side of the street (Christchurch Cycle Design Guidelines, 2013, p. 24). The cycle path for the contra-flow cyclists should be located away from the vehicle road. The path should be designed wide enough to give the cyclists enough room to pass each other in a convenient way. The “two-way cycle path” guide boards should be

placed and the cyclist's position should be marked clearly (Christchurch Cycle Design Guidelines, 2013, p. 24).

Guidelines recommend that demarcated cycle paths sharing the same road surface should be located on the carriageway and should be identified by a painted chevron (a saw-toothed symbol about 0.6 m–1 m wide). The function of the chevron is to clearly demarcate the cycle path as separate from the vehicle lane or on-street parking areas (Figure 3-2). To be specific, in such a design, the location of the cycle path is between the kerb of the sidewalk and on-street parking areas (Christchurch Cycle Design Guidelines, 2013, p. 24). Clear signs or markings should be placed in strategic places to enable pedestrians, cyclists and vehicle drivers to easily locate the parts of the street they are allowed to occupy (Christchurch Cycle Design Guidelines, 2013, p. 28).

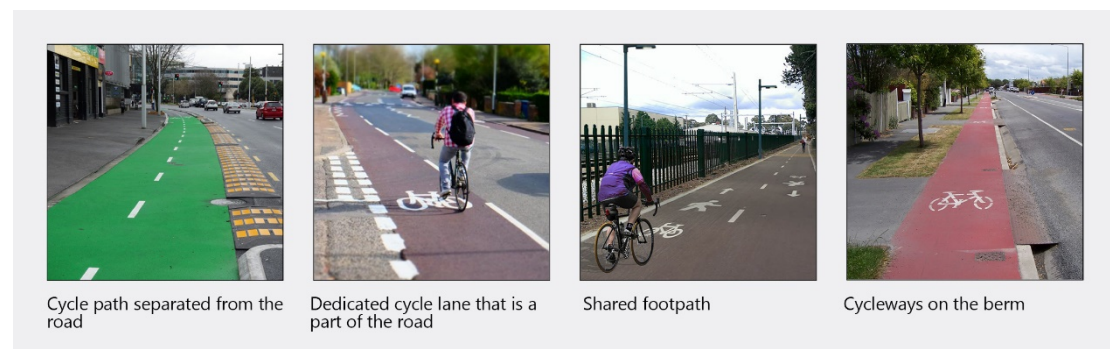


Figure 3-1. Designs that can be considered on busier residential streets where traffic volumes and speeds cannot be reduced (Cycle route intersection and crossing treatments, 2018; Cross City Cycling, 2017; Marino Rocks Greenway, n.d.; LennyBoy, 2013)

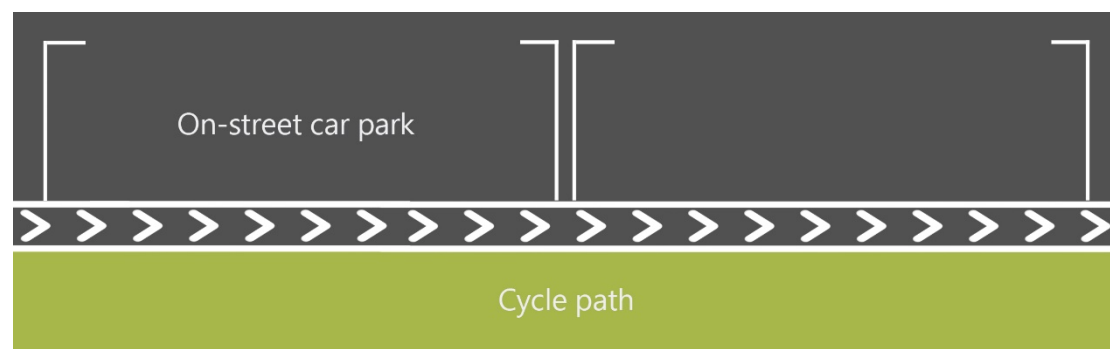


Figure 3-2. Illustration of a chevron (Wang, 2018)

Guidelines also recommend that main cycle paths would better be located at the area near to the greenways in urban residential streets to provide a comfortable and safe environment for the mixture of bicycles, cars and passengers (Christchurch Cycle Design Guidelines, 2013, p. 28). Higher priorities should be given to the cyclists and pedestrians but not the other traffic, so as to let the cyclists share the whole carriageway of the street in a comfortable and convenient manner (Christchurch Cycle Design Guidelines, 2013, p. 28).

3.5. Design Exemplar

During my study, I analysed two international design exemplars (Bourke Street Cycleway in Sydney and Rio Park in Madrid) to explore best-practice design solutions for cycle routes. The exemplars are well suited to serve as guidance for my study because a variety of cycleway designs were developed to accommodate different circumstances in each exemplar. Thus, I can compare different design options and find suitable solutions for Christchurch.

3.5.1. Bourke Street Cycleway. Bourke Street Cycleway was Sydney, Australia's first large-scale separated cycleway (Figure 3-3). Its construction was aimed at improving the quality of the local cycling network and to increase the number of local cycleways. The 3.2-km route was renovated based on the original cycleway traversing Bourke Street. By separating the cycle lane from motorised traffic, safety for cyclists and convenience for all road users were achieved (Ceccon & Zampieri, 2016). It is an ideal example for Christchurch to follow.



Figure 3-3. A section of the Bourke Street Cycleway in Sydney, Australia (Jennings, 2011).

The Bourke Street Cycleway was designed according to different circumstances along the street. The method of separating vehicles from cycles, the shape of the cycle lanes and intersections with roads caused changes to overall road layout, to greater or lesser extent. Furthermore, the whole cycleway maintained continuity. After its construction, cyclists using Bourke Street increased 1.5 times. In addition, since the designer fully considered their options and melded designs with the original architecture and landscape of Bourke Street, this cycleway also provided a fairly good recreational space for local people. Consequently, it became a landmark for downtown areas of Sydney (Ceccon & Zampieri, 2016). Examples of detailed designs used along Bourke Street, which could be used in Christchurch to mitigate conflicts, are shown in Figures 3-4 and 3-5.

Figure 3-4 presented a shared vehicle-cycle zone at a T-junction. I found the key point of using paving area at T-junctions can alert road users and increase safety of them. Figure 3-5 compared four design approaches of separated cycleway path. These designs could be used as references for my design-based solutions.

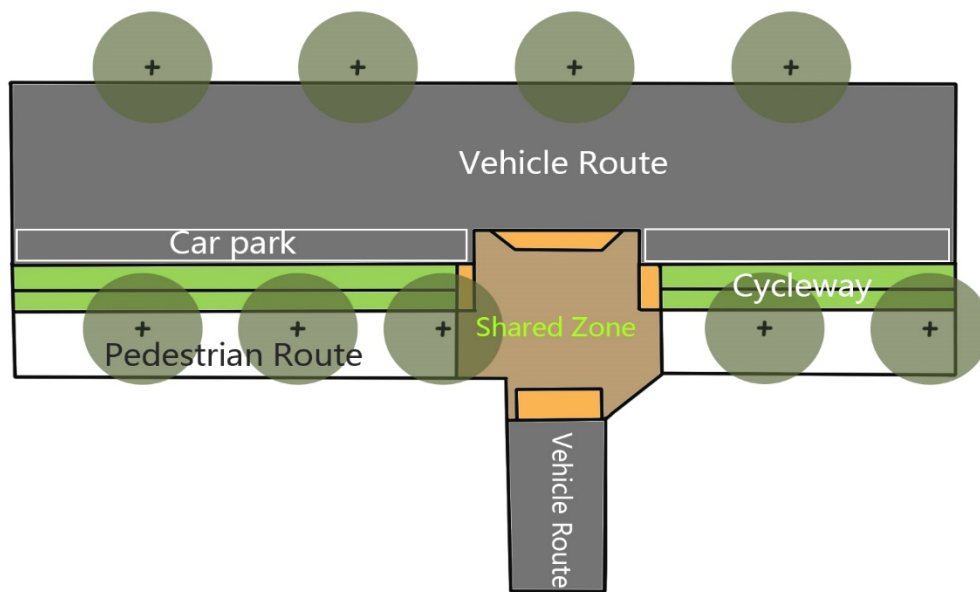


Figure 3-4. Design solution for a T-junction with a shared vehicle–cycle zone (Wang, 2018).

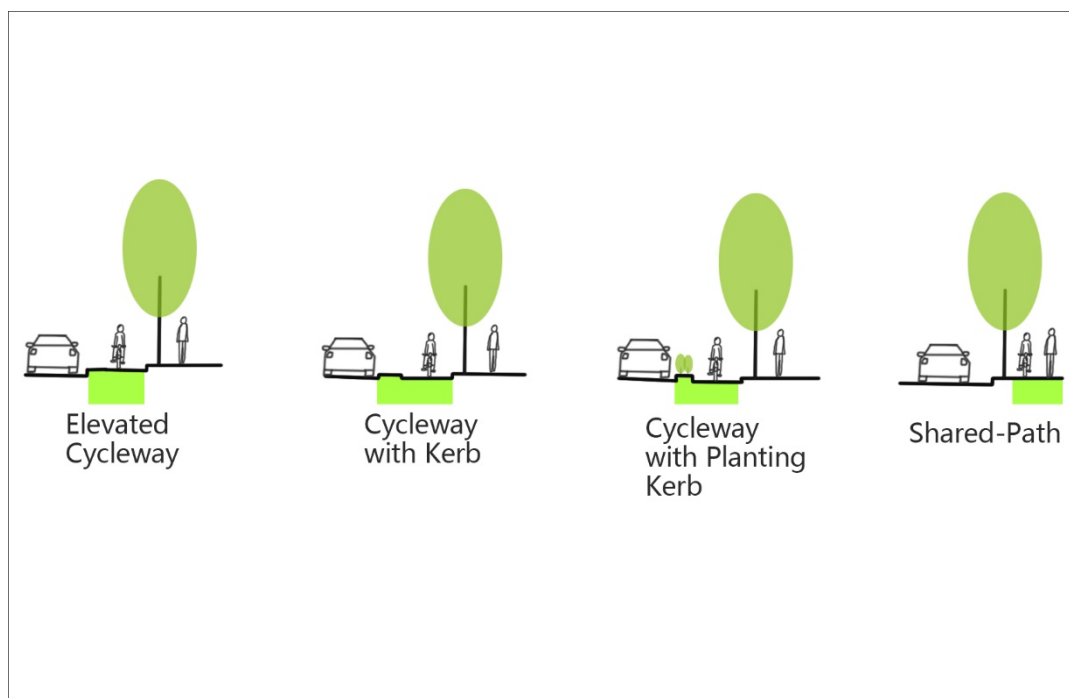


Figure 3-5. Section drawing of different cycleway designs that could be used in Christchurch (Wang, 2018).

3.5.2. Madrid Rio Park. In 2011, Madrid government rebuilt infrastructure measures over a total length of 43 kilometers along the banks of the River Manzanares (LANDEZINE, n.d.). Infrastructure of the park included underground vehicle tunnels, waterfront plazas, playgrounds, green corridors, bridges, cycleways, etc. The total length of major cycleways was approximately 30 kilometers. They linked to a variety of surrounding spaces, for instance, small parks, bridges and waterfront platforms etc. (Figure 3-6, Figure 3-7, Figure 3-8). Because of these links, interactions among cyclists and their surrounding urban spaces increased a lot. In addition, due to the separation between cycleways and vehicle routes, cycling safety were greatly improved (Ceccon & Zampieri, 2016).



Figure 3-6. Perspective view of a part of Rio Park in Madrid, Spain (Park space, Madrid Rio, 2011).

Figure 3-7 showed a perspective view of a pedestrian and cycling bridge. The bridge provided an extra link to the other side of the river.



Figure 3-7. Pedestrian and cycling bridge with designed canopy (The City Project, 2012).

Figure 3-8 illustrated a perspective view of a waterfront shared-path (shared by pedestrians and cyclists). The shared-path was separated from vehicle route by planting pools.



Figure 3-8. Shared-path on the waterfront platform (Connections: Madrid Rio, 2011).

Figure 3-9 provided a section view of a waterfront park with underground tunnels. The vertically separated traffic improved cycling safety and experience of cyclists.

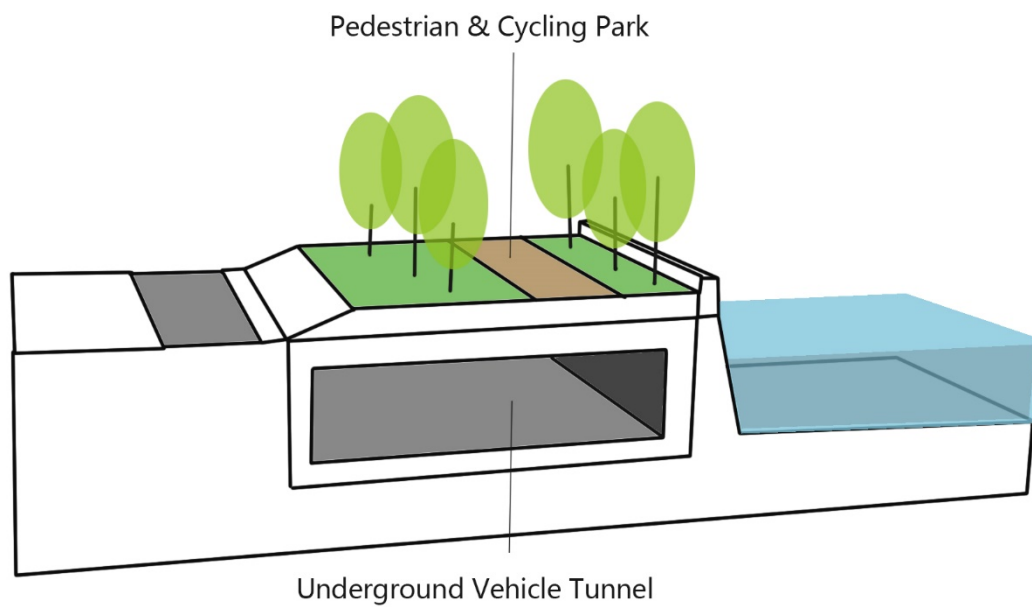


Figure 3-9. Section drawing of a part of Rio Park in Madrid, Spain (Wang, 2018).

Chapter 4: Analysis and Results

I presented all my findings about the cycleways and conflicts in this chapter to answer the first research question listed in Chapter 1.

4.1. Cycleways and Conflicts in Christchurch

Based on my findings, all five articles in relation to cycleways and conflicts were published between February 16, 2016 and March 30, 2017 (Table 4-1). Reported conflicts included the loss of carparks, newly imposed limitations to accessways, reduced road safety, traffic congestion, loss of existing buildings and heritage impacts (Table 4-2).

Article/Author/Date	Author	Date of Publication
<i>Christchurch cycleway sections given green light, but businesses attack Ferry Rd plan</i>	Nick Truebridge	March 30, 2017
<i>Christchurch cycleway blamed for near closure of business</i>	Maddison Northcott	March 7, 2017
<i>Christchurch residents urge council to change cycleway routes</i>	Tina Law	February 16, 2016
<i>Council's dilemma: demolish houses or car parks for cycleway</i>	Charlie Mitchell	November 2, 2016
<i>Residents oppose 'cycle highway' through Riccarton House grounds</i>	Tina Law	March 2, 2016

Table 4-1. Article with author and date of publication (Truebridge, 2017; Northcott, 2017; Law, 2016a; Mitchell, 2016; Law, 2016b)

Article/Conflict	Loss of car park	Limit of access	Road safety	Traffic congestion	Loss of building	Heritage impact
<i>Christchurch cycleway sections given green light, but businesses attack Ferry Rd plan</i>	✓					
<i>Christchurch cycleway blamed for near closure of business</i>	✓	✓	✓			
<i>Christchurch residents urge council to change cycleway routes</i>		✓		✓		
<i>Council's dilemma: demolish houses or car parks for cycleway?</i>	✓				✓	
<i>Residents oppose 'cycle highway' through Riccarton House grounds</i>			✓			✓

Table 4-2. Topic and categorization of article (Truebridge, 2017; Northcott, 2017; Law, 2016a; Mitchell, 2016; Law, 2016b)

4.1.1. Loss of car parking. During the Christchurch MCR implementation, some on-street carparks were temporarily blocked in order to make room for proposed cycleways. In Northcott's (2017) news article, it was reported that the construction of Papanui Parallel near Pahs Dairy meant contractors occupied three customer carparks in front of the shop. In addition, Northcott (2017) reported that the proposed cycleway would remove some on-street carparks permanently. Furthermore, based on Truebridge's (2017) article, some community members and business owners opposed the cycleway proposal for the Heathcote Expressway. They worried that businesses and community facilities would be affected due to the removal of some on-street carparks. A church minister was concerned that the

Ferry Road plan would affect his church to the point of near closure (Truebridge, 2017). Furthermore, according to Mitchell's (2016) news item, the proposed Quarryman's Trail Cycleway would remove many carparks along the entire route. The Somerfield Residents Association chairwoman argued that the loss of carparks would have a negative impact on surrounding communities (Mitchell, 2016).

4.1.2. Limitations to access. In Christchurch, access to some (business) premises became temporarily restricted due to cycleway network construction. Northcott (2017) reported that the owners of Pahs Dairy faced this situation during the construction of the Papanui Parallel. Temporary fences blocked customer carparks in front of their shop. The links between carparks and the shop were cut off. The cycleway also impacted delivery trucks so that they could not stop safely to unload shop items (Northcott, 2017). Furthermore, although the Rapanui Shagrock Cycleway was still in the planning stages, a few local Linwood residents and business owners were worried about the proposed plans to "restrict access to and from Worcester Street from Fitzgerald Avenue and England Street" (Law, 2016a). They argued that the cycleway would negatively affect nearby businesses in the future.

4.1.3. Reduced road safety. Design and implementation of proposed cycleways also caused some concerns about road safety. For example, a dairy owner pointed out that the kerb of the cycleway might endanger elderly or disabled customers who parked in front of his shop, because they had to traverse the high kerb (Northcott, 2017). Some residents in Ngahere St., Riccarton questioned the safety of the proposed cycleway. One resident argued that "families and small children should be allowed to roam freely and not have the dangerous hazard of cyclists amongst them" (Law, 2016b).

4.1.4. Traffic congestion. Some residents worried about traffic congestion generated by proposed cycleways. For instance, a St. Albans Catholic School board member argued that traffic condition became worse after the Papanui Parallel was

constructed, because two cycle lanes outside the school narrowed the street (Law, 2016a). The owner of a childcare centre in Trafalgar Street stated that zig-zag cycleways through already congested streets would cause more traffic congestion and would inconvenience local residents trying to access the centre (Law, 2016a).

4.1.5. Loss of existing buildings. Some residential properties were potentially affected by the MCR project in Christchurch. In order to link Roker Street and Strauss Place, Christchurch City Council staff planned to remove two properties that separated them. After consultation, the council confirmed that at least one property should be removed to accommodate the proposed cycleway. The chairwoman of the Somerfield Residents Association argued that the route was not the best choice due to its impact on local residents and the community (Mitchell, 2016).

4.1.6. Heritage impacts. One Christchurch cycleway goes through the grounds of a historic site — Riccarton Bush. As reported by Law (2016b), “Christchurch City Council is proposing to run part of the 5.6-km Uni-cycle route on an existing shared cycle and pedestrian path through the grounds of Riccarton House and Bush”. This report upset some local residents of Ngahere Street, Riccarton. One resident argued that a cycleway through historic grounds would cause "desecration" of surrounding heritage homes and grounds (Law, 2016b).

4.2. The Identification of Hot Spots

According to the articles I analysed, eight major conflict areas currently affect the Christchurch MCS project. Identified conflict areas, which were reported with exact addresses, were located at 49 Rutland Street, 222 Barrington Street, 96 Trafalgar Street, 150 Ferry Road and 969 Colombo Street. Other areas were general vicinities in Ngahere Street, Worcester Street between Fitzgerald Street and England Street, and Milton Street. I have marked those locations on a map (Figure 4-1). I conducted two site surveys at each hot spot (in September 22, 2017 and December 15, 2017). No precise location details were provided by the news articles I used to identify some hot spots (Law, 2016a; Law, 2016b; Mitchell, 2016) including Worcester, Milton and Ngahere Streets. Thus, these streets were comprehensively investigated.

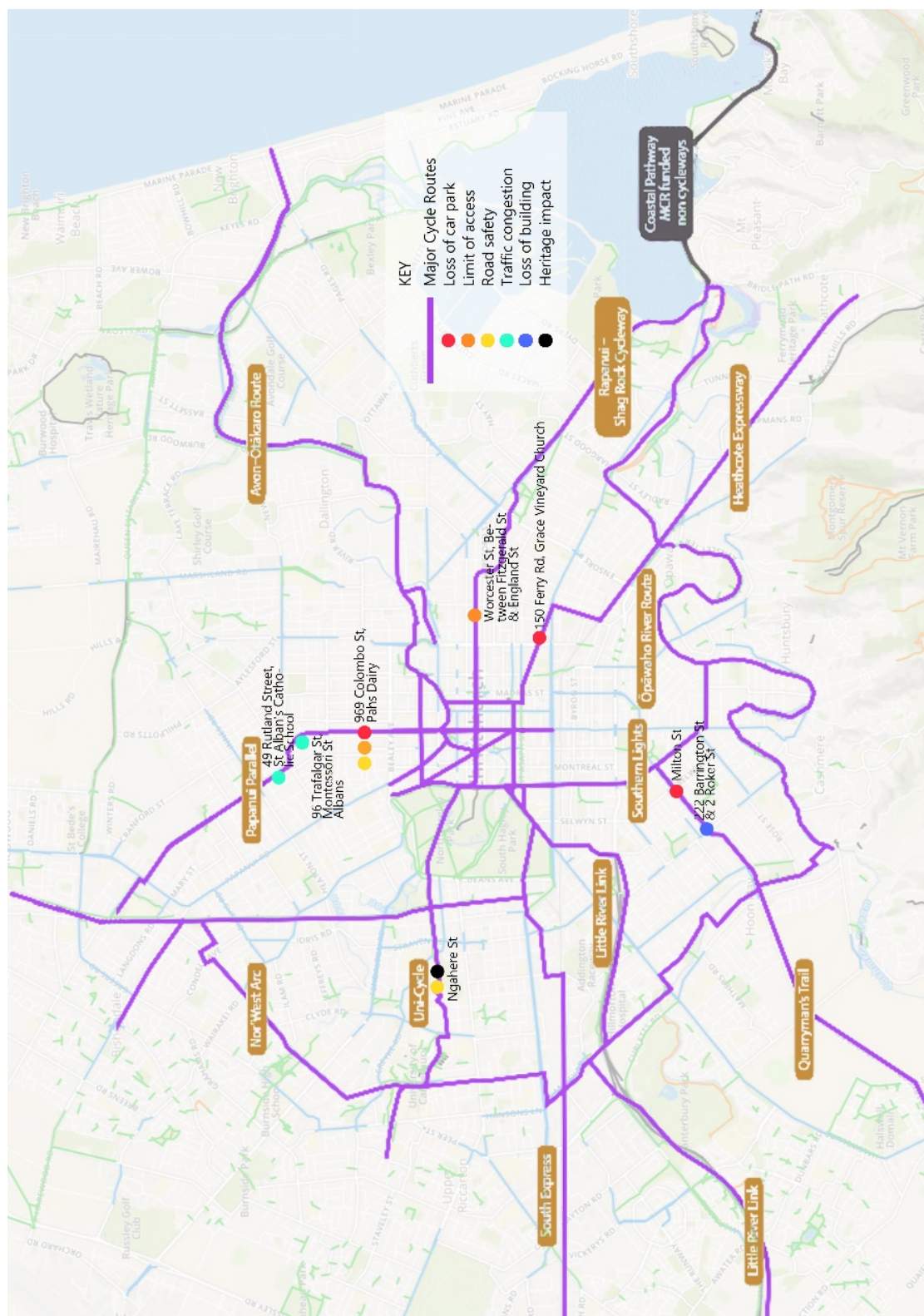


Figure 4-1. Location of conflict area (source of base map: Major Cycle Routes network map, n.d.).

Note. Conflicts are marked in different colours.

4.3. Initial Hot Spot Site Inspection

Based on my standards of hot spot site selection listed in Chapter 2 and the results of my site surveys, I listed the results of initial hot spot site inspection as follows.

Unclearly identifiable Christchurch MCR conflict areas included Ngahere Street, 222 Barrington Street, Milton Street, 150 Ferry Road and Worcester Street (between Fitzgerald Street and England Street). These hot spots are not discussed further in this study, because no conflicts at these sites were found at the time I visited the areas. In Ngahere Street, vehicle volume was quite low during the site surveys. Vehicles normally slowed down after entering the street, because the street was a small residential street. I could not identify any road safety issues during my observations.

In addition, I found that the residential property at 222 Barrington Street could be demolished to make way for Quarryman's Trail. Instead of using design as a solution, the conflict could be resolved by negotiating with local residents and by providing them compensation.

Milton Street and 150 Ferry Road cycleway sections had not been constructed at the time of my site survey, so I could not directly observe potential conflicts. In addition, more consultation and changes to plans could be made to reduce the impact of carpark losses. I could not find any access impediments at the Worcester Street hot spot (between Fitzgerald and England Streets). I did not observe other conflicts in this area, either, so I discounted it as a study subject.

After the initial site inspections, I decided four hot spots qualified for additional analysis. The hot spots around 49 Rutland Street, 96 Trafalgar Street and 969 Colombo Street qualified because conflicts were readily observable in these locations. In addition, during the site survey, I found that the fourth area, a location

around 5/63 Rutland Street, was similar in scope to the hot spot at 969 Colombo Street, making it ideal to compare the two.

4.4. Analysis of Selected Conflict Areas

Detailed analyses of selected conflict areas and the results were presented in following sections (4.4.1, 4.4.2, 4.4.3, 4.4.4).

4.4.1. Hot spot 1: 969 Colombo Street

Previous situation. Pahs Dairy at 969 Colombo Street provides convenience items to its local community. Based on informal conversations with the shop owners (December 15, 2017), the shop has been running well for many years. A lot of nearby elderly people and young families often buy essential items from the shop. Before the MCR project, there were no cycle lanes along the street (Figure 4-2). The car parking area in front of Pahs Dairy provided three carparks for customers. Customers could park easily and reach the entrance without encountering obstacles. On the other side of the street, a bus stop (shown in the red frame in Figure 4-2) adjoined the edge of sidewalk. Vehicle lanes in the middle of the street were wide enough to allow most vehicles to pass easily.



Figure 4-2. Pahs Dairy, 969 Colombo Street, before Papanui Parallel Cycleway construction (Google Earth, 2012).

Note. The red frame denotes the bus parking area on the eastern side of the street.

Current situation. As shown in my Colombo Street site photos taken in December 15, 2017 (Figures 4-6 and 4-7), most changes proposed during the consultation process were implemented. However, the paved wheelie bin set-down pads on the western side of the street were left out. In addition, the bus stop (Figure 4-7, red rectangle) was larger than what was originally proposed.



Figure 4-3. Western Pahs Dairy side of Colombo Street after construction of the Colombo Street section of the Papanui Parallel Cycleway (Wang, 2017),



Figure 4-4. Eastern side of Colombo Street after the Papanui Parallel Cycleway was constructed (Wang, 2017).

Note. Red rectangle shows the location of the new bus stop (outside the cycleway kerb).

Planning and design documents. According to two local council plans (Figures 4-3 and 4-4), carparks were to be retained on the western side of the street only. The number of customer carparks in front of Pahs Dairy was set to decrease from three to two parks. Small paved surfaces, such as Number 85 in Figure 4-3, were designed for placing wheelie bins. Before consultation, bus stops were designed very close to each other (Figure 4-3). After consultation (Figure 4-4), the proposed bus stop on the eastern side was moved back to its original position (in front of 966 Colombo Street, marked as Number 46).

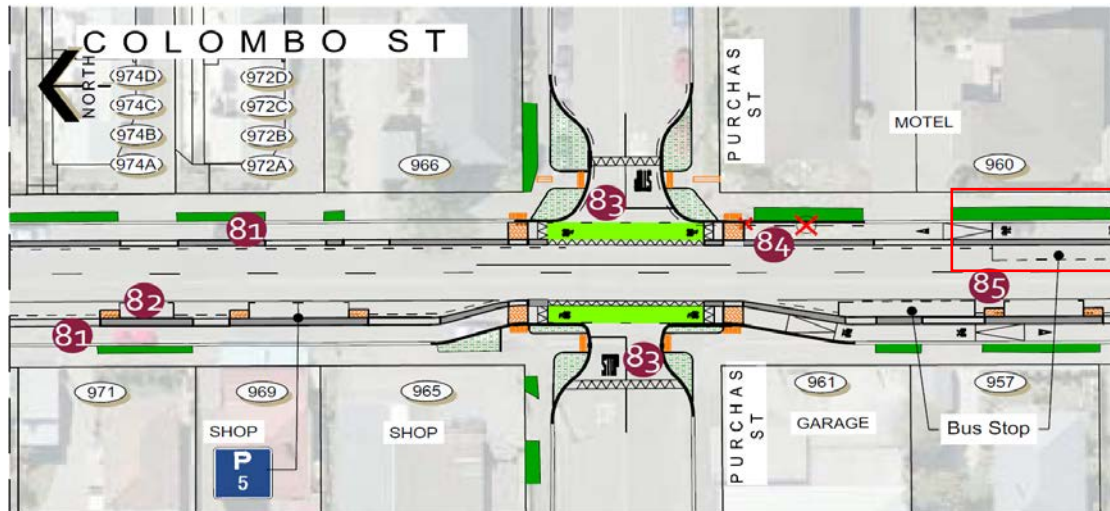


Figure 4-5. Detailed pre-consultation council plan for the Colombo Street section of the Papanui Parallel Cycleway (Christchurch City Council, 2015).

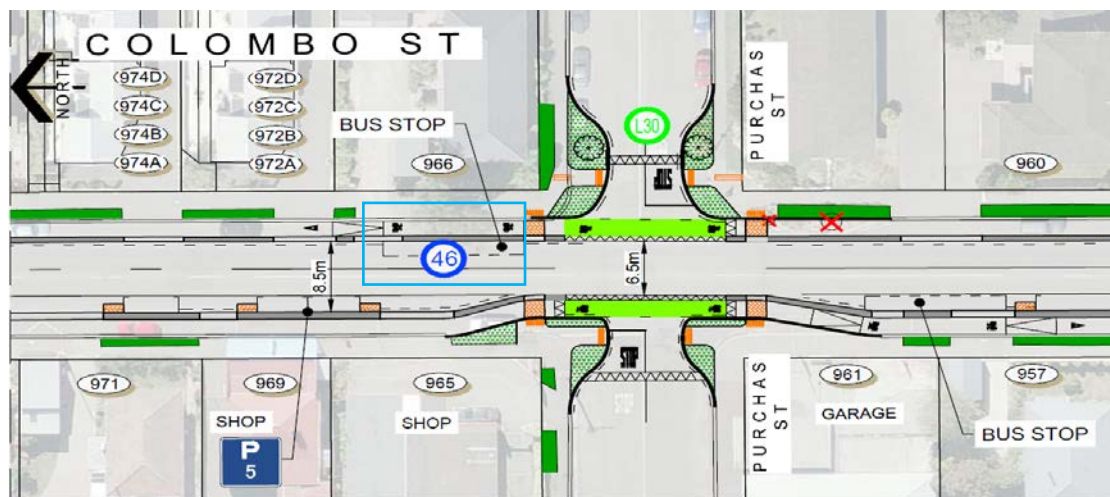


Figure 4-6. Detailed post-consultation council plan for the Colombo Street section of the Papanui Parallel Cycleway (Christchurch City Council, 2016).

Cross sections were reviewed to support post-consultation plans. Based on a cross-sectional diagram drawn after consultation (Figure 4-5), the Colombo Street cycle lane was set at 2.0 m wide. Kerbs were drawn at 0.6 m and 0.8 m widths. The two vehicle lanes were narrowed down to a 6.5 m width in total.

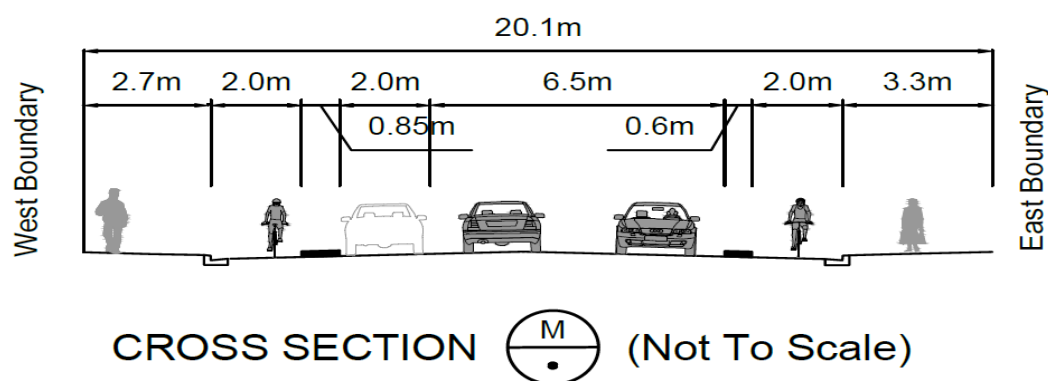


Figure 4-7. Cross-sectional diagramme for cycle lane on Colombo Street post consultation with stakeholders (Christchurch City Council, 2016).

Discussion. According to my site survey (December 15, 2017) and Christchurch City Council planning documents, it can be confirmed that conflicts reported in Northcott's (2017) article still exist. Based on the site analysis, in order to create a safe route for cyclists, kerbs were designed to provide cyclists with physical separation from vehicles. However, in order to create space for placing a wheelie bin and to ensure safety when vehicles were turning out of the drive of a shop or unit, carparks outside the kerb had to be made smaller to leave enough space at both ends of a single kerb. The reduction of car parks caused inconvenience for both local customers and passing customers.

The cycleway and kerbs may cause safety issues and traffic inconvenience, too. Kerbs may endanger the elderly or disabled customers, due to their height. The Pahs Dairy owner told me about an incident in which an elderly lady drove her car inside the kerb to avoid walking on the kerb. In addition, access to the dairy became more limited because of the kerbs. Delivery trucks could not pull over easily, especially when customer car parks were all occupied. Above major site uses and conflicts are shown in a diagram (Figure 4-8). Furthermore, buses stopping at the bus stop on the eastern side of the street would hold up the traffic. But the latter issue was not a major conflict due to the low frequency of buses arriving at the stop.



Figure 4-8. Major site uses and conflicts at 969 Colombo Street (source of base map: Christchurch City Council, 2016)

4.4.2. Hot spot 2: 5/63 Rutland St

Previous situation. Similar to Pahs Dairy, the dairy shop at 5/63 Rutland Street (Figure 4-9, red rectangle), and nearby shops, provide convenience items to the local community. Based on my site analysis, nearby shops included a barber shop, a clothing shop, a fish 'n' chips takeaway and a souvenir shop. Before the Papanui Parallel Cycleway was constructed, there were no cycle lanes along Rutland Street. Seven cars could park in an area in front of the shops. Parking demands could be met in most cases. Delivery trucks could pull over easily and park without causing congestion.



Figure 4-9. Aerial view of 5/63 Rutland Street and surrounding shops before the Papanui Parallel Cycleway was constructed (Google Earth, 2016).

Note. Red rectangle shows the location of the dairy and surrounding shops.

Current situation. Two photos I took during site visits in December 15, 2017 (Figures 4-14 and 4-15) show current site layout after the Rutland Street portion of the Papanui Parallel Cycleway was constructed. Paved wheelie bin set-downs near the shops were missing. The rest of the changes shown in post-consultation plan and cross section had been made.



Figure 4-10. The western side of Rutland Street after construction of the Papanui Parallel Cycleway (Wang, 2017).



Figure 4-11. The eastern side of Rutland Street after construction of the Papanui Parallel Cycleway (Wang, 2017).

Planning and design documents. Before consultation, two options were available for proposed cycle lanes along Rutland Street. Both options were to be 2.0 m wide. Kerbs were set to be 0.5 m on one side, and 1.0 m wide on the other side. Three trees were to be removed to make room for the cycle lane. In option A (Figure 4-10), Hawkesbury Avenue was to be permanently closed to provide five more carparks along Rutland Street. In option B (Figure 4-11), Hawkesbury Avenue was to remain open to the vehicles for higher traffic flows. However, no additional carparks were provided. After consultation, the modified plan allowed Hawkesbury Avenue to remain open (Figure 4-12). Seven carparks were to be created outside Rugby Park. Stakeholders recommended that trees lining the street should be kept.

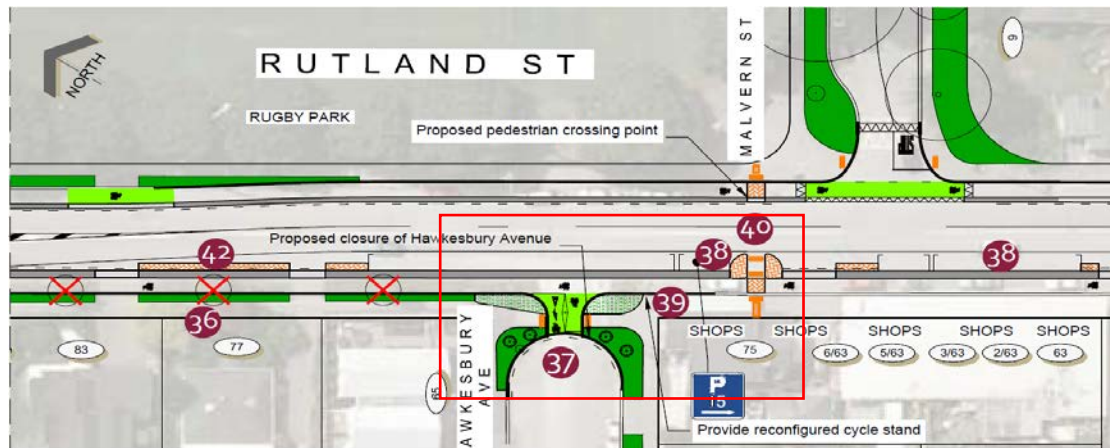


Figure 4-12. Pre-consultation option A for constructing the Rutland Street portion of the Papanui Parallel Cycleway (Christchurch City Council, 2015).

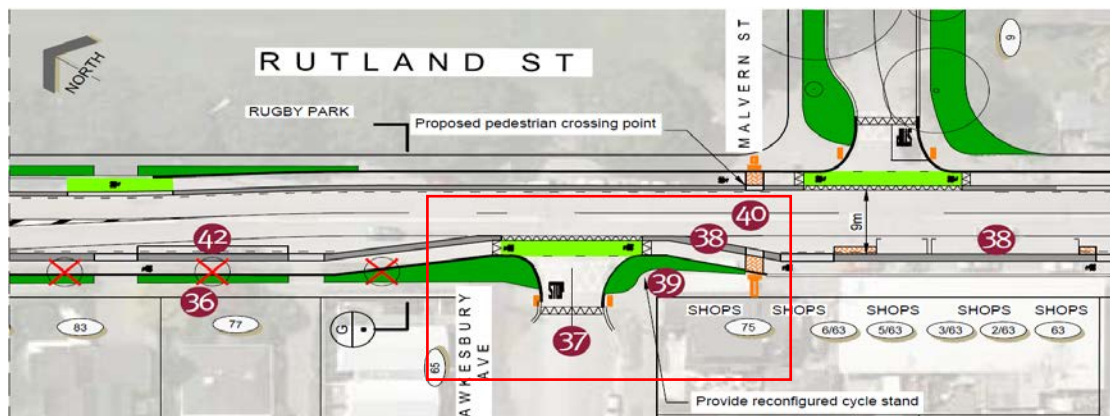


Figure 4-13. Pre-consultation option B for constructing the Rutland Street portion of the Papanui Parallel Cycleway (Christchurch City Council, 2015).

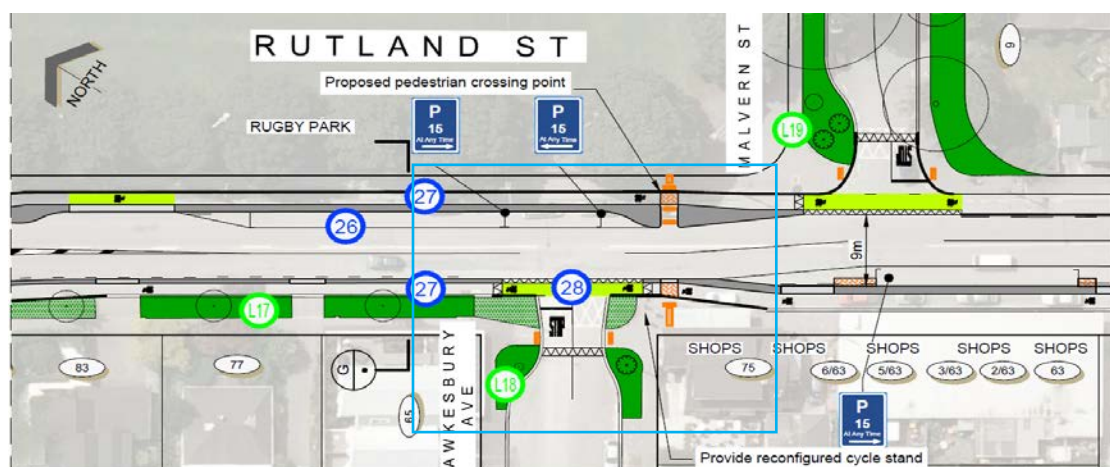


Figure 4-14. Post-consultation option for constructing the Rutland Street portion of the Papanui Parallel Cycleway (Christchurch City Council, 2016).

The cross-sectional diagram below indicates that the proposed Rutland Street cycle lane was narrowed down from 2.0 m to 1.6 m (Figure 4-13). Kerbs were set to remain 0.5 m wide on one side of the road, but were narrowed down to be 0.9 m wide on the other side. Vehicle lanes were narrowed down to a 6.5 m width for both lanes.

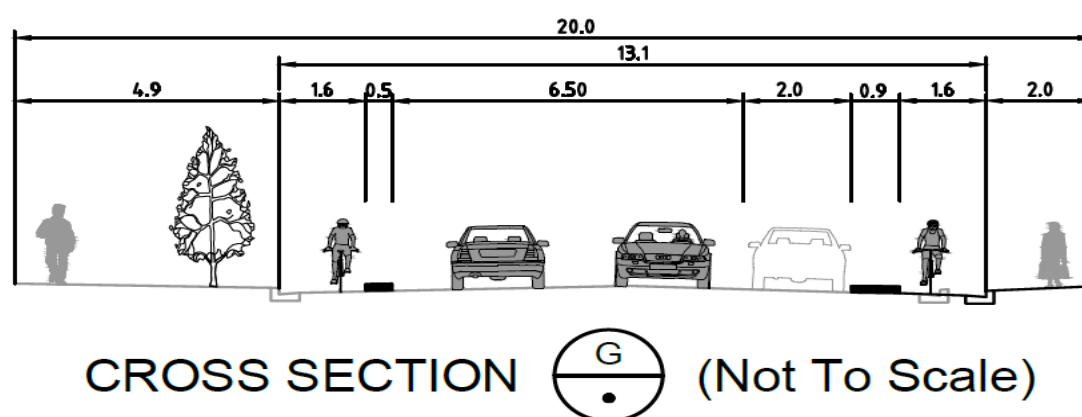


Figure 4-15. Cross-sectional diagramme for cycle lane on Rutland Street developed post-consultation with stakeholders (Christchurch City Council, 2016).

Discussion. My site survey (December 15, 2017) and informal conversations with shop owners of the dairy and fish ‘n’ chips takeaway indicated that their shops caused higher demand for parking spaces at certain times of day. Before the cycleway was built, the section from 75 Rutland Street to 63 Rutland Street could provide seven parking spaces, which fulfilled customer demand. After the cycleway was built, only four cars could be parked at best, a figure reduced by nearly half. This issue, a complaint made to me by the dairy owner, was quite similar to what the owner of Pahs Dairy had said. A series of issues caused by the cycleway, especially the loss of customer carparks, had seemingly led to income declines for all the neighbouring shops. In addition, the Rutland Street dairy owner highlighted the safety concerns about the cycleway kerb. Based on her anecdotal description, she once witnessed a driver accidentally drive over the kerb at night, resulting in a loss of

control that almost pushed the car onto the inner sidewalk. Above major site uses and conflicts are shown in a diagram (Figure 4-16).

From both dairy owners' points of view, the negative consequences caused by cycleways were far worse than their positive effects. The owners' reflections implied that driving was still the first choice of transport for the majority of residents, and that promoting cycling did not help their businesses at this stage.



Figure 4-16. Major site uses and conflicts at 5/63 Rutland Street (source of base map: Christchurch City Council, 2016)

4.4.3. Hot spot 3: 49 Rutland Street

Previous situation. Located at 49 Rutland Street, St. Albans Catholic School provides a strong link between members of the local community. Students and their families come from several cultural backgrounds and come together at the school. In April 2016, there were 95 students enrolled (St. Albans Catholic School, 2016). The street was busy for long periods of time, both before and after school hours. Before the Papanui Parallel Cycleway was constructed, the street was relatively wide (Figure 4-17). Plenty of on-street carparks were available. There were no cycle lanes, and a pedestrian crossing point was available near the school.

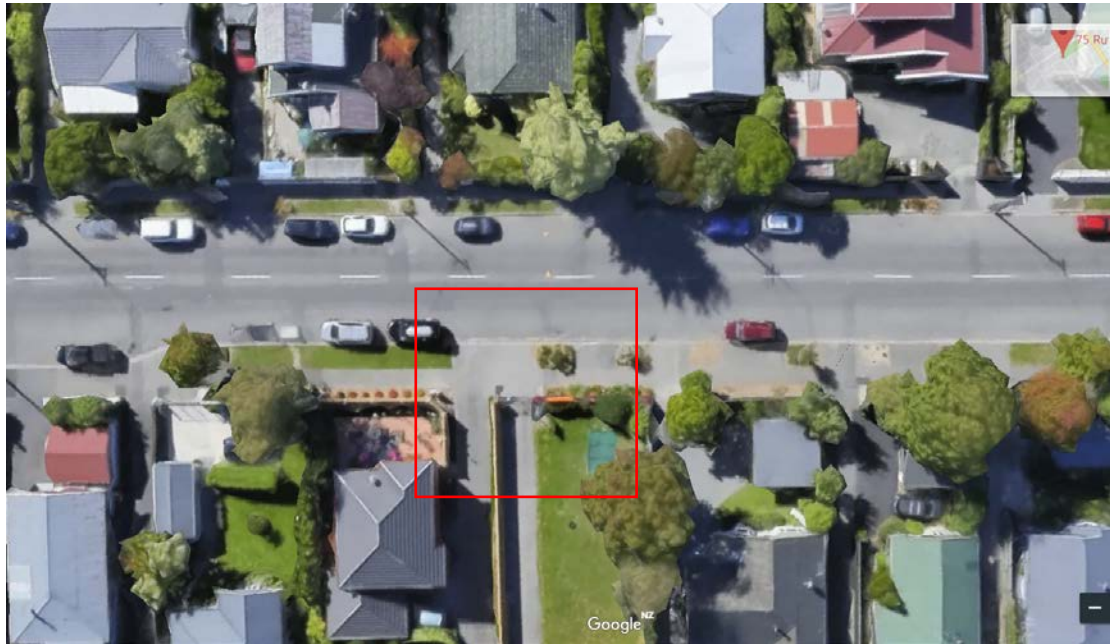


Figure 4-17. Aerial view of St. Albans Catholic School area before the Papanui Parallel Cycleway was constructed (Google Earth, 2016).

Note. Red rectangle shows location of St. Albans Catholic School entrance at 49 Rutland Street.

Current situation. Based on my site survey in September 22, 2017, except for paved pads adjacent to carparks, all other proposed changes after the consultation process were made at the St. Albans Catholic School location (Figure 4-21, Figure 4-22). However, as shown in Figure 4-23, I found very uneven surfacing on the cycleway near the entrance of St Albans Catholic School.



Figure 4-18. Photo taken near entrance of the St. Albans Catholic School, 49 Rutland Street, after the Papanui Parallel Cycleway was built (Wang, 2017).



Figure 4-19. The pedestrian crossing point outside St. Albans Catholic School after the Papanui Parallel Cycleway was built (Wang, 2017).



Figure 4-20. The Papanui Parallel Cycleway outside the St. Albans Catholic School, which connects to 5/63 Rutland St (Wang, 2017).

Note. The uneven surface can be seen

Plan and design documents. Before consultation, kerbs were designed alongside both cycle lanes. On-street carparks were to be removed on the eastern side of Rutland Street. No planting zone was designed around the proposed pedestrian crossing point (Figure 4-18). After consultation, it was decided that all kerbs would be removed except for those to the north of 1/55 Rutland Street. Stakeholders also suggested that four on-street carparks should be kept on the eastern side of the street. Planting zones were to be provided around the proposed pedestrian crossing point (Figure 4-19).

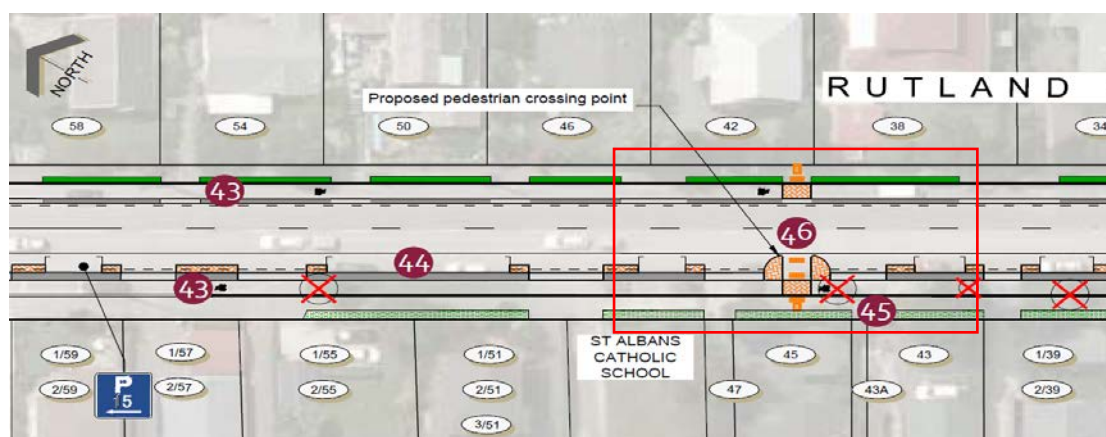


Figure 4-21. Pre-consultation plan for constructing the Rutland Street portion of the Papanui Parallel Cycleway outside the St. Albans Catholic School (Christchurch City Council, 2015).

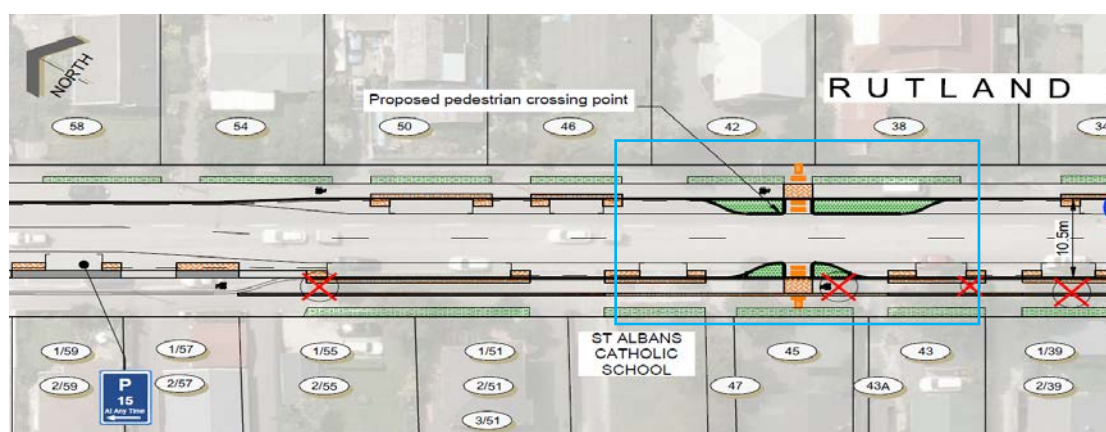


Figure 4-22. Post-consultation plan for constructing the Rutland Street portion of the Papanui Parallel Cycleway outside the St. Albans Catholic School (Christchurch City Council, 2016).

Based on the cross-sectional diagram, after consultation, vehicle lanes were narrowed down to 6.5 m wide (Figure 4-20). Level of cycle lanes were raised to meet the height of sidewalks.

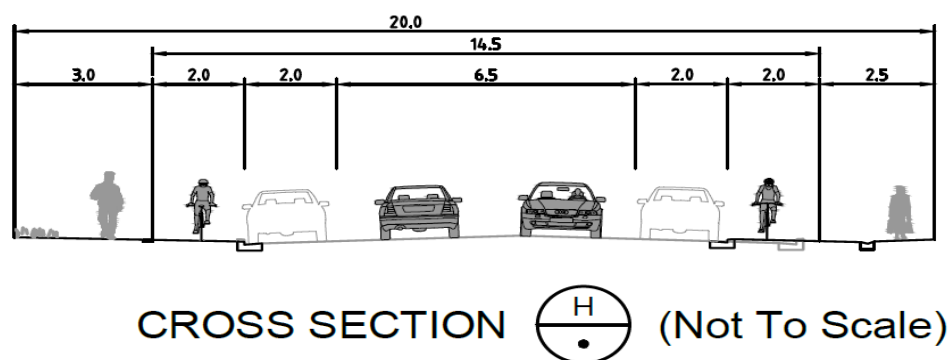


Figure 4-23. Post-consultation cross-sectional diagram through Rutland Street (near the St. Albans Catholic School at 49 Rutland Street) showing cycleway constructs (Christchurch City Council, 2016).

Discussion. According to previous analysis of Press article, traffic congestion was listed as a major conflict near the entrance of St. Albans Catholic School. Based on my first site survey (September 22, 2017), traffic became congested before and after the school time. Parents and children were the main users of the street during this period. Road safety was therefore a potential concern during this busy time. Cyclists and drivers had to pass with care in order to avoid conflicts. In addition, based on informal conversations, I found that some parents complaint about loss of on-street carparks caused inconvenience. Thus, my analysis shows that the impacts caused by these conflicts were heightened at certain times of the day (the hour before and after school). There were no obvious conflicts most of the time, however.

4.4.4. Hot spot 4: 96 Trafalgar Street

Previous situation. Montessori St. Albans is a childcare centre located at 96 Trafalgar Street (Figure 4-24). It is an infant community centre for children aged 12 months to 3 years old, and offers a full Montessori classroom for children aged from 3–6 years old (Montessori St. Albans, 2015). Before the cycleway was built, there were no cycle lanes on the street. Three on-street carparks (shown in the red frame in Figure 4-24) in front of the childcare centre were provided.



Figure 4-24. Before the cycleway construction at Montessori St. Albans, 96 Trafalgar Street (Google Maps, 2012).

Note. The red frame denotes the three on-street carparks in front of the childcare centre.

Current situation. According to my site survey, all proposed changes from post-consultation plans for cycleway construction on Trafalgar Street were made during construction. In addition, an extra painted zone (shown in the red frame in Figure 4-29) was provided to guide cyclists.



Figure 4-25. The cycleway near 96 Trafalgar Street after construction (Wang, 2017).

Note. The red frame denotes the extra painted zone.

Planning and design documents. Before consultation and in order to accommodate the proposed cycleway, the Christchurch City Council proposed to remove on-street carparks on the western side of the street (the side facing Massey Crescent) and in front of 1/104 Trafalgar Street. Planners also wanted to remove most of the trees lining the street (Figure 4-25). After consultation, however, it was decided that two restricted carparks would be provided in front of 1/104 Trafalgar Street. Furthermore, the width of cycleway kerbs was reduced to make more room for vehicle traffic. The angle and shape of the kerbs at the intersection were adjusted to increase turning radius (Figure 4-26).

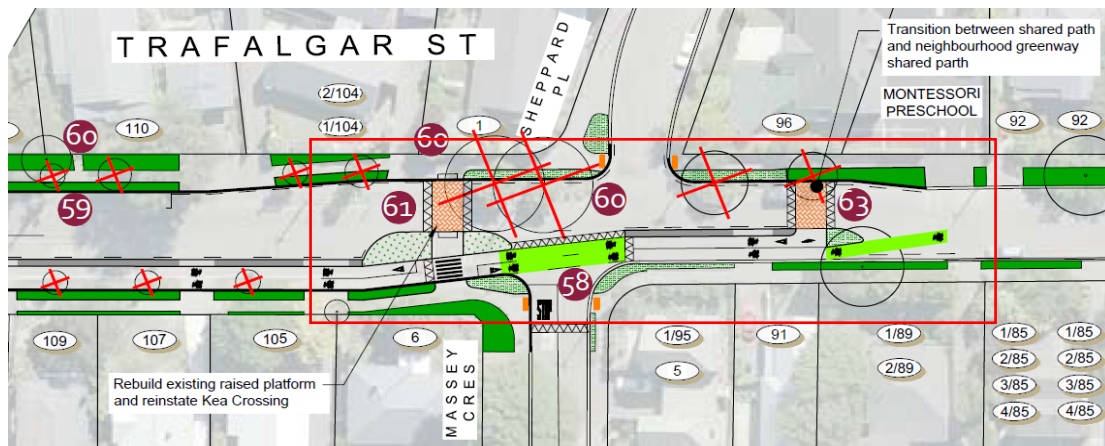


Figure 4-26. Pre-consultation plan for constructing the Trafalgar Street portion of the Papanui Parallel Cycleway outside the Montessori St. Albans School, 96 Trafalgar Street (Christchurch City Council, 2015).

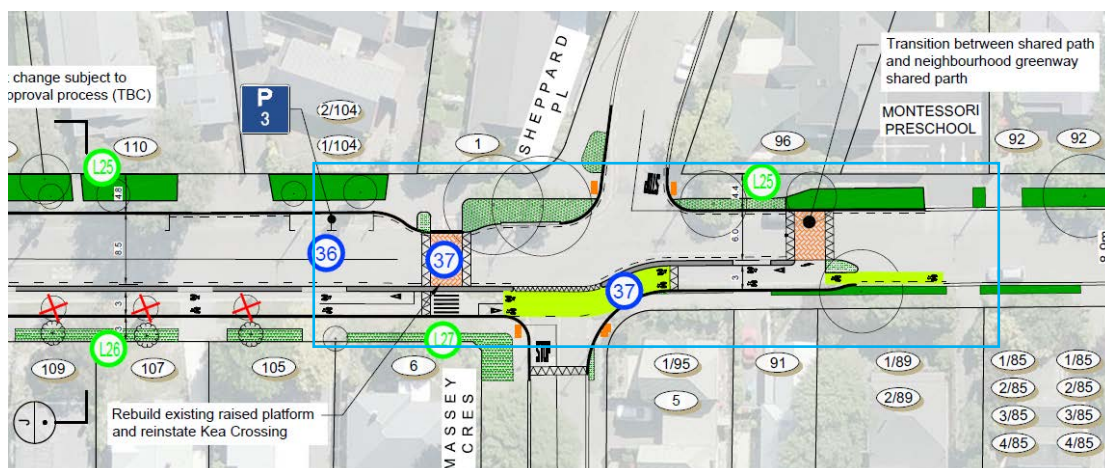


Figure 4-27. Post-consultation plan for constructing the Trafalgar Street portion of the Papanui Parallel Cycleway outside the Montessori St. Albans School, 96 Trafalgar Street (Christchurch City Council, 2016).

Two cross sections were presented due to different cycleway designs in Trafalgar Street. After consultation, plans were adjusted to make the cycle lane 3.0 m wide before passing the transition point in front of Montessori St. Albans School. Kerbs designs were adjusted to be 0.85 m wide. Vehicle lanes were narrowed down to a 6.6 m width, but were widened near the intersection (Figure 4-27). After the

pedestrian crossing transition zone, modified plans depicted cyclists and drivers sharing the 9.0-m wide road (Figure 4-28).

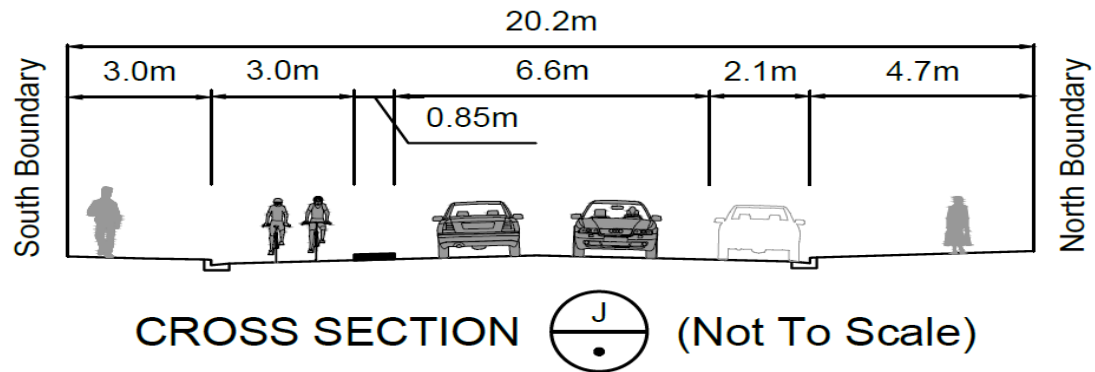


Figure 4-28. Post-consultation cross-sectional diagram through Trafalgar Street (near 110 Trafalgar Street) showing cycleway constructs (Christchurch City Council, 2016).

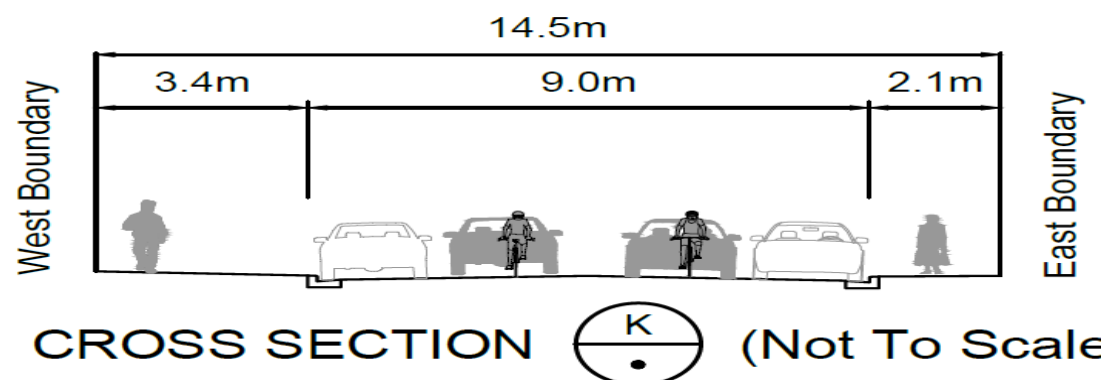


Figure 4-29. Post-consultation cross-sectional diagram through Trafalgar Street (near 96 Trafalgar Street) showing cycleway constructs (Christchurch City Council, 2016).

Discussion. The overall aim of choosing Trafalgar Street to become part of Christchurch's MCRs was to create a quieter and safer cycling environment. Trafalgar Street was considered by the Christchurch City Council to be ideal, because it carries a low traffic volume and is a quiet neighborhood street able to be shared with vehicles. According to the owner of Montessori St Albans, however, the cycleway now causes more traffic congestion. No complaint about car park loss were heard. Based on my observations, congestion occurred only on one portion of

the shared roadway, where cars park on both sides of the street. In this situation, I observed that drivers could not pass cyclists in front of them. They had to drive slowly, with much more attention and patience in order to ensure road safety. However, in contrast with hot spots I observed previously, no obvious differences pre- or post-cycleway could be found in terms of traffic congestion.

4.5. Summary of Major Conflicts in Real Situations

Based on my analysis, I found that loss of car parks and a reduction of road safety caused by cycleway kerbs were the two major conflicts experienced by road users at 969 Colombo and 5/63 Rutland Streets. These conflicts now need to be solved or mitigated as soon as possible due to their directly impacts (such as safety issues) on road users and indirect impacts (such as income decline) on surrounding business owners. For areas around 49 Rutland Street, conflicts such as increased need of carparks, reduced road safety, or traffic congestion only happened in specific situations or time periods. The frequency of impact was relatively low. For areas around 96 Trafalgar Street, no obvious differences could be found pre- or post-cycleway. I summarized above results into a table (Table 4-3).

Hot Spot	Major Conflict(s)	Frequency
969 Colombo Street	Loss of car parks	High
	Reduction of road safety	High
5/63 Rutland Street	Loss of car parks	High
	Reduction of road safety	High
49 Rutland Street	Increased need of carparks	Low
	Reduction of road safety	Low
	Traffic congestion	Low
96 Trafalgar Street	Traffic congestion	Very low

Table 4-3. Hot spot, major conflict type and frequency of conflict (Wang, 2018)

Chapter 5: Discussion

The aim of this chapter was to answer the second and the third research question listed in Chapter 1. The scope of my discussion encompasses the development of design-based solutions for conflict areas along the Papanui Parallel Cycleway in Christchurch. In respect of differences between conflict areas, proposed design details can be different. Currently, there are three major limitations when developing design-based solutions. First, street spaces are usually limited for making substantial changes due to land privatization. Second, the current preference of city populations for vehicle transportation cannot be changed in a short time. Third, the current budget for MCRs is limited. Therefore, in the short term, Christchurch designers need to achieve a balance in their designs between cyclists and vehicles, together with considerations of limited street spaces and budget.

Based on current situations and limitations, the small-scale solutions I propose for specific conflict areas will not change the overall structures of the sites. For the two hot spots around 5/63 Rutland Street and 969 Colombo Street, I recommend that kerbs near the shops and bus stop be removed in consideration of vehicle and pedestrian safety. I further recommend that an elevated cycleway, with a chevron painted on its outside edge, should be constructed to ensure cyclists' safety. With this solution, the number of carparks in front of shops at both hot spot locations will increase by one.

For the area around 49 Rutland Street, my design alternative will allow two more carparks near the school for parents. My novel design provides a paved crosswalk for cyclists set between two crosswalks to improve safety for both pedestrians and cyclists. According to my design, cycleway surfaces in front of 1/57 Rutland Street will be re-paved for a better cycling experience.

I develop an alternative design-based solution for above three sites. The design will create a double-way cycle path on eastern side of each street. Carparks in front of shops or the school will be shifted adjoin the western sidewalk to provide greater convenience for customers or parents.

No significant structural changes can be made to the area around 96 Trafalgar Street at this stage due to the limitation of street width and the low impact frequency. Improvements to signage and road surfaces can be considered in the short term.

5.1. Recommended Design 1: 969 Colombo Street

The design I propose for 969 Colombo Street, in front of Pahs Dairy, is shown in Figure 5-1. Compared to previous plans, cycleway kerbs near the bus stop on the eastern side of the street and in front of Pahs Dairy have been removed to improve access and pedestrian safety. In their place, I propose an elevated cycleway with chevrons painted on its edge. This will allow the number of carparks in front of Pahs Dairy to increase by one. A paved wheelie bin set-down pad can also be placed near the entrance of 971 Colombo Street to support rubbish removal from three nearby properties. The bus stop area on the eastern side of the street will remain in its current position due to the limitations in street width.

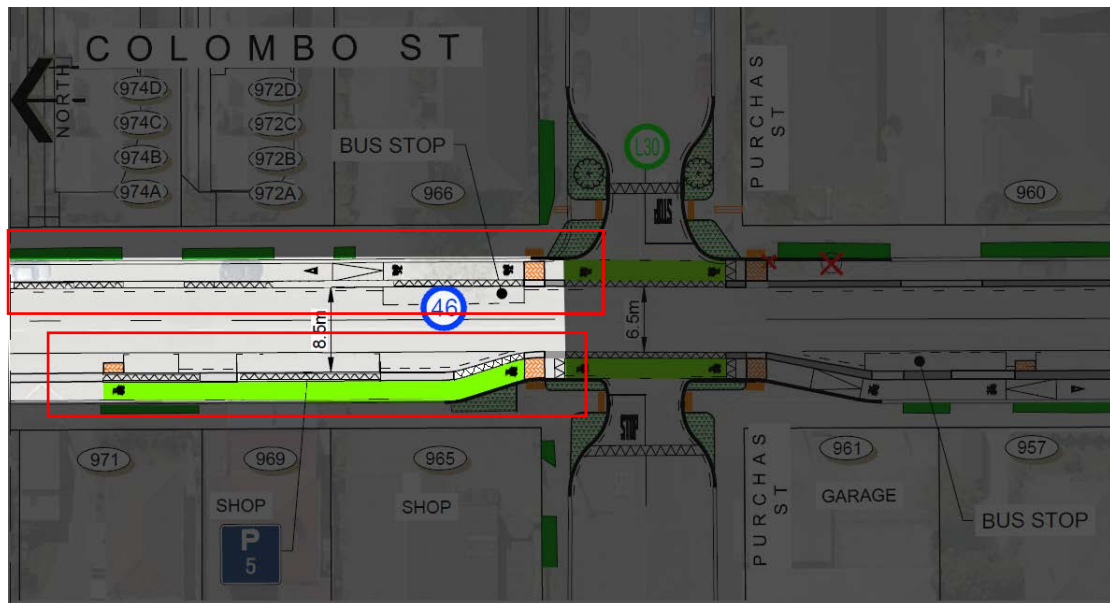


Figure 5-1. Detailed design proposed to mitigate conflicts at 969 Colombo Street caused by current cycleway design (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the proposed changes.

The cross section I created for my new plan (Figure 32) shows the width and levels of different lanes. Width of all lanes will remain the same. The level of the cycleway will be raised to half the height of the sidewalk kerb, however. Original cycleway kerbs were replaced by painted chevrons with the same width to leave spaces for opening car doors. I believe this design would create a welcome improvement for elderly and disabled people.

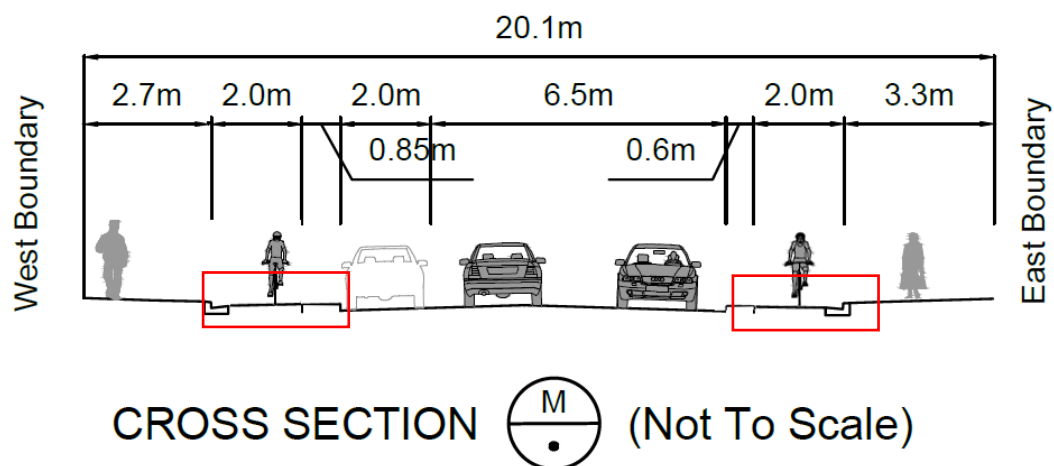


Figure 5-2. Cross section of my new design for Colombo Street showing improvements to kerbing and cycleway (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the raised cycle path.

Another alternative design-based solution was to shift the cycle path in the western side of the street to the eastern side and set 0.85m kerb/painted chevron along the route. By merging two cycle paths on one side, safety of cyclists would increase. Customer carparks could be shifted adjoin the sidewalk on the western side. This would create more convenience for customers and delivery person. The only concern for this method was decreased convenience for some cyclists who want to visit the dairy shop. More simulations could be made to identify its incidence.

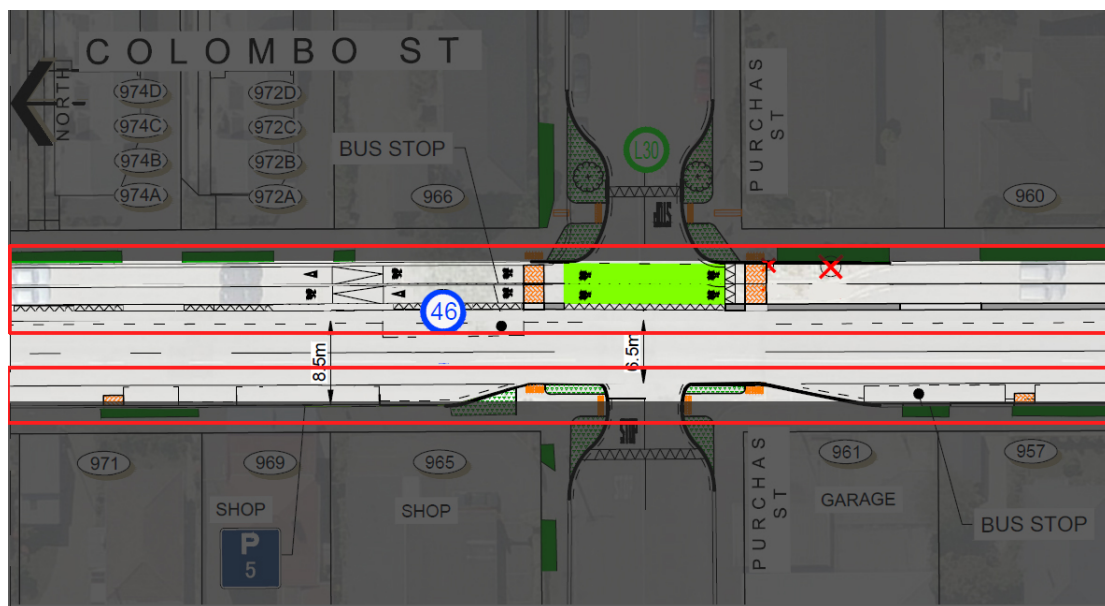


Figure 5-3. Alternative detailed design proposed to mitigate conflicts at 969 Colombo Street caused by current cycleway design (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the proposed changes.

5.2. Recommended Design 2: 5/63 Rutland Street

The proposed plan for conflict mitigation around the 5/63 Rutland Street dairy is illustrated in Figure 33. Compared to the existing design, I propose to shift the cycleway in front of the shops 0.5 m closer to the sidewalk to make room for adding

one more carpark near 6/63 Rutland Street. Kerbs in front of 6/63 to 63 Rutland Street will be removed. I propose an elevated cycleway with a chevron painted on the edge to demarcate travel areas. Paved wheelie bin set-down pads will be set near the entrances of 75 and 63 Rutland Street to support nearby properties.

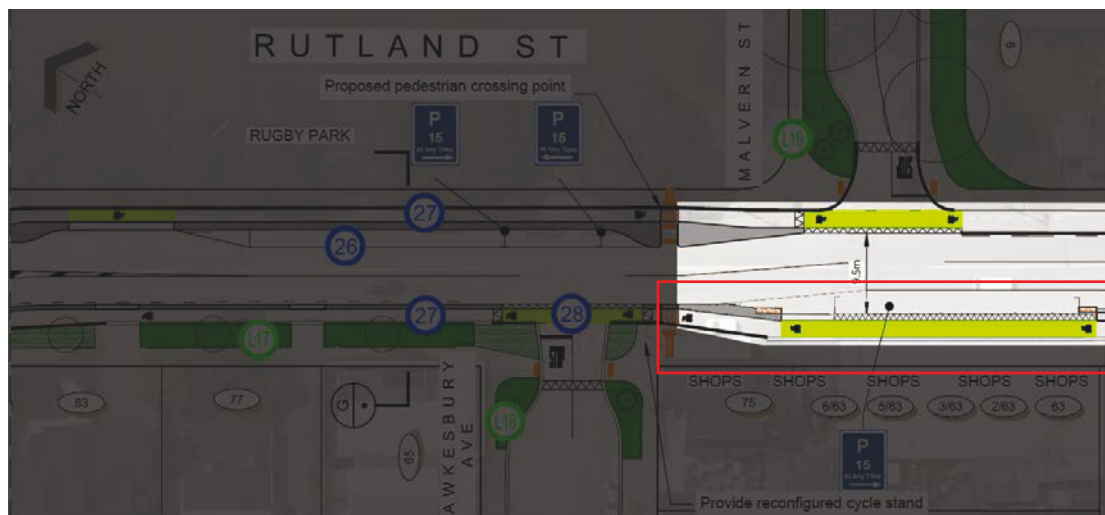


Figure 5-4. Detailed design proposed to mitigate conflicts at 5/63 Rutland Street caused by current cycleway design (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the proposed changes.

The cross section of my plan shows the width and level of proposed lane (Figure 34). Widths of on-street carparks will vary from 2.0 m–2.5 m. The level of the cycleway will be raised to half the height of the sidewalk kerb. Original cycleway kerbs were replaced by painted chevrons with the same width. These design solutions are the same as solutions I propose for 969 Colombo Street, because the problems and current construction are virtually the same.

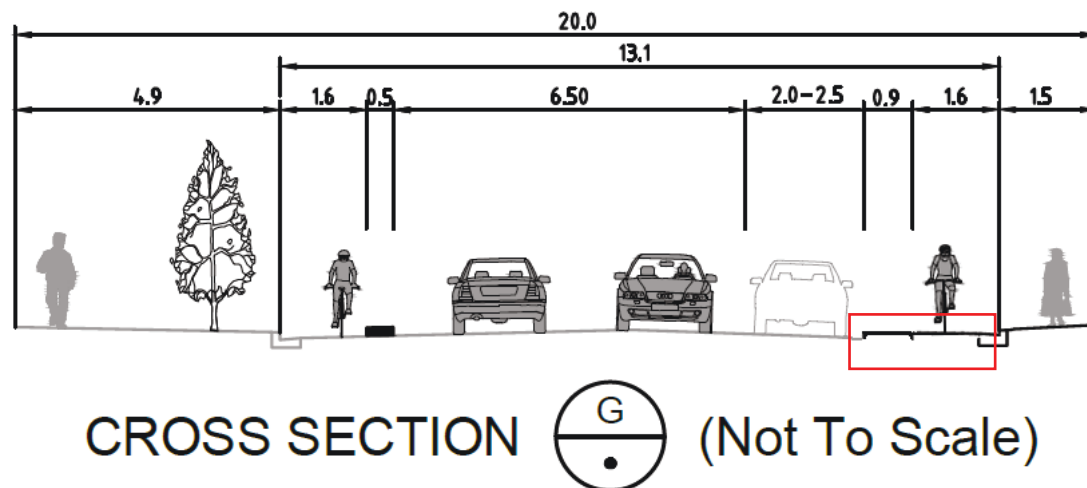


Figure 5-5. Cross section of my new design for the area around 5/63 Rutland Street (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the raised cycle path.

I considered the second design-based solution to create a double-way cycle path on the eastern side of Rutland Street and set 0.85m kerb/painted chevron along the route, too. My considerations and concerns were the same to that in the case of 969 Colombo Street.

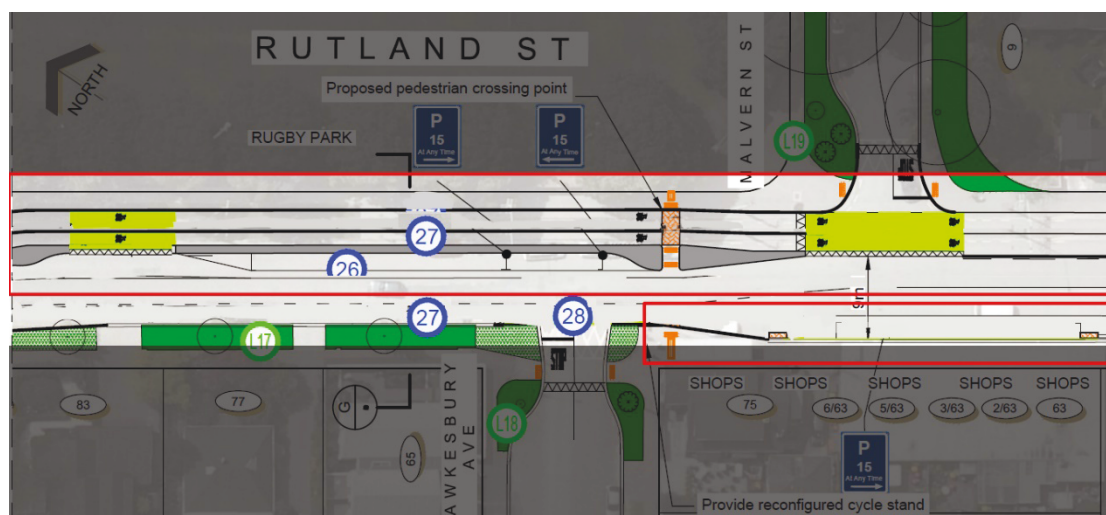


Figure 5-6. Alternative detailed design proposed to mitigate conflicts at 5/63 Rutland Street caused by current cycleway design (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the proposed changes.

5.3. Recommended Design 3: 49 Rutland Street

Based on previous analysis, I see that changes can be made to increase the number of on-street carparks and to improve the cycleway surface outside 49 Rutland Street, the St. Albans Catholic School. As shown in my proposed design (Figure 35), the size of the planting zone in front of 38 Rutland Street can be reduced to make room for one more carpark. In addition, the parking area in front of the school can be extended to can provide one more carpark, too. My design also provides a paved area at the crossing point for the improved safety of all road users.

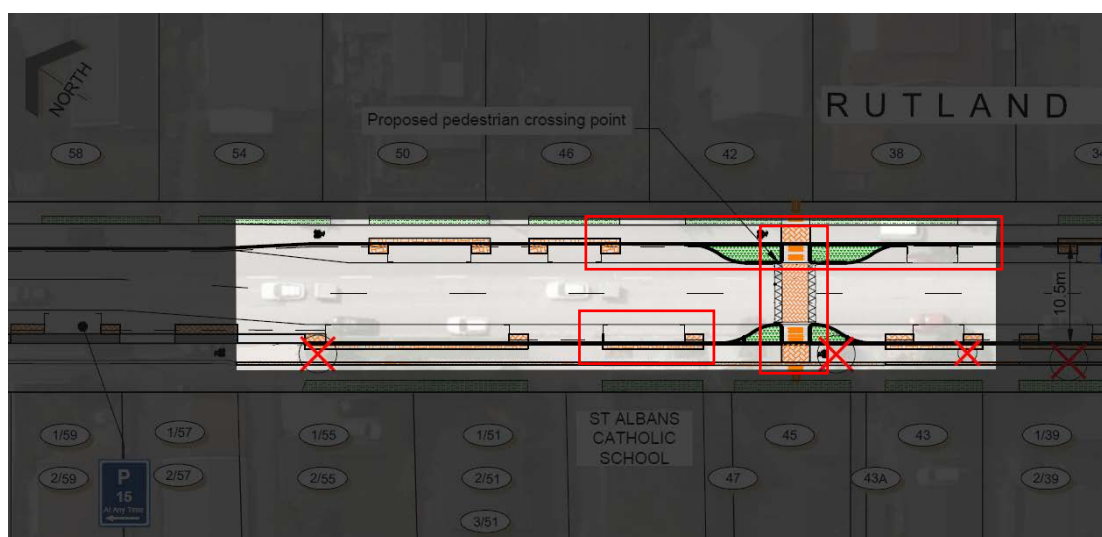


Figure 5-7. Detailed design proposed to mitigate conflicts at 49 Rutland Street caused by current cycleway design (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the proposed changes.

Traffic congestion during peak hours before and after school could not be solved by designs at this stage, due to the limitation of street space. This issue might be mitigated by considering more traffic management methods.

I considered the second design-based solution to create a double-way cycle path on the eastern side of Rutland Street and set a 0.6m kerb/painted chevron along the

route, too. My considerations were the same to that in the case of 969 Colombo Street and 5/63 Rutland Street. No extra concern was found in this area.

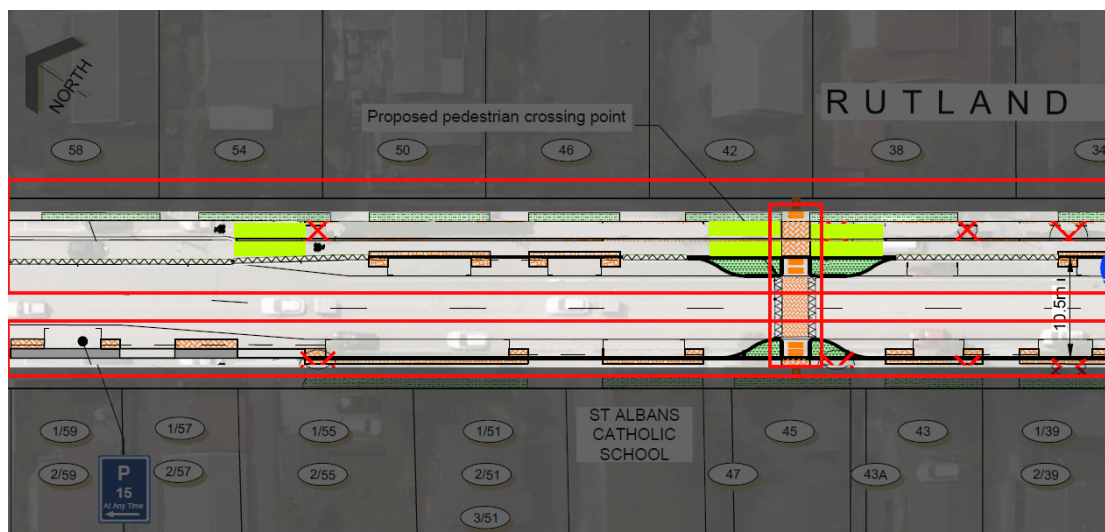


Figure 5-8. Alternative detailed design proposed to mitigate conflicts at 49 Rutland Street caused by current cycleway design (source of base map: Christchurch City Council, 2016).

Note. The red frame denotes the proposed changes.

5.4. Recommended Design 4: 96 Trafalgar Street

Due to low conflict frequency and current limitations of the street width, no significant improvement can be made to the area outside the Montessori School at 96 Trafalgar Street at this stage. However, I still think that the overall cycling experience and safety can be further enhanced in this area if designers focus on improving design by aiming for clear directional signage and high-quality, comfort shared-way surfaces with recognizable colour to replace existing ones.

5.5. Design Ideas in Relation to Long-term Situations

Above design-based solutions can be summarized as elevated cycle path with chevron, two-way cycle path with kerbs or chevron, obvious signs and surficial guidance. They can be applied to most of current urban areas. Improving safety and convenience of both cyclists and other road users are two major goals of these solutions.

I also explore one more design model that can be considered in long-term situations. The model cannot be achieved in the short term because of the limitation of current population size and budget. However, it can provide new ideas or choices for urban MCR designs in the future. I introduce the method of building pedestrian and cycling bridge, shared-path separated from vehicle routes and surficial pedestrian and cycling spaces with underground vehicle tunnels. I summarize these methods into 'Madrid Rio Park model'. The key ideas of this model are to promote urban cycling and to increase its benefits by providing a variety of safe and multi-functional spaces for cyclists (Figure 5-9). In the future, once related limitations and barriers are removed, the model can be first applied to some key areas in Christchurch City Centre where public transportation, walking, cycling and public interactions are encouraged. Ideally, it can be widely used in other urban areas with higher population density and traffic volume.

When applying this model, designers should consider many aspects, for instance, traffic routes, thresholds, soil quality, underground water level, storm water system, illumination, monitoring etc.

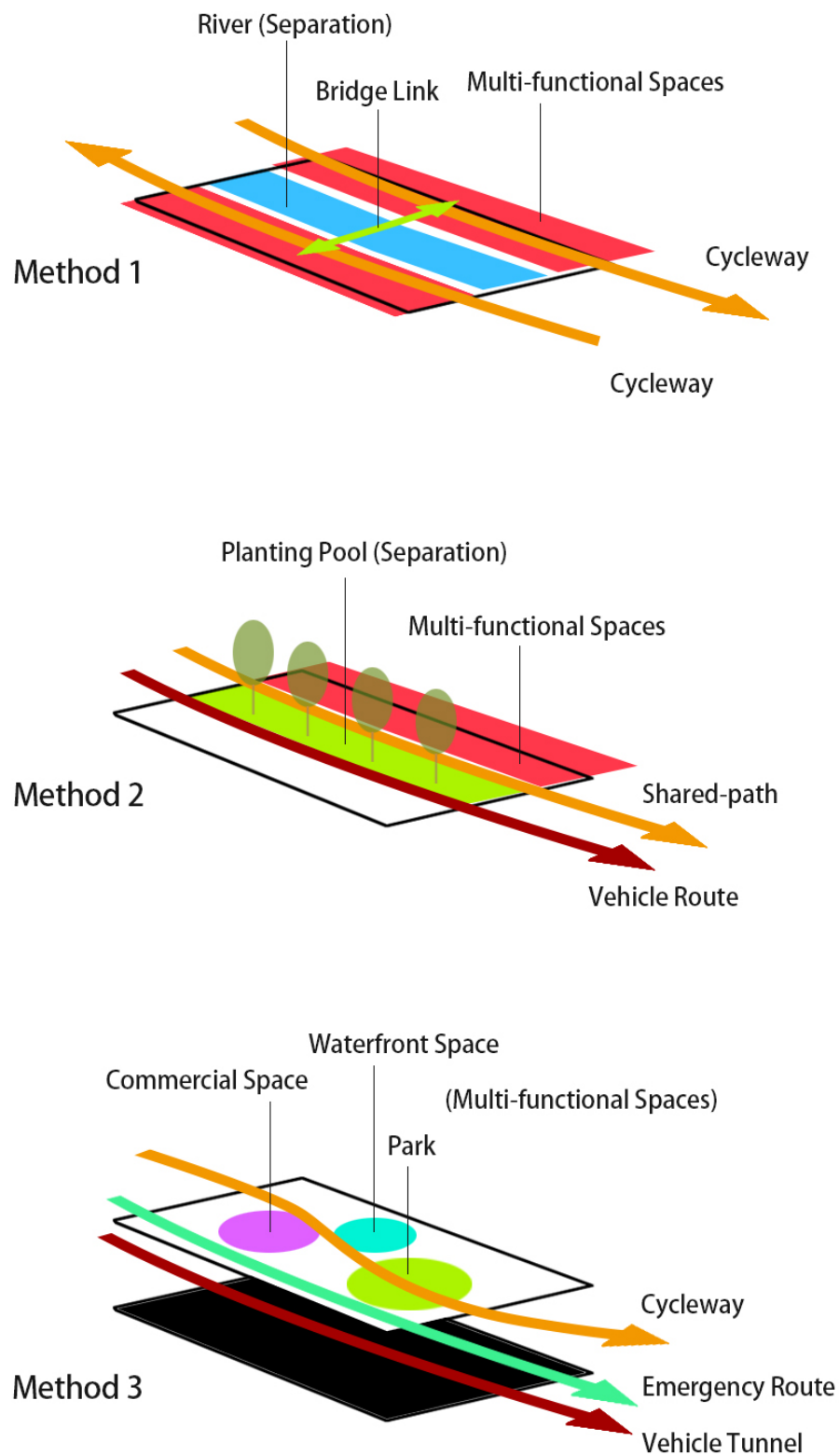


Figure 5-9. The concept of 'Madrid Rio Park model' (Drawn by Wang, 2018).

Chapter 6: Conclusion

The key method of this study was based on finding conflicts during the implementation of MCRs and using detailed design-based solutions to solve identified conflicts. The literature review identified the benefits of cycling in the urban environment, the importance of cycling safety, the methods of cycle-friendly route designs, the policies and design guidelines for cycleways in Christchurch, and international design exemplars that provided a reference for improving future design of MCRs. The analysis provided insights into how hot spots and conflicts were identified and filtered. The key was to utilize local Christchurch news articles as the conflict searcher and to use site surveys as the conflict filter. Related planning documents for selected hot spots were used for further analysing.

The scope of discussion mainly encompassed the development of design-based solutions for conflict areas along the Papanui Parallel Cycleway in Christchurch. Key designs included elevated cycle path with chevron, two-way cycle path with kerbs or chevron, obvious signages and surficial guidance. For larger-scale design decisions, I believe the design suggestions I have made for 969 Colombo and 5/63 Rutland Streets can be considered in other areas where MCRs meet small buildings with public services. Solutions for 49 Rutland Street can be used in areas with schools or childcare centres. Low-grade solutions for 96 Trafalgar Street can be applied to shared-way areas that have low vehicle traffic volumes. In addition, the 'Madrid Rio Park model' can be considered in some key areas where more outdoor activities and public interactions are recommended. For example, using the method of creating vertically separated spaces for areas around Cathedral Square or large shopping malls, connecting both sides of Avon River at some key points by applying the method of pedestrian and cycling bridge, and implementing the shared-path method near some urban parks or waterfront spaces. Ultimately, all above designs should link to the whole MCR system and aim at ensuring safety of cycling, improving

convenience of cycling, reducing car dependency and increasing cycle-related activities in urban environment.

In terms of promoting cycling and designing MCRs in Christchurch, barriers include lack of street space, high car dependency and budget limitation. The first barrier can be mitigated or moved in the short term by applying suggested detailed design approaches. The second one can be solved by applying innovative design models in the long term. The third one cannot be directly solved by designs. More researches and studies about reducing car dependency and attracting more investment can be conducted in the future.

There are several limitations for my study. First, I collected information about conflicts from limited number of local Press articles. I assume that, in the future, more conflicts can be reported or analyzed in more sources (such as in academic articles) to support my analysis. Second, accurate data in relation to different conflicts were missing (such as accurate number of customers pre and post cycleway construction per day). More observations and data collections should be conducted in order to obtain more precise results.

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