Utilisation of the kerbside through-lane at signalised intersections

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R. Karma, R. Douglas-Jones and M. Jaglal
GHD Ltd

I. Jurisich
Traffic Engineering Solutions Ltd

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NZ Transport Agency
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
research@nzta.govt.nz
www.nzta.govt.nz

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Abbreviations and acronyms

2-laner	Two through-lane intersections
3-laner	Three through-lane intersections
ARR123	*Australian Road Research Report 123* (Akçelik 1995)
D/S	Downstream
GIS	Geographical information system
HCV	Heavy commercial vehicle
MOTSAM	*Manual of traffic signs and markings* (NZTA 2009)
NZTA	New Zealand Transport Agency
SCATS	Sydney Coordinated Adaptive Traffic System
SEART	Southeastern arterial
SIDRA Intersection 4	An advanced micro-analytical traffic evaluation tool that employs lane-by-lane and vehicle drive cycle models.
U/S	Upstream
Vpd	Vehicles per day

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Executive summary

Introduction

Lane under-utilisation at signalised intersections can be described as the unequal distribution of traffic travelling in the same direction, within the available traffic lanes of a particular approach. It has significant effects on intersection capacity, which has consequences for congestion. Little research has been undertaken in New Zealand and Australia on this topic. Lane under-utilisation is attributable to causes varying from intersection design features to driver perception when selecting available lanes.

As lane under-utilisation at signalised intersections is not considered a major problem in New Zealand, road controlling authorities seldom implement intersection improvements just to increase lane utilisation. However, other intersection capacity improving techniques, such as signal coordination and optimisation, are often adopted. Further efficiencies can be realised if these also encompass improvements to lane utilisation. Thus, improving lane utilisation at intersections, particularly the larger and more congested intersections within a road network, would contribute to reducing overall levels of congestion and vehicle emissions into the environment.

The type of lane configuration at signalised intersections is possibly the main reason why lanes are used differently by drivers. This study focused on the three through-lane intersection (3-laner) configuration as observations have shown that the lane under-utilisation problem tends to manifest itself more noticeably at larger intersections than at two through-lane (2-laner) or single through-lane intersections, as motorists are provided with more choice when having to select lanes at the former.

Factors that influence lane utilisation

Other factors affecting lane utilisation are identified and discussed with the aim of providing a knowledge base of the lane utilisation problem in New Zealand. Thirteen factors in total have been identified; however, the most important factors influencing lane utilisation are auxiliary lane length, shared lanes, lane blockage and side friction caused by driveways and parking close to the intersection.

Most intersections display a combination of these factors. Increasing combinations of these at a particular intersection is likely to result in poorer usage rates. By understanding the effects of lane under-utilisation and the various factors causing it, more realistic assessments of the expected lifecycle and economic feasibility will be possible when undertaking intersection improvement work.

Data collection and methodology

After considering the extent of the different factors influencing lane utilisation and the range of different types of intersection in the Auckland region, data for 13 sites (seven 2-laners and six 3-laners) was analysed. The data collected for these sites included geometric data, traffic volume and movement count data and signal information. Traffic volume data was collected either by using Sydney Coordinated Adaptive Traffic System (SCATS) counts, or manual counts at the stop line at each site during both the commuter peak periods, and also during the midday off-peak period to assess usage during lighter traffic conditions.

The intersections chosen for each of the study sites were limited to one category, ie short upstream and downstream lanes with exclusive left- and right-turn lanes. In ideal circumstances the rate of use of each lane would be equal, ie 50% in the 2-laner scenario and 33% for 3-laners.

It was hypothesised that where auxiliary lanes were provided to increase intersection capacity, the length of these lanes was the main contributory factor to lane under-utilisation. This study therefore investigated the effect of short auxiliary through-lane lengths on utilisation of the short lane.

Data analysis

An initial review showed that 2-laners and 3-laners displayed different operational characteristics with differing lane utilisation effects. In the case of 2-laner intersections the results showed that lane under-utilisation was less of a problem and 2-laners tended to display more variable rates of lane utilisation. Therefore there was potentially greater value in researching the high-volume 3-laner situations where intersection capacity was a primary consideration.

Data for 3-laners was analysed and the rate of use of the auxiliary lane (shown as a percentage of the overall through-traffic volume) was compared with the length of that lane, during the am, pm and off-peak periods. This initial comparison showed that, in the case of the 3-laners, a positive relationship between lane use and the total length of the auxiliary lane generally held true for the sample sites.

Further analysis for each of the six 3-laners compared short-lane utilisation against time of day using data for five weekdays. The commonality between most of the graphs was that utilisation of the auxiliary lane increased during the tidal peak period, ie when traffic demand was higher. The results showed considerable variation in lane utilisation throughout the day and it was thus considered that for a true like-for-like comparison between the performance of various approaches only the peak hour should be used. This resulted in a scatter plot showing the use of the short lane against the total auxiliary length for the tidal peak period only. The result was a positive relationship; however, this was not particularly conclusive as the sample was too small to bring confidence in the outcome.

A basic comparison between field data and the formulas used in ARR 123 (Akçelik 1995) and SIDRA Intersection 4 (SIDRA) was also undertaken. This investigation revealed that the rates based on the method in SIDRA to account for the effects of lane under-utilisation greatly overestimated actual utilisation. This indicated that the default parameters and model used in SIDRA for modelling the utilisation of auxiliary lanes were not well suited for New Zealand conditions and that the values needed to be calibrated against field data here in New Zealand

Measures to improve lane utilisation

The widely varying rates of auxiliary lane utilisation indicate that intersection design has a strong influence over this aspect of the operation. A draft auxiliary lane design guide has been prepared based on the results of this study. It brings together guidance for auxiliary lane design including recommendations on lane length, length of merges and diverges, sight distances and lane width. The design guide is only a starting point and further research will lead to greater refinement and additional evidence.

Conclusions

Analysis of the lane usage rates showed that in most situations, the utilisation of short lanes was far below the ideal rate. Utilisation rates for short lanes in the 2-laner situation ranged between 18% and 49%, averaging about 34% across all sites. Utilisation rates in the 3-laner situation ranged between 7% and 19%, averaging approximately 14%.

The results of the study showed a positive relationship between lane length and utilisation; however, it was not found to be a strong link. Increasing auxiliary lane length only resulted in minor improvements in lane utilisation. Based on the sample analysed in this study, an increase in the total upstream and downstream length of the short kerbside through-lane would result in only marginally higher rates of use for both 2-laners and 3-laners.

Key conclusions from the study include:

- Previous study looked at comparing peaks. We found each intersection had differing peaks (because of tidal flow) and a more realistic comparison was determining the actual peak of each intersection and comparing 'approach peaks' for each sample.
- The relationship between use and length was not found to be as strongly correlated as indicated by earlier studies.
- If SIDRA was used to estimate capacity for each of the sites analysed in this report using default values, lane utilisation of the auxiliary lanes would have been significantly overestimated in most.

Recommendations

Four low-cost alternative/improvement treatments have been suggested as an outcome of this study. These include:

1. auxiliary lane on the right
2. advance lane designation signage and road marking
3. converting auxiliary lanes into bus or transit lanes
4. phasing and cycle time changes.

A trial of treatments 1 and 2 is recommended to determine their effectiveness in influencing the rate of use of auxiliary lanes. The objective of the trial would be to identify measures that result in a more even distribution of lane utilisation, and therefore more efficient intersection operation. However, in order to accurately measure the effectiveness of each treatment, the trial would have to be conducted in two stages:

- Stage 1: Install signage that communicates lane arrangements to drivers on the approach to the intersection.
- Stage 2: Relocate the auxiliary lane from the left-hand side to the right-hand side.

The trial is considered to be a valuable exercise as both treatments are potentially low-cost improvements to increase lane utilisation at signalised intersections.

The number of sites with short though-lanes in New Zealand is limited, and the sample size used in studies to date is less than satisfactory. It is therefore recommended that further research be undertaken to include sites from Australia, since traffic characteristics and operation are similar to New Zealand. If a large enough sample is identified it may be possible to develop a prediction model that can be used for assessing proposed intersection improvements that include auxiliary lanes.

As various areas of the draft design guide lack evidence to confirm some of the guidelines it should be further developed based on trials and/or wider research.

Abstract

Lane under-utilisation is commonly experienced at signalised intersections. This has significant effects on intersection capacity, which has consequences for congestion, especially in the urban environment. Ultimately, this results in overly optimistic design predictions. Little research has been undertaken in New Zealand and Australia on this topic. The main focus of this study was to determine the effect of short kerbside through-lanes on utilisation.

The results of the study show a positive relationship between lane length and utilisation; however, it was not found to be a strong link. Increasing auxiliary lane length only resulted in minor improvements in lane utilisation. Based on the small sample analysed in this study, it is therefore concluded that increasing the total upstream and downstream length of the short kerbside through-lane is likely to result in only marginally higher rates of use for both 2-laners and 3-laners.

Low-cost alternative/improvement treatments have been suggested as a part of this study. Since a relatively small sample was studied, further research with a larger sample is recommended to further confirm these findings and measure the significance of the results. Further research will also enable the other causes of lane under-utilisation to be determined and measured.

1 Introduction

1.1 Background to the research

This research project was commissioned by Land Transport NZ (now the NZ Transport Agency) in 2006 and followed on from the research described in *Land Transport NZ research report no.297* 'Through-lane use at traffic signals' (Royce et al 2006), completed by GHD Limited and the University of Auckland in 2006.

The aim of research report 297 was to determine the effect short-approach through-lanes and downstream merges had on lane use at signalised intersections. It involved surveying and modelling two signalised intersections in the Auckland area. The key finding from the surveys was that short through-lanes on the approach and departure from signalised intersections were used less than the adjacent full-length lanes. A positive relationship was identified between the length and use of the short through-lane. It was thus suggested that short through-lanes be lengthened to improve lane utilisation. Economic analysis of one of the study sites demonstrated it was economically viable to lengthen the short through-lane for this site.

In summary, the report provided a preliminary guide for predicting and improving short-lane utilisation and was the first significant step towards understanding the lane utilisation problem in New Zealand.

The initial study made some valuable findings based on a small sample of three through-lane intersections. In this subsequent research project the sample size was expanded so that lane utilisation at these higher-volume situations, where intersection capacity was a primary consideration, could be studied in more detail.

1.2 Research scope

The original scope of this research project included assessing the effect short auxiliary through-lanes had on lane utilisation at both two through-lane (2-laners) and three through-lane intersections (3-laners). It was initially proposed to do this by developing a statistically significant database, which compared the length of the short approach and departure lanes to the relative use of the lane. This technical database would enable traffic engineering practitioners to accurately predict the use of proposed short lanes at intersections, which in turn could be used to improve traffic model calibration.

However, a statistically significant database would require the analysis of a larger sample size. Upon closer review of typical intersection configurations in New Zealand and the results of the sample sites surveyed, it was found that 2-laners and 3-laners were in fact very different in terms of their operational characteristics, with differing effects on lane utilisation. The 2-laners also tended to display more variable rates of lane utilisation. Furthermore, within these two broad intersection categories there were a number of different lane configurations, all of which affected lane utilisation in varying ways.

Also, the intersections generally differed in levels of congestion and significance on the overall road network. Consequently, the 2-laner and 3-laner layouts were studied and analysed separately. It was thus impossible to find a large enough sample size of 'like' 2-laners and 'like' 3-laners in New Zealand to analyse and use to develop a prediction equation. As a result, the focus of this research was changed to providing robust guidelines to equip practitioners with valuable information when designing and assessing typical intersection upgrades, thereby realising more efficiencies in the improvements.

1.3 Problem identification

Short auxiliary lanes, for use by through traffic, are added to increase the capacity of a signalised intersection. However, in terms of maximising intersection capacity this is most effective when all available through-lanes, including these short auxiliary lanes, are equally used. Because of their limited length, as well as other factors, the auxiliary lanes are under-utilised compared with the adjacent continuous through-lanes. In ideal circumstances, each lane on a three-lane approach to an intersection will cater for 33% of traffic volumes. Similarly, for a two-lane approach, traffic volumes will ideally be distributed 50/50 across the two lanes. Lane under-utilisation at signalised intersections is thus the unequal distribution of traffic travelling in the same direction, within the available traffic lanes of a particular approach.

Figure 1.1 Lane under-utilisation evident at multiple through-lane signalised intersection

The lane under-utilisation problem is attributable to causes varying from intersection design features (eg the addition of a kerbside auxiliary lane, which is shorter than the adjacent continuous lanes) to driver perception when selecting available lanes. The problem is particularly common at multiple through-lane intersections where there is either one or a combination of factors such as short auxiliary lanes (upstream and downstream), shared lanes, lane blockage, traffic composition (ie the proportion of heavy vehicles), or the effect of a prominent downstream destination. Single through-lane signalised intersections are not as likely to experience significant effects of lane under-utilisation as there is no other choice of lane for through traffic.

A direct consequence of lane under-utilisation is the adverse effect on the capacity of signalised intersections, which has far-reaching consequences in terms of congestion. Lane under-utilisation reduces the overall throughput at the stop line and adaptive signal timings are adjusted to suit the lower degree of saturation, thereby creating extra delay.

Most intersection layouts force drivers to bias their choice of lane according to the perceived benefits of using one lane over another. Intersection design features have a significant impact on driver perception and a classic example of this is the auxiliary, discontinuous through-lane at intersections. Drivers show a propensity to avoid this lane because of the perception that they will be disadvantaged, mostly because of the stressful merge at the departure end. Short lanes make merging downstream of the intersection difficult. If drivers in the continuous through-lanes do not allow gaps for drivers in the short lane then the latter have to force their way into the continuous lane or risk getting trapped in the short lane This influences drivers' decision-making when selecting a lane on the intersection approach.

Given that driver behaviour and perception significantly influence lane under-utilisation (Akçelik 1995), the intersection layout should ideally provide opportunities for drivers to freely select their lanes without having to consider the consequences of their choice. Equal distribution of traffic between auxiliary and continuous through-lanes will maximise efficiency and capacity of the lanes.

Quite often, intersection upgrades are carried out in the expectation that intersection capacity will be optimised through full utilisation of the available through-lanes on each approach. However, the objective of improving capacity is not entirely achieved due to the unequal use of the auxiliary lane, which is often unforeseen due to the lack of reliable local data. As a result, many intersection upgrades are under-designed and the actual economic lifespan of the improvements is significantly lower than predicted.

As lane under-utilisation at signalised intersections is not considered a major problem in New Zealand, road controlling authorities seldom adjust traffic signal phasing and timings just to improve lane utilisation. However, other intersection capacity improving techniques, such as signal coordination and optimisation are often adopted. Further efficiencies could be realised if these improvement techniques also encompassed improvements to lane utilisation.

Therefore, improving lane utilisation at intersections, particularly the larger and more congested intersections within a road network, would contribute to reducing overall levels of congestion and vehicle emissions into the environment.

1.4 Status of current data

In New Zealand, research into lane utilisation is very much in its infancy. This is evident in the very limited literature on the topic. Currently there is no technical design data that will accurately predict the expected rate of use for a short auxiliary through-lane based on its length. Traffic models frequently used to assess intersection upgrades often provide designers with inaccurate data, as they tend to overestimate the utilisation rate of these short through-lanes. In addition practitioners may not be fully aware of the causes and effects of lane under-utilisation, apart from varied individual experiences. As there are no definitive guidelines, practitioners tend not to take into account the full implications of lane under-utilisation during the design process, thus resulting in overly optimistic predictions of intersection capacity.

Except for the widely used software package, SIDRA Intersection 4.0 (SIDRA), the only known sources of data based on research in New Zealand are:

- *Amalgamation of lane flows in traffic signal design and analysis* (Dunn 1982)
- *Australian roads research report no.123* (Akçelik 1995)
- A study of lane utilisation and lane blockage at the Mt Eden Rd/Balmoral Rd intersection (Jurisich 1999) (unpublished report)
- *Land Transport NZ research report no.297* (Royce et al 2006).

A literature review of the above sources of data is discussed in detail in chapter 2.

1.5 Objectives of this research

The purpose of this research was to provide a practical insight into the main reasons why traffic lanes at multiple-lane approaches to signalised intersections might not be fully utilised. This information could be used to better predict lane utilisation. Low-cost treatments for improving lane utilisation were also investigated as part of the research project and are discussed further in chapter 7.

After considering the range of different types of intersections in the Auckland region, it was decided to limit the scope of the research to multiple through-lane intersections. Two-laners and 3-laners were selected, as single through-lane intersections would be unlikely to display significant effects of lane under-utilisation. The overall objectives of the research are summarised below:

- Provide preliminary information on 2-laners, based on initial surveys, and identify patterns and problems related to these configurations. This information would provide useful guidance and understanding of the 2-laner situation at this stage.
- Provide better understanding of the lane under-utilisation problem at 3-laners by concentrating the research study on these intersections for the purpose of providing robust technical guidelines for designers and highlighting the issue of using default values in intersection modelling packages such as SIDRA.
- Investigate low-cost options to improve lane utilisation without having to undertake significant, intrusive road works.

The scope of this research included surveying and analysing seven 2-laners and eight 3-laners within the Auckland region. Sites with multiple-turn lanes were excluded due to their limited number in Auckland.

1.6 Report outline

There are two main parts to this report.

1 The overall theory behind lane utilisation. This is underpinned by the literature review of current data sources. A discussion of the typical intersection configurations and the factors that are likely to influence lane utilisation at signalised intersections is also included.

2 An analysis of a sample of 15 sites and a test of the relationship between the auxiliary through-lane length and its effect on lane utilisation. This includes a description of the methodology used to conduct the research, which could also be used for further research. A logical framework for investigating lane use and a discussion on developing a model to predict lane use are also included.

The report also investigates cost-effective treatment measures to improve lane utilisation at signalised intersections.

The following is a brief overview of the chapters in this report:

- Chapter 2 – **Literature review**: A review of existing literature on lane utilisation
- Chapter 3 –**Factors that influence lane utilisation**: An overview of the common intersection configurations and discussion of the main factors that influence lane utilisation
- Chapter 4 – **Data collection and methodology**: Outline of the methodological approach used

- Chapter 5 – **Data analysis**: Analysis of the data collected
- Chapter 6 – **Towards developing a model for predicting lane utilisation**: A discussion on what will be needed to develop a model for lane utilisation prediction
- Chapter 7 – **Measures to improve lane utilisation**: Possible alternative treatments to improve lane utilisation without undertaking major road works
- Chapter 8 – **Conclusions**: Conclusions and recommendations for further research.

2 Literature review

2.1 Overview

The scope of the literature review is limited to New Zealand and Australia as these two countries have very similar traffic characteristics. In general, there is very little guidance provided on lane utilisation and this can often result in practitioners incorrectly estimating capacity, delay and level of service at signalised intersections with short through-lanes.

2.2 Current data sources

Current data sources in New Zealand and Australia do not appear to cover all aspects of lane utilisation at signalised intersections. There is also little guidance for practitioners on the required lengths of short lanes at signalised intersections. This is likely to result in substandard intersection designs and may lead to many upgraded intersections reaching capacity within a few years of construction, resulting in unnecessary congestion throughout the road network.

In addition, SIDRA (the software most commonly used in New Zealand when designing isolated signalised intersections) does not deal adequately with lane under-utilisation. There is also no definitive guide on lane utilisation rates for different intersection configurations and this may be another reason for substandard designs.

The overall content of the main sources of information, available in New Zealand and Australia, is summarised below.

2.2.1 Amalgamation of lane flows in traffic signal design analysis

A technical paper, 'Amalgamation of lane flows in traffic signal design and analysis' (Dunn 1982), examined the common design technique of amalgamating lane flows on approaches with two or more lanes. Dunn (1982) also examined the implications of the assumptions made when using this technique.

The amalgamation technique combines individual lane saturation flows of an approach to determine the flow ratio for the total approach. The fundamental assumption when using this technique is that the flow ratios, y (flow/saturation flow; y=q/s) of each lane are equal. However, Dunn (1982) pointed out that this was often not the case due to lane under-utilisation.

This then led to the lane-by-lane analysis method. Lane-by-lane analysis is the calculation of individual movement saturation flows by summing the saturation flows of individual lanes allocated to each movement. As explained by Akçelik (1995) in his well-known report 'Traffic signals: capacity and timing analysis' (ARR123), this contrasts with the method of expressing saturation flows as a function of the total approach width as used by Webster and Cobb (1966) and the Highway Research Board (1965).

The common technique of assuming all lanes on an approach are fully utilised is often called amalgamation. Dunn (1982) identified the following cases where using the amalgamation technique is not appropriate:

- where there are insufficient lanes available downstream for through traffic

- when there is a heavy turning movement and there are insufficient lanes available downstream for turning traffic
- when there is under-utilisation of lanes.

2.2.2 Australian roads research report (ARR123)

ARR123 (Akçelik 1995) provides detailed techniques for the capacity and timing analysis at traffic signals and also gives guidance on the operational design of signalised intersections. ARR123 states that lane under-utilisation effects must be correctly accounted for in capacity and timing calculations during the design process for signalised intersections. The report observes that lane utilisation is governed by drivers' lane choice, which is based on two basic principles:

- *Required destination*: either at the intersection under consideration or downstream of the intersection
- *Perceived delay*: associated with the length and composition of queues (due to the presence of heavy or opposed turning vehicles in particular).

The methods for estimating lane flow are based on equal degrees of saturation for each lane group. The lane utilisation ratio (ρ) is described as the ratio of the degree of saturation of the lane under consideration (χi) to the largest degree of saturation of any other lane on the approach (χ), where:

$$\rho = \chi_i / \chi$$

From this it follows that equal lane utilisation means equal flow ratios, y or q/s (where q is flow and s is saturation flow) and assuming that each lane group has the same effective green time, hence equal lane degrees of saturation. The above equation does not take into account short lanes or downstream destinations.

ARR123 states that it is generally difficult to prescribe a simple predictive method for lane utilisation because it is affected by destination downstream and other behavioural factors. Therefore, in the case of an existing study site, field observations are recommended instead. However, if a new intersection is being designed and lane under-utilisation is likely to occur, then the only predictive method that ARR123 gives is as follows:

$$qT_1 = qT/2n$$

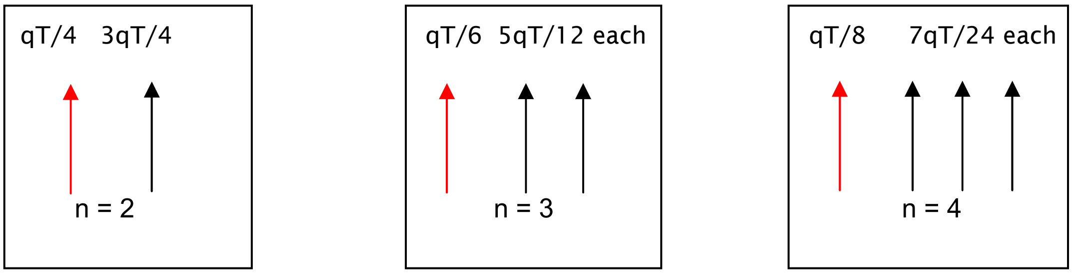
where: qT_1 = the through-traffic flow in the under-utilised lane

qT = the total through-traffic flow

n = the number of lanes available for through traffic.

Applying the above formulation to two, three and four through-lane situations, the ratio of the under-utilised lane to total through movement volume is 25%, 16% and 12.5% respectively, as illustrated in figure 2.1. The under-utilised lanes are shown in red:

Figure 2.1 Lane utilisation predictive method, ARR123 (Akçelik 1995)



This is a simplistic rule and there is no evidence to suggest it is what occurs in practice. ARR123 (Akçelik 1995) suggests treating flows in the under-utilised lanes as separate movements when estimating saturation flows and signal timings. Example 7 in section 9 of ARR123 (Akçelik 1995) describes this method in more detail.

2.2.3 SIDRA Intersection 4.0 (SIDRA)

SIDRA Intersection is a micro-analytical traffic modelling tool originally developed in 2007 by Akçelik and Associates and is based on the principles contained in ARR123 (Akçelik 1995). It is widely used in intersection capacity analyses and employs lane-by-lane analysis, as explained in Dunn (1982), to carry out all capacity and performance calculations. The lane utilisation ratio (□) defined in SIDRA Intersection is exactly that contained in ARR123, ie

$$\square = x_j / x_c$$

where

x_j = the degree of saturation on the j^{th} lane

x_c = the highest degree of saturation/the degree of saturation of the critical lane.

By default □ = 1, ie equal lane utilisation or 100%. There is allowance, however, for users to manually adjust the lane utilisation rates to indicate potential lane under-utilisation. However, this is subjective as there is no definitive guide on what the lane utilisation rates are for different intersection layouts. Also, being a default function of the programme, practitioners are not prompted to adjust lane utilisation factors and often run the risk of ignoring the effects of lane under-utilisation, particularly in the kerbside lane, if they are not fully aware of the implications of the design.

SIDRA Intersection 4.0 (2009), contains a new feature, which automatically includes the effect short downstream lanes have on lane utilisation in upstream approach lanes. R_{LU}, the lane utilisation ratio for short lanes, is calculated from the following equation 6.10.9 in the SIDRA user guide (Akçelik and Associates 2009):

$$R_{LU} = R_{LUm} + (100 - R_{LUm}) [(D_s - D_m) / ((D_{sf} - D_{sm})]^n$$

where

R_{LUm} = minimum downstream utilisation ratio

D_s = downstream short-lane distance

D_{sm} = minimum downstream short-lane distance

D_{sf} = downstream short-lane distance for full utilisation (R_{LU} = 100%)

n = a model calibration parameter.

The above equation attempts to replicate the effect short downstream lanes have on lane utilisation. However, it is not based on sound field data and does not appear to fully account for lane under-utilisation caused by differing lengths of short lanes, or other factors. Also, default parameters that SIDRA uses in the above relationship overestimate the utilisation rate of short downstream lanes. The ability to calibrate these values is non-existent in SIDRA. This is discussed later in more detail in chapter 6 – Data analysis, where the equations used to calculate the rate of utilisation of short lanes in ARR123 and SIDRA are compared against actual field data.

In the case of insufficient exit lanes, under-utilisation of the upstream lane is automatically calculated by SIDRA by treating it as an exit lane of zero length. Once again the onus appears to be on the practitioner to be aware of the lane under-utilisation problem based on his/her individual experience.

2.2.4 Intersection lane utilisation and lane blockage study

An unpublished study by Jurisich (1999) entitled 'A study of lane utilisation and lane blockage at the Mt Eden Road/Balmoral Road intersection', undertaken by City Design Ltd (now GHD) assessed the effects of short lanes at signalised intersections. The study reviewed the effect of lane utilisation and lane blockage on capacity and overall operation of the Mt Eden Road/Balmoral Road intersection in Auckland. Although this was a study of only one site, the findings were very valuable and confirmed some of the uncertainties regarding lane utilisation at this particular intersection.

Jurisich (1999) found that lane blockage and short downstream lane lengths did indeed have a significant effect on lane utilisation. The study concluded that downstream merge lanes should be long enough so that traffic could merge safely and comfortably without causing congestion downstream, thereby encouraging drivers to use the short lane.

Jurisich (1999) recommended that the downstream lane length be designed 1½ times the 95th percentile upstream queue length, where practical. This would ensure that queues at the intersection were adequately dispersed without congestion downstream.

2.2.5 Austroads part 5 – intersections at grade

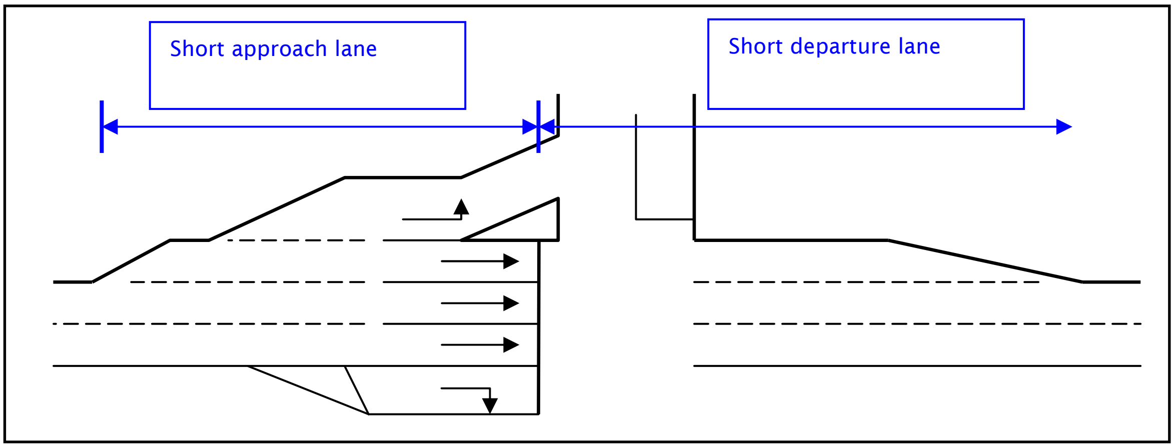
Austroads (2005) *Guide to traffic engineering practice – part 5: intersections at grade* does not contain much information on lane utilisation per se. However, it does contain a guideline for the design of auxiliary through-lanes at intersections. It indicates that the length of the auxiliary through-lane depends on the amount of storage required for through vehicles waiting to enter the intersection. The downstream auxiliary lane should be dropped clear of the intersection, desirably 200m beyond the intersection, or a minimum 100m if constrained by site conditions (chapter 6.8.3.1 Length on auxiliary through lanes).

The guide also indicates that if the downstream departure lane is short then this will lead to under-utilisation of the auxiliary through-lane. Similarly, it states that if the added lane on the approach is not long enough to offer drivers an advantage over using the continuous through-lane (ie they know they can clear the intersection by the next green phase by using the continuous lane instead), then the auxiliary lane is likely to be under-utilised.

2.2.6 Land Transport research report 297: 'Through-lane use at traffic signals'

Land Transport research report 297. (Royce et al 2006) is the only significant research on lane utilisation at signalised intersections in New Zealand. The aim of this study was to determine the scale of effect of short approach through-lanes and downstream merge lanes on lane utilisation at signalised intersections, and find ways of improving usage. The study concentrated on through-lane utilisation at intersections with three through-lanes only, and involved surveying and modelling three major intersections in Auckland. A typical approach layout of the intersections studied is illustrated in figure 2.2:

Figure 2.2 Typical three through-lane intersection studied by Royce et al (2006)



From the data collected at these sites, it was also found that short approach and departure through-lanes and short slip lanes caused the short through-lanes to be under-utilised. A direct correlation was identified between short through-lane length and the level of lane utilisation. Because only a small sample was used, it did not provide strong confidence in the results, and further research with a larger sample size was therefore recommended.

The study also developed a preliminary prediction model using the data from the three sites, and primarily used short lane length, congestion (measured as the average queue length in the through-lane with the longest queue), and downstream turn volumes as the main variables.

These findings were an important first step toward understanding the effects of lane under-utilisation, and provided a sound foundation for this current research project and for further research in New Zealand.

3 Factors that influence lane utilisation

3.1 Types of intersections affected by lane under-utilisation

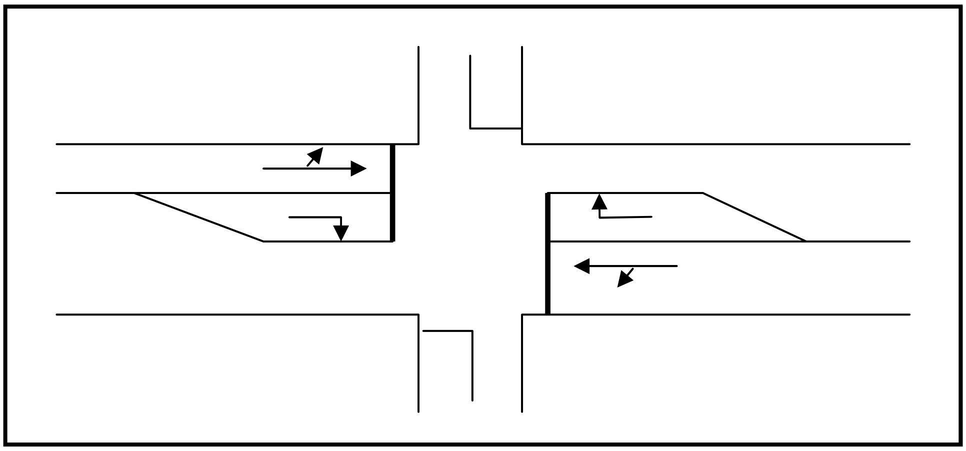
3.1.1 Introduction

The type of lane configuration used at signalised intersections is possibly the main reason why lanes are utilised differently by drivers. There are a number of different signalised intersection configurations with varying numbers of lanes. This section discusses the most common intersection types in Auckland and the consequential effects on lane utilisation.

3.1.2 Single through-lane intersections

A typical single through-lane intersection is illustrated in figure 3.1. This type of intersection configuration can include either an exclusive through-lane or a shared lane (through and left or through and right) with an exclusive turn lane (left or right).

Figure 3.1 A typical single through-lane intersection



This type of intersection layout is found mostly in lower volume situations, where capacity and overall network congestion is not necessarily a primary focus. Single through-lane intersections are less likely to experience significant effects of lane under-utilisation as through traffic has no other choice but to use the single through-lane provided.

However, depending on the intersection lane arrangement, lane blockage as a result of a short turning lane or phasing is more likely to be the only contributor to through-lane under-utilisation.

3.1.3 Multiple through-lane intersections

Lane under-utilisation is typically more evident at multiple through-lane intersections, where driver choice and the factors that affect choice become more influential. Two-laners and 3-laners are the most common multiple intersection configurations found in Auckland.

Theoretically, in order to achieve maximum capacity at these intersections, the individual through-lane utilisation for 2-laners and 3-laners should be 50% (1/2) and 33% (1/3) respectively, ie equal lane utilisation. However, in reality this is often not the case due to the effects of lane under-utilisation, resulting in a reduction in intersection capacity.

3.1.3.1 2-laners

Two-laners are the more common type of intersection within our road network and there are several basic configurations within these types, all of which affect lane utilisation differently. These intersections are either located on corridors that have two continuous lanes both upstream and downstream of the intersection, or where single lane approaches flare out into two lanes at the intersection with a lane being dropped downstream of the intersection.

Figure3.2 Typical 2-laner approach layouts

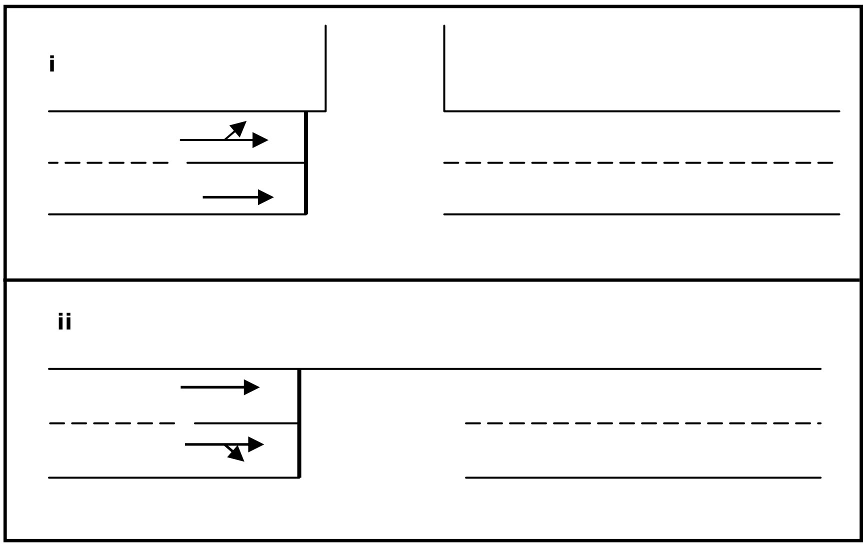


Figure 3.2 illustrates two typical 2-laner configurations with continuous lanes. With this type of intersection layout, vehicles travelling straight through are less likely to use the shared lane, to avoid possible delays caused by the slower turning vehicles in the shared lanes. This situation gets progressively worse as the proportion of turning vehicles increases, especially if the turning vehicles are opposed (either by opposing through vehicles for the right turns, or a parallel pedestrian phase or opposing right turners for left turns).

In the case of a shared through- and right-turn lane, the usual arrangement is to allow right turners to filter through the opposing through traffic for the intersection to operate efficiently. Hence, opposed right turners pose delays to and therefore discourage through vehicles from using these lanes. An alternative signal phasing arrangement that could be adopted to improve use of the shared through- and right-turn lane is a split signal phase, where the opposite approaches are run separately. However, this phasing arrangement could have a negative impact on the overall efficiency of the intersection, and is usually avoided unless there is a related safety problem.

Figure3.3 Two continuous approach and departure lanes with exclusive turn lanes

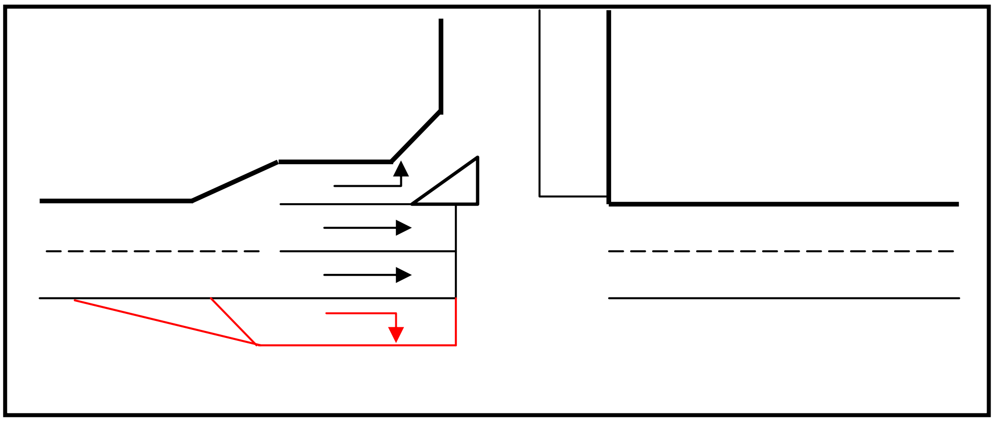


Figure 3.3 illustrates a better layout in terms of using through-lanes. The exclusive right- and left-turn lanes are optional, depending on the intersection layout, and should only be considered when turning traffic volumes are high. The problems associated with the shared lanes discussed above are eliminated and the expectation is that the through-lanes will have better rates of use. However, lane under-utilisation becomes prevalent if the exclusive left- or right-turn lanes are not long enough, resulting in blockage of the adjacent through-lane.

Figure3.4 Typical 2-laner configurations with short approach and departure auxiliary lanes

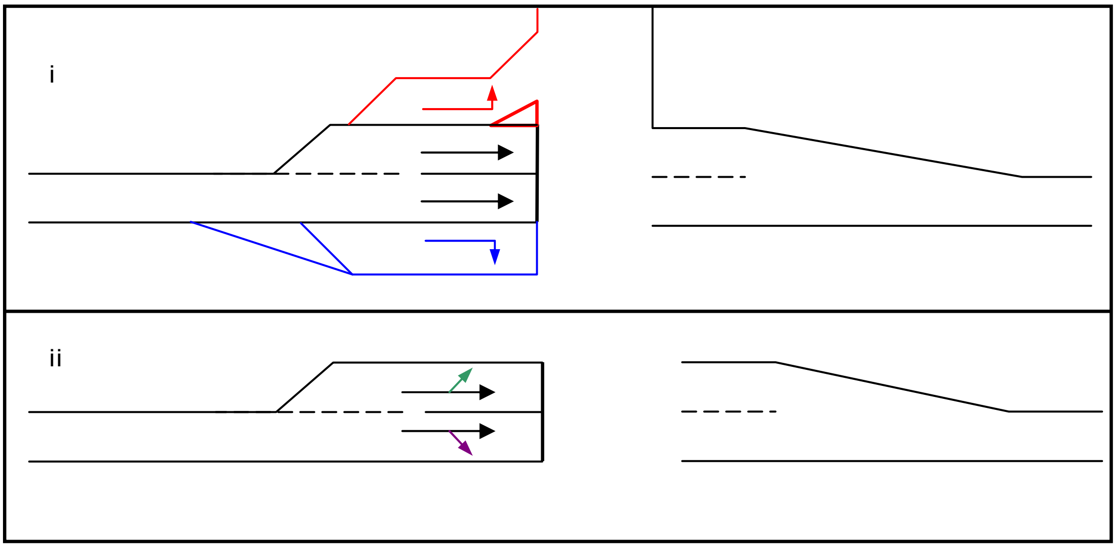


Figure 3.4 illustrates, in different colours, more possible configurations of auxiliary lanes at intersections. An intersection may display either one or a combination of these configurations.

Also, figure 3.4 illustrates short auxiliary through-lanes upstream and downstream of an intersection. By contrast, figures 3.2 and 3.3 illustrate 2-laners with continuous upstream and downstream lanes.

Comparing these two basic intersection types, the continuous lane situation demonstrates the effects of lane under-utilisation caused predominantly by the lane configuration employed, ie shared lanes (figure 3.2) or lane blockage (figures 3.3 and 3.4), with no effect downstream of the intersection. Shared lanes and lane blockage are looked at in more detail in the following section.

Figure 3.4 introduces another significant factor causing lanes to be under-utilised, ie the effects of short auxiliary through-lanes upstream and downstream. Through vehicles tend to avoid the short through-lanes causing these lanes to be under-utilised.

The lane under-utilisation problem can be further exacerbated at intersections that display a combination of short auxiliary through-lanes and shared lanes (figure 3.4ii).

3.1.3.2 3-laners

On-site observations show that lane under-utilisation is more of an issue at 3-laners than at 2-laners. It should also be noted that most 3-laners in New Zealand are in the urban environment and generally located on roads with higher traffic volumes, such as regional arterial roads and state highways, and therefore it is very important that they operate efficiently.

Often, intersection capacity improvements involve upgrading 2-laners to 3-laners and this is mostly achieved by adding auxiliary lanes, which are usually short. The main reason why these auxiliary lanes are of limited length is because land is not freely available, especially in the urban environment, and land acquisition issues can be avoided. Physical works costs, and possible environmental issues, also affect the length of auxiliary lanes. In most cases, this results in improvements providing less than the desired benefits.

Corridors with three continuous lanes in each direction are generally not common within the road network. The capacity of an urban transport corridor is usually constrained by intersections. Therefore the narrower corridors (ie two lanes in each direction) are often widened at the intersection to improve capacity. This results in short auxiliary lanes at these intersections causing lane under-utilisation issues. Typical 3-laner intersection layouts are illustrated in figures 3.5 and 3.6.

Figure3.5 Typical 3-laner with short approach and departure auxiliary lanes

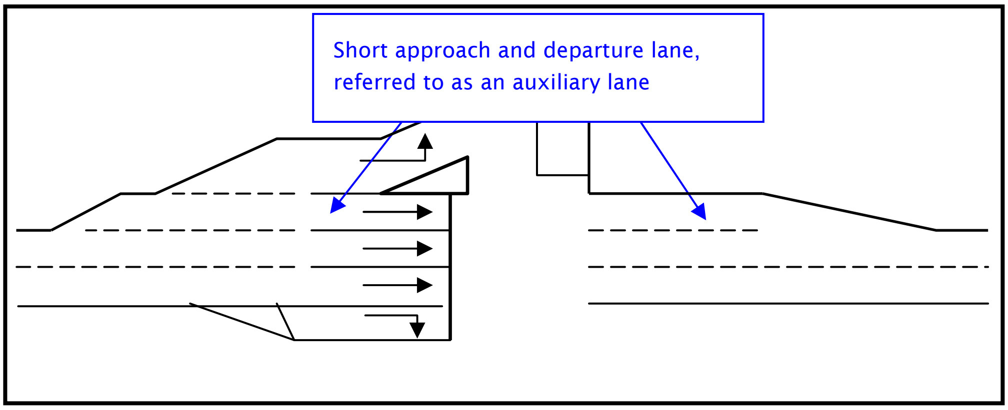
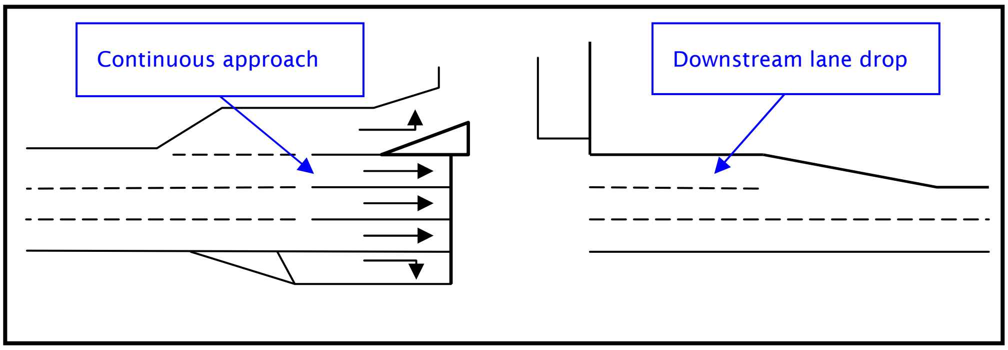


Figure 3.6 Typical 3-laner with three continuous approach lanes and a lane drop downstream



Figures 3.5 and 3.6 illustrate cases of potential lane under-utilisation at 3-laners. The effects are similar to those experienced at 2-laners, ie lane utilisation is affected by lane configuration, short auxiliary lanes or lane blockage as a result of short-turn lanes, roadside parking or bus lanes.

3.2 Other factors influencing lane utilisation

While auxiliary through-lane length is considered to have a significant effect on lane utilisation, there are also several other factors that contribute to the lane utilisation problem at signalised intersections. This chapter aims to identify and discuss the main factors, which will assist in providing an overall knowledge base of the lane utilisation problem in New Zealand.

This coupled with an outlined methodological approach towards developing a detailed technical database and the preliminary analysis undertaken in this study, will equip researchers and practitioners alike with essential insight into the problems associated with lane utilisation. Also, by understanding the effects of lane under-utilisation and the various factors that cause it, more realistic assessments of the expected lifecycle and economic feasibility should be possible when undertaking intersection improvement work.

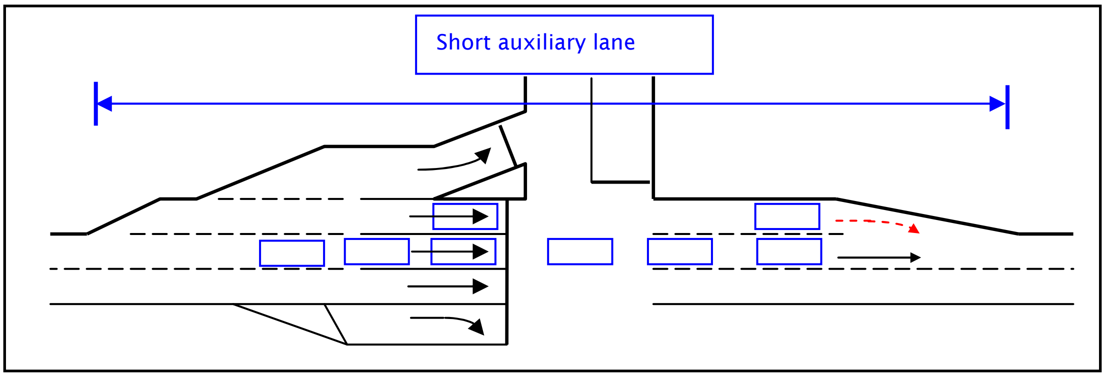
Some intersections may display one or a combination of these factors. Increasing combinations of these factors at a particular intersection are likely to result in poorer rates of utilisation.

3.2.1 Short auxiliary lane length – departure lane

An auxiliary lane is an additional lane added to an intersection to increase the capacity by providing a short upstream lane on the approach with the downstream lane being dropped shortly after the intersection, ie a short downstream lane. Short auxiliary lane length is likely to be one of the more significant contributors to lane under-utilisation, particularly in the case of 3-laners. Departure auxiliary lanes of limited length are likely to have a significant effect on how the lane is used. Usually drivers are reluctant to move into the short lane, as there is a major disincentive due to the perceived stressful merge downstream of the intersection.

Drivers are most likely to use the auxiliary lane if they perceive that this will result in travel time savings compared with the other available through-lanes, otherwise they will avoid using it. Also, if the kerbside auxiliary lane is not long enough there is potential for it to be blocked by queues in the adjacent through-lane, making it inaccessible. A typical 3-laner with a short auxiliary lane is shown in figure 3.7.

Figure 3.7 Typical 3-laner layout with short upstream and short downstream lane



Typically use of the short upstream through-lane will also be limited if the corresponding downstream lane length is short. Use of the upstream lane is also directionally proportional to its length. Full utilisation of the short upstream lane will result in an increase in capacity of the intersection, ie the maximum additional capacity of the intersection is dictated by the queue storage capacity. Thus under-utilisation of the short lane upstream will result in a reduction in capacity.

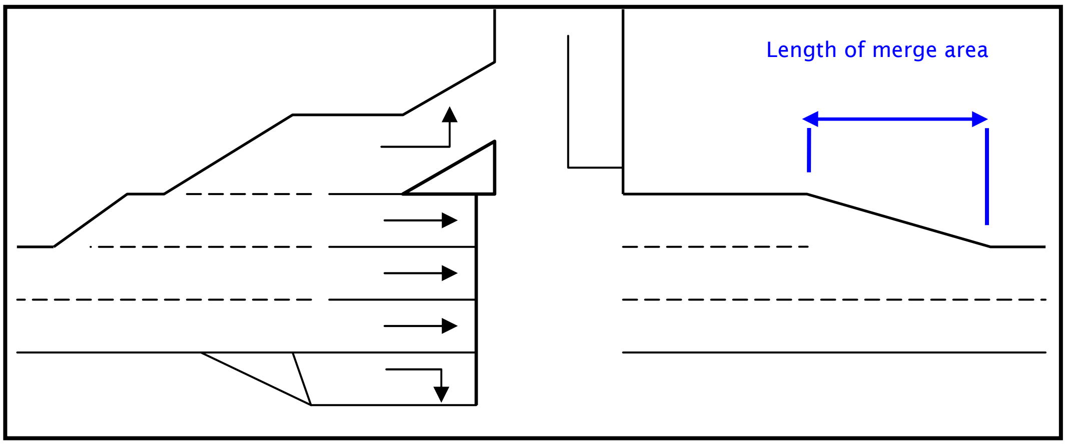
3.2.2 Short auxiliary lane length – approach lane

A short approach lane at an intersection limits lane utilisation due to the limited queue storage capacity. A short lane upstream of the intersection adds capacity up to a maximum equivalent of the number of vehicles than can be accommodated queuing in the short lane per traffic signal cycle. Therefore, the short lane only provides additional capacity for a limited time, which is governed by the time required to discharge a queue the length of the upstream lane.

3.2.3 Length of merge area

The length of the merge area on the departure side of the intersection has a significant impact on the safety of operation, and is also likely to impact on the utilisation of the short lane. If the merge area is perceived to be unsafe then drivers are likely to avoid using it.

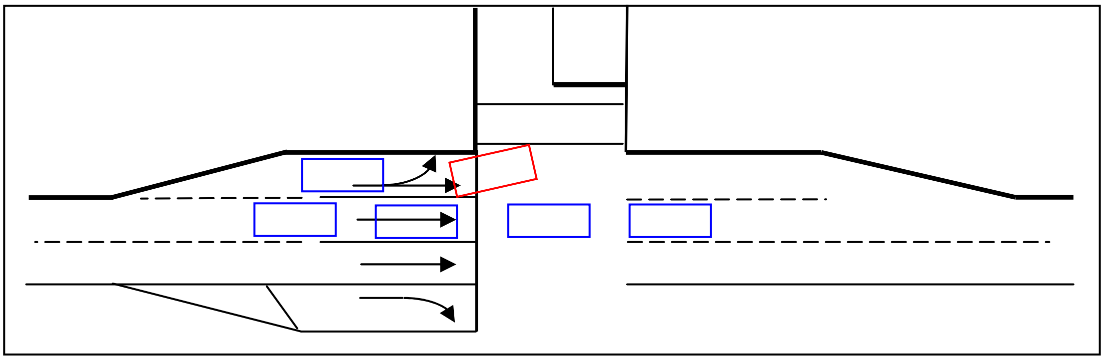
Figure 3.8 Length of merge area



3.2.4 Shared lanes

A high proportion of turning traffic in a shared lane (through and left or through and right) is likely to discourage through-vehicles from using that lane and will cause the downstream section of the shared lane to be under-utilised. Turning vehicles opposed by other movements, eg a parallel pedestrian phase, pose delays to through vehicles thereby resulting in lower usage of the shared lanes by through vehicles.

Figure 3.9 Typical intersection configuration with a shared (through/left) auxiliary lane



3.2.5 Traffic volumes, congestion and queuing

It would be expected that at peak times when vehicle queues are longer, utilisation of short auxiliary lanes at intersections would improve. Vehicles would be more likely to use a short lane to advance queues in the adjacent through-lanes and clear the intersection within the same green period. Hence higher rates of use of the short lane would be expected as traffic volume intensity at an intersection increases. However, there are circumstances when congested conditions actually have a negative impact on short-lane utilisation, for example when congestion causes the exit of the intersection to be blocked. The issue of lane under-utilisation only causes problems when traffic volumes are high and the intersection is nearing capacity.

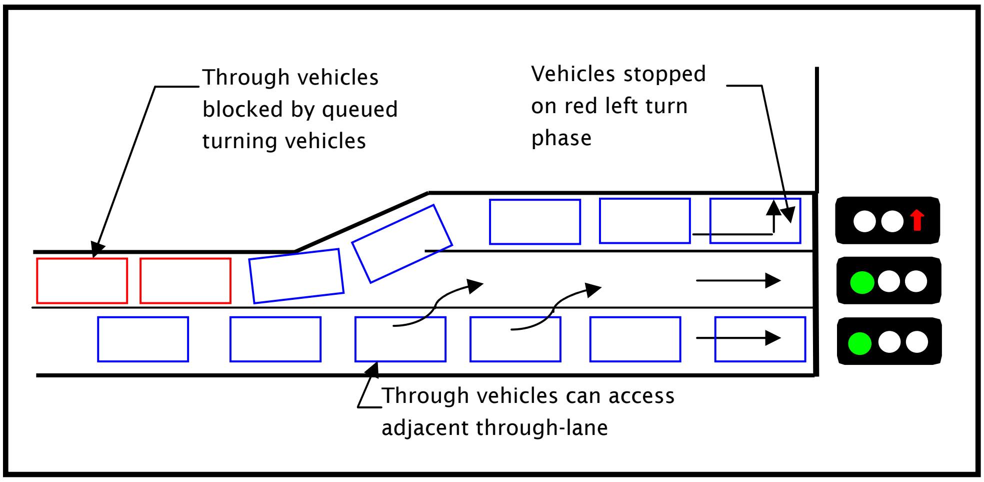
3.2.6 Lane blockage

Lane blockage occurs when queues in an adjacent traffic lane block access to a lane, causing that lane to be under-utilised. Lane blockage has different effects on lane utilisation and hence affects capacity of a particular approach in different ways.

Figures 3.10 and 3.11 illustrate two possible cases of lane blockage involving turning traffic:

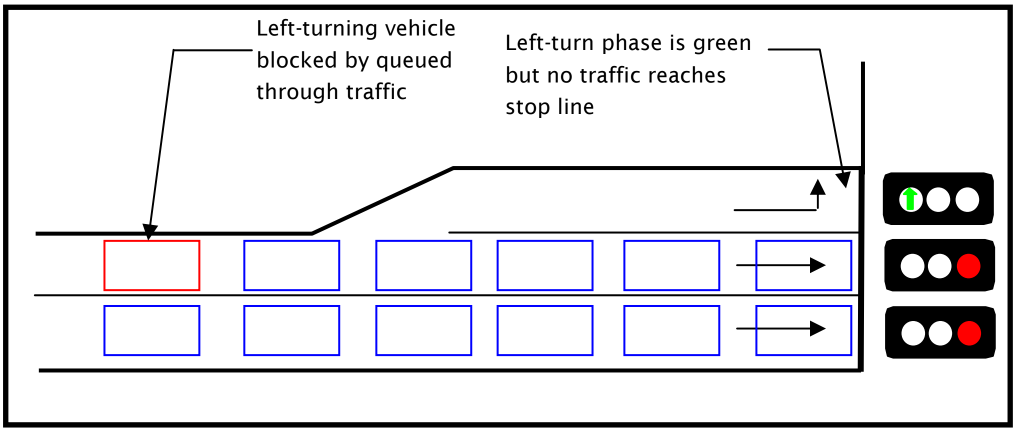
1 A through-lane is blocked by queued traffic in a turning lane. This is because the storage capacity of the turning lane is inadequate. The through-lane, however, can be accessed from another lane as shown below.

Figure 3.10 Straight through-lane blocked by queue in turning lane



2 Access to an exclusive turning lane is blocked by queued traffic in the adjacent through-lane.

Figure 3.11 Exclusive turning lane blocked by queue in through traffic lane



As illustrated in figures 3.10 and 3.11, lane blockage occurs either when there is limited space for queuing in the turn slip lane, or in the case of a turn slip lane being blocked, when the turn lane is not long enough for vehicles to access it. This results in wasted green time at multiple-lane approaches, impacting on overall intersection capacity.

3.2.7 Sight distance from back of queues

Through-lanes across an intersection should be aligned so that drivers can clearly perceive the vehicle travel-path ahead. Poor visibility downstream of the intersection where drivers are unable to see the lane arrangement may result in a lane being under-utilised.

If drivers are unable to judge how long the departure lane is, they may simply assume that the merge downstream is too short and perceive conditions to be less than desirable thereby opting to use the continuous lanes instead. Forward visibility can be obscured by the back of the queue or if an intersection is located on a vertical crest and/or on a horizontal bend.

3.2.8 Downstream destination effect

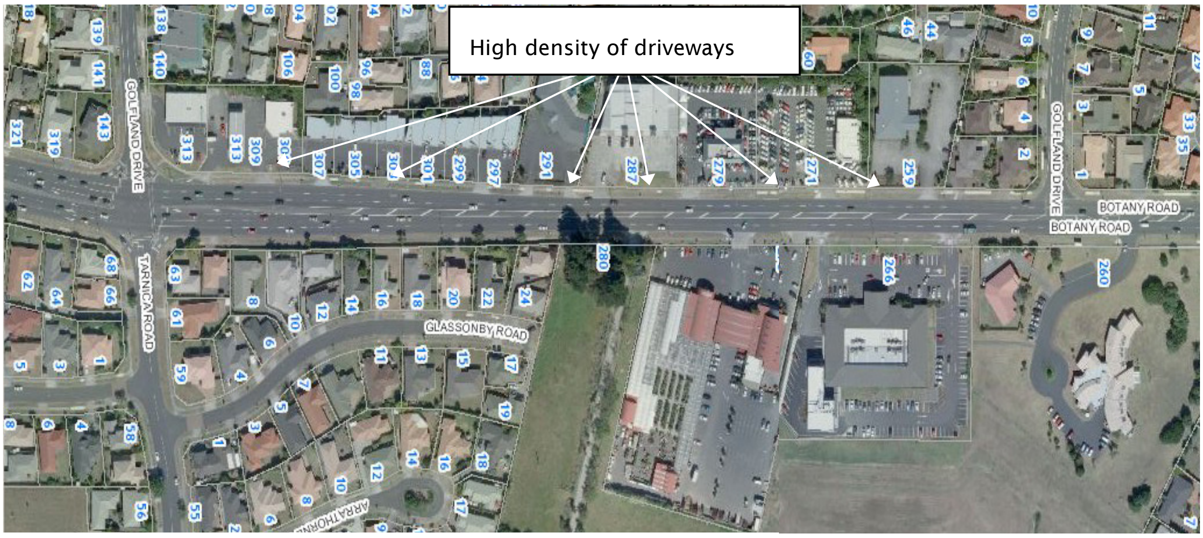
Significant destinations, such as major shopping malls and motorways, downstream of an intersection tend to bias use of the lane at the intersection. Vehicles heading to these destinations arrange themselves in the lanes that travel directly to these locations. If these are major traffic-generating destinations, then this is likely to significantly influence the way in which lanes are utilised at the intersection under consideration.

Practitioners need to be aware of the effects of downstream destination on lane utilisation, and hence account for this when assessing intersection operation.

3.2.9 Side friction

Left-turning movements into and out of driveways, parking manoeuvres and bus stops generate a considerable amount of side friction and may discourage use of a kerbside auxiliary lane by vehicles continuing straight through. If these driveways, parking areas or bus stops are located close to the intersection, either upstream or downstream, it is likely that through vehicles will position themselves on the inner continuous lanes upstream of the intersection in order to avoid possible delays. A high number of driveways located close to the intersection, as shown in figure 3.12, coupled with a short downstream lane length will further limit use of the kerbside auxiliary lane by straight-through vehicles.

Figure 3.12 High number of driveways located downstream of intersection



3.2.10 Proportion of heavy commercial vehicles (HCVs)

If there is a high percentage of HCVs in a particular lane, through-vehicles are less likely to use that lane, particularly on uphill approaches, because of the lower acceleration capability of HCVs compared with passenger cars. Since HCVs are more likely to use the kerbside lane, this lane would be used less by other vehicles.

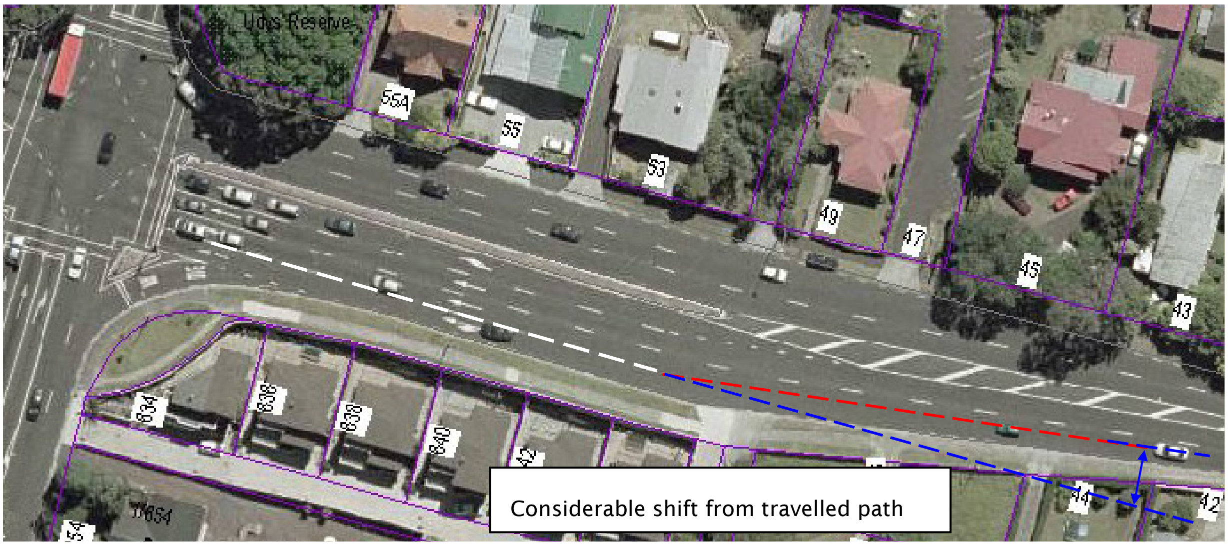
3.2.11 Lane width

Lane widths have a considerable effect on the safety and comfort of drivers. A narrow lane will force vehicles to travel laterally closer to one another than drivers are normally comfortable with, especially when travelling at higher speeds. Thus if the auxiliary lane is narrower than the adjacent continuous lanes this will result in lower travelling speeds and drivers may avoid using this lane. Therefore a reduction in the width of the auxiliary lane is likely to result in lane under-utilisation and a reduction in intersection capacity.

3.2.12 Approach alignment

If the approach alignment is such that drivers have to divert from their travel course in order to enter an auxiliary lane, it is less likely to be utilised. Examples of this can be seen at Mt Eden Road/Balmoral Road, Auckland, Sandringham Road/Balmoral Road, Auckland and East Coast Road/Rosedale Road, North Shore.

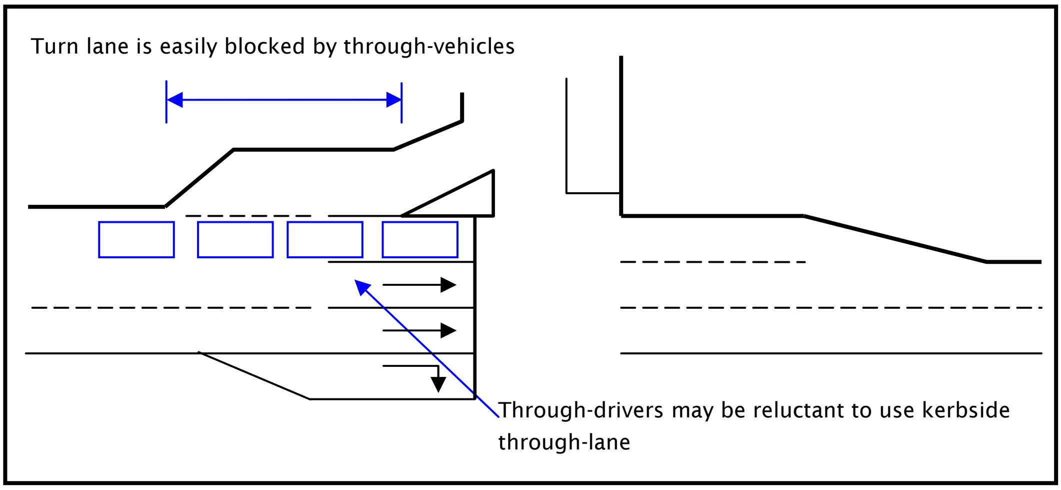
Figure 3.13 Approach alignment of Mt Eden Road/Balmoral Road Intersection



3.2.13 Queue forming an obstruction

In a situation where a queue in the auxiliary through-lane will quickly block access to a short turn lane, as shown in figure 3.14, some drivers may be reluctant to use the auxiliary through-lane to avoid blocking the turn lane. This would impact on the utilisation of the through-lane.

Figure3.14 Auxiliary lane blocking access to short turn lane



4 Data collection and methodology

This chapter outlines the data collection procedures and the methodological approach used in the study and provides guidance to researchers conducting further research in this area.

4.1 Site selection criteria

4.1.1 Introduction

After considering the extent of the different factors influencing lane utilisation, the range of different types of intersections in the Auckland region and previous research on this topic, it was decided to limit the scope of the research to 2-laners and 3-laners. Single through-lane intersections were excluded from the study as they are mostly found in lower volume situations, where capacity and overall road network congestion is not necessarily a primary focus.

An initial review showed that 2-laners and 3-laners display different operational characteristics with differing lane utilisation effects. The different operational dynamics between 2-laners and 3-laners is summarised below:

- As a result of short auxiliary lanes, the lane under-utilisation problem tends to manifest itself more noticeably in the larger 3-laner intersections than with typical 2-laners, as motorists are provided with more choice when having to select lanes at the former.
- Usually 3-laners are major nodes on the road network. Uneven usage of the available lanes at these intersections is likely to have more significant consequences on capacity and ultimately traffic congestion.

Also, 2- and 3-laners differ in the levels of congestion and significance on the overall road network. Hence, these two general intersection layouts were studied and analysed separately.

4.1.2 Selecting the intersection categories for study

Most sites would display more than one of the factors described in chapter 3. At each site a combination of factors would have a collective effect on lane utilisation. It was therefore difficult to separate and measure the effect of each individual factor for a limited sample size. Since lane under-utilisation could occur due to a variety of causes, it was preferable to simplify these into the factors that were likely to be the most significant contributors to lane under-utilisation. The suggested categories are listed below:

- sites with short auxiliary upstream and downstream lanes
- sites with shared lanes
- sites where lane blockage occurs
- side friction caused by driveways.

There would also be many sites with varying combinations of these categories. Hence, the overall criteria for selecting the study sites was categorised by the most common intersection configurations that displayed the main factors listed above. These categories also corresponded with the common intersection layouts described in chapter 3. Therefore, the sample sites were identified by the following criteria:

- short upstream and downstream lanes with exclusive left- and right-turn lanes
- short upstream and downstream lanes with shared lanes
- continuous approach and departure lanes with shared lanes
- continuous upstream lanes with a lane drop downstream (these could include shared lanes at the intersection or exclusive turn and through-lanes).

Along with the above typical configurations, downstream destinations or driveways could also have an effect on lane utilisation.

The effect that the operation of a shared lane has on the capacity and utilisation of a lane can be easily modelled; however, the effect that short lanes have on lane utilisation is not so well known nor is this issue adequately addressed by modelling packages such as SIDRA. Therefore, for the purposes of this research, and due to the limited number of sites, only one category was chosen for analysis, ie short upstream and downstream lanes with exclusive left- and right-turn lanes. This primarily assessed the effect of auxiliary lane length on lane utilisation.

Also, sites with multiple turn lanes were excluded from the study, limiting the research to sites with multiple through-lanes only.

4.1.3 Study site configurations

As mentioned earlier, the research was limited to multiple through-lane intersections. Figures 4.1 and 4.2 illustrate the two typical layouts that were studied, namely 2-laner and 3-laner intersection sites.

Figure 4.1 Typical 2-laner

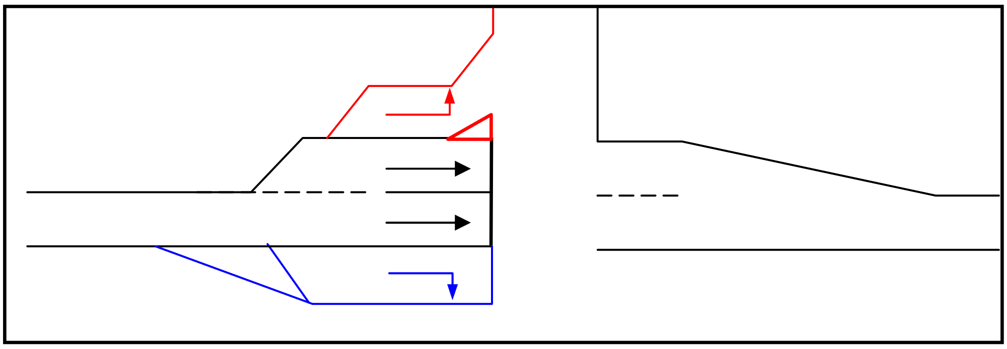
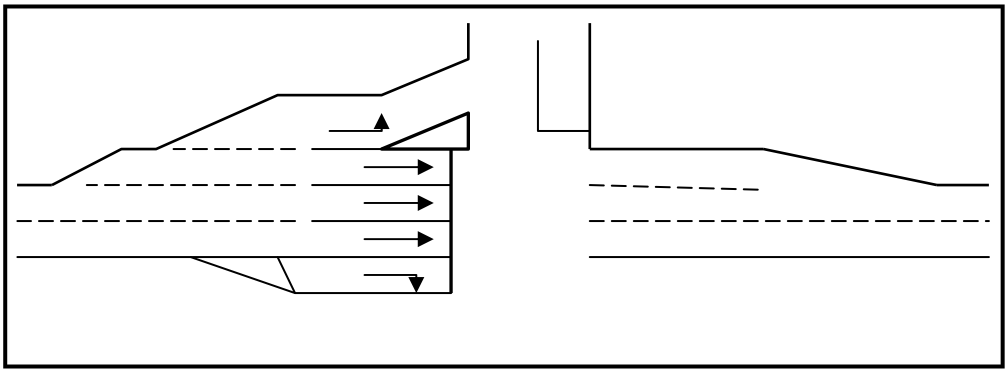


Figure 4.2 Typical 3-laner



Since these intersections have exclusive turning lanes and queues in the turn lane were observed not to block the through-lanes, it was assumed that turning traffic would have no effect on through traffic.

4.1.4 Selection of sites

The process of identifying the appropriate sites and collating data took place between April 2007 and October 2008. A desktop survey was carried out to select candidate sites by first inspecting all corridors that were higher on the road hierarchy. This initial step used a standard street map and a transportation planning map of the study area. Following this and after considering the criteria in section 4.1, a list of major intersections was compiled. The identified sites were inspected more closely by viewing aerial photographs. This enabled the layout of each site to be studied closely and suitable sites selected and categorised. Geographic information systems (GIS) and/or Google-Earth™ were used to conduct this desktop assessment. Three-laner sites were sought in all of the major centres in New Zealand; however, suitable sites were found only in the Auckland region.

Once the candidate sites were selected, each site was visited and observed to understand its individual operational characteristics and whether lane under-utilisation occurred, briefly assessing the likely causes of this. Other site-specific factors such as downstream destinations and the effect of significant driveways close to the intersection were also noted, where applicable.

Once this process was completed for each site, the list of candidate sites, categorised by short auxiliary lanes with exclusive turn lanes, was further short-listed and analysed.

All the 3-laner and 2-laner sites selected were located in the Auckland metropolitan region. Only selected approaches at each chosen site were studied as each approach had different lane configurations. The site selection procedure described above was adopted and the following 13 sites and their relevant approaches were selected. While conducting the research it became apparent that there were relatively few 2-laners and 3-laners in the greater Auckland region.

4.1.4.1 2-laners

- Mayoral Drive/Cook Street/Vincent Street (north approach)
- Kepa Road/Patterson Avenue (west approach)
- Kepa Road/Patterson Avenue (east approach)
- Glenfield Road/Eskdale Road (south approach)
- Albany Highway/Upper Harbour Drive (east approach)
- Oteha Valley Road/East Coast Road/Carlisle Road (north approach)
- Oteha Valley Road/State Highway 17/Albany Expressway (south approach)
- Titirangi Road/Margan Avenue (south approach)

4.1.4.2 3-laners

- Church Street/O’Rorke Road/Hugo Johnston Drive (west approach)
- South Eastern Highway (SEART)/Waipuna Road/Pakuranga Highway (west approach)

- George Bolt Memorial Drive/Kirkbride Road/State Highway 20A (south approach)
- Mt Eden Road/Balmoral Road (east approach)
- Sandringham Road/Balmoral Road (east approach)
- Sandringham Road/Balmoral Road (west approach)
- Botany Road/Golflands Drive/Tarnica Road (south approach)
- Esmonde Road.

Aerial photographs showing the layout of each site are included in appendix A. The aerial photographs were sourced from the Auckland, North Shore and Manukau City Councils' GIS.

4.2 Data collection procedures

There are various types of data that can be collected at each study site. However, data collection was narrowed down to three types for the purposes of this research: geometric data, traffic volume and movement count data and signal information. The data collection procedures are described in detail below and were applied to all selected sites.

4.2.1 Traffic volume data

Traffic volume counts are the most critical data set. Each individual lane and movement at the relevant approach was counted. Data was collected during the am and pm commuter peaks, and also during the off-peak period to assess usage during lighter traffic conditions. In the case of shared lanes, which were not included in the analysis in this research, turning volumes should be accurately recorded in order to determine proportions of through traffic to turning traffic. All count data was classified into the various vehicle categories to determine the effect of heavy vehicles on lane utilisation.

Video surveys were used at some sites when undertaking traffic volume counts because it allowed data capturers to collect information that was otherwise too difficult or confusing to collect while recording other data on site. An example of the data collection spreadsheet used is included in appendix B.

It also allowed the data to be scrutinised in more detail and each movement counted individually and more accurately. This also enabled the operational characteristics at each site to be assessed in more detail. At other sites, Sydney Coordinated Adaptive Traffic System (SCATS) count data was used.

4.2.2 Geometric data

The geometric layout and lane configuration of each intersection was checked against the aerial layout plans on site to ensure no recent changes had been implemented that might affect the candidacy of the sites. The actual upstream and downstream lengths could also be measured at each site and recorded. For the preliminary analysis, auxiliary lane lengths were determined using GIS only. Horizontal and vertical alignment was also noted at each site, as this was also likely to have an effect on lane utilisation at the intersection.

General information such as date, time, weather, intersection ID number (if known) and posted speed limit of each surveyed approach was also recorded.

4.2.3 Traffic signal data

Traffic signal phasing and timing information including the green time at each site can be collected on site. Alternatively, these can be obtained from the SCATS intersection diagnostic data. Signalised intersection capacity is a function of the saturation flow rate and the green-time ratio. For a given green time the expected saturation flow rate at each site can be calculated and then compared with the actual saturation flow where lane under-utilisation occurs.

4.2.4 Other features

Other features that have an effect on lane utilisation at a particular site were also noted. These included driveways close to the intersections, downstream destinations and adjacent upstream and downstream intersections.

4.3 Site surveys

4.3.1 Vehicle counts and validation of data collection methods

Vehicle count information at the appropriate approach at each site was collected for both the commuter peak periods, ie am and pm peak, and also during the midday off-peak period to assess usage during lighter traffic conditions. Counts were categorised into 15-minute intervals during the peaks and the four highest quarter-hour flows made up the highest hourly flow rate used in the analysis. The analysis was based only on the vehicle count at the stop line to determine usage. The effect of heavy vehicles on usage of these lanes was not included.

Traffic volume data was collected either by using SCATS counts, or manual counts at the stop line at each site. SCATS count data is generally known to vary from manual count data by approximately 10%. Manual count data is generally more accurate than SCATS. A simple test was conducted at three sample sites to test the level of difference between the two types of counts and to determine whether using only SCATS count data would be reliable for the purposes of this preliminary assessment. The results of the test are displayed in the tables below:

Table 4.1 Comparison of manual traffic counts to SCATS count data for Church St/O'Rorke Rd (3-laner)

Church St/O'Rorke	Aux lane	Middle	Right
Manual count (ave)	13%	39%	49%
SCATS count (ave)	14%	40%	45%
Difference	**8%**	**3%**	**8%**

Table 4.2 Comparison of manual traffic counts to SCATS count data for SEART/Pakuranga Hway (3-laner)

SEART/Pakuranga Hway	Aux lane	Middle	Right
Manual count (ave)	11%	44%	45%
SCATS count (ave)	10%	48%	43%
Difference	**9%**	**9%**	**4%**

Table 4.3 Comparison of manual traffic counts to SCATS count data for Glenfield Rd/Eskdale Road (2-laner)

Glenfield Rd/Eskdale Rd	Aux lane	Right
Manual count (ave)	40%	60%
SCATS count (ave)	41%	59%
Difference	3%	2%

Tables 4.1, 4.2 and 4.3 show that the difference between the two types of count data (2%–9%) was not significant and thus SCATS data would be reliable enough to use for this study. In addition, as part of the manual count survey, another test was conducted to determine whether lane utilisation rates during queued conditions differed significantly from using total vehicle count over the stop line during each signal cycle, irrespective of queues.

Manual count surveys were undertaken at four sites only: Glenfield Road/Eskdale Road (pm peak only); Sandringham Road/Balmoral Road; Church Street/O'Rorke Road/Hugo Johnston Drive; and South Eastern Highway/Waipuna Road/Pakuranga Highway. However, at the latter two sites, video surveys were also undertaken. The video camera was carefully positioned on site so that a clear view of the relevant approach could be obtained. In some cases, this required the camera to be elevated so that heavy vehicles did not block the view of the other lanes.

The video footage for each site was viewed in more detail after the site surveys were conducted. Traffic in two lanes was counted on site while the other lanes were counted in the office using the video footage. Operation of the left- and right-turn lanes was also observed from the video footage. At both sites, the exclusive turn lanes were observed to not impede flow on the through-lanes, and hence did not cause lane blockage. For the remainder of the sites, SCATS count data was used and then highest hour flows determined.

Utilisation of the through-lanes was surveyed using two processes. First, the level of utilisation was determined by measuring the number of vehicles queued in each through-lane at the start of the green period. This included vehicles that had stopped as well as partial stops. Second, lane utilisation was measured using the total vehicle count during the same green period. This included the queued vehicle count plus the number of vehicles that passed the stop line without any stops during the same green period. SCATS count data for the same period as the manual counts was then obtained and summarised. The three count types, ie queue counts, total vehicle counts and SCATS counts, were then compared in order to gauge the difference between the different count types. For sites where SCATS data was not available during the same count period, the closest representative day at the same peak times was used. All count information is summarised in appendix A.

Overall, it was found that for the sample counts, there was no significant difference between the data sets. In the case of the manual counts, there was little difference between the lane utilisation rates derived from the two survey methodologies. This test was conducted to determine if lane utilisation results differed significantly during queued conditions compared with total vehicle count over the stop line. This revealed that lane utilisation rates were very similar for these two manual count methodologies and that lane utilisation rates determined by only using total vehicle count were suitable for the purposes of this research.

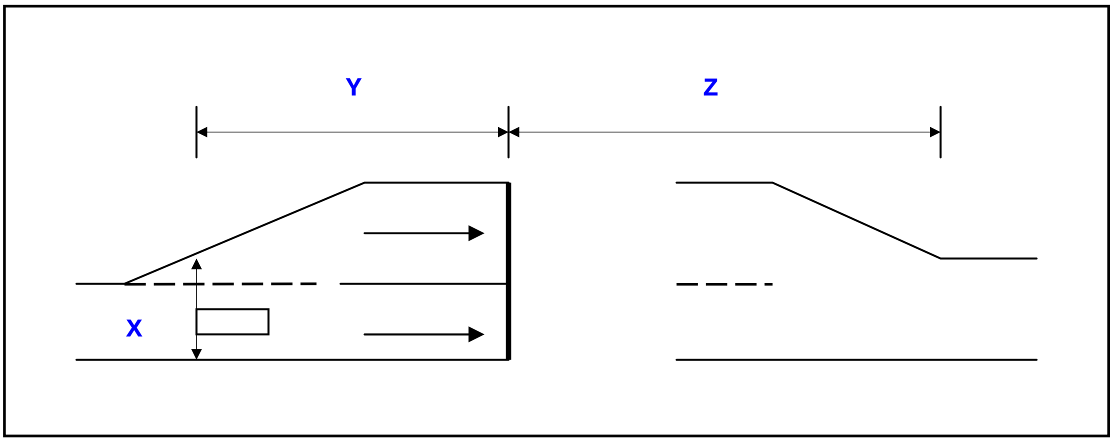
The SCATS counts were then compared with manual counts, and the data was, on average, within 10%–15%. This is close to the commonly known average of approximately 10%, outlined above. Based on this it was decided that, for the purposes of this research, it would be acceptable to determine lane utilisation rates at the other sample sites by using SCATS counts only.

It should be noted that there are limitations to SCATS counts, for example vehicle classifications cannot be recorded and turning traffic proportions cannot be obtained at shared lanes. It was also assumed that heavy vehicles would use all lanes on the intersection approaches. These limitations, however, were not of particular relevance to this study.

4.3.2 Determining auxiliary through-lane length

The upstream and downstream auxiliary through-lane lengths were determined from GIS. The extent of the effective length of the auxiliary lanes is shown in figure 4.3 below:

Figure 4.3 Measuring the effective length of short auxiliary lanes



The upstream auxiliary lane length, denoted by distance ‘Y’ in figure 4.3, was measured from the limit line to a point where the carriageway was wide enough for two typical passenger cars to pass, denoted by distance ‘X’. The reason for this was because this point was roughly as far as vehicles in the auxiliary lane could queue before being blocked, and was the effective usable length of the auxiliary lane. Distance ‘X’ typically ranges from 4.0m to 4.5m.

The downstream auxiliary lane length, denoted by distance ‘Z’ in figure 4.3, was measured from the stop line to the point where the two lanes merged to one lane including the taper length.

5 Data analysis

5.1 Introduction

Given the limitations of the study, the analysis aimed to assess only the effect of the length of approach and departure lanes on the utilisation of kerbside through-lanes. There were too few sites identified to be able to test the effect of other factors on the rate of usage of auxiliary lanes. Guidelines for further research are detailed in chapter 9.

The analysis focused on the lane under-utilisation problem at 3-laners and these are reported first, followed by preliminary analysis of the 2-laners. Full results of the traffic counts at each site, the relevant peak periods, the upstream, downstream and total auxiliary lane lengths and whether SCATS or manual count (survey) data was used is included in appendix A.

5.2 3-laners

5.2.1 Comparison of the rate of use vs lane length

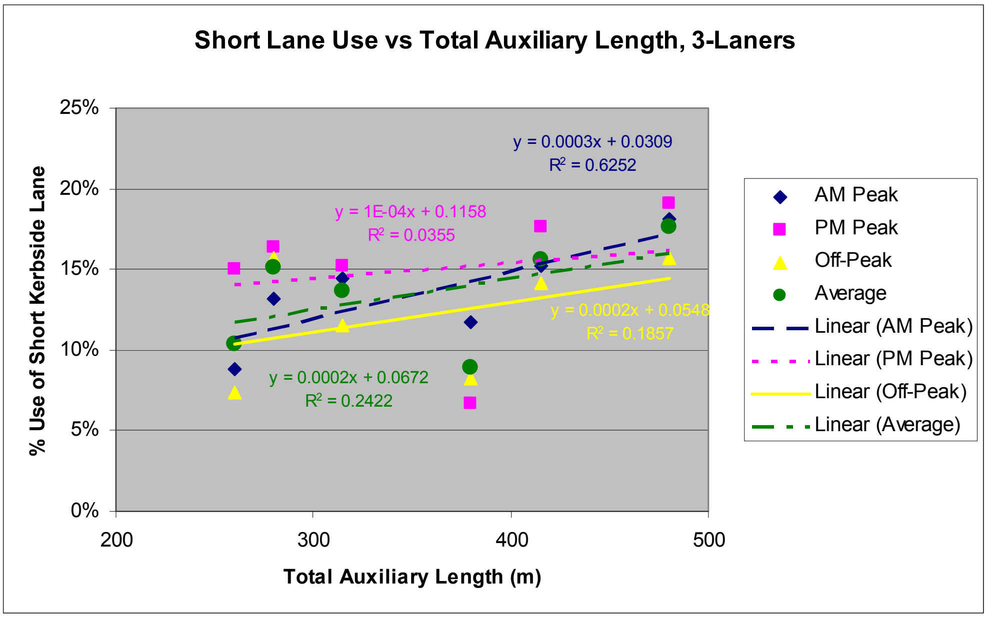
The initial lane utilisation study completed by Royce et al (2006) compared the rate of use of the short auxiliary lane to the total length (upstream + downstream) of that lane for two 3-laners in Auckland, namely Sandringham Road/Balmoral Road and Mt Eden Road/Balmoral Road for the am, pm and off-peak periods. The 2006 study showed the short through-lanes were under-utilised and there was a direct correlation between the length of the lane and its use.

Continuing with a slightly larger sample size, this research attempted to add more significance to the above findings by similarly comparing the rate of use of the short auxiliary lane with the length of the lane, during the am, pm and off-peak periods. These results are tabulated and included in appendix A.

Initially a comparison, illustrated in the scatter plots on the following pages, was undertaken between the total length and rate of use of the auxiliary lane for this larger sample (1). The rate of use is shown as a percentage of the overall through traffic volume. The analysis was then extended to include individual comparisons between upstream and downstream length and the rate of use of the auxiliary lane (2). This was done to determine whether the upstream or downstream auxiliary lane had more of an impact on lane use.

The results from (1) and (2) displayed similar trends and these are shown in figures 5.1, 5.2 and 5.3.

Figure 5.1 Scatter plot showing short-lane use vs total auxiliary length for 3-laners



The positive relationship between lane use and length of the auxiliary lane found in the initial research study held true for the larger sample size. The main exception to this rule was the SEART/Waipuna Road site, which at 380m in length showed a relatively low rate of utilisation of the left lane. Further discussion on this site is included in section 5.2.3.

Following the comparison between the total length of the auxiliary lane (combining the upstream and downstream lengths), individual comparisons between upstream and then downstream lengths to the rate of use, was then analysed (figures 5.2 and 5.3) to try to identify which of these factors had a stronger influence on the use of the auxiliary lane.

Figure 5.2 Scatter plot showing short-lane use vs upstream short-lane length for 3-laners

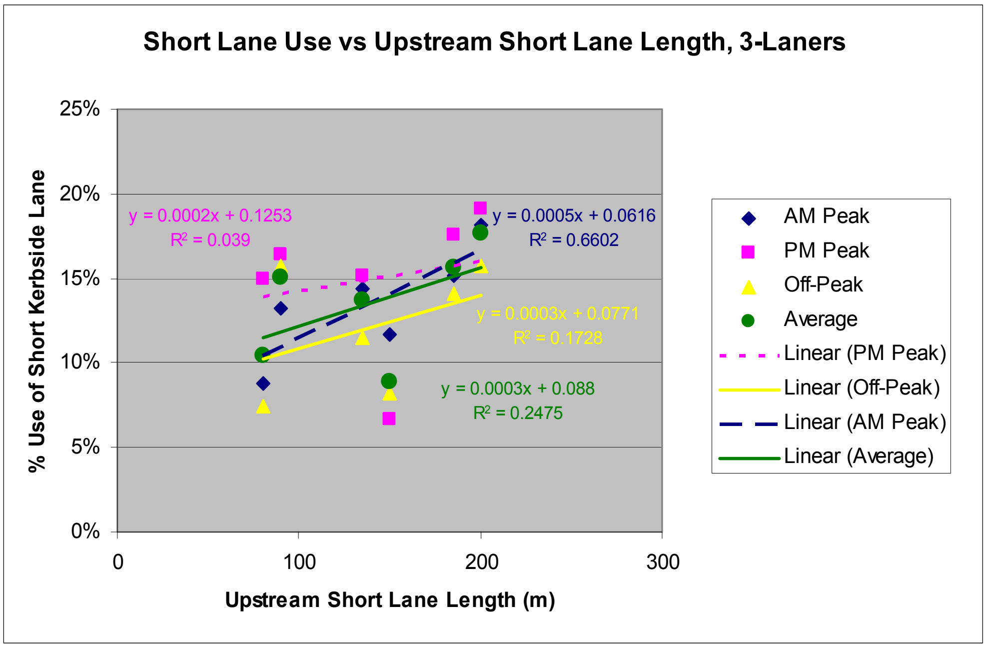
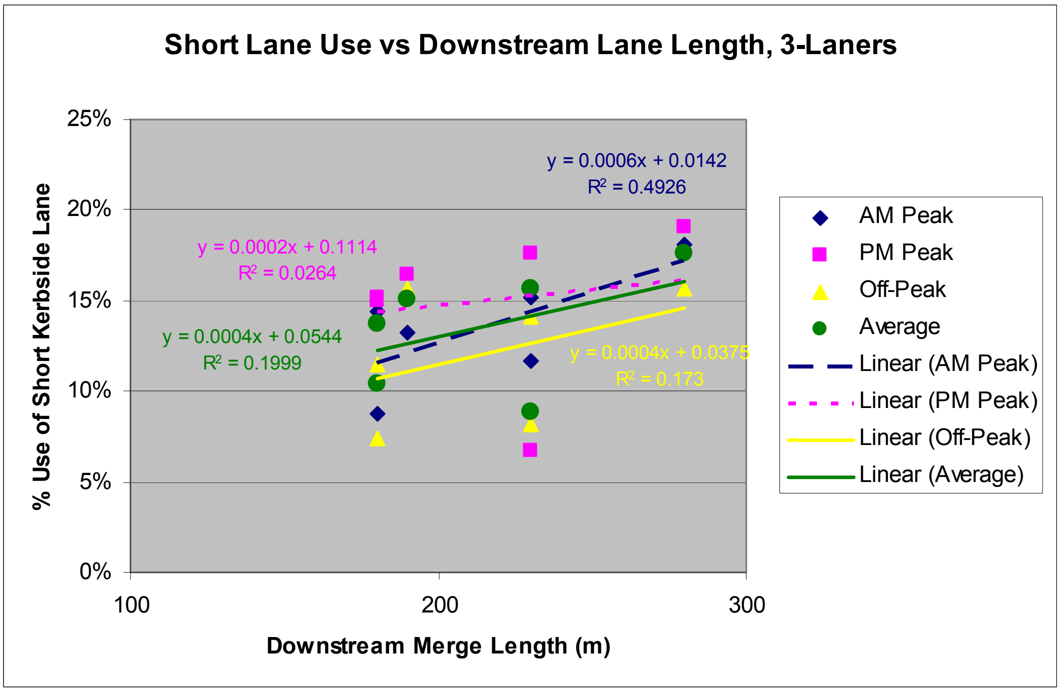


Figure 5.3 Scatter plot showing short-lane use vs downstream lane length for 3-laners



The investigation revealed that the downstream lane length had a marginally stronger influence on the use of the auxiliary lane. This was as expected; however, the results were not conclusive and due to the small sample size, it was not possible to isolate the influence of upstream lane lengths from the downstream lane lengths.

Figures 5.1, 5.2 and 5.3 demonstrate that generally a relationship exists between the length of the auxiliary through-lane and the rate at which the auxiliary lane is used at the study intersections. The linear regression best-fit trend lines added to the data scatter show that the rate of use of the short kerbside through-lane is directly proportionate to the total length of the auxiliary lane.

The general trend appears to be that short kerbside lanes at 3-laners are greatly under-utilised regardless of the length of the total auxiliary lane. This could possibly be attributed to the fact that drivers have more of a choice between which through-lanes they use and that, in addition to the site-specific factors that influence lane utilisation, drivers prefer to position themselves in the right and middle lane, as they perceive that the lanes from slowest to fastest are the kerbside lane, the middle lane and the rightmost lane.

It should be noted, however, that this is an assessment of only a small sample and further research needs to be conducted to determine whether a strong association exists between these factors, as well as determine the likely effect of other factors. It is recommended that research focuses on the 3-laner situation as auxiliary lanes at these sites are used less than the 2-laners. Unfortunately no further 3-laner sites could be identified in New Zealand, and it would therefore be necessary to look to overseas examples, initially in Australia due to the similar traffic environment there. One potential site is Sangate Road/Zillmere Road in Queensland, which has auxiliary lanes in both northbound and southbound directions. Further study sites would need to be identified with the help of the ARRB Group Ltd and local road controlling authorities.

5.2.2 Lane-use variation with increase in demand volumes

It was noted that the variability of the results could be attributed to the fact that some of the approaches used in the analysis were at their busiest during the morning peak period while others were busier during the afternoon peak period (ie some of the intersections exhibited strong tidal peak flow patterns). Thus in order to get a true representation of the utilisation rate of short lanes and considering that demand at each intersection also influenced how the lanes were used, it was decided to compare the daily peak hour (ie the hour that the study approach had the highest volume or was fully saturated) to the total length of the lane. To gain a better understanding of the influence of traffic demand on usage of the auxiliary lane, the variation of lane utilisation throughout the day was investigated.

For each of the six approaches investigated short lane utilisation was plotted against time of day using data for five weekdays. A moving average line was added to each scatter plot to clearly show the trend. Although the data collected from SCATS was for a 24-hour period and over a seven-day week, the utilisation profiles were only plotted between 6am and 9pm, Monday to Friday, as data results outside of this period showed random fluctuations due to the low traffic volumes. The individual profiles for each site are shown in the figures below.

Figure 5.4 Sandringham Road/Balmoral Road (west approach) 15-hour profile

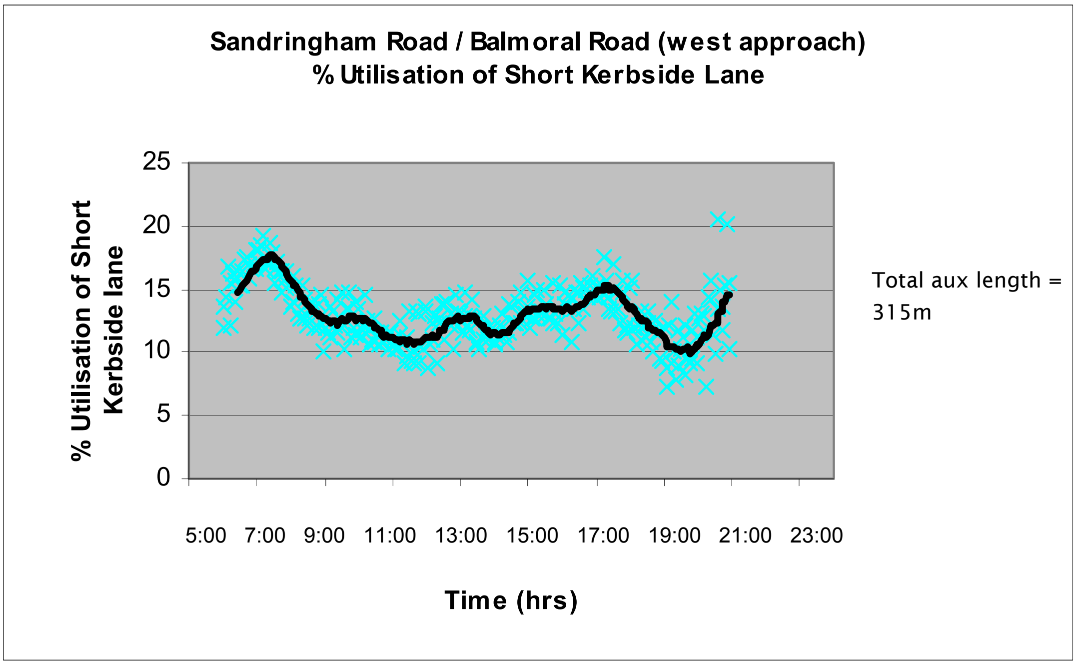


Figure 5.5 Sandringham Road/Balmoral Road (east approach) 15-hour profile

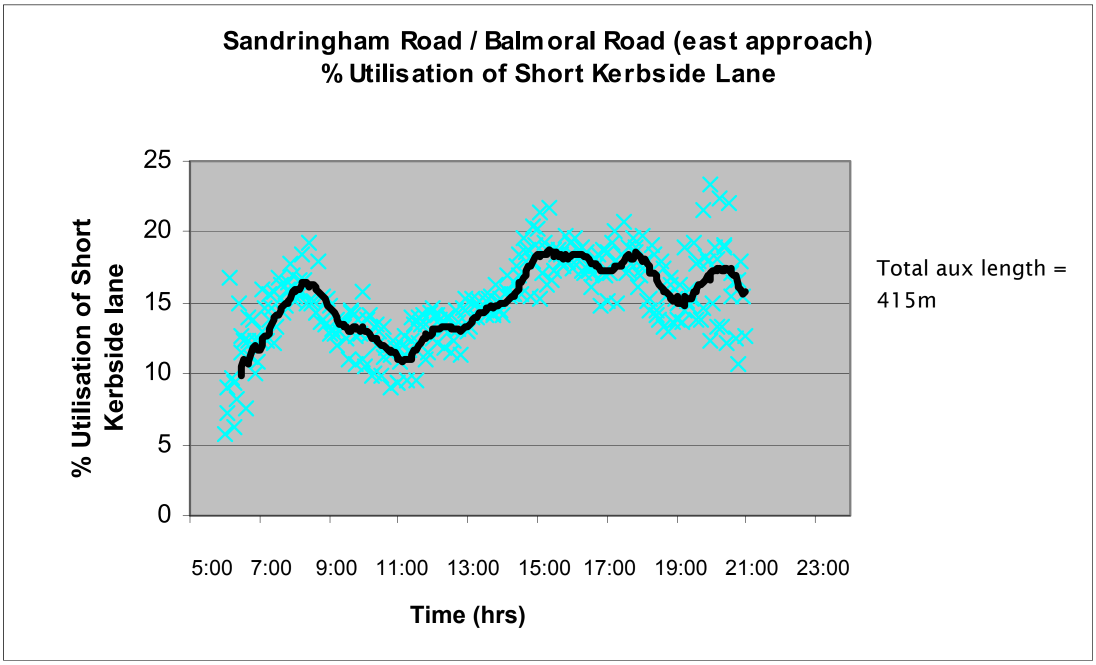


Figure 5.6 Mt Eden Road/Balmoral Road (east approach) 15-hour profile

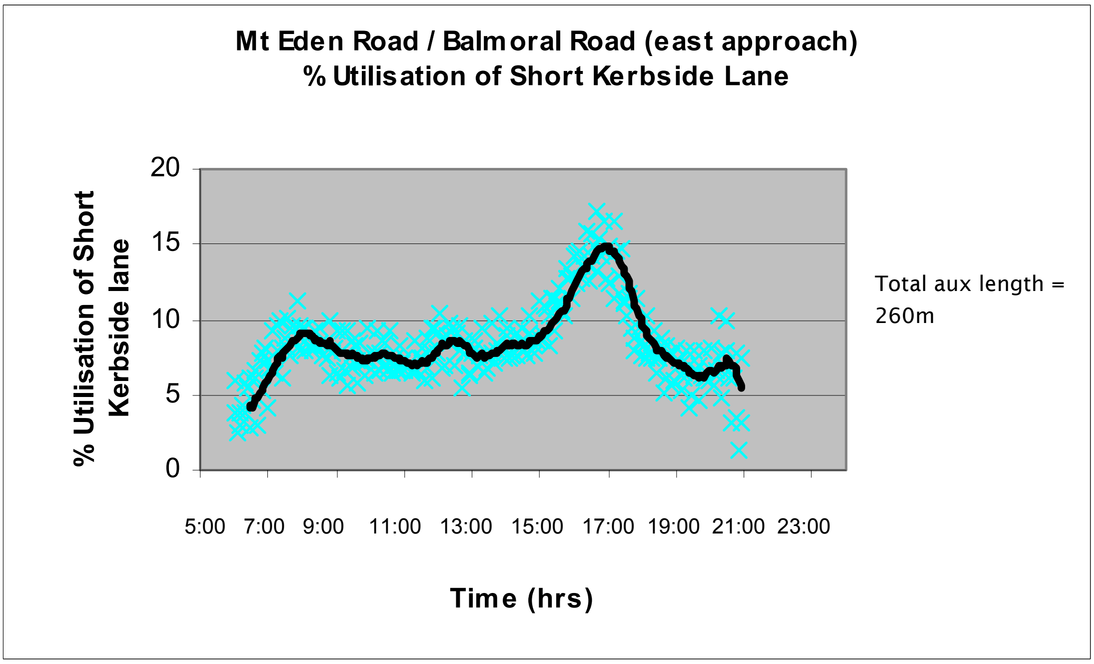


Figure 5.7 George Bolt Memorial Drive/Kirkbride Road 15-hour profile

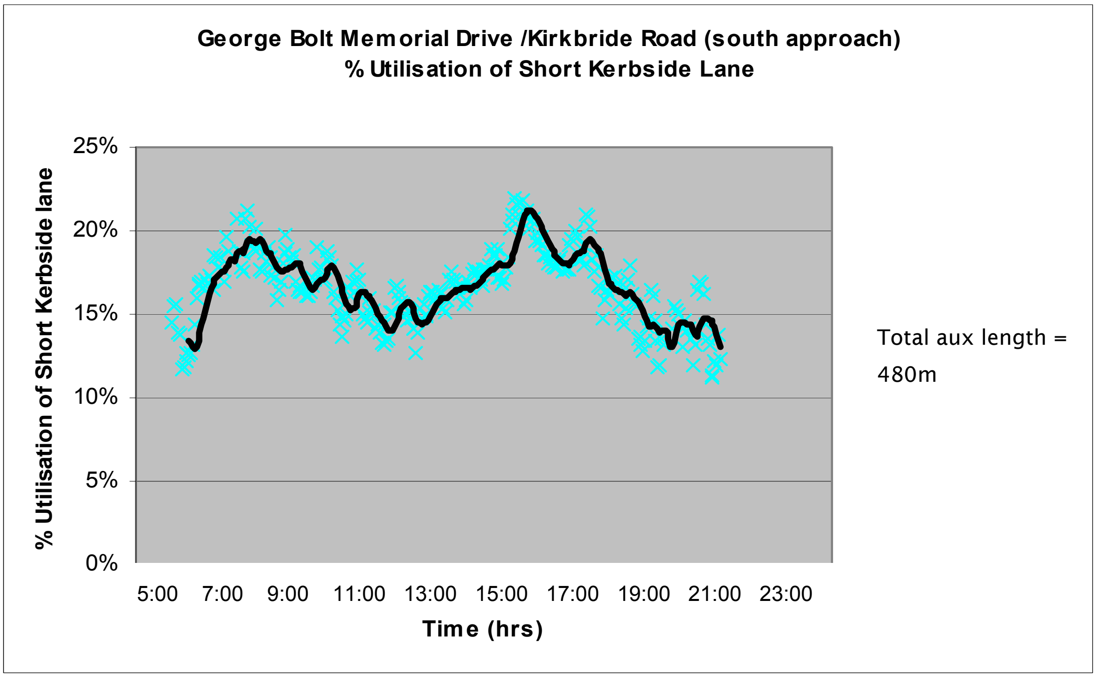


Figure 5.8 SEART/Waipuna Road 15-hour profile

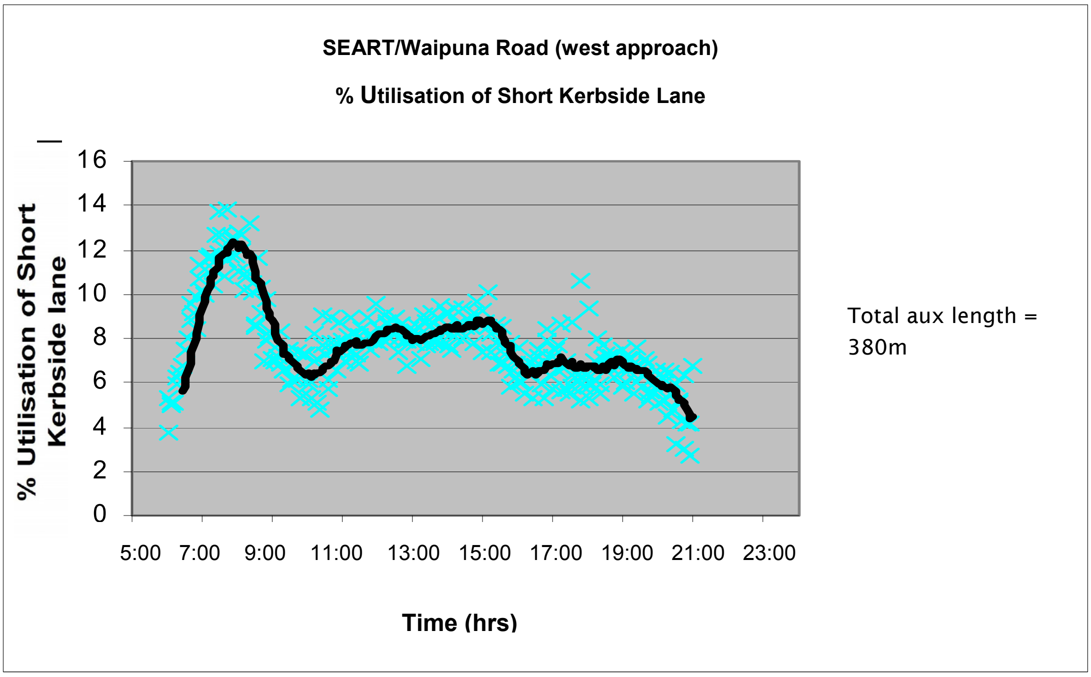
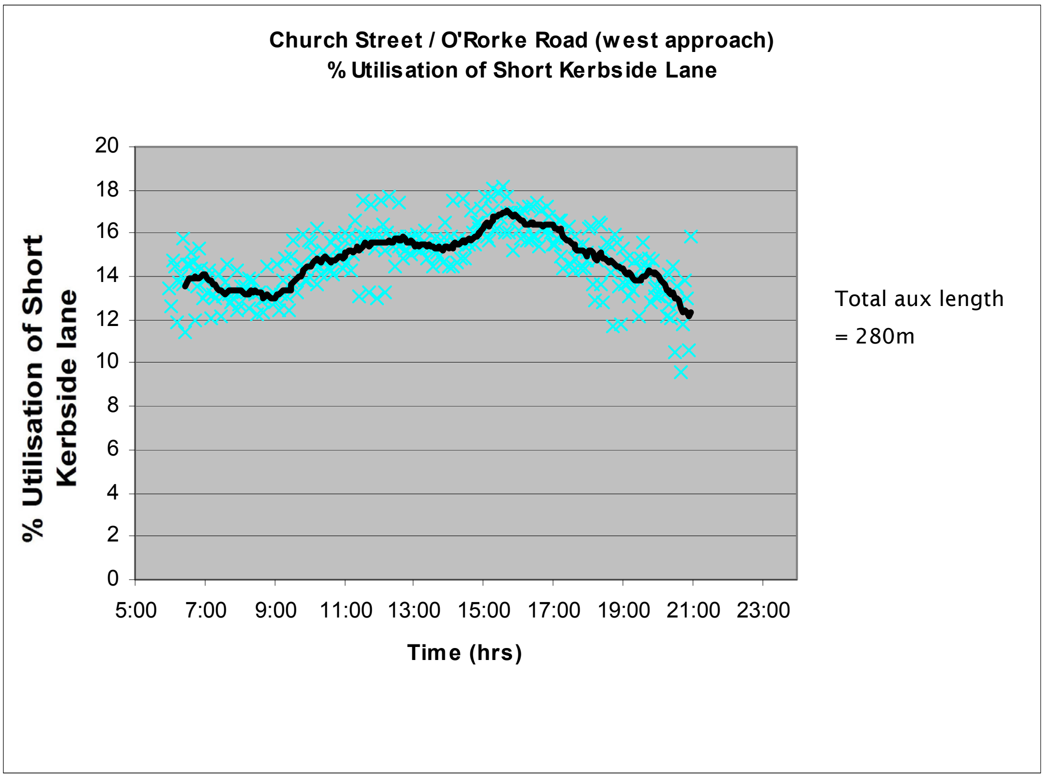


Figure 5.9 Church Street/O'Rorke Road 15-hour profile



It is evident from the profiles above that:

- The commonality between most of the graphs is that use of the auxiliary lane increases during the tidal peak period, ie when traffic demand is higher. The exception, however, is the intersection of SEART/Waipuna Road where auxiliary lane use is at its lowest during the most congested period.
- During the off-peak periods the auxiliary lanes are very poorly utilised, with the exception of Church Street/O'Rourke Road.
- In addition to the length of the short through-lane impacting the rate of its use, there are a number of other inputs that contribute to the under-utilisation such as those previously discussed in chapter 3.
- In order to obtain more conclusive results for the above profiles, more like sample sites are needed.
- Each site is looked at below in more detail, to see how the different factors affecting lane utilisation impact on the site.

5.2.3 Rate of use vs lane length for peak hour only

With the above results showing considerable variability of lane utilisation throughout the day it was considered that for a true like-for-like comparison between the performance of various approaches only the peak hour should be used. The profiles above clearly show the peak hour for the Mt Eden/Balmoral east approach is in the afternoon, while for the Sandringham/Balmoral west approach it is in the morning.

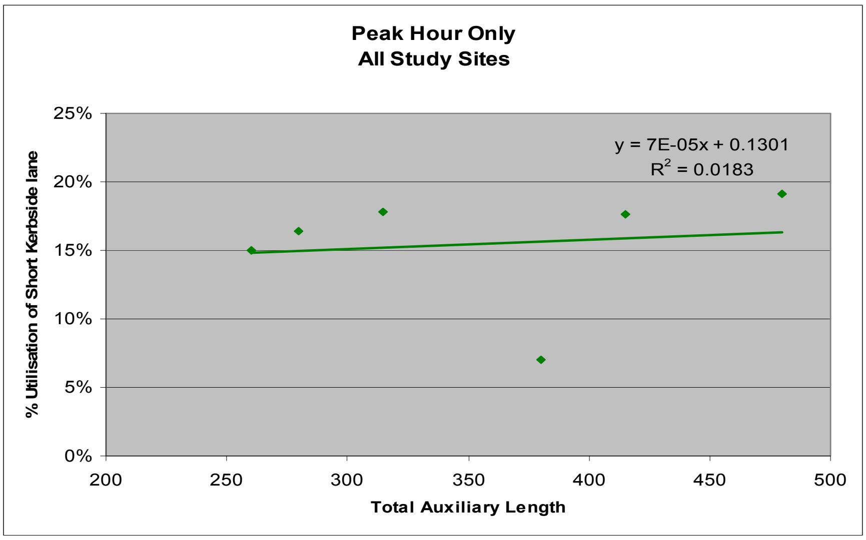
Table 5.1 shows the lane utilisation rate for the auxiliary lanes during the peak hour. It should be noted that the peak hour is taken to be the time when the highest volume of traffic is recorded, which does not necessarily correlate with the time when the utilisation rate of the short lanes is at its maximum.

Table 5.1 Peak-hour periods for 3-laners

Intersection	Total auxiliary length	Peak traffic demand		% use of short lane
		am/pm	Time	
Church St/O'Rorke Rd (west approach)	280	pm	14:30 - 15:30	16.4
SEART/Waipuna Rd/Pakuranga HWay (west approach)	380	pm	17:00 - 18:00	7.0
George Bolt Drive/Kirkbride Rd/SH20A (south approach)	480	pm	17:00 - 18:00	19.1
Mt Eden Rd/Balmoral Rd (east approach)	260	pm	16:00 - 17:00	15.0
Sandringham Rd/Balmoral Rd (east approach)	415	pm	16:00 - 17:00	17.6
Sandringham Rd/Balmoral Rd (west approach)	315	am	07:00 - 08:00	17.8

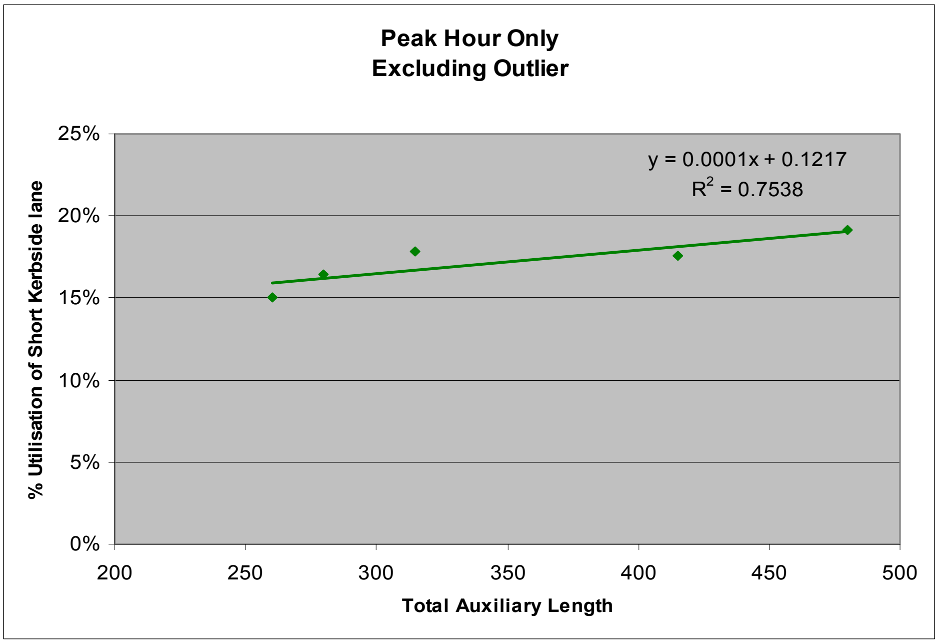
A comparison of the above results is represented in figure 5.10.

Figure5.10 Scatter plot showing short-lane use vs total auxiliary length for one peak only



The results of this analysis still show very little correlation between lane usage and lane length. The graph also highlights that one intersection (SEART/Waipuna) displayed a significantly lower rate of use than the others. When the operation of this particular site was investigated it was discovered that during the afternoon peak period the downstream exit from the intersection was routinely blocked during the pm peak. This congestion made it very difficult for drivers to force their way back into the continuous lane downstream, and observations showed that relatively few drivers were willing to attempt this. This site was therefore treated as on 'outlier' and removed from the data scatter. An outlier is one or more values of a data set that appear unusually large or small and out of place when compared with the other data values. The following figure shows the revised trend line.

Figure 5.11 Scatter plot showing short-lane use vs total auxiliary length for one peak only



After removing the outlier site, a positive relationship emerges and with an R^2 value of 0.75 the trendline shows good correlation to the data points. However, this is not particularly conclusive as the gradient is very shallow, and therefore the relationship is not a very strong one. Furthermore the small sample also undermines confidence in this outcome.

5.2.4 Site specific observations

5.2.4.1 Church Street/O'Rorke Road/Hugo Johnston Drive (west approach)

This intersection is located in the industrial area of Penrose in Auckland and has a posted speed limit of 50km/h. The composition of traffic travelling through this intersection consists of both light vehicles and a high proportion of heavy vehicles (16% HCVs). On average, the short auxiliary lane is used at a rate of approximately 13%. This poor utilisation could be attributed to a combination of factors, which are briefly discussed below:

- Downstream destination – the middle and right lane could have a higher utilisation possibly because a high percentage of the traffic travelling through Church St/O' Rorke Rd intersection is heading towards the southbound motorway and intent on turning right at the intersection of Great South Road and SEART.
- The presence of heavy vehicles could discourage drivers from using the kerbside lane.
- Forward visibility of the downstream section of this intersection is obscured by a crest in the road and this could be a deterrent to drivers as they cannot see the lane arrangement ahead.
- This intersection has high traffic volumes and is heavily congested during the peak hours. Drivers are potentially using the middle and right lane in order to avoid the stressful merge ahead. (The utilisation rate did increase slightly during the peak period, possibly because drivers needed to wait for more than one cycle if they were to stay in the middle or right lanes when it was heavily congested).

5.2.4.2 SEART/Waipuna Rd/Pakuranga Highway (west approach)

This intersection is located in the industrial area of Mt Wellington in Auckland and has a posted speed limit of 80km/h. The South Eastern Highway is a regional arterial road, carrying in excess of 40,000 vehicles per day (vpd) and is one of the main routes providing access between SH1 and the eastern suburbs of Auckland. The proportion of heavy vehicles using this intersection is approximately 8%. The rate of utilisation of the short auxiliary lane is approximately 11%, averaged over the three peak periods. The utilisation rate is at its highest during the morning peak period but, contrary to the other intersections in the study sample, is at its lowest during the most congested period (pm peak). This is probably due to the fact that the exit from the intersection is often blocked during the pm peak and drivers are aware of the difficulty of forcing their way back into the continuous lane in these congested circumstances.

5.2.4.3 George Bolt Memorial Drive/Kirkbride Rd/SH20A (south approach)

This intersection is located in Mangere in South Auckland and has a posted speed limit of 60km/h. The intersection is located on a stretch of SH20A with a 100km/h speed limit for most of its length, and a 60km/h speed limit applying to the immediate approaches and exits from the intersection. George Bolt Memorial Drive/SH20A carries in excess of 40,000vpd and lies on the primary route to and from Auckland International Airport. Traffic travelling through this intersection comprises about 9% HCVs, with taxis or shuttle buses forming a significant proportion of light vehicle traffic. This intersection has the highest utilisation rate, (approximately 18% on average) in comparison with the other sites in the sample. Factors that influence utilisation at this intersection include:

- Length of the auxiliary lane: the longest upstream short-lane length at this site is 200m and the longest downstream merge length is 280m, giving it the longest total auxiliary length in the sample. George Bolt Memorial Drive is a state highway, and therefore has a shoulder that could act as a run-off area for drivers to use if they fail to merge within the allocated merge area, thus giving them some sense of confidence. The generous length of the short lane and the available run-off area could have a positive effect on its rate of utilisation.
- The high proportion of taxis likely to be (a) driving with some urgency, and (b) familiar with the road layout and the way the intersection operates, may also contribute to the high rate of use.
- Motorists heading towards Auckland are informed by overhead advanced direction signage if all three through-lanes are free and this could be another factor improving the use of the auxiliary lane.

5.2.4.4 Mt Eden Rd/Balmoral Rd (east approach)

The intersection of Mt Eden Road and Balmoral Road is located in the residential suburb of Mt Eden in Auckland and has a posted speed limit of 50km/h. The short auxiliary through-lane is used at a rate of 10.6%, on average, the lowest in comparison with the other sites in the sample set. Incidentally, this intersection has the shortest upstream (80m) and the shortest total auxiliary length (260m) compared with the other 3-laner sites. The poor utilisation rate could be attributed to the short length of the auxiliary lane which results in drivers using the lane less to avoid the merge ahead. Other significant factors that are likely to affect use of this short lane include:

- a downstream bus stop at the point where drivers merge

- an unusual approach alignment with a lateral shift to the left on the approach. This means that in order to access the kerbside short through-lane, drivers have to divert from the route they are travelling and therefore are less likely to use that lane
- the very short left-turn slit lane is likely to impact on lane utilisation either because of left turners queuing back into the through-lane, or through traffic avoiding blocking the left-turn lane.

5.2.4.5 Sandringham Rd/Balmoral Rd (east approach)

This intersection is located in Sandringham, a residential suburb in Auckland. It has a posted speed limit of 50km/h, is two intersections to the west of the Mt Eden Road/Balmoral Road intersection and close to a large suburban shopping mall (St Lukes). The short auxiliary lane has a utilisation rate of approximately 15% on average. The factors likely to affect utilisation of the short lane are similar to those affecting the Mt Eden Road intersection and are as follows:

- A downstream bus stop exists at the point where the kerbside auxiliary lane and centre lane merge.
- The approach alignment requires drivers to shift significantly to the left to access the short lane.
- An upstream bus stop is located approximately 30m into the start of the auxiliary lane, possibly discouraging drivers from using this lane. Balmoral Road is an important bus route servicing the surrounding residential area, Greenlane Hospital and UNITEC Campus.
- A prominent downstream destination (St Lukes Mall) may also be encouraging drivers to position themselves in the offside two lanes.

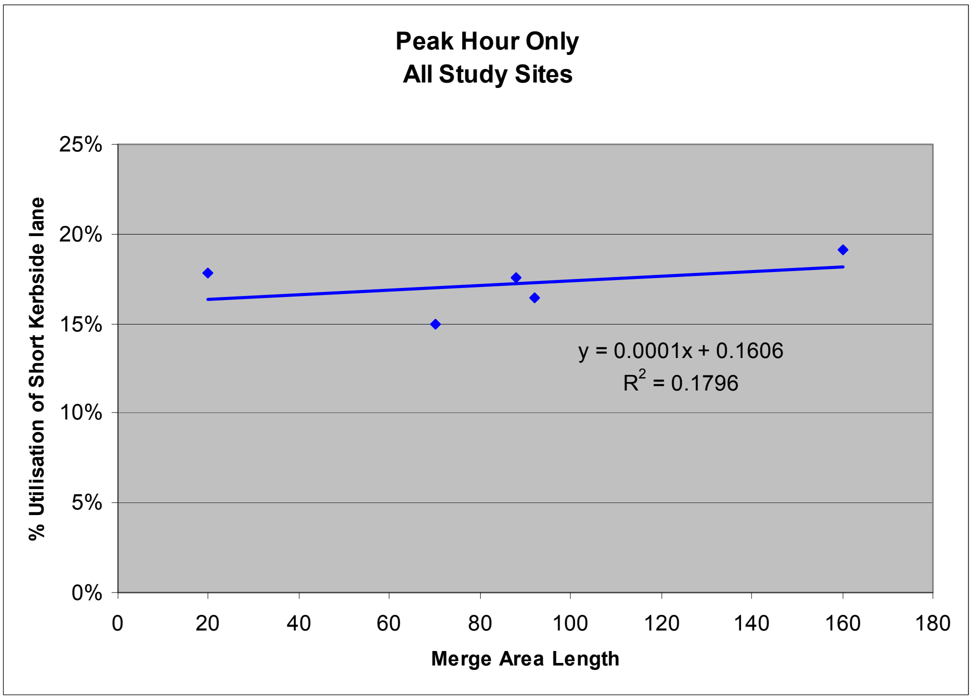
5.2.4.6 Sandringham Rd/Balmoral Rd (west approach)

The auxiliary lane of the western approach to the above intersection is used, on average, at a rate of approximately 15%. Similar to the eastern approach, upstream and downstream bus stops are located along the auxiliary lane, possibly discouraging use of the lane.

5.2.5 The influence of merge area length

It was considered that the level of 'stress' experienced by drivers when merging would be influenced by the length of the area provided for merging rather than just the lane length. Therefore the merge area lengths were measured and compared with auxiliary lane utilisation to see if there was a measurable relationship. The graph in figure 5.12 shows this comparison for the study sites, excluding the SEART/Waipuna Road outlier.

Figure 5.12 Scatter plot showing short-lane use vs merge area length for one peak only



The above graph shows there is very little correlation between the length of the merge area and lane utilisation for the sites in our study sample. Although it is likely that the merge area length has an influence on lane utilisation, we were unable to determine its influence in isolation to other factors and therefore unable to draw any conclusions from the data available.

5.3 Special case sites

The following three 3-laner sites were considered as special sites and analysed separately from the previous six 3-laner intersections:

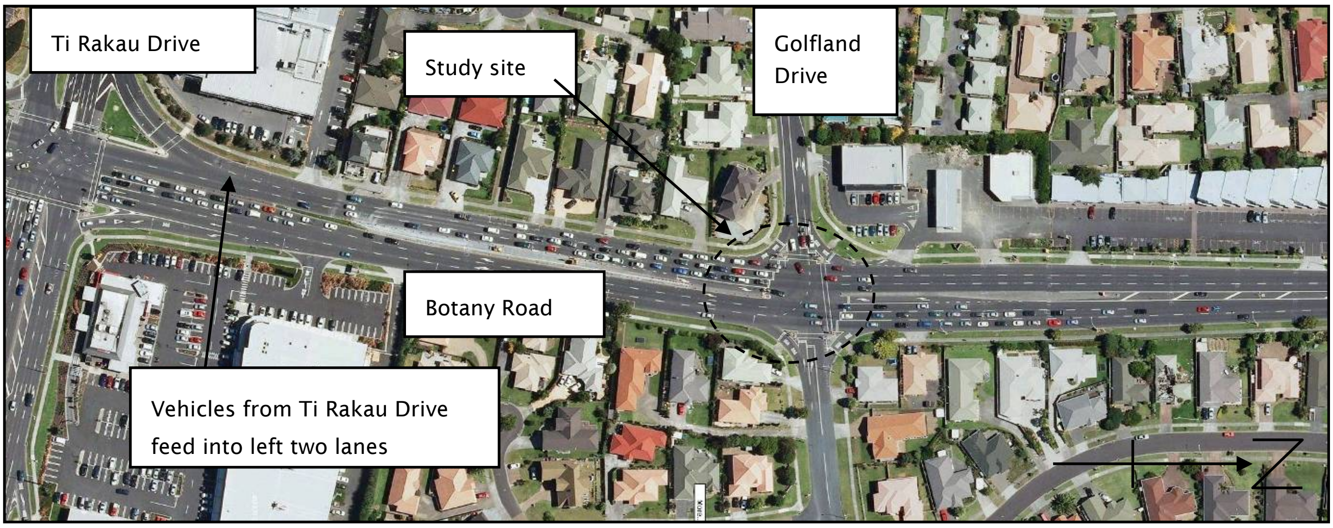
- Botany Road/Golflands Drive/Tarnica Road (south approach)
- Esmonde Road
- SEART/Carbine Road.

The above sites have specific and unique factors which affect lane utilisation rates. It was not considered appropriate to compare them directly with the other six sites analysed. However, it was considered important to report on these sites separately as they raise awareness of the extent to which the different factors mentioned in chapter 3 influence lane utilisation. They also demonstrate to practitioners that it is important to be aware of all the factors when selecting candidate sites or when upgrading intersections.

5.3.1 Botany Road/Golfland Drive/Tarnica Road (south approach)

The site is located in an area adjacent to both residential and business zones and a number of significant shopping developments. This site differs from the other 3-laners because it has three continuous lanes on the approach side. The lane arrangement on the south approach results in much of the traffic that originates from Ti Rakau Drive feeding into lanes 1 and 2. Figure 5.13 shows the layout of the site.

Figure 5.13 Intersection of Botany Road/Golfland Drive/Tarnica Road



A summary of the average lane utilisation rates at this intersection is included in table 5.2.

Table 5.2 Lane utilisation survey results at the Botany Rd/Golfland Dr/Tarnica Rd intersection

Period	Average through-lane use (%)			D/S merge length (m)
	Aux lane	Middle	Right	
am peak	25	36	39	210
pm peak	24	23	53	
Off-peak	25	36	39	

As can be seen from table 5.2, the kerbside lane is more highly utilised than the short lanes at the other 3-laners studied. This is considered attributable to the approach lane arrangement, with traffic from Ti Rakau Drive feeding directly into the left two lanes. This intersection has therefore not been included in the study sample for 3-laners because the approach lane arrangement means that driver behaviour on the northbound approach is significantly different from the study sample sites.

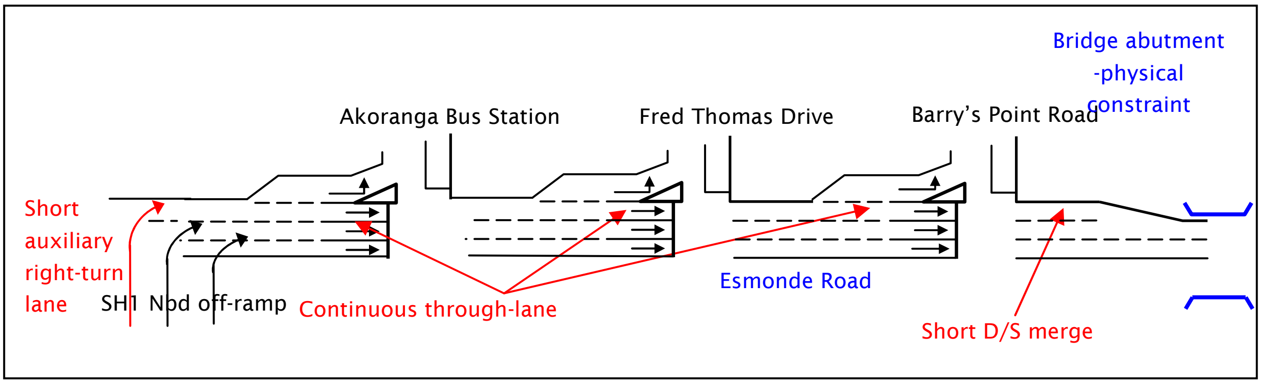
5.3.2 Esmonde Road

Three intersections along Esmonde Road were studied collectively as one site:

- Akoranga Bus Station access
- Fred Thomas Drive
- Barry's Point Road.

A sketch of the general layout of the section of Esmonde Road, which was studied as part of this research, is shown below in figure 5.14. Akoranga Bus Station access and Fred Thomas Drive have continuous upstream and downstream kerbside lanes; however, the continuous upstream kerbside lane on Barry's Point Road has a very short downstream merge (approximately 80m). The ability to increase the downstream merge distance is constrained by the Esmonde Road bridge abutment, located just east of the intersection.

Figure 5.14 Esmonde Road between SH1 and Barry's Point Road



The utilisation rate of the kerbside through-lane between SH1 northbound on-ramp and Barry's Point Road during the three peak periods is tabulated below in tables 5.3, 5.4 and 5.5.

Table 5.3 Lane utilisation survey results along Esmonde Road for am peak period

am peak	Average through-lane use			Barry's Point left-turning and through traffic split (# vehicles)	
	Left/aux lane	Middle lane	Right lane	LT slip lane	Total traffic
Akoranga Bus Station	45	33	22	17	1835
Fred Thomas Drive	33	40	27	342	1520
Barry's Point Road	12	52	36	391	1147

Table 5.4 Lane utilisation survey results along Esmonde Road for pm peak period

am peak	Average through-lane use			Barry's Point left-turning and through traffic split (# vehicles)	
	Left/aux lane	Middle lane	Right lane	LT slip lane	Total traffic
Akoranga Bus Station	43	30	27	107	2023
Fred Thomas Drive	35	32	33	205	1940
Barry's Point Road	16	39	44	413	1514

Table 5.5 Lane utilisation survey results along Esmonde Road for off-peak period

am peak	Average through-lane use			Barry's Point left-turning and through traffic split (# vehicles)	
	Left/aux lane	Middle lane	Right lane	LT slip lane	Total traffic
Akoranga Bus Station	45	34	21	153	1450
Fred Thomas Drive	40	34	26	462	1568
Barry's Point Road	22	42	36	484	1231

On average, the utilisation rate of the kerbside lane is fairly high (ranging 33%–45%) up until the left-turn slip lane into Barry's Point Road. The utilisation rate of the left lane at Barry's Point Road ranges between 12%–22%. The relatively high utilisation rate of the left lanes approaching the Akoranga Station and Fred Thomas Drive intersections is likely to be due to the large volume of left turners at the downstream intersections, while the low volumes using the left lane at the Barry's Point Road intersection will be influenced by the short merge, which takes place on a right-hand bend.

5.3.3 SEART/Carbine Road (east approach)

The SEART/Carbine Road east approach differs from the other sites in the sample because the auxiliary lane is positioned on the right-hand side because of a right-hand bend in the merge area. It is located within an 80km/h speed limit zone and is upstream of one of the busiest on-ramps on the Southern Motorway. The table below shows that lane utilisation at this approach is very even, with approximately 1/3, 1/3, 1/3 split throughout the day. The auxiliary lane at this intersection is considered to be operating at the ideal rate of utilisation, ie 33% of through traffic, as shown in table 5.6 below.

Table 5.6 Lane utilisation survey results at the SEART/Carbine Road intersection

Site	Ave through-lane use (%)			U/S short-lane length (m)	D/S merge length (m)	Total aux lane length (m)	SCATS/ Survey
	Aux lane	Middle	Right				
am peak	35.2	33.0	31.9	250	220	470	SCATS
pm peak	33.9	30.6	36.5				
Off-peak	33.0	31.0	36.0				

It is not immediately obvious why this particular auxiliary lane operates so effectively; however, the following factors probably contribute to its high rate of use:

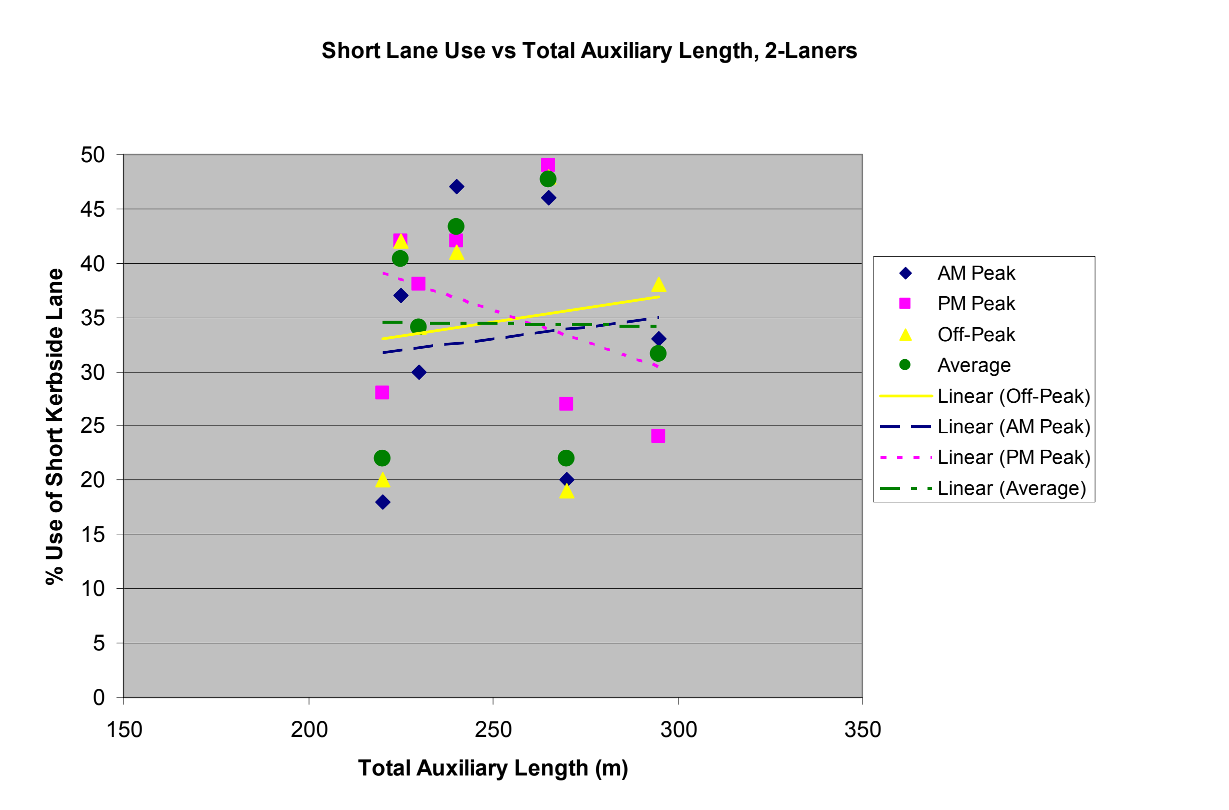
- Downstream of this intersection the turn off to SH1 northbound is on the right-hand side. This may encourage drivers who are heading to SH1 to use the right-hand lanes.
- The position on the right-hand side and the absence of side friction may in itself encourage more drivers to use the auxiliary lane.
- This intersection is heavily used throughout the day, and the relatively high levels of congestion may encourage better use of the auxiliary lane.

5.4 2-laners

A basic comparison was undertaken of the rate of use of the auxiliary lane to the total auxiliary length at seven 2-laner sites. An initial study found that lane under-utilisation was less of a problem at 2-laners which tended to display more variable rates of lane utilisation. This indicated there was potentially greater value in researching the high-volume situations where intersection capacity was a primary consideration, and consequently the research focused on 3-laners.

The relationship between the rate of use of the auxiliary lane and the total length of the auxiliary lane at each relevant 2-laner approach during the three peak periods (averaged over three days) is illustrated in the scatter plot below. Again, a best-fit trend line was added to each scatter plot to show more clearly the trend between the data. These results are tabulated and are included in appendix A.

Figure 5.15 Scatter plot for 2-laners showing short-lane use vs total auxiliary lane length, with trend lines added



In the case of the 2-laners, it is evident that a positive relationship exists between the length of the auxiliary through-lane and the rate of use of the auxiliary lane **only** during the am and off-peak periods. However, even these results show significant variability as evident by the wide ranging scatter, and it is difficult to justify drawing any sound conclusions from these results. During the pm peak period, the best-fit trend line has a negative slope indicating that the rate of use for the 2-laners decreases with increasing length. This result is not sensible as it is an unrealistic representation of how 2-laners operate, and can be attributed to the limited data set. More sites are needed to display a more defined pattern with significant results.

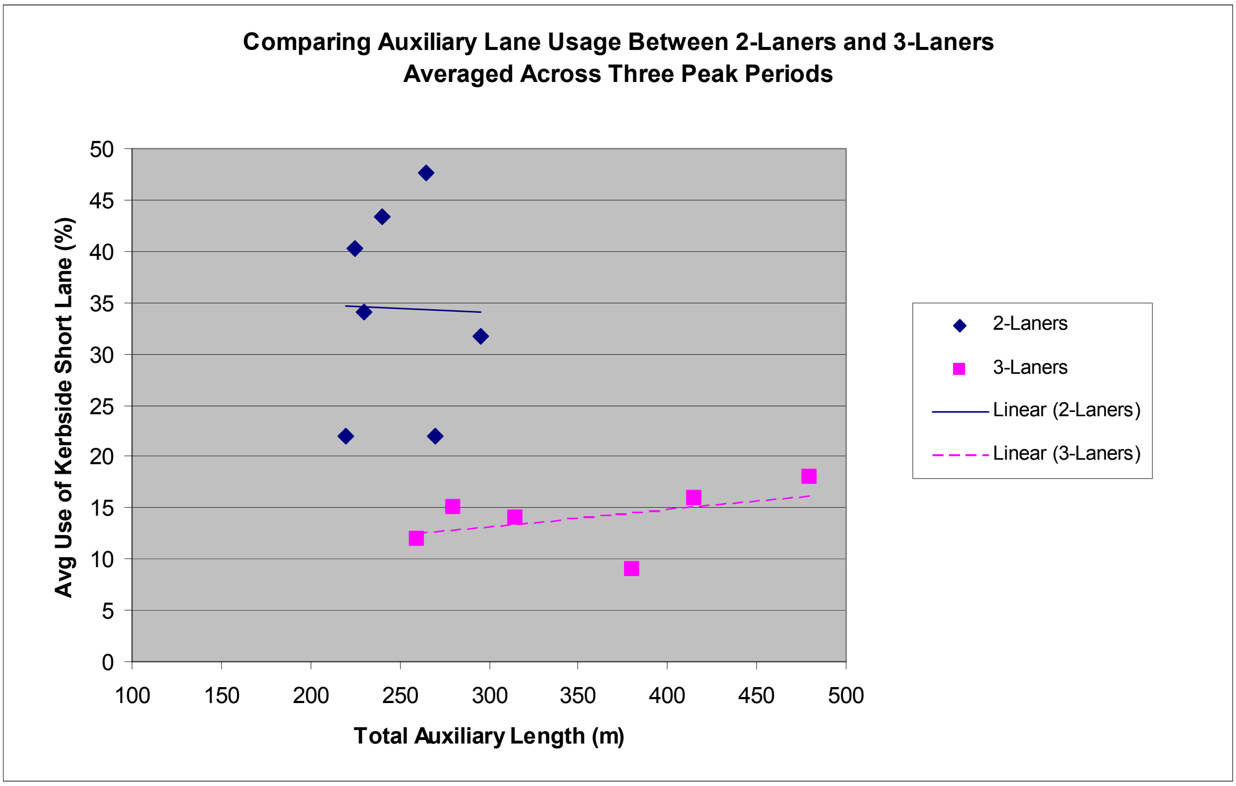
It should also be noted that the results for the 2-laners are more variable (utilisation values for the above data set range from 18% to 49%). This can be attributed to the fact that there is little choice with only two through-lanes available for drivers.

Because of the limited number of two-lane sites studied it is difficult to make comparisons between them, as location, posted speed limit and many of the outlined factors in chapter 3 could have a more significant influence on lane utilisation at 2-laners.

5.5 Comparison between 2-laners and 3-laners

The survey information collected at the 3-laners and 2-laners above was combined and a comparison made of the average rates of use of the auxiliary through-lane between the 3-laners and 2-laners. Figure 5.16 illustrates this relationship.

Figure5.16 Comparing short kerbside lane use between 2-laners and 3-laners



Based on this preliminary study sample, it can be seen that the average rate of use of the auxiliary lane at 2-laners is much higher than at 3-laners. In the case of 2-laners, higher usage rates are recorded for a considerably lower total length of auxiliary lane. Furthermore, for the sites included in this study, the optimum combined length of auxiliary lane required at 2-laners for even lane utilisation is approximately 250m, whereas 3-laners appear to require much longer auxiliary lanes. It would appear that use of the auxiliary lane at 2-laners is less dependent on length, as different lengths tend to display relatively high usage rates in all cases.

5.6 Comparing prediction methods for determining auxiliary lane utilisation rates

A basic comparison between field data and the formulae used in ARR123 and SIDRA was undertaken. This exercise was only carried out for the 3-laner sites and the results are included in table 5.7.

The utilisation rates based on the method in ARR123 were calculated using the following formula:

$$qT_1=qT/2n$$

where: qT_1 = the through-traffic flow in the under-utilised lane

qT = the total through-traffic flow

n = the number of lanes available for through traffic.

The utilisation rates based on the method in SIDRA were calculated using the following formula: -

$$R_{LU} = R_{LUm} + (100 - R_{LUm}) [(D_s - D_m) / ((D_{sf} - D_{sm})]^n$$

where

R_{LUm} = minimum downstream utilisation ratio

D_s = downstream short lane distance

D_{sm} = minimum downstream short lane distance

D_{sf} = 200m = downstream short lane distance for full utilisation (R_{LU} = 100%)

n = a model calibration parameter (1.2)

Table 5.7 Utilisation rate using the SIDRA equation (R_{LU}), ARR123 equation (qT_1) and field data

Intersection	D/S merge length (m)	Field (%)	ARR 123 qT_1 (%)	SIDRA R_{LU} (%)
Church St/O'Rorke Rd (west approach)	190	13	16.7	32
SEART/Waipuna Rd/Pakuranga HWay (west approach)	230	11	16.7	33
George Bolt Drive/Kirkbride Rd / SH20A (south approach)	280	18	16.7	33
Mt Eden Rd/Balmoral Rd (east approach)	180	10.6	16.7	31
Sandringham Rd/Balmoral Rd (east approach)	230	15	16.7	33
Sandringham Rd/Balmoral Rd (west approach)	135	15	16.7	24

Based on the above investigation it can be seen that the formula used in SIDRA to account for the effects of lane under-utilisation greatly overestimates the actual utilisation. SIDRA assumes that a downstream short-lane distance of 200m will correspond to full utilisation of that lane; however, it can be seen from the field data that the highest utilisation rate of the kerbside auxiliary lane was just 18% regardless of the length of that lane. This implies that the default values used in the lane utilisation relationship are not well suited for New Zealand conditions and that the values need to be calibrated against field data here in New Zealand. The equation used by Akçelik (1995) in ARR123 is more reflective of how short auxiliary lanes, in the case of 3-laners, are used in New Zealand.

6 Towards developing a model for predicting lane utilisation

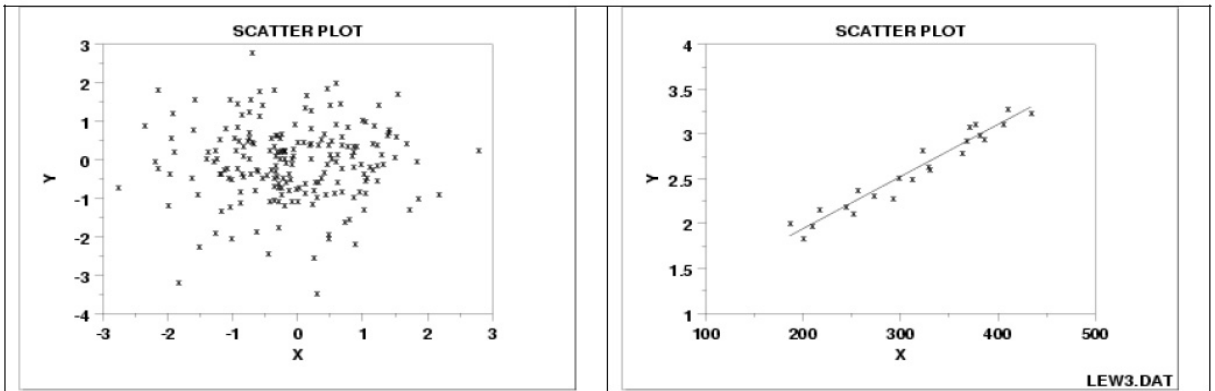
As the research results in this area expand and a reliable technical database is developed, a likely outcome could be a prediction model that estimates lane utilisation for varying intersection configurations. With a lane utilisation prediction model based on a statistically significant technical database of actual site data, and also having a more clear understanding of the factors that influence lane utilisation, practitioners would be able to more accurately predict lane utilisation when undertaking major intersection improvements. Current analytical traffic models such as SIDRA overestimate the actual utilisation rate of short auxiliary lanes. A more accurate prediction of lane usage for a range of design layouts would enable a more representative simulation of the proposed improvements. This would avoid possible under-design and consequently, a shorter economic life of the infrastructure.

When investigating the effects of all factors, candidate sites must be carefully selected to ensure enough information is collected about each. Based on the geometric and traffic volume data collected practitioners should identify as many factors as possible that affect lane utilisation. Taking into consideration the sample sites of this study, for example, 13 factors influencing the rate of utilisation of auxiliary lanes have been listed and explained in chapter 3.

The first step towards developing a model for predicting lane utilisation is to use statistical tests such as scatter plots to examine the relationship between the dependent variable, Y (lane utilisation factor), and the independent or explanatory variables, X (various factors that contribute to lane under-utilisation and influence the dependent variable).

Since the analysis would include a number of variables, typical correlation tests would first need to be conducted to test the association or strength of the explanatory variables to lane utilisation. A large enough sample of each of the factors under consideration would be required to enable a robust statistical assessment of the relationship between the explanatory and dependant variables. The figure below shows an example of a scatter plot suggestive of a strong linear relationship (positive correlation) and one showing no relationship between the dependent and explanatory variable.

Figure 6.1 Example of typical scatter plots



No relationship	Strong Linear (positive correlation) Relationship

At this stage all variables should be screened and only those that exhibit a strong enough association to the dependent variable should be included in further analysis. However, careful consideration must be given to the possible problem of multi-collinearity when there are many independent variables. Multi-collinearity occurs when there is a high correlation between the explanatory variables and they are thus not independent and cannot be resolved uniquely. This means that these variables are likely to influence the dependent variable considerably though they may not be significant. The overall correlation matrix must be checked and the appropriate multi-collinearity tests done to ensure the highly correlated variables are excluded as necessary.

Next, based on the variables that qualified in the above step, stepwise regression consisting of forward selection and backward elimination should be conducted to assist with choosing those factors to include in the multiple regression model. A multiple regression model, simply put, incorporates two or more explanatory variables in a prediction equation. Forward stepwise regression starts with no variables in the model. At each step it adds the variables that are most statistically significant one by one, until there are none left. Backward stepwise regression starts with all possible variables in the model and removes the least significant variables, one by one, leaving behind only the statistical significant ones – completion of this process is identified once any further elimination does not change the fit of the model.

An important assumption behind the above method is that some input variables in a multiple regression model do not have an important explanatory effect on the response. In this case, it is convenient to simplify the model by keeping only the statistically significant variables.

Once the variables have been screened and short-listed by the above method, the model is examined using residual plots, which reveal inadequacies in the model. Lastly, model transformation is applied which allows the analyst to transform the model to linearity, ie approximating a linear relationship between the dependent and explanatory variables.

The statistical tests described above provide the factors that are most likely to influence lane utilisation and determine the likely weighting of each factor. The multiple linear regression model developed could be used to predict lane utilisation for various intersection configurations. This means that lane utilisation rates would be a function of the most significant variables, where actual operational data has been obtained. Separate prediction models would have to be developed for 3-laners and 2-laners because, as already outlined in this study, these configurations are innately different from each other. The typical form of a multiple linear regression model is illustrated below:

$$Y = a + bX + cY + dZ$$ [1]

Where:

Y = dependent variable (lane utilisation)

a = constant (determined by regression analysis)

X, Y, Z = explanatory variables (determined by screening and sensitivity testing)

b, c, d = coefficient of explanatory variables (determined by regression analysis)

[1] Based on the standard multiple linear regression equation contained in the University of Auckland (2005) Civil 762 transport planning handout notes, chapter 6.

The coefficient of determination (R2) for each equation must also be determined to test the relationship between the explanatory variables and the response variable. This ranges between 0 and 1, and the closer the R2 value is to 1 the stronger the relationship. Once the models have been developed, predicted lane utilisation rates can then be compared to the actual lane utilisation rates observed on site, to further test the accuracy of the prediction model.

It should also be noted that the logic of the model should be examined to determine if it produces sensible results. If a linear model proves unrealistic, a hyperbolic tangent curve can be applied in the model to see if it reflects lane utilisation rates more effectively.

7 Measures to improve lane utilisation

7.1 Introduction

This study has indicated that increasing the length of auxiliary lanes provides some improvements in lane utilisation. Results show that a 100m increase in lane length will improve lane utilisation by 1.4%. Increasing lane length is very costly and often restricted by land acquisition and environmental constraints, and is unlikely to achieve a positive benefit-cost ratio. Road controlling authorities are receiving strong messages from NZTA to employ cost-effective measures to improve network operation and ultimately ease congestion. This requires better management of existing infrastructure, without the need for intrusive road works. The four alternative treatments suggested in this chapter are closely aligned with these overall principles.

These treatments could also be rolled out on a network-wide basis, which is likely to result in collective benefits across the network that would be economically viable. It is recommended that a trial be undertaken, followed by a road safety audit, to measure the effectiveness of each alternative treatment. The alternative treatments are explained further in section 7.2.

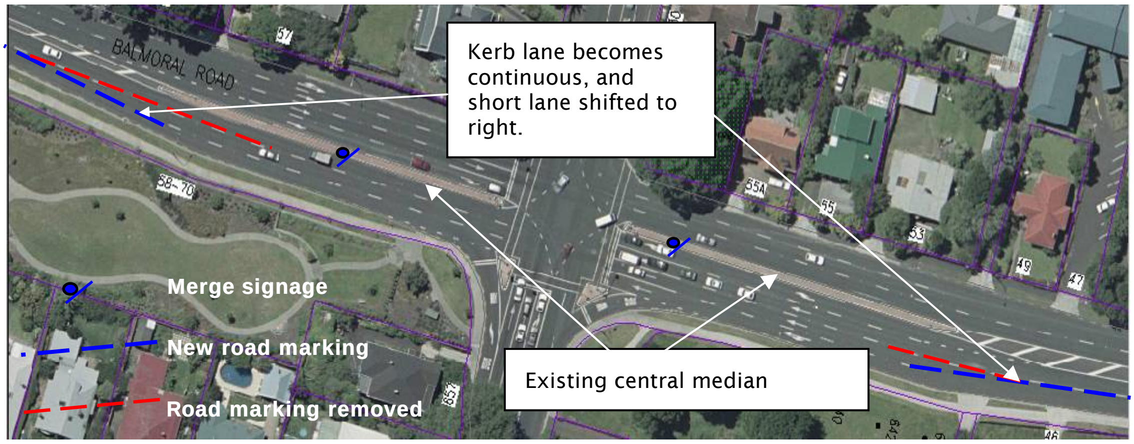
7.2 Alternative treatments

7.2.1 Auxiliary lane on the right

This treatment was originally suggested in Royce et al (2006) and outlined in chapter 2. The commonly adopted convention at multiple-lane intersections with auxiliary lanes is to merge the two through-lanes from the left. The proposed treatment essentially swaps the more conventional merge from the left to merging the two through-lanes from the right-hand side instead. Vehicles in the extreme right-hand through-lane would therefore be required to merge with the middle through-lane. In doing this, the upstream short lane would also be shifted from the left- to the right-hand side. This would be achieved by simply reconfiguring the existing road marking. This alternative treatment was suggested as a trial because of the high rate of lane utilisation observed at the SEART/Carbine Road intersection, where the utilisation rates are approximately 1/3, 1/3, 1/3.

Figure 7.1 illustrates how the existing lane configuration at a 3-laner intersection can be manipulated to change the merge to the right.

Figure 7.1 Reconfiguring the lane arrangement of a 3-laner intersection



As can be seen from figure 7.1, this treatment is only suited to 3-laners or larger intersections. The principle behind this technique is to make the approach kerbside lane feed directly into the otherwise under-utilised kerbside lane at the intersection with a continuous downstream lane. No merging would be required at the downstream kerbside lane, thereby encouraging higher use of this lane. Drivers also tend to avoid using kerbside lanes for the numerous reasons outlined in chapter 3, and are more inclined to use the right-hand lanes instead. With vehicles being directed into the kerbside lane, and driver tendencies to use the right-hand lane, it is expected that more even rates of lane utilisation can be achieved.

It is possible that this measure may transfer lane under-utilisation from the left lane to the right lane. However, given that driver behaviour in terms of lane choice is a significant factor in lane utilisation, this is not expected to eventuate, as most drivers tend to use the right-hand lanes, as illustrated in the SEART/Carbine Road example. This treatment seeks to capitalise on these behavioural patterns, to achieve a more even distribution of traffic in the available through-lanes.

As this layout is somewhat unusual and drivers may not be expecting the merge on the right, safety could be an issue. Furthermore, if there are any vehicle conflicts in the merge area on the right then there is a higher risk of errant vehicles colliding head-on with on-coming traffic. However, this problem could be overcome by designing merges long enough to allow vehicles to merge safely. A solid median island could also be installed with additional merge signage to further safeguard against possible head-on collisions. Therefore, if the proposed layout were designed correctly and safely, then this type of configuration could operate safely and possibly improve lane utilisation at substantially lower cost than major road works. The effectiveness of this proposal could be determined by trialling this arrangement, and monitoring the SCATS counts over a period of months.

7.2.2 Advance lane designation signage and road marking

Driver perception, and in some cases misinformation about the road layout ahead, contribute to lane under-utilisation. Advance lane designation signage and road marking, similar to that provided on George Bolt Memorial Drive (see figure 7.2), would therefore serve to encourage use, as well as inform drivers that the short through-lane is available. Often visibility from the back of queues to the downstream side of the intersection is restricted by a vertical crest curve or horizontal bend. Drivers are unable to see what lanes are provided downstream, assume that conditions are undesirable and opt to use the full lanes instead.

Figure 7.2 Example of overhead lane signage, George Bolt Memorial Drive, Manukau

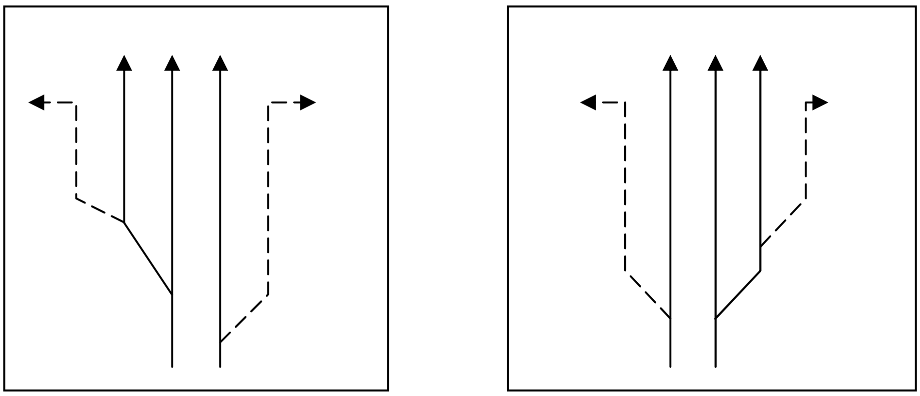
Advance signage and road marking would inform drivers of the road layout ahead and could encourage use of the short lane. Overhead lane designation signage is likely to be the most effective treatment, and is preferred, mainly because it would ideally be located above the lanes and easily understood by drivers. These signs would be located at a point upstream of the intersection where the auxiliary lane flares out to full width. At this point the designation of each lane would be signed directly above the lanes. Figures 7.3 and 7.4 illustrate examples of overhead lane designation signs used in Australia and the US.

Figure 7.3 Example of overhead lane use in Australia

Figure 7.4 Example of overhead lane use signage and road marking in the US

However, careful consideration must be given to the location of these signs as they could block overhead traffic signals at the intersection. The gantry sign supports are also expensive and are not, due to their aesthetic impact, appropriate for all locations. Alternatively, map type roadside signs could be used if overhead signs are not appropriate. Figure 7.5 illustrates an indicative lane arrangement that could be represented on a roadside type map sign providing information about the road layout ahead.

Figure 7.5 Possible advance sign designs for the merge-from-left and merge-from-right situations



The above roadside sign layout examples could be designed similar to the UK examples shown in figures 7.6 and 7.7. In addition to this they could be mounted overhead to provide advanced directional guidance at busier intersections, similar to the sign shown in figure 7.8.

Figure7.6 Typical UK motorway advance direction sign

Figure7.7 Typical UK primary route advance direction sign

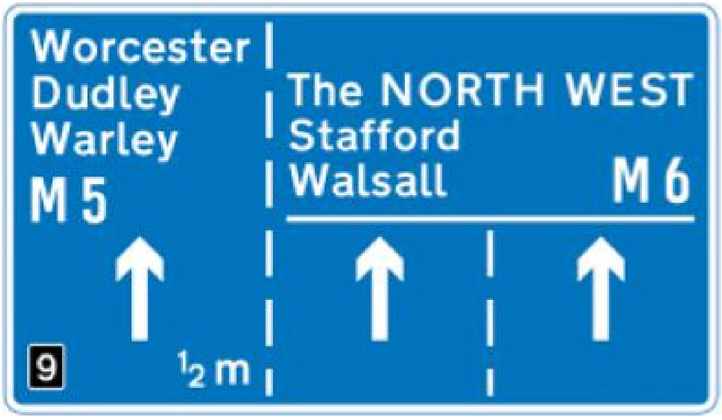


Figure7.8 Overhead advance directional signs in Auckland

Advance arrow road markings could also be included to further complement the advance lane designation signage. This option is useful where there is a short kerbside auxiliary lane with a downstream merge and could also be implemented in conjunction with the merge-from-right measure as discussed above. It is recommended that a trial site be set up to assess the safety and operational efficiency of this alternative treatment. The trial should include a public survey of sign options to determine how these would be perceived by road users; and hence help ascertain the most effective option. This alternative treatment is considered to be the least costly option for improving lane utilisation.

7.2.3 Converting auxiliary lanes into bus or transit lanes

A number of the 3-laner sites studied in this research were found to have poor utilisation rates. The auxiliary lane can increase the size of the intersection but add little to capacity. Where the auxiliary lane is located on a bus route, such as Balmoral Road, consideration should be given to converting it into a bus or transit lane. An analysis should be undertaken based on 'person throughput' at the intersection, using actual lane utilisation rates, to determine the most appropriate treatment. This could provide benefits by making the intersection more efficient by increasing person throughput and it would encourage bus usage and car sharing.

7.2.4 Phasing and cycle times

Low utilisation of the approach lanes leads to low saturation flow rates which in turn results in reduced capacity. One method of addressing this is to shorten the cycle time to improve utilisation of the auxiliary lane. In Auckland, SCATS extends the phase time based on maximum degree of saturation on any given approach. SCATS can be set to extend the green time based on the average degree of saturation of the approach, which would result in a shorter cycle time and may encourage an increase in lane utilisation. The shorter cycle time would also have the benefit of reducing delays for pedestrians and could result in reduced average traffic delays at the intersection. However, should drivers continue to under-utilise the auxiliary lane then this could result in reduced capacity at that approach.

7.3 Recommendation of a trial site

7.3.1 Introduction

It is recommended that two of the alternative treatments discussed above, ie the 'auxiliary lane on the right' and the 'advance lane designation signage' are carried out as a trial to determine how effective they are in influencing the rate of use of auxiliary lanes. The objective of the trial would be to identify measures that result in a more even distribution of lane utilisation, and therefore more efficient intersection operation.

The advance lane designation signage has been selected for trial because if it is successful at improving lane utilisation then it would be one of the more cost-effective measures. The auxiliary lane on the right treatment would also be adopted for the trial site as traffic volumes analysed for the northbound approach at Carbine Road/SEART intersection show that traffic is distributed fairly equally between the three approach lanes. The short right-hand approach lane has an average utilisation rate of 34%. These results imply that the short right-hand merge arrangement encourages more evenly distributed flows. Conducting the trial would help to further understand whether the establishment of right-hand short through-lanes would increase the utilisation of short lanes.

However, each treatment would have to be trialled separately to measure its effectiveness. Also, to assess whether each trial was successful, before and after traffic surveys would need to be carried out to determine the net increases on lane utilisation rates.

The trial is considered to be a valuable exercise as both treatments would be representative of potentially low-cost improvement to increase lane utilisation at signalised intersections.

7.3.2 Selection of trial site

The Mt Eden Road/Balmoral Road intersection has been identified as the best site to trial. The existing rate of utilisation of the short kerbside lane during the 'peak one hour' is 15% with an average rate of use of 10.6%. Lane utilisation at this particular site is likely to have little or no influence from downstream destinations and it is located within a 50km/h speed limit area.

7.3.3 Trial methodology

The following should be measured/quantified before and after the trials to determine how effective the treatments are at improving lane use, and to ensure that road safety is not compromised:

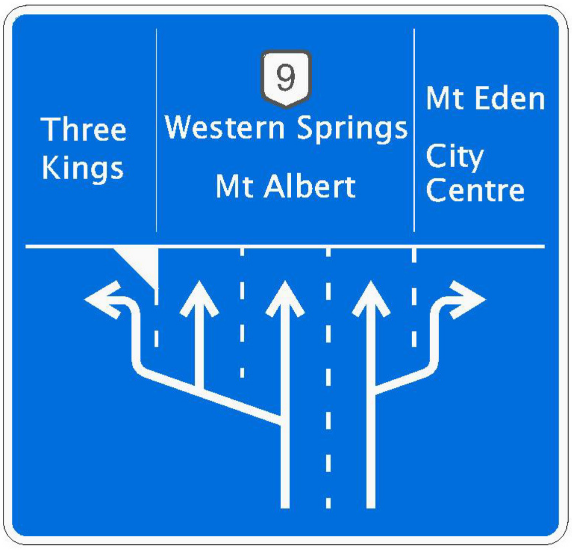
- The rate of use – assessed using SCATS count data to determine how influential the new arrangement is on lane utilisation.
- Safety – assessed using video surveys to determine if the change is likely to create any safety issues.
- Headway – taken from SCATS, to ensure that the change in lane arrangement does not result in an increase in headway that could impact negatively on the capacity of the intersection.

The trial should be carried out in two stages:

Stage 1 - Advance lane designation sign

- Design a sign in accordance with the guidelines in the *Manual of traffic signs and markings* (MOTSAM) (NZTA 2009), which provides information about the road layout at the intersection. A possible sign layout for this trial is provided below.

Figure7.9 Possible trial ADS layout



- Trial the effectiveness of the sign's message by conducting a survey of a sample of drivers to ensure that the sign can be interpreted quickly, eg walk around with an illustration of the sign and ask the general public what they perceive.
- Manufacture the sign and place on site in accordance with MOTSAM requirements. Ensure that the sign does not restrict driver visibility.
- Record the lane utilisation using SCATS. The duration of this trial would be at least three months.

Stage 2 – Auxiliary lane on the right

- Design a revised roadmarking arrangement that has the auxiliary lane on the right-hand side, similar to the SEART/Carbine Road site, which operates with very evenly distributed lane utilisation.
- Obtain approval from the corresponding road controlling authority.
- Conduct a road safety audit of the proposed layout.
- Cover existing roadmarkings and install new road marking layout. This can be done using temporary roadmarkings.
- Install temporary warning signage to warn drivers of layout change.
- Record lane utilisation using SCATS.
- Monitor the site using a video camera to observe the operation of the merge area and to check for vehicles encroaching into the flush median.
- The duration of this trial would be three months.

7.4 Draft auxiliary lane design guide

The widely varying rates of auxiliary lane utilisation indicate that intersection design has a strong influence over this aspect of the operation. A draft auxiliary lane design guide has therefore been prepared that brings together guidelines and learnings from this study. The design guide provided below is a starting point and further research would lead to refinements and additional evidence to back up guidance.

Table 7.1 Draft auxiliary lane design guide

Factor	Guidance	Source of guidance	Comments
Approach lane length	'The lane should commence far enough in advance of the intersection to accommodate a queue length that will enable saturation flow to be maintained across the stop line for the duration of the green time.'	Austroads: Guide to road design – part 4A: unsignalised and signalised intersections	This does not consider how long an auxiliary lane needs to be to make it an attractive and convenient option for drivers to fully use. Further research is required.

Factor	Guidance	Source of guidance	Comments
Departure lane length	'It is important that the departure lane is long enough to enable the capacity of the approach lane to be utilised. In order to satisfactorily discharge a queue similar to that described, it is suggested that the length of the parallel departure lane should be based on about 4s to 6s of travel time at the operating speed of the through-lane plus a taper length'	Austroads: Guide to road design – part 4A: unsignalised and signalised intersections	
Length of diverge taper /approach alignment	'For a through-lane the physical diverge taper on the approach should be based on a lateral rate of movement of 1.0m/sec'	Austroads: Guide to road design – part 4A: unsignalised and signalised intersections	
Length of merge	'The merge taper on the departure should be calculated on the basis of a lateral rate of movement of 0.6 m/sec.'	Austroads: Guide to road design – part 4A: unsignalised and signalised intersections	
Shared lanes	Site specific, however, where possible this should be avoided as turning traffic will delay through traffic, thus discouraging lane usage. This will pose a greater problem where turning movements are signalised separately to through movements.	Author experience	
Traffic volumes and congestion	Studies show that increased traffic volumes and congestion can encourage better usage of kerbside lanes. This is likely to contribute to drivers accessing the auxiliary lane to ensure that they proceed through the intersection in the minimum number of traffic signal cycle times. It is also possible that lane utilisation at off-peak times by adjusting traffic signal phasing at the intersection	Author experience	It is acknowledged that improving lane utilisation during off-peak times will be low priority, and that intersections are generally designed to cater for peak-hour traffic demands.
Lane blockage	Studies show that downstream queuing can have a significantly detrimental effect on lane utilisation. This cannot be mitigated through improved design, but downstream blockages should be avoided whenever possible.	Current research	
Sight distance	Ensure that the alignment and lane arrangement is visible to approaching motorists from approach sight distance (ASD) in advance of the diverge.	Author experience	

Factor	Guidance	Source of guidance	Comments
Lane width	Austroads minimums	Austroads: Guide to road design – part 3: geometric design	
Queue forming an obstruction	Design based on signal analysis to assess the potential for the queue in the adjacent through-lane to block access to the added short through-lane.	Austroads: Guide to road design – part 4A: unsignalised and signalised intersections	
Downstream destinations	Short lane on the side of the destination, ie if there is a significant destination on the right, put short lane on the right side.	Hypothesis	Further research required. The safety implications of installing the auxiliary lane on the right-hand side should be assessed on a site-by-site basis.
Side friction	Install the short lane away from the side friction, ie if there is side friction on the left side due to parallel parking, install the auxiliary lane on the right-hand side.	Hypothesis	
Proportion of HCVs	If the majority of HCVs use the left lane then install the auxiliary lane on the right side.	Hypothesis	

8 Conclusions

The rate of lane utilisation across multiple-lane approaches at signalised intersections is often uneven, reducing intersection efficiency and capacity. This study investigated kerbside through-lane utilisation at 2-laners and 3-laners and identified at least 13 different factors that were likely to have an influence on lane utilisation. Based on experience and observations the most important factors were:

- short auxiliary lane length
- shared lanes
- lane blockage
- side friction caused by parking and driveways close to the intersection.

It was hypothesised that where auxiliary lanes were provided to increase intersection capacity, the length of these lanes was the main contributory factor to lane under-utilisation. This study therefore investigated the effect of short auxiliary through-lane lengths on utilisation of these lanes.

A sample of 13 sites (seven 2-laners and six 3-laners) were analysed in this study. The intersections chosen for each of the study sites were limited to one category, ie short upstream and downstream lanes with exclusive left- and right-turn lanes. In ideal circumstances the rate of use of each lane would be equal, therefore being 50% in the 2-laner scenario and 33% for 3-laners.

Analysis of lane usage rates showed that in the majority of situations, the utilisation of short lanes was far below the ideal rate. When short kerbside through-lane utilisation rates were compared between 2-laners and 3-laners, the 2-laners had a higher use of the kerbside through-lane than 3-laners, for considerably shorter lengths of auxiliary lane. Utilisation rates for short lanes in the 2-laner situation ranged between 18% and 49%, averaging about 34% across all sites. Utilisation rates at 3-laners ranged between 7% and 19%, averaging approximately 14%.

Based on the data obtained from the sample sites, utilisation of 3-laner auxiliary lanes was found to be reasonably close to the ARR123 prediction model (=q/12, see section 2.2.2), which equates to approximately 17%. However, this model did not correspond closely to the traffic count results in the 2-laner situation.

The results of the study showed a positive relationship between lane length and utilisation; however, this was not found to be a strong link. Increasing auxiliary lane length only resulted in minor improvements in lane utilisation. Results indicated that a 100m increase in total lane length would improve lane utilisation by 1.4% on average for 3-laners. Based on the sample analysed in this study, the conclusion was that increasing the total upstream and downstream length of the short kerbside through-lane was likely to result in only marginally higher rates of use for both 2-laners and 3-laners

Further analysis was undertaken to try to identify a relationship between lane utilisation rates and either the upstream or downstream lane length for 3-laners. The investigation revealed that the downstream lane length had a marginally stronger influence on the use of the auxiliary lane. This was as expected; however, the results were not conclusive and due to the small sample size, it was not possible to isolate the influence of the length of upstream from downstream lane lengths.

The study also looked at how use of the auxiliary lane varied with traffic demand. This was done by plotting the lane utilisation by time of day. The profiles obtained clearly showed that in most cases the utilisation rate of the auxiliary lanes increased during peak times.

An investigation into how SIDRA estimated lane utilisation showed that this intersection analysis software tended to significantly overestimate actual utilisation. In order to model lane use closely it would be necessary to manually adjust the lane utilisation rates, but failure to do so could easily lead to an overestimation of the benefits attributable to intersection upgrades. Many practitioners are unaware of this problem and use default values, overestimating intersection capacity.

This study identified at least 13 different factors likely to have an influence on lane utilisation. It was therefore impossible to identify the proportion of the influence of each of these factors due to the relatively small number of sample sites available in New Zealand. More extensive research with a larger and more diverse sample is therefore strongly recommended. This would enable the scale of the effect of short through-lanes, as well as the other main factors, to be more accurately assessed.

Key conclusions include:

- Previous study looked at comparing peaks, ie am with am and pm with pm. We found each intersection had differing peaks (because of tidal flow) and it was more realistic to determine the actual peak of each intersection and compare the ‘intersection peaks’ for each sample.
- The relationship between use and length was found not to be as strongly correlated as indicated by earlier studies.
- If SIDRA had been used, and default values applied, to estimate capacity for each of the sites analysed in this report, lane utilisation of the auxiliary lanes would have been significantly overestimated in all but one case.

8.1 Recommendations

8.1.1 Improving lane utilisation rates – recommended trials

Alternative methods of improving lane utilisation by way of road marking and/or advance lane designation signage are also suggested in this report. It is recommended that these treatments be further investigated and a trial implemented to measure their actual effectiveness and safety implications. The trial should be conducted in two stages:

- Stage 1: Install signage that communicates lane arrangements to drivers on the approach to the intersection.
- Stage 2: Relocate the auxiliary lane from the left-hand side over to the right-hand side by reconfiguring the roadmarking.

In certain specific circumstances, converting short lanes into bus or T3 lanes may provide benefits to road users. This option would need to be assessed in terms of person delays rather than the traditional assessment of vehicle delays. One potential trial site is Mt Eden Road/Balmoral Road on the northbound Mt Eden Road approach.

It is also possible that lane utilisation could be improved by adjusting traffic signal phasing at intersections. There is opportunity to improve overall intersection efficiency at a street network level by including improvements to lane utilisation with other routine intersection capacity improving techniques, such as signal coordination and optimisation.

8.1.2 Further research

The number of sites with short though-lanes in New Zealand is limited, and the sample size used in studies to date is less than satisfactory. It is therefore recommended that further research be undertaken to include sites from Australia, since traffic characteristics and operation are similar to New Zealand. If a large enough sample is identified it may be possible to develop a prediction model that can be used for assessing the operation of proposed intersection improvements that include auxiliary lanes.

A draft design guide for auxiliary lanes has been developed and is provided in section 7.4 of this report. As illustrated in table 7.1 there are factors in the draft design guide that do not have a confirmed source and are based on anecdotal evidence and/or author experience. This draft design guide should therefore be further developed based on trials and/or wider research. The design guide aims to mitigate some of the factors affecting lane utilisation listed in section 3.2 and could also include suggestions for alternative trials.

9 References

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Appendix A

Relevant information for each site is collated in the following order by site:

- aerial
- SCATS graphic
- count data.

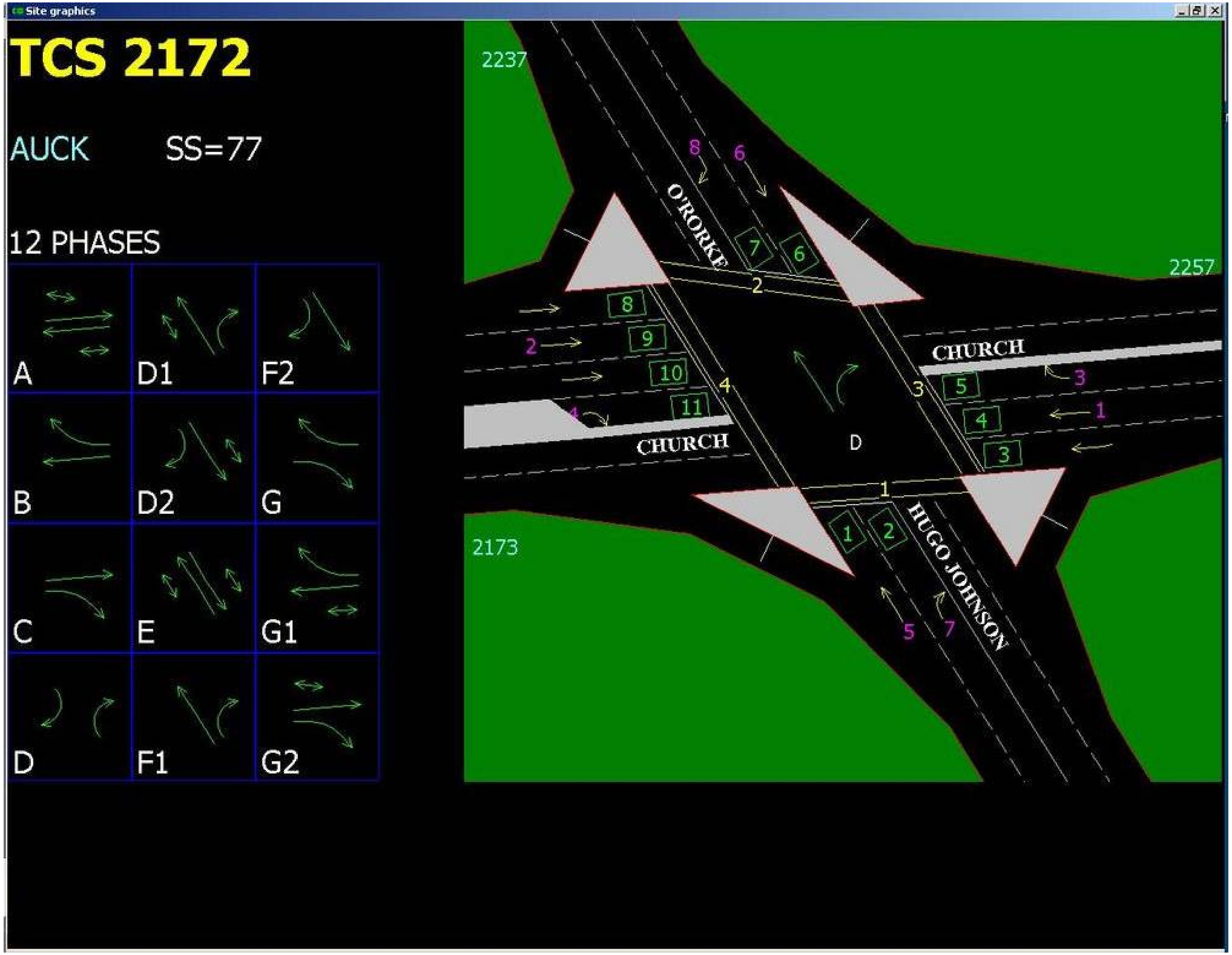
3-laners

Lane utilisation survey results at the 3-lane sample sites

Site	Ave through-lane use (%)			U/S short lane length (m)	D/Sm merge length (m)	Total aux lane length (m)	SCATS survey
	Aux lane	Middle	Right				
am peak							
Church St/O'Rorke Rd (west approach)	13	41	46	90	190	280	Survey
SEART/Waipuna Rd/Pakuranga Hway (west approach)	15	42	44	150	230	380	Survey
George Bolt Drive/Kirkbride Rd/SH20A (south approach)	19	36	45	200	280	480	SCATS
Mt Eden Rd/Balmoral Rd (east approach)	8	43	49	80	180	260	SCATS
Sandringham Rd/Balmoral Rd (east approach)	16	38	46	185	230	415	Survey
Sandringham Rd/Balmoral Rd (west approach)	18	35	47	180	135	315	Survey
pm peak							
Church St/O'Rorke Rd (west approach)	15	44	41	90	190	280	Survey
SEART/Waipuna Rd/Pakuranga HWay (west approach)	9	46	45	150	230	380	Survey
George Bolt Drive/Kirkbride Rd/SH20A (south approach)	19	37	44	200	280	480	SCATS
Mt Eden Rd/Balmoral Rd (east approach)	13	42	45	80	180	260	SCATS
Sandringham Rd/Balmoral Rd (east approach)	16	37	48	185	230	415	Survey
Sandringham Rd/Balmoral Rd (west approach)	15	39	46	180	135	315	Survey
Off-peak							
Church St/O'Rorke Rd (west approach)	13	39	48	90	190	280	Survey
SEART/Waipuna Rd/Pakuranga HWay (west approach)	10	43	46	150	230	380	Survey
George Bolt Drive/Kirkbride Rd/SH20A (south approach)	17	38	45	200	280	480	SCATS
Mt Eden Rd/Balmoral Rd (east approach)	11	38	51	80	180	260	SCATS
Sandringham Rd/Balmoral Rd (east approach)	14	37	49	185	230	415	Survey
Sandringham Rd/Balmoral Rd (west approach)	13	28	40	180	135	315	Survey

Site 1: Church Street/O'Rorke Road

Church Street / O'Rorke Road (west approach)


Site graphics
TCS 2172
AUCK
SS=77
12 PHASES
A
D1
F2
B
D2
G
C
E
G1
D
F1
G2
2237
2257
2173
O'RORKE
CHURCH
CHURCH
HUGO JOHNSON

Appendix A

SCATS count during period 27 July 2009 - 31 July 2009
Church Street / O' Rorke Rd

Detectors 8, 9 & 10

Mon 27 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:15 - 7:30	49	127	157	15%	38%	47%
7:30 - 7:45	49	147	154	14%	42%	44%
7:45 - 8:00	45	157	154	13%	44%	43%
8:00 - 8:15	38	159	135	11%	48%	41%
Total	181	590	600	13%	43%	44%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
12:00 - 12:15	38	111	129	14%	40%	46%
12:15 - 12:30	41	93	108	17%	38%	45%
12:30 - 12:45	47	90	122	18%	35%	47%
12:45 - 13:00	57	137	173	16%	37%	47%
Total	183	431	532	16%	38%	46%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
4:30 - 4:45	55	172	176	14%	43%	44%
4:45 - 5:00	65	136	168	18%	37%	46%
5:00 - 5:15	71	165	162	18%	41%	41%
5:15 - 5:30	58	189	158	14%	47%	39%
Total	249	662	664	16%	42%	42%

Tues 28 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:15 - 7:30	48	145	150	14%	44%	45%
7:30 - 7:45	44	163	158	13%	47%	45%
7:45 - 8:00	47	166	166	13%	47%	47%
8:00 - 8:15	50	176	145	15%	53%	44%
Total	189	650	619	14%	47%	45%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
12:00 - 12:15	44	121	136	16%	44%	49%
12:15 - 12:30	60	115	138	25%	48%	57%
12:30 - 12:45	55	111	122	21%	43%	47%
12:45 - 13:00	56	130	143	15%	35%	39%
Total	215	477	539	19%	42%	47%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
4:30 - 4:45	68	187	180	17%	46%	45%
4:45 - 5:00	77	148	159	21%	40%	43%
5:00 - 5:15	79	190	151	20%	48%	38%
5:15 - 5:30	61	178	154	15%	44%	38%
Total	285	703	644	18%	45%	41%

Wed 29 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:15 - 7:30	43	119	139	14%	40%	46%
7:30 - 7:45	46	165	131	13%	48%	38%
7:45 - 8:00	58	200	215	12%	42%	45%
8:00 - 8:15	50	159	153	14%	44%	42%
Total	197	643	638	13%	44%	43%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
12:00 - 12:15	58	132	164	16%	37%	46%
12:15 - 12:30	67	139	190	17%	35%	48%
12:30 - 12:45	61	142	162	17%	39%	44%
12:45 - 13:00	57	151	162	15%	41%	44%
Total	243	564	678	16%	38%	46%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
4:30 - 4:45	53	171	177	13%	43%	44%
4:45 - 5:00	69	173	174	17%	42%	42%
5:00 - 5:15	64	179	156	16%	45%	39%
5:15 - 5:30	62	189	149	16%	47%	37%
Total	248	712	656	15%	44%	41%

Thurs 30 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:15 - 7:30	43	109	127	14%	36%	42%
7:30 - 7:45	44	158	147	13%	46%	43%
7:45 - 8:00	65	187	151	14%	40%	32%
8:00 - 8:15	39	157	130	11%	43%	36%
Total	191	611	555	13%	41%	38%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
12:00 - 12:15	48	116	143	14%	33%	40%
12:15 - 12:30	49	124	159	12%	31%	40%
12:30 - 12:45	42	130	134	12%	36%	37%
12:45 - 13:00	52	122	136	14%	33%	37%
Total	191	492	572	13%	33%	39%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
4:30 - 4:45	72	176	159	18%	44%	40%
4:45 - 5:00	61	145	175	15%	35%	42%
5:00 - 5:15	70	163	158	18%	41%	40%
5:15 - 5:30	68	175	168	17%	44%	42%
Total	271	659	660	17%	41%	41%

Fri 31 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:15 - 7:30	36	123	148	12%	40%	48%
7:30 - 7:45	52	145	158	15%	41%	45%
7:45 - 8:00	43	172	176	11%	44%	45%
8:00 - 8:15	37	170	116	11%	53%	36%
Total	168	610	598	12%	44%	43%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
12:00 - 12:15	40	144	154	12%	43%	46%
12:15 - 12:30	45	146	156	13%	42%	45%
12:30 - 12:45	46	129	158	14%	39%	47%
12:45 - 13:00	50	127	168	14%	37%	49%
Total	181	546	636	13%	40%	47%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
4:30 - 4:45	61	162	176	15%	41%	44%
4:45 - 5:00	62	159	167	16%	41%	43%
5:00 - 5:15	64	174	168	16%	43%	41%
5:15 - 5:30	66	137	166	18%	37%	45%
Total	253	632	677	16%	40%	43%

Site 2: SEART/Waipuna Road/Pakuranga Highway

South Eastern Highway/Pakuranga Highway/Waipuna Road (west approach)


Site graphics
TCS 2260
AUCK
SS=147
2 PHASES
A
B
2182
WAIPUNA RD
3
7
6
WAIPUNA RD
2
5
4
1
2
3
1
A
SOUTH EASTERNN HWY
2259

SCATS count during period 27 July 2009 - 31 July 2009
SEART / Waipuna Road

Detectors 1, 2 & 3

Mon 27July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
8:00 - 8:15	36	112	127	13%	41%	46%
8:15 - 8:30	46	115	100	18%	44%	38%
8:30 - 8:45	30	106	99	13%	45%	42%
8:45 - 9:00	17	115	103	7%	49%	44%
Total	129	448	429	13%	45%	43%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
12:00 - 12:15	24	155	135	8%	49%	43%
12:15 - 12:30	15	151	148	5%	48%	47%
12:30 - 12:45	32	131	139	11%	43%	46%
12:45 - 13:00	27	153	141	8%	48%	44%
Total	98	590	563	8%	47%	45%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
15:45 - 16:00	43	242	240	8%	46%	46%
16:00 - 16:15	47	305	309	7%	46%	47%
16:15 - 16:30	63	338	273	9%	50%	41%
16:30 - 16:45	49	385	290	7%	53%	40%
Total	202	1270	1112	8%	49%	43%

Tues 28 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
8:00 - 8:15	24	116	105	9%	42%	38%
8:15 - 8:30	42	118	117	16%	45%	45%
8:30 - 8:45	23	116	115	10%	49%	49%
8:45 - 9:00	20	98	96	9%	42%	41%
Total	109	448	433	11%	45%	43%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
12:00 - 12:15	21	139	126	7%	44%	40%
12:15 - 12:30	33	174	156	11%	55%	50%
12:30 - 12:45	27	152	132	9%	50%	44%
12:45 - 13:00	29	166	151	9%	52%	47%
Total	110	631	565	9%	50%	45%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
15:45 - 16:00	46	278	257	9%	53%	49%
16:00 - 16:15	43	323	320	7%	49%	48%
16:15 - 16:30	32	356	354	5%	53%	53%
16:30 - 16:45	38	354	314	5%	49%	43%
Total	159	1311	1245	6%	51%	48%

Wed 29 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
8:00 - 8:15	25	101	115	10%	42%	48%
8:15 - 8:30	27	96	112	11%	41%	48%
8:30 - 8:45	35	105	87	15%	46%	38%
8:45 - 9:00	29	90	90	14%	43%	43%
Total	116	392	404	13%	43%	44%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
12:00 - 12:15	20	159	150	6%	48%	46%
12:15 - 12:30	34	159	139	10%	48%	42%
12:30 - 12:45	28	156	147	8%	47%	44%
12:45 - 13:00	26	171	164	7%	47%	45%
Total	108	645	600	8%	48%	44%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
15:45 - 16:00	58	275	287	9%	44%	46%
16:00 - 16:15	32	328	322	5%	48%	47%
16:15 - 16:30	35	336	331	5%	48%	47%
16:30 - 16:45	55	357	317	8%	49%	43%
Total	180	1296	1257	7%	47%	46%

Thurs 30 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
8:00 - 8:15	31	104	104	13%	43%	43%
8:15 - 8:30	27	120	109	11%	51%	46%
8:30 - 8:45	34	106	97	15%	47%	43%
8:45 - 9:00	26	129	102	12%	62%	49%
Total	118	459	412	13%	50%	45%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
12:00 - 12:15	22	173	179	7%	53%	54%
12:15 - 12:30	36	159	151	11%	48%	45%
12:30 - 12:45	25	155	136	8%	47%	41%
12:45 - 13:00	27	166	160	7%	46%	44%
Total	110	653	626	8%	48%	46%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
15:45 - 16:00	41	268	261	7%	43%	42%
16:00 - 16:15	36	304	301	5%	45%	44%
16:15 - 16:30	62	354	328	9%	50%	47%
16:30 - 16:45	40	369	258	5%	51%	35%
Total	179	1295	1148	7%	47%	42%

Fri 31 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
8:00 - 8:15	23	104	103	10%	45%	45%
8:15 - 8:30	29	110	106	12%	45%	43%
8:30 - 8:45	26	100	106	11%	43%	46%
8:45 - 9:00	18	114	104	8%	48%	44%
Total	96	428	419	10%	45%	44%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
12:00 - 12:15	23	179	165	6%	49%	45%
12:15 - 12:30	42	177	161	11%	47%	42%
12:30 - 12:45	38	178	143	11%	50%	40%
12:45 - 13:00	30	188	153	8%	51%	41%
Total	133	722	622	9%	49%	42%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
15:45 - 16:00	47	239	236	9%	46%	45%
16:00 - 16:15	40	312	302	6%	48%	46%
16:15 - 16:30	35	329	309	5%	49%	46%
16:30 - 16:45	35	330	315	5%	49%	46%
Total	157	1210	1162	6%	48%	46%

Site 3: George Bolt Memorial Drive/Kirkbride Road/SH20

George Bolt Memorial Drive/Kirkbride Road/SH20a (south approach)

Site graphics
TCS 4903
MANGERE
MANPAC SS=51
12 PHASES
A
D1
F2
B
D2
G
C
E
G1
D
F1
G2
KIRKBRIDE RD
SH20A
GEORGE BOLT DR
KIRKBRIDE RD
4112
4113
4905

SCATS count during period 19 March 2007 - 25 March 2007
George Bolt Dr / Kirkbridge Rd

Detectors 5, 6 & 7

Mon 19 March

AM 1	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
7:45 - 8:00	32	56	69	20%	36%	44%
8:00 - 8:15	30	58	81	18%	34%	48%
8:15 - 8:30	35	67	76	20%	38%	43%
8:30 - 8:45	35	70	83	19%	37%	44%
Total	132	251	309	19%	36%	45%

AM 2	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
10:40 - 10:55	38	89	100	17%	39%	44%
10:55 - 11:10	33	84	83	17%	42%	42%
11:10 - 11:25	37	82	88	18%	40%	43%
11:25 - 11:40	41	96	96	18%	41%	41%
Total	149	351	367	17%	40%	42%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
12:45 - 1:00	52	95	114	20%	36%	44%
1:00 - 1:15	43	96	108	17%	39%	44%
1:15 - 1:30	38	94	111	16%	39%	46%
1:30 - 1:45	42	102	121	16%	38%	46%
Total	175	387	454	17%	38%	45%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
2:40 - 2:55	49	104	127	18%	37%	45%
2:55 - 3:10	47	111	131	16%	38%	45%
3:10 - 3:25	63	102	121	22%	36%	42%
3:25 - 3:40	72	121	146	21%	36%	43%
Total	231	438	525	19%	37%	44%

Wed 21 March

AM 1	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
7:55 - 8:10	36	50	65	24%	33%	43%
8:10 - 8:25	30	52	57	22%	37%	41%
8:25 - 8:40	37	62	76	21%	35%	43%
8:40 - 8:55	30	54	69	20%	35%	45%
Total	133	218	267	22%	35%	43%

AM 2	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
10:40 - 10:55	27	86	87	14%	43%	44%
10:55 - 11:10	31	81	82	16%	42%	42%
11:10 - 11:25	32	92	93	15%	42%	43%
11:25 - 11:40	47	87	96	20%	38%	42%
Total	137	346	358	16%	41%	43%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
12:30 - 12:45	42	112	115	16%	42%	43%
12:45 - 1:00	55	103	125	19%	36%	44%
1:00 - 1:15	60	112	130	20%	37%	43%
1:15 -1:30	39	86	130	15%	34%	51%
Total	196	413	500	18%	37%	45%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
4:05 - 4:20	87	136	156	23%	36%	41%
4:20 - 4:35	82	115	136	25%	35%	41%
4:35 - 4 50	62	109	121	21%	37%	41%
4:50 - 5:05	71	110	137	22%	35%	43%
Total	302	470	550	23%	36%	42%

Fri 23 March

AM 1	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
8:00 - 8:15	34	61	80	19%	35%	46%
8:15 - 8:30	15	49	47	14%	44%	42%
8:30 - 8:45	33	61	73	20%	37%	44%
8:45 - 9:00	24	44	48	21%	38%	41%
Total	106	215	248	19%	38%	44%

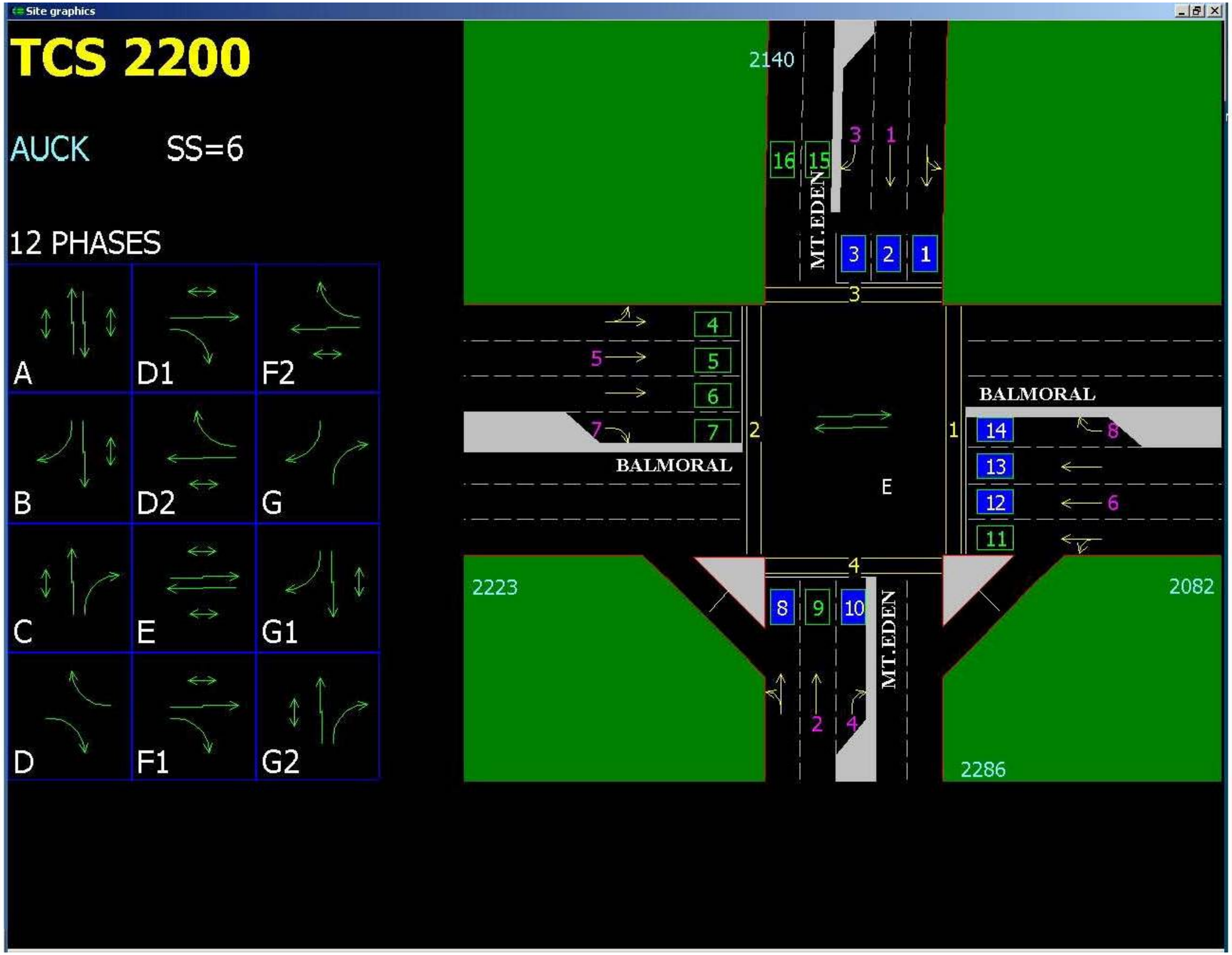
AM 2	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 3	Det 4	Det 5
11:00 - 11:15	51	90	108	20%	36%	43%
11:15 - 11:30	37	84	79	19%	42%	40%
11:30 - 11:45	37	95	96	16%	42%	42%
11:45 - 12:00	39	91	87	18%	42%	40%
Total	164	360	370	18%	40%	41%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
1:00 - 1:15	37	112	130	13%	40%	47%
1:15 - 1:30	48	109	121	17%	39%	44%
1:30 - 1:45	41	107	124	15%	39%	46%
1:45 - 2:00	63	126	162	18%	36%	46%
Total	189	454	537	16%	38%	46%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 5	Det 6	Det 7	Det 5	Det 6	Det 7
2:35 - 2:50	77	115	140	23%	35%	42%
2:50 - 3:05	73	125	148	21%	36%	43%
3:05 - 3:20	78	133	166	21%	35%	44%
3:20 - 3:35	83	134	150	23%	37%	41%
Total	311	507	604	22%	36%	42%

Site 4: Mt Eden Road/Balmoral Road

Mt Eden Road/Balmoral Road (east approach)


Site graphics
TCS 2200
AUCK
SS=6
12 PHASES
A
D1
F2
B
D2
G
C
E
G1
D
F1
G2
2140
MT.EDEN
BALMORAL
BALMORAL
MT.EDEN
2223
2082
2286
E

SCATS count during period 27 July 2009 - 31 July 2009
Mt Eden Rd / Balmoral Rd

Detectors 11, 12 & 13

Mon 27 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
8:00 - 8:15	17	56	54	13%	44%	43%
8:15 - 8:30	12	85	74	7%	50%	43%
8:30 - 8:45	14	52	80	10%	36%	55%
8:45 - 9:00	13	58	77	9%	39%	52%
Total	56	251	285	9%	42%	48%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
12:00 - 12:15	9	54	62	7%	43%	50%
12:15 - 12:30	10	50	63	8%	41%	51%
12:30 - 12:45	13	50	58	11%	41%	48%
12:45 - 13:00	13	58	59	10%	45%	45%
Total	45	212	242	9%	42%	48%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
4:00 - 4:15	22	64	82	13%	38%	49%
4:15 - 4:30	26	94	97	12%	43%	45%
4:30 - 4:45	43	100	109	17%	40%	43%
4:45 - 5:00	33	97	101	14%	42%	44%
Total	124	355	389	14%	41%	45%

Tues 28 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
8:00 - 8:15	15	61	80	12%	48%	63%
8:15 - 8:30	12	63	85	7%	37%	50%
8:30 - 8:45	14	70	89	10%	48%	61%
8:45 - 9:00	13	80	100	9%	54%	68%
Total	54	274	354	9%	46%	60%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
12:00 - 12:15	12	54	44	10%	43%	35%
12:15 - 12:30	14	68	64	11%	55%	52%
12:30 - 12:45	12	43	62	10%	36%	51%
12:45 - 13:00	15	55	68	12%	42%	52%
Total	53	220	238	11%	44%	48%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
4:00 - 4:15	14	64	94	8%	38%	56%
4:15 - 4:30	33	89	97	15%	41%	45%
4:30 - 4:45	38	98	102	15%	39%	40%
4:45 - 5:00	41	89	122	18%	39%	53%
Total	126	340	415	15%	39%	48%

Wed 29 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
8:00 - 8:15	16	50	68	12%	37%	51%
8:15 - 8:30	12	63	66	9%	45%	47%
8:30 - 8:45	20	65	80	12%	39%	48%
8:45 - 9:00	9	58	95	6%	36%	59%
Total	57	236	309	9%	39%	51%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
12:00 - 12:15	9	42	77	7%	33%	60%
12:15 - 12:30	8	42	98	5%	28%	66%
12:30 - 12:45	8	44	65	7%	38%	56%
12:45 - 13:00	12	52	84	8%	35%	57%
Total	37	180	324	7%	33%	60%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
4:00 - 4:15	25	92	112	11%	40%	49%
4:15 - 4:30	24	88	94	12%	43%	46%
4:30 - 4:45	26	81	109	12%	38%	50%
4:45 - 5:00	34	93	105	15%	40%	45%
Total	109	354	420	12%	40%	48%

Thurs 30 July 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
8:00 - 8:15	6	45	80	4%	34%	60%
8:15 - 8:30	17	55	81	12%	39%	57%
8:30 - 8:45	16	51	88	10%	31%	53%
8:45 - 9:00	15	57	102	9%	35%	63%
Total	54	208	351	9%	35%	58%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
12:00 - 12:15	10	44	124	8%	34%	97%
12:15 - 12:30	7	44	80	5%	30%	54%
12:30 - 12:45	26	49	64	22%	42%	55%
12:45 - 13:00	8	44	88	5%	30%	59%
Total	51	181	356	9%	33%	66%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
4:00 - 4:15	25	71	106	11%	31%	46%
4:15 - 4:30	33	90	114	16%	44%	55%
4:30 - 4:45	39	84	98	18%	39%	45%
4:45 - 5:00	42	121	129	18%	52%	56%
Total	139	366	447	16%	41%	51%

Fri 31 July 2009

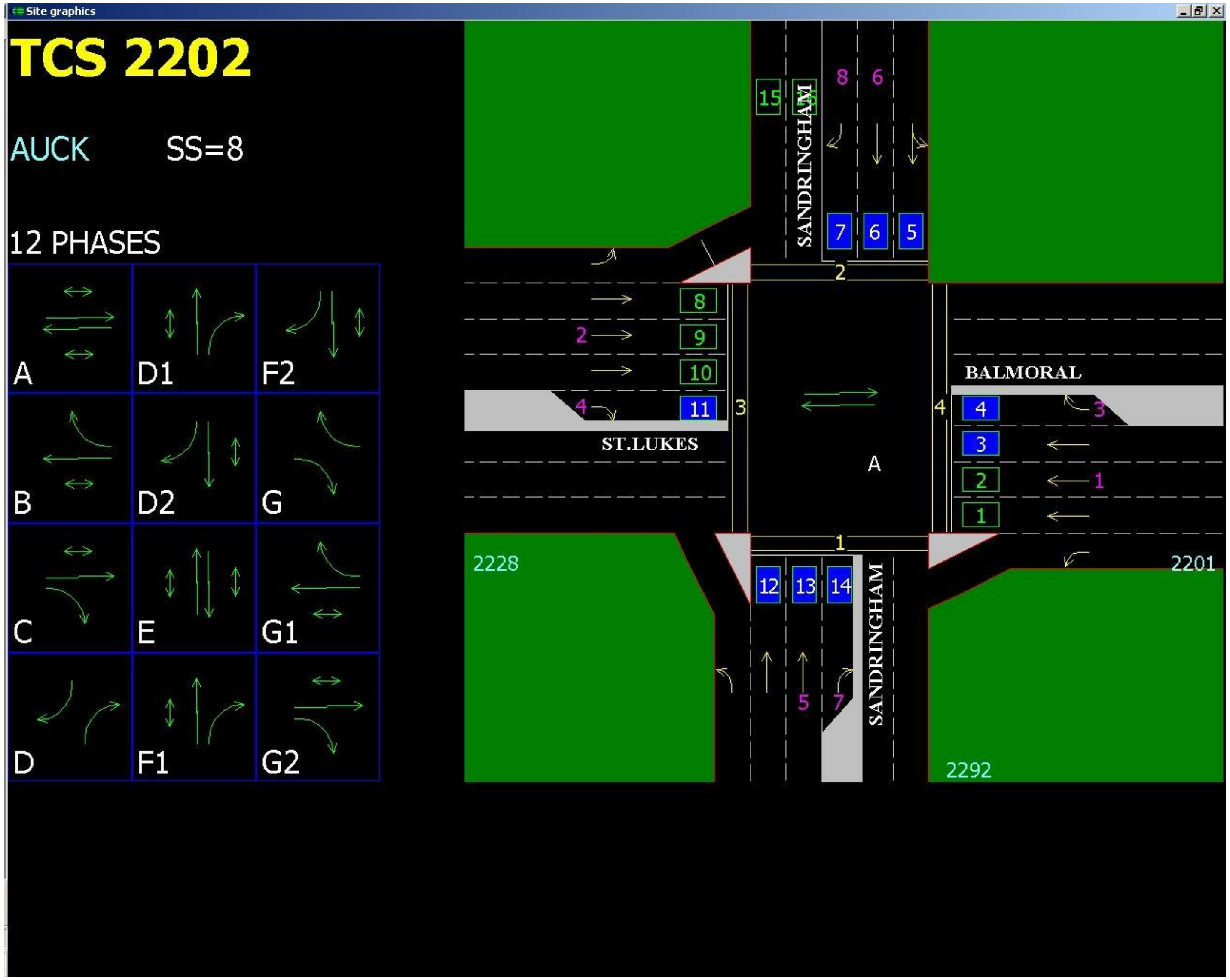
AM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
8:00 - 8:15	13	44	74	10%	34%	56%
8:15 - 8:30	14	61	67	10%	43%	47%
8:30 - 8:45	12	61	82	8%	39%	53%
8:45 - 9:00	10	70	81	6%	43%	50%
Total	49	236	304	8%	40%	52%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
12:00 - 12:15	12	67	73	8%	44%	48%
12:15 - 12:30	17	72	77	10%	43%	46%
12:30 - 12:45	6	64	80	4%	43%	53%
12:45 - 13:00	8	63	75	5%	43%	51%
Total	43	266	305	7%	43%	50%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 11	Det 12	Det 13	Det 11	Det 12	Det 13
4:00 - 4:15	25	94	85	12%	46%	42%
4:15 - 4:30	22	86	102	10%	41%	49%
4:30 - 4:45	36	112	124	13%	41%	46%
4:45 - 5:00	32	86	102	15%	39%	46%
Total	115	378	413	13%	42%	46%

Site 5: Sandringham Road/Balmoral Road

Sandringham Road/Balmoral Road (east and west approach)


Site graphics
TCS 2202
AUCK
SS=8
12 PHASES
A
D1
F2
B
D2
G
C
E
G1
D
F1
G2
SANDRINGHAM
ST.LUKES
BALMORAL
SANDRINGHAM
2228
2201
2292
A

SCATS count during period 3 August 2009 - 7 August 2009
Sandringham Rd / Balmoral Rd (east approach)

Detectors 1, 2 & 3

Mon 3 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
7:30 - 7:45	7	51	40	7%	52%	41%
7:45 - 8:00	15	38	56	14%	35%	51%
8:00 - 8:15	23	57	80	14%	36%	50%
8:15 - 8:30	20	54	49	16%	44%	40%
Total	65	200	225	13%	41%	46%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
13:00 - 13:15	21	49	88	13%	31%	56%
13:15 - 13:30	16	45	75	12%	33%	55%
13:30 - 13:45	17	53	61	13%	40%	47%
13:45 - 14:00	15	38	55	14%	35%	51%
Total	69	185	279	13%	35%	52%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
17:00 - 17:15	29	76	91	15%	39%	46%
17:15 - 17:30	27	59	72	17%	37%	46%
17:30 - 17:45	38	61	76	22%	35%	43%
17:45 - 18:00	32	55	61	22%	37%	41%
Total	126	251	300	19%	37%	44%

Tues 4 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
7:30 - 7:45	12	32	31	12%	33%	32%
7:45 - 8:00	22	54	53	20%	50%	49%
8:00 - 8:15	21	66	67	13%	41%	42%
8:15 - 8:30	37	67	84	30%	54%	68%
Total	92	219	235	19%	45%	48%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
13:00 - 13:15	14	46	71	9%	29%	45%
13:15 - 13:30	19	52	67	14%	38%	49%
13:30 - 13:45	12	48	72	9%	37%	55%
13:45 - 14:00	31	62	79	29%	57%	73%
Total	76	208	289	14%	39%	54%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
17:00 - 17:15	32	70	88	16%	36%	45%
17:15 - 17:30	17	54	82	11%	34%	52%
17:30 - 17:45	24	69	74	14%	39%	42%
17:45 - 18:00	26	51	67	18%	34%	45%
Total	99	244	311	15%	36%	46%

Wed 5 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
7:30 - 7:45	11	39	43	12%	42%	46%
7:45 - 8:00	25	46	63	19%	34%	47%
8:00 - 8:15	20	50	62	15%	38%	47%
8:15 - 8:30	26	73	78	15%	41%	44%
Total	82	208	246	15%	39%	46%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
13:00 - 13:15	17	45	74	13%	33%	54%
13:15 - 13:30	21	53	77	14%	35%	51%
13:30 - 13:45	25	50	70	17%	34%	48%
13:45 - 14:00	19	60	73	13%	39%	48%
Total	82	208	294	14%	36%	50%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
17:00 - 17:15	27	66	81	16%	38%	47%
17:15 - 17:30	32	77	99	15%	37%	48%
17:30 - 17:45	26	57	58	18%	40%	41%
17:45 - 18:00	34	61	81	19%	35%	46%
Total	119	261	319	17%	37%	46%

Thurs 6 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
7:30 - 7:45	10	41	32	11%	44%	34%
7:45 - 8:00	19	37	53	14%	28%	40%
8:00 - 8:15	28	57	66	21%	43%	50%
8:15 - 8:30	19	49	57	11%	28%	32%
Total	76	184	208	14%	34%	39%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
13:00 - 13:15	25	47	76	18%	35%	56%
13:15 - 13:30	25	71	86	17%	47%	57%
13:30 - 13:45	31	66	80	21%	46%	55%
13:45 - 14:00	29	81	105	19%	53%	69%
Total	110	265	347	19%	45%	59%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
17:00 - 17:15	32	66	84	18%	38%	48%
17:15 - 17:30	36	61	80	17%	29%	38%
17:30 - 17:45	42	72	98	30%	51%	70%
17:45 - 18:00	36	65	87	20%	37%	49%
Total	146	264	349	21%	38%	50%

Fri 7 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
7:30 - 7:45	7	37	35	9%	47%	44%
7:45 - 8:00	15	47	63	12%	38%	50%
8:00 - 8:15	17	59	55	13%	45%	42%
8:15 - 8:30	33	67	67	20%	40%	40%
Total	72	210	220	14%	42%	44%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
13:00 - 13:15	28	57	65	19%	38%	43%
13:15 - 13:30	22	59	93	13%	34%	53%
13:30 - 13:45	25	62	76	15%	38%	47%
13:45 - 14:00	16	34	76	13%	27%	60%
Total	91	212	310	15%	35%	51%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 1	Det 2	Det 3	Det 1	Det 2	Det 3
17:00 - 17:15	25	58	84	15%	35%	50%
17:15 - 17:30	33	65	103	16%	32%	51%
17:30 - 17:45	41	71	88	21%	36%	44%
17:45 - 18:00	39	72	89	20%	36%	45%
Total	138	266	364	18%	35%	47%

SCATS count during period 3 August 2009 - 7 August 2009
Sandringham Rd / Balmoral Rd (west approach)

Detectors 8, 9 & 10

Mon 3 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:00 - 7:15	15	36	56	14%	34%	52%
7:15 - 7:30	26	47	64	19%	34%	47%
7:30 - 7:45	21	47	61	16%	36%	47%
7:45 - 8:00	24	57	66	16%	39%	45%
Total	86	187	247	17%	36%	48%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
13:00 - 13:15	19	64	68	13%	42%	45%
13:15 - 13:30	28	57	72	18%	36%	46%
13:30 - 13:45	17	75	85	10%	42%	48%
13:45 - 14:00	20	55	79	13%	36%	51%
Total	84	251	304	13%	39%	48%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
16:45 - 17:00	19	70	79	11%	42%	47%
17:00 - 17:15	19	67	97	10%	37%	53%
17:15 - 17:30	30	67	87	16%	36%	47%
17:30 - 17:45	34	67	75	19%	38%	43%
Total	102	271	338	14%	38%	48%

Tues 4 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:00 - 7:15	22	31	53	21%	29%	50%
7:15 - 7:30	21	51	55	15%	37%	40%
7:30 - 7:45	28	58	74	22%	45%	57%
7:45 - 8:00	28	59	68	19%	40%	46%
Total	99	199	250	19%	38%	48%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
13:00 - 13:15	14	55	67	9%	36%	44%
13:15 - 13:30	21	56	75	13%	36%	48%
13:30 - 13:45	11	69	68	6%	39%	38%
13:45 - 14:00	22	65	62	14%	42%	40%
Total	68	245	272	11%	38%	43%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
16:45 - 17:00	23	53	71	14%	32%	42%
17:00 - 17:15	28	81	82	15%	44%	45%
17:15 - 17:30	33	62	86	18%	34%	47%
17:30 - 17:45	26	85	85	15%	48%	48%
Total	110	281	324	15%	40%	46%

Wed 5 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:00 - 7:15	17	44	52	15%	39%	46%
7:15 - 7:30	25	54	63	18%	38%	44%
7:30 - 7:45	29	51	65	20%	35%	45%
7:45 - 8:00	23	59	73	15%	38%	47%
Total	94	208	253	17%	37%	46%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
13:00 - 13:15	22	57	63	15%	40%	44%
13:15 - 13:30	25	54	67	17%	37%	46%
13:30 - 13:45	25	77	76	14%	43%	43%
13:45 - 14:00	19	62	71	13%	41%	47%
Total	91	250	277	15%	40%	45%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
16:45 - 17:00	22	67	82	13%	39%	48%
17:00 - 17:15	22	69	87	12%	39%	49%
17:15 - 17:30	26	72	85	14%	39%	46%
17:30 - 17:45	30	60	67	19%	38%	43%
Total	100	268	321	15%	39%	47%

Thurs 6 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:00 - 7:15	18	43	46	16%	38%	41%
7:15 - 7:30	30	44	56	21%	31%	39%
7:30 - 7:45	23	64	69	16%	44%	48%
7:45 - 8:00	27	47	66	17%	30%	43%
Total	98	198	237	18%	36%	43%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
13:00 - 13:15	20	59	53	14%	42%	37%
13:15 - 13:30	19	79	82	13%	54%	56%
13:30 - 13:45	26	61	77	15%	34%	43%
13:45 - 14:00	14	62	59	9%	41%	39%
Total	79	261	271	13%	42%	44%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
16:45 - 17:00	31	85	94	18%	50%	55%
17:00 - 17:15	35	71	74	20%	40%	42%
17:15 - 17:30	25	79	92	14%	43%	50%
17:30 - 17:45	26	61	60	17%	39%	38%
Total	117	296	320	17%	43%	46%

Fri 7 August 2009

AM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
7:00 - 7:15	19	33	45	20%	34%	46%
7:15 - 7:30	23	48	50	19%	40%	41%
7:30 - 7:45	26	42	65	20%	32%	49%
7:45 - 8:00	28	50	73	19%	33%	48%
Total	96	173	233	19%	34%	46%

OFFPEAK	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
13:00 - 13:15	22	57	62	16%	40%	44%
13:15 - 13:30	21	75	85	12%	41%	47%
13:30 - 13:45	21	55	87	13%	34%	53%
13:45 - 14:00	16	67	96	9%	37%	54%
Total	80	254	330	12%	38%	50%

PM	SCATS count info			Lane Use per SCATS count info		
	Det 8	Det 9	Det 10	Det 8	Det 9	Det 10
16:45 - 17:00	26	78	95	13%	39%	48%
17:00 - 17:15	30	78	89	15%	40%	45%
17:15 - 17:30	29	66	77	17%	38%	45%
17:30 - 17:45	24	78	86	13%	41%	46%
Total	109	300	347	14%	40%	46%

2-laners

Lane utilisation survey results at the 2-lane sample sites

Site	Avg through-lane use (%)		U/S short-lane length (m)	D/S merge length (m)	Total aux lane length (m)	SCATS/ survey
	Aux lane	Right				
am peak						
Mayoral Dr/Cook St/Vincent St (north approach)	19	81	135	85	220	SCATS
Kepa Rd/Patterson Ave (west approach)	20	80	130	140	270	SCATS
Kepa Rd/Patterson Ave (east approach)	30	70	105	190	295	SCATS
Glenfield Rd/Eskdale Rd (south approach)	46	54	90	150	240	Survey
Albany Hway/Upper Harbour Dr (north approach)	46	54	105	160	265	SCATS
Oteha Valley Rd/East Coast Road/Carlisle Rd (north approach)	31	69	70	160	230	SCATS
Titirangi Drive/Margan Avenue (south approach)	37	62	75	150	225	SCATS
pm peak						
Mayoral Dr/Cook St/Vincent St (north approach)	26	74	135	85	220	SCATS
Kepa Rd/Patterson Ave (west approach)	27	73	130	140	270	SCATS
Kepa Rd/Patterson Ave (east approach)	39	61	105	190	295	SCATS
Glenfield Rd/Eskdale Rd (south approach)	42	58	90	150	240	Survey
Albany Hway/Upper Harbour Dr (north approach)	49	51	105	160	265	SCATS
Oteha Valley Rd/East Coast Road/Carlisle Rd (north approach)	37	63	70	160	230	SCATS
Titirangi Drive/Margan Avenue (south approach)	42	58	75	150	225	SCATS
Off-peak						
Mayoral Dr/Cook St/Vincent St (north approach)	26	74	135	85	220	SCATS
Kepa Rd/Patterson Ave (west approach)	21	79	130	140	270	SCATS
Kepa Rd/Patterson Ave (east approach)	37	63	105	190	295	SCATS
Glenfield Rd/Eskdale Rd (south approach)	41	59	90	150	240	Survey
Albany Hway/Upper Harbour Dr (north approach)	47	53	105	160	265	SCATS
Oteha Valley Rd/East Coast Road/Carlisle Rd (north approach)	37	63	70	160	230	SCATS
Titirangi Drive/Margan Avenue (south approach)	42	58	75	150	225	SCATS

Site 1: Mayoral Drive/Cook Street/Vincent Street

Mayoral Drive/Vincent Street/Cook Street (north approach)


Site graphics
TCS 2102
CENTRA
SS=25
9 PHASES
A
E
G2
B
F1
C
G
D
G1
2057
MAYORAL DR
2101
COOK ST
MAYORAL DR EAST
2097
VINCENT ST
2094

SCATS Count Info for 2102 - Mayoral Drive / Cook Street

Detectors 8 & 9

Mon 30 April

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
07:45 - 08:00	9	28	24%	76%
08:00 - 08:15	4	28	13%	88%
08:15 - 08:30	4	25	14%	86%
08:30 - 08:45	10	37	21%	79%
Total	27	118	19%	81%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
11:30 - 11:45	10	30	25%	75%
11:45 - 12:00	10	42	19%	81%
12:00 - 12:15	4	34	11%	89%
12:15 - 12:30	8	23	26%	74%
Total	32	129	20%	80%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
16:45 - 17:00	13	58	18%	82%
17:00 - 17:15	16	75	18%	82%
17:15 - 17:30	22	52	30%	70%
17:30 - 17:45	14	58	19%	81%
Total	65	243	21%	79%

Wed 02 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
07:45 - 08:00	9	33	21%	79%
08:00 - 08:15	5	22	19%	81%
08:15 - 08:30	3	27	10%	90%
08:30 - 08:45	7	30	19%	81%
Total	24	112	18%	82%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
12:00 - 12:15	7	33	18%	83%
12:15 - 12:30	7	37	16%	84%
12:30 - 12:45	12	23	34%	66%
12:45 - 13:00	6	38	14%	86%
Total	32	131	20%	80%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
17:00 - 17:15	17	54	24%	76%
17:15 - 17:30	23	49	32%	68%
17:30 - 17:45	25	56	31%	69%
17:45 - 18:00	15	51	23%	77%
Total	80	210	28%	72%

Fri 04 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
08:00 - 08:15	7	26	21%	79%
08:15 - 08:30	12	29	29%	71%
08:30 - 08:45	8	39	17%	83%
08:45 - 09:00	6	27	18%	82%
Total	33	121	21%	79%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
11:30 - 11:45	17	23	43%	58%
11:45 - 12:00	9	26	26%	74%
12:00 - 12:15	14	15	48%	52%
12:15 - 12:30	10	18	36%	64%
Total	50	82	38%	62%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 8	Det. 9	Det. 8	Det. 9
17:00 - 17:15	23	48	32%	68%
17:15 - 17:30	26	44	37%	63%
17:30 - 17:45	15	58	21%	79%
17:45 - 18:00	18	52	26%	74%
Total	82	202	29%	71%

Site 2: Kepa Road/Patterson Avenue

Kepa Road/Patterson Avenue/Eastridge Mall Accessway (east and west approach)


Site graphics
TCS 2244
AUCK
SS=39
8 PHASES
A
E
B
G
C
G1
D
G2
2242
2128
PATTESON
KEPA
KEPA
EASTRIDGE
1
2
3
4
5
6
7
8
9
10
11
12
E

SCATS Count Info for 2244
Kepa Road / Patterson Avenue (east)

Detectors 6 & 7

Mon 30 April

AM	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
07:45 - 08:00	12	125	4	9%	91%
08:00 - 08:15	28	83	1	25%	75%
08:15 - 08:30	61	72	0	46%	54%
08:30 - 08:45	105	113	4	48%	52%
Total	206	393	9	34%	66%

OFF Peak	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
11:30 - 11:45	60	60	13	50%	50%
11:45 - 12:00	44	52	13	46%	54%
12:00 - 12:15	39	47	12	45%	55%
12:15 - 12:30	46	49	11	48%	52%
Total	189	208	49	48%	52%

PM	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
17:00 - 17:15	74	85	13	47%	53%
17:15 - 17:30	61	73	10	46%	54%
17:30 - 17:45	60	73	16	45%	55%
17:45 - 18:00	70	70	14	50%	50%
Total	265	301	53	47%	53%

Wed 02 May

AM	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
07:00 - 07:15	90	118	4	43%	57%
07:15 - 07:30	83	130	4	39%	61%
07:30 - 07:45	22	144	2	13%	87%
07:45 - 08:00	42	83	2	34%	66%
Total	237	475	12	33%	67%

OFF Peak	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
11:30 - 11:45	41	51	6	45%	55%
11:45 - 12:00	35	55	12	39%	61%
12:00 - 12:15	16	52	12	24%	76%
12:15 - 12:30	44	61	10	42%	58%
Total	136	219	40	38%	62%

PM	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
17:00 - 17:15	19	89	5	18%	82%
17:15 - 17:30	11	74	9	13%	87%
17:30 - 17:45	38	91	7	29%	71%
17:45 - 18:00	31	54	12	36%	64%
Total	99	308	33	24%	76%

Fri 04 May

AM	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
07:00 - 07:15	81	119	5	41%	60%
07:15 - 07:30	39	153	2	20%	80%
07:30 - 07:45	20	153	1	12%	88%
07:45 - 08:00	15	112	0	12%	88%
Total	155	537	8	22%	78%

OFF Peak	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
11:30 - 11:45	19	64	15	23%	77%
11:45 - 12:00	9	64	11	12%	88%
12:00 - 12:15	39	63	10	38%	62%
12:15 - 12:30	12	64	12	16%	84%
Total	79	255	48	24%	76%

PM	SCATS count info			Lane Use	
	Det. 6	Det. 7	Det.11	Det. 4	Det. 5
17:00 - 17:15	55	72	14	43%	57%
17:15 - 17:30	81	89	12	48%	52%
17:30 - 17:45	72	74	5	49%	51%
17:45 - 18:00	70	81	10	46%	54%
Total	278	316	41	47%	53%

SCATS Count Info for 2244
Kepa Road / Patterson Avenue (west)

Detectors 1 & 2

Mon 30 April

AM	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
08:00 - 08:15	15	82	15%	85%
08:15 - 08:30	19	77	20%	80%
08:30 - 08:45	31	103	23%	77%
08:45 - 09:00	17	79	18%	82%
Total	82	341	19%	81%

OFF Peak	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
11:45 - 12:00	25	89	22%	78%
12:00 - 12:15	23	84	21%	79%
12:15 - 12:30	21	77	21%	79%
12:30 - 12:45	24	73	25%	75%
Total	93	323	22%	78%

PM	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
16:45 - 17:00	67	154	30%	70%
17:00 - 17:15	64	174	27%	73%
17:15 - 17:30	74	162	31%	69%
17:30 - 17:45	69	153	31%	69%
Total	274	643	30%	70%

Wed 02 May

AM	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
08:00 - 08:15	21	74	22%	78%
08:15 - 08:30	17	80	18%	82%
08:30 - 08:45	23	81	22%	78%
08:45 - 09:00	21	97	18%	82%
Total	82	332	20%	80%

OFF Peak	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
11:30 - 11:45	29	99	23%	77%
11:45 - 12:00	20	86	19%	81%
12:00 - 12:15	20	93	18%	82%
12:15 - 12:30	22	99	18%	82%
Total	91	377	19%	81%

PM	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
16:45 - 17:00	58	153	27%	73%
17:00 - 17:15	50	166	23%	77%
17:15 - 17:30	65	166	28%	72%
17:30 - 17:45	74	167	31%	69%
Total	247	652	27%	73%

Fri 04 May

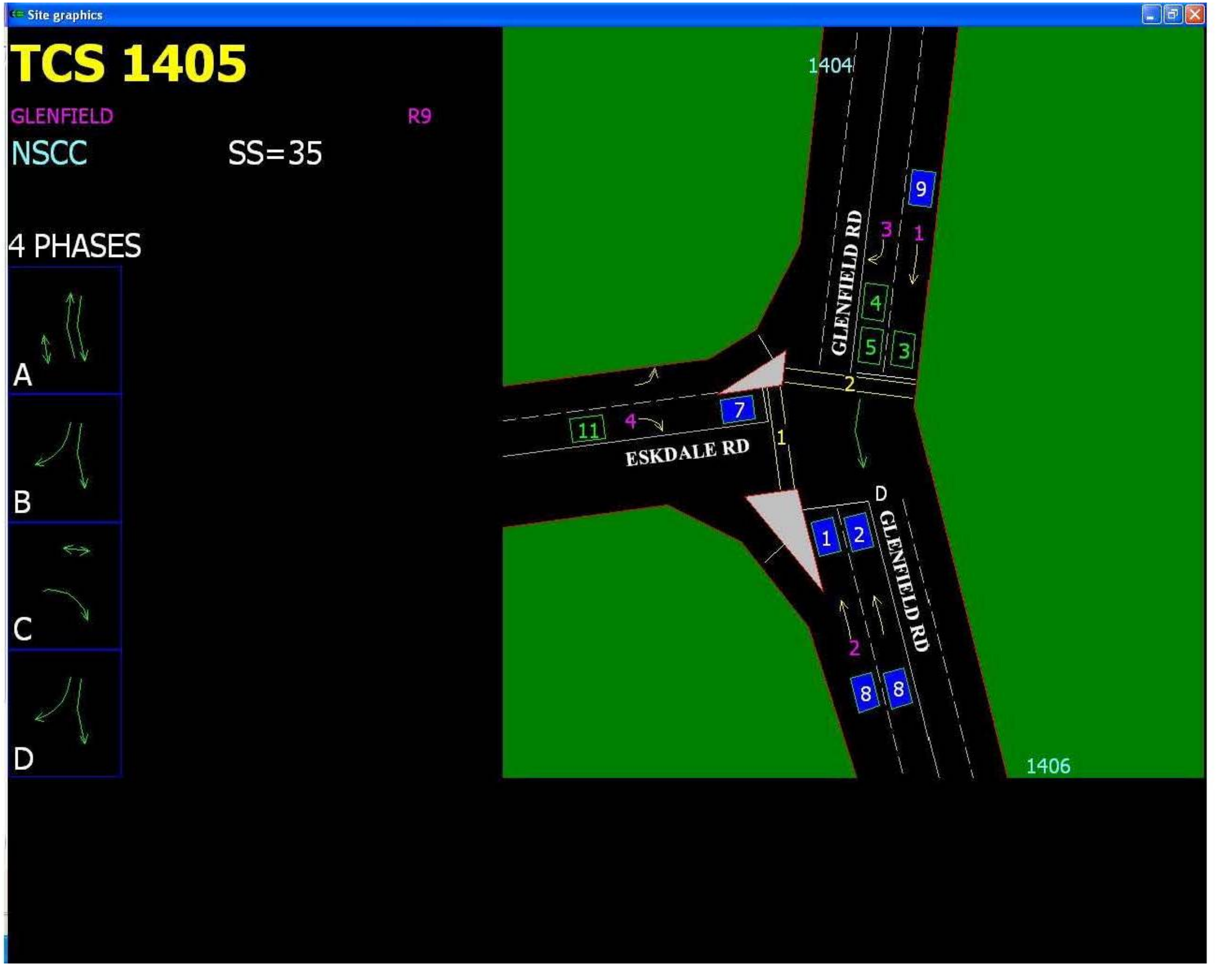
AM	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
07:00 - 07:15	11	59	16%	84%
07:15 - 07:30	14	64	18%	82%
07:30 - 07:45	19	62	23%	77%
07:45 - 08:00	20	88	19%	81%
Total	64	273	19%	81%

OFF Peak	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
11:30 - 11:45	24	101	19%	81%
11:45 - 12:00	24	102	19%	81%
12:00 - 12:15	37	96	28%	72%
12:15 - 12:30	28	110	20%	80%
Total	113	409	22%	78%

PM	SCATS count info		Lane Use	
	Det. 1	Det. 2	Det. 1	Det. 2
16:00 - 16:15	54	173	24%	76%
16:15 - 16:30	50	168	23%	77%
16:30 - 16:45	40	167	19%	81%
16:45 - 17:00	64	178	26%	74%
Total	208	686	23%	77%

Site 3: Glenfield Road/Eskdale Road

Glenfield Road/Eskdale Road (south approach)



Site graphics
TCS 1405
GLENFIELD
R9
NSCC
SS=35
4 PHASES
A
B
C
D
1404
1406
GLENFIELD RD
GLENFIELD RD
ESKDALE RD

SCATS Count Info for 1405 - Glenfield Rd / Eskdale

Detectors 1 & 2

Mon 30 April

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
07:30 - 07:45	65	73	47%	53%
07:45 - 08:00	77	104	43%	57%
08:00 - 08:15	83	99	46%	54%
08:15 - 08:30	70	108	39%	61%
Total	295	384	43%	57%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
12:00 - 12:15	37	73	34%	66%
12:15 - 12:30	38	60	39%	61%
12:30 - 12:45	41	79	34%	66%
12:45 - 13:00	40	70	36%	64%
Total	156	282	36%	64%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
17:00 - 17:15	80	116	41%	59%
17:15 - 17:30	75	103	42%	58%
17:30 - 17:45	76	101	43%	57%
17:45 - 18:00	65	100	39%	61%
Total	296	420	41%	59%

Wed 02 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
07:45 - 08:00	87	87	50%	50%
08:00 - 08:15	73	87	46%	54%
08:15 - 08:30	79	90	47%	53%
08:30 - 08:45	69	85	45%	55%
Total	308	349	47%	53%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
12:00 - 12:15	46	68	40%	60%
12:15 - 12:30	60	78	43%	57%
12:30 - 12:45	49	59	45%	55%
12:45 - 13:00	46	80	37%	63%
Total	201	285	41%	59%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
16:45 - 17:00	87	122	42%	58%
17:00 - 17:15	90	121	43%	57%
17:15 - 17:30	72	105	41%	59%
17:30 - 17:45	90	117	43%	57%
Total	339	465	42%	58%

Fri 04 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
08:00 - 08:15	78	88	47%	53%
08:15 - 08:30	82	85	49%	51%
08:30 - 08:45	65	78	45%	55%
08:45 - 09:00	78	90	46%	54%
Total	303	341	47%	53%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
12:00 - 12:15	56	58	49%	51%
12:15 - 12:30	63	80	44%	56%
12:30 - 12:45	54	59	48%	52%
12:45 - 13:00	57	73	44%	56%
Total	230	270	46%	54%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
16:45 - 17:00	95	116	45%	55%
17:00 - 17:15	75	105	42%	58%
17:15 - 17:30	81	122	40%	60%
17:30 - 17:45	77	106	42%	58%
Total	328	449	42%	58%

Site 4: Albany Highway/Upper Harbour Drive

Albany Highway/Upper Harbour Drive (north approach)

Site graphics
TCS 1901
GLENFIELD
L7
NSCC
SS=32
3 PHASES
A
B
C
1923
12
2
ALBANY HWY
11
4
C
ALBANY HWY
3
2
1
5
9
8
1
UPPER HARBOUR DR
3
6
7
10
1409

SCATS Count Info for 1901
Albany Highway / Upper Harbour Drive

Detectors 2 & 3

Mon 30 April

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
06:45 - 07:00	66	59	53%	47%
07:00 - 07:15	59	65	48%	52%
07:15 - 07:30	74	82	47%	53%
07:30 - 07:45	76	86	47%	53%
Total	275	292	49%	51%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
12:00 - 12:15	45	41	52%	48%
12:15 - 12:30	49	51	49%	51%
12:30 - 12:45	46	57	45%	55%
12:45 - 13:00	47	62	43%	57%
Total	187	211	47%	53%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
17:00 - 17:15	62	61	50%	50%
17:15 - 17:30	69	70	50%	50%
17:30 - 17:45	51	50	50%	50%
17:45 - 18:00	60	74	45%	55%
Total	242	255	49%	51%

Wed 02 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
07:00 - 07:15	61	64	49%	51%
07:15 - 07:30	80	84	49%	51%
07:30 - 07:45	77	91	46%	54%
07:45 - 08:00	59	80	42%	58%
Total	277	319	46%	54%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
12:00 - 12:15	54	58	48%	52%
12:15 - 12:30	48	49	49%	51%
12:30 - 12:45	46	53	46%	54%
12:45 - 13:00	55	63	47%	53%
Total	203	223	48%	52%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
16:45 - 17:00	64	71	47%	53%
17:00 - 17:15	58	56	51%	49%
17:15 - 17:30	64	72	47%	53%
17:30 - 17:45	62	62	50%	50%
Total	248	261	49%	51%

Fri 04 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
07:15 - 07:30	74	81	48%	52%
07:30 - 07:45	65	78	45%	55%
07:45 - 08:00	60	80	43%	57%
08:00 - 08:15	43	71	38%	62%
Total	242	310	44%	56%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
12:00 - 12:15	44	49	47%	53%
12:15 - 12:30	36	46	44%	56%
12:30 - 12:45	47	54	47%	53%
12:45 - 13:00	60	71	46%	54%
Total	187	220	46%	54%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 2	Det. 3	Det. 2	Det. 3
17:00 - 17:15	52	64	45%	55%
17:15 - 17:30	57	58	50%	50%
17:30 - 17:45	68	69	50%	50%
17:45 - 18:00	53	59	47%	53%
Total	230	250	48%	52%

Site 5: Oteha Valley Road/East Coast Road/Carlisle Road

Oteha Valley Road/East Coast Road/Carlisle Road (north approach)


Site graphics
TCS 1610
ALBANY
NSCC
SS=49
12 PHASES
A
D1
F2
B
D2
G
C
E
G1
D
F1
G2
EAST COAST RD
CARLISLE RD
OTEHA VALLEY ROAD
EAST COAST RD
1621
1609

SCATS Count Info for 1610 - Oteha Valley Road / ECR

Detectors 6 & 7

Mon 30 April

AM	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
07:45 - 08:00	54	111	141	33%	67%
08:00 - 08:15	64	126	156	34%	66%
08:15 - 08:30	61	122	123	33%	67%
08:30 - 08:45	54	126	156	30%	70%
Total	233	485	576	32%	68%

OFF Peak	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
12:00 - 12:15	17	23	57	43%	58%
12:15 - 12:30	12	22	46	35%	65%
12:30 - 12:45	17	25	54	40%	60%
12:45 - 13:00	19	28	61	40%	60%
Total	65	98	218	40%	60%

PM	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
16:00 - 16:15	26	36	53	42%	58%
16:15 - 16:30	25	49	60	34%	66%
16:30 - 16:45	19	40	78	32%	68%
16:45 - 17:00	27	38	61	42%	58%
Total	97	163	252	37%	63%

Wed 02 May

AM	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
07:30 - 07:45	49	112	145	30%	70%
07:45 - 08:00	51	119	165	30%	70%
08:00 - 08:15	51	119	143	30%	70%
08:15 - 08:30	60	133	151	31%	69%
Total	211	483	604	30%	70%

OFF Peak	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
12:00 - 12:15	19	30	53	39%	61%
12:15 - 12:30	14	25	51	36%	64%
12:30 - 12:45	10	23	50	30%	70%
12:45 - 13:00	11	29	57	28%	73%
Total	54	107	211	34%	66%

PM	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
16:45 - 17:00	31	39	62	44%	56%
17:00 - 17:15	15	41	52	27%	73%
17:15 - 17:30	25	41	50	38%	62%
17:30 - 17:45	24	36	72	40%	60%
Total	95	157	236	38%	62%

Fri 04 May

AM	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
08:00 - 08:15	56	102	155	35%	65%
08:15 - 08:30	52	120	152	30%	70%
08:30 - 08:45	55	133	123	29%	71%
08:45 - 09:00	51	121	151	30%	70%
Total	214	476	581	31%	69%

OFF Peak	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
11:30 - 11:45	20	23	55	47%	53%
11:45 - 12:00	16	35	55	31%	69%
12:00 - 12:15	18	24	61	43%	57%
12:15 - 12:30	12	27	67	31%	69%
Total	66	109	238	38%	62%

PM	SCATS count info			Lane Use per SCATS count info	
	Det. 6	Det. 7	Det. 8	Det. 6	Det. 7
16:00 - 16:15	26	36	70	42%	58%
16:15 - 16:30	20	51	63	28%	72%
16:30 - 16:45	23	37	58	38%	62%
16:45 - 17:00	24	36	59	40%	60%
Total	93	160	250	37%	63%

Site 6: Titirangi Drive/Margan Avenue

Titirangi Drive/Margan Avenue (south approach)

Site graphics
TCS 3038
HENDERSON
WTKERE
SS=33
5 PHASES
A
E
B
C
D
3007
3039
DRIVEWAY
TITIRANGI RD
TITIRANGI RD
MARGAN AVE

SCATS count info for 3038
Titirangi Road / Margan Avenue -

Detectors 1 & 2

Mon 30 April

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
08:00 - 08:15	49	51	49%	51%
08:15 - 08:30	66	71	48%	52%
08:30 - 08:45	84	53	61%	39%
08:45 - 09:00	72	47	61%	39%
Total	271	222	55%	45%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
12:00 - 12:15	60	83	42%	58%
12:15 - 12:30	56	84	40%	60%
12:30 - 12:45	57	82	41%	59%
12:45 - 13:00	62	90	41%	59%
Total	235	339	41%	59%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
17:00 - 17:15	93	220	30%	70%
17:15 - 17:30	70	271	21%	79%
17:30 - 17:45	86	199	30%	70%
17:45 - 18:00	78	227	26%	74%
Total	327	917	26%	74%

Wed 02 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
07:00 - 07:15	41	27	60%	40%
07:15 - 07:30	43	40	52%	48%
07:30 - 07:45	45	36	56%	44%
07:45 - 08:00	53	48	52%	48%
Total	182	151	55%	45%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
12:00 - 12:15	64	93	41%	59%
12:15 - 12:30	71	82	46%	54%
12:30 - 12:45	74	86	46%	54%
12:45 - 13:00	57	90	39%	61%
Total	266	351	43%	57%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
16:45 - 17:00	87	224	28%	72%
17:00 - 17:15	76	208	27%	73%
17:15 - 17:30	83	240	26%	74%
17:30 - 17:45	102	238	30%	70%
Total	348	910	28%	72%

Fri 04 May

AM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
08:00 - 08:15	51	54	49%	51%
08:15 - 08:30	64	55	54%	46%
08:30 - 08:45	69	53	57%	43%
08:45 - 09:00	84	53	61%	39%
Total	268	215	55%	45%

OFF Peak	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
12:00 - 12:15	66	90	42%	58%
12:15 - 12:30	63	97	39%	61%
12:30 - 12:45	63	109	37%	63%
12:45 - 13:00	74	103	42%	58%
Total	266	399	40%	60%

PM	SCATS count info		Lane Use per SCATS count info	
	Det. 1	Det. 2	Det. 1	Det. 2
17:00 - 17:15	69	207	25%	75%
17:15 - 17:30	88	223	28%	72%
17:30 - 17:45	95	208	31%	69%
17:45 - 18:00	77	210	27%	73%
Total	329	848	28%	72%

Appendix B

DATA COLLECTION SHEET

Intersection Type:
Site:
Approach Short Lane Length:
Departure Merge Length:
Left Slip lane length:
Survey time:
Survey Date:

Peak Period	15 minute time period	Queue length at Start of Green (stops & Partial)			No Stops - veh pass during same green period		Lane Use - queues only		Lane Use - total count per green		Lane Use per SCATS count info for period 19-26 Mar 07	
		Lane 1		Lane 2	Lane 1	Lane 2	Lane 1	Lane 2	Lane 1	Lane 2	Lane 1	Lane 2
AM Peak												
OP												
PM peak												
						Ave						