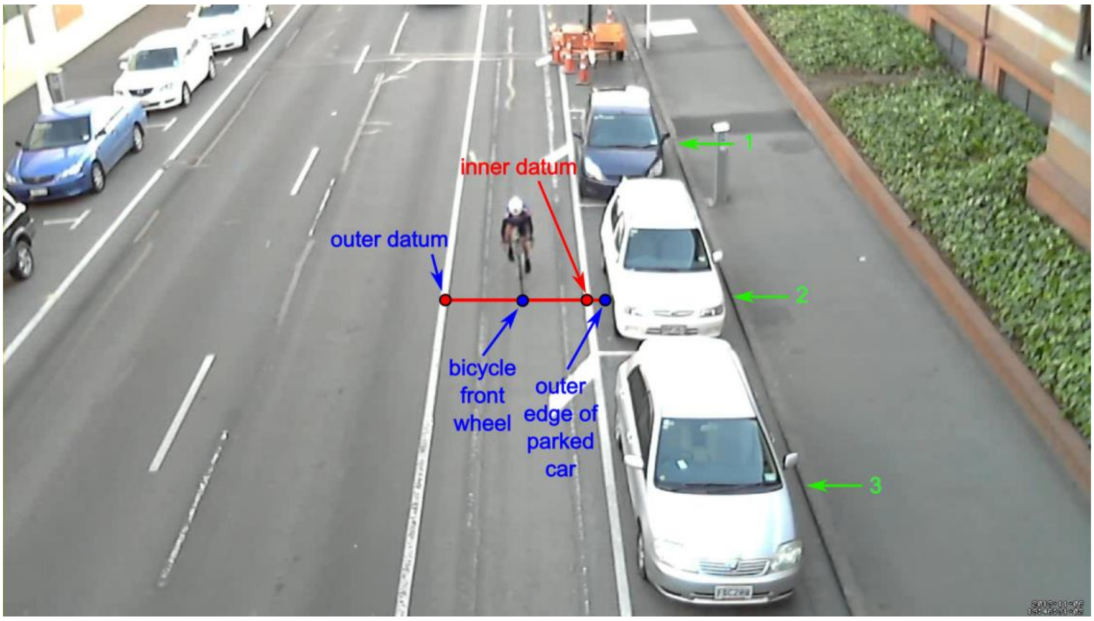
Dunedin Cycle Lane Marking Trial

Report prepared for

NZ Transport Agency



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(The photo on the cover page details the method used to analyse cyclist tracking positions.)

Summary

This report documents a formal New Zealand Transport Agency trial carried out on Dunedin's Cumberland Street (State Highway 1) in the block between Hanover and Frederick Streets. Non-standard road markings for cycle lanes were tested for their effectiveness.

Following a cycling fatality at the site in 1998, cycle lanes were progressively installed beginning in 2001. A further fatality happened in November 2012 when a cyclist was either hit by an opening car door, or swerved to avoid the door, and ended up under the wheels of a stock truck; Figure 1 shows a memorial to the person killed in that incident.

Figure 1: Chris He memorial outside Dunedin Hospital

The purpose of this trial was to establish to what extent changed road markings can influence the relative positioning of parked vehicles and cyclists in an adjacent cycle lane. It is acknowledged that many cyclists may not be aware that their actual greatest mid-block risk stems from opening car doors, and they may consider themselves to be more at risk from moving traffic. As such, we measured whether changing the marking style can change behaviour without having to explicitly educate cyclists where best to cycle and motorists where to park. The desired effect was an increased separation between cyclists and parked vehicles.

For this research, some road markings were removed and remarked in a different location, which changed the cross sectional layout. The non-standard treatment that required a trial were diagonal hatched markings within a widened cycle lane that created a buffer between parked vehicle opening door zones and where cyclists track.

Manual measurements were taken of parking discipline (by measuring the offset of rear wheels of cars from the kerb face) and vehicle widths. Video measurements were taken of the tracking position of cyclists, and parking discipline. Data were collected during three trial stages, representing the existing layout, the modified cross section, and the added diagonal hatched markings. Some parts of SH1 through Dunedin have a relatively large physical lip between the carriageway and the drainage channel; a by-product of this research was to find out whether there is economic justification in milling out these lips for improved parking discipline, thus increasing the safety of people cycling. It was also researched whether the length of stay was correlated to parking discipline.

The parking discipline study was designed to achieve statistically significant results by sampling not just in the area where the video surveys were carried out, but also in six adjacent blocks. Unfortunately, the markings actually installed in the two zones where tracking videos were taken were slightly different to the other six survey zones, and this significantly impacted on parking discipline. As a consequence, combining the results from the eight survey zones was not valid, and most of the sample sizes from the parking discipline surveys are too low for the results to be statistically significant.

The findings from an American study on parking discipline (Furth et al., 2010) show that 30% of a widened parking lane will be taken up by decreased parking discipline, i.e. drivers park further from the kerb, and Dunedin data display this well. The reverse is also the case, as when drivers perceived the parking space to be narrower, they parked closer to the kerb. An increased length of parking duration corresponded to improved parking discipline. The data as collected do not support the hypothesis that a lip between the carriageway and channel results in reduced parking discipline.

It was found that the marking changes resulted in an overall increase of the proportion of cyclists tracking within the dooring zone, and with two exceptions, these changes were all statistically significant. This runs contrary to the design expectation. Consequently, discussions should be held as to what further changes should be tried that may help to achieve the design expectation.

Table of Contents

Appendices

Table of Figures

List of Tables

1 Introduction

1.1 Purpose

This report documents the trial of new road markings on the left hand side of a cycle lane adjacent to parked vehicles. The purpose of the trial was to establish to what extent the road markings influence the relative positioning of parked vehicles and of cyclists in an adjacent cycle lane. Appendix A contains the formal trial application.

1.2 Background

The Otago / Southland office of the NZ Transport Agency wished to improve the safety of cyclists using the one-way pair that runs through the centre of Dunedin, which is part of State Highway 1. A cyclist fatality occurred at the site (outside the University Bookstore) in 1998 and in response, cycle lanes were progressively installed on the State Highway one-way pair through Dunedin from 2001. The resulting cross section was as shown in Figure 2, where a cycle lane is located between parking on the left hand side and the traffic lanes.

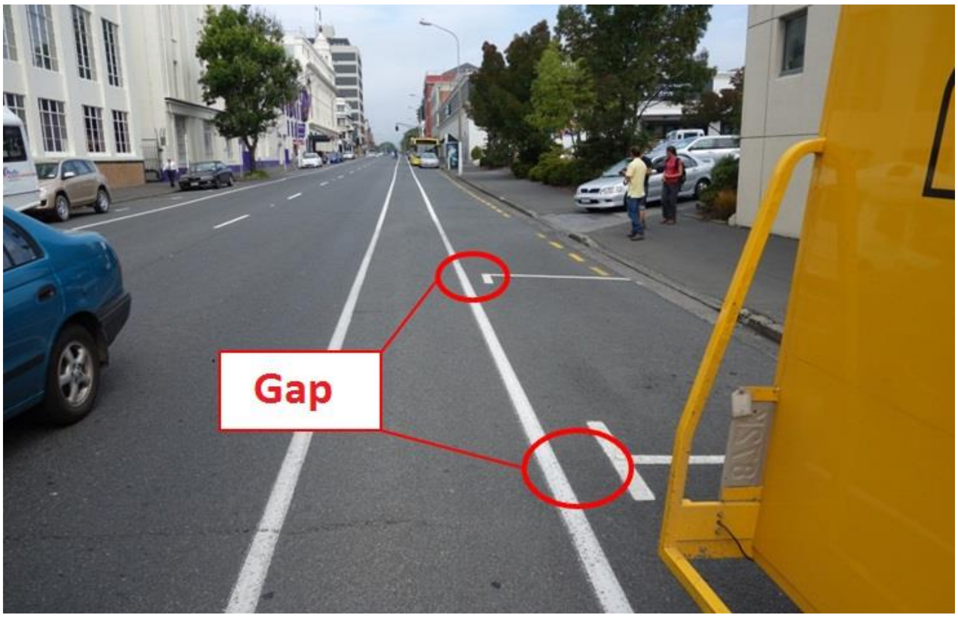

Figure 2: Existing layout with parking, and inner and outer edgelines forming cycle lane

On the left hand side of the 1.2 m to 1.5 m cycle lane, a narrow 0.6 m gap is created by the inner (left) edgeline and the parking ticks. Of specific concern with this layout is the proximity between parked vehicles and cyclists, as opening car doors leave little or no space for cyclists to avoid crashing into the door or entering the adjacent vehicle lanes.

Despite the installation of the original cycle lane markings, a second fatality occurred at the site in November 2012 when a cyclist was either hit by an opening car door, or swerved to avoid the door, and ended up under the wheels of a following stock truck.

The basic questions that this research tries to answer are:

- Can road marking layout changes decrease the parking offset from the kerb (i.e. is it possible to achieve better parking discipline)?
- Can road marking layout changes increase the average lateral cyclist tracking position with respect to the kerb?

- Can road marking layout changes reduce the proportion of cyclists travelling within the opening car door zone (i.e. within 1 m of the parking zone)?

When those research questions are considered together, the issue is whether the separation between cyclists and parked vehicles increases as a consequence of how their lane is marked. Increased separation might be achieved by cyclists changing their tracking, or by drivers parking closer to the kerb, but ideally both these effects will happen simultaneously and the outcomes compounded. The 1 m offset from parked cars for cyclists to be clear of opening doors has been adopted as per the discussion in the research report by Munro (2012).

The length of the zone of influence of a parked car on a cyclist's tracking is not known precisely. Perhaps more importantly, cyclists using the cycle lane are likely to adjust their lateral offset to the row of parked cars depending on the parking discipline of the cars ahead of them. Those users who are aware of the risk of opening doors may adjust their tracking based on the parked vehicle that is closest laterally to the cycle lane. It is acknowledged that many cyclists may not be aware that their greatest mid-block risk stems from opening car doors; they may perceive to be more at risk from moving traffic and thus choose to cycle as close to parked cars as possible.

Cyclist tracking was measured before and after the new marking changes by video at a given datum as is explained later in this report. Whilst we also measured the parking discipline of the parked vehicle at the datum, it is clear from the above discussion that the resulting offset was not necessarily representative, as cyclist tracking could have been influenced by various parking factors away from the datum. For that reason, we measured parking discipline in the whole block and computed offset from the difference in cyclist tracking and average parking discipline.

Furthermore, we measured parking discipline as the offset from kerb to the inside (i.e. left) rear tyre side wall,[1] but vehicles have different widths, and we thus measured the width of a sufficiently large sample size to get a statistically significant vehicle width distribution. Lastly, it needs to be noted that vehicles did not necessarily park perfectly parallel to the kerb. All these issues are demonstrated in Figure 3.

[1] The rationale for not measuring to the outside of a car is explained in section 3.1.

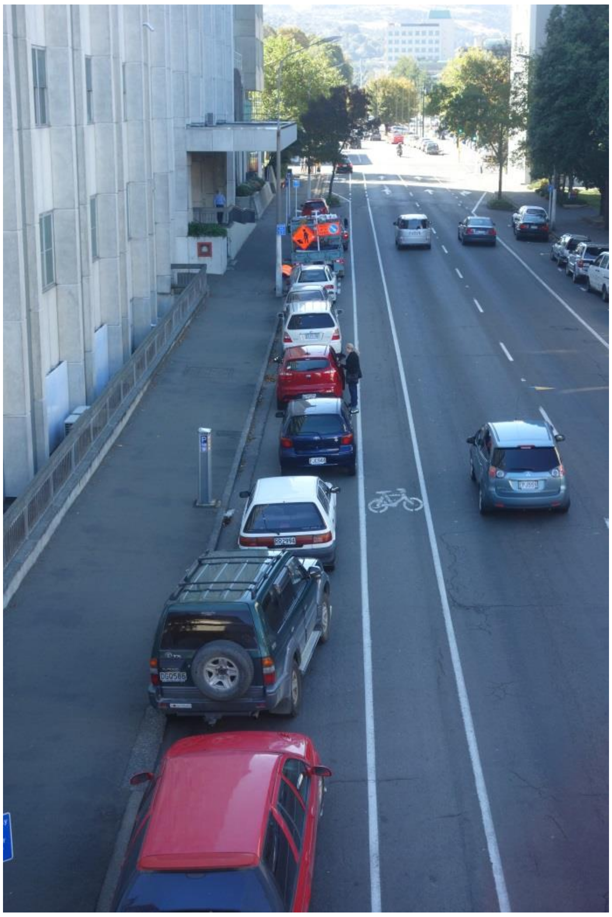

Figure 3: Different parking disciplines and vehicle sizes will influence cyclist tracking

1.3 Trial location

The marking trial was located on the northbound section of the SH1 pair through central Dunedin. The survey site, as illustrated in Figure 4 was located on Cumberland Street between Hanover and Frederick Streets outside the hospital. The site has two lanes of traffic in the northbound direction and the speed limit is 50 km/h. The Average Annual Daily Traffic (AADT) and percentage of heavy vehicles for the two one-way pair streets, north and south of the trial location are detailed in Table 1.

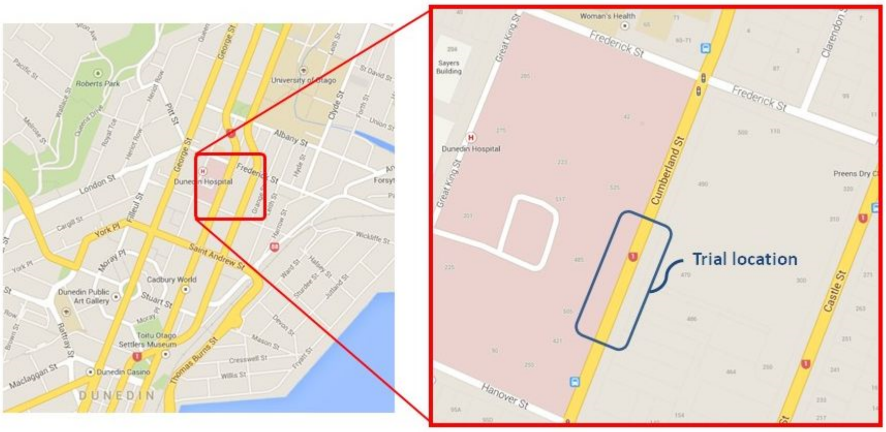

Figure 4: Trial location

Table 1: Average Annual Daily Traffic (and percentage heavy vehicles) in site vicinity

	Trial Street (northbound)	Adjacent one-way pair street (southbound)
South of site	Cumberland St (between Stuart St and St Andrew St) 15,000 veh/day (3.7)%	Castle St (between Stuart St and St Andrew St) 14,000 veh/day (3.9%)
North of site	Great King St (near Willowbank) 9,200 veh/day (7.2%)	Cumberland St (near Willowbank) 9,400 veh/day (5.9%)

If the surveys confirm the effectiveness of the measure, it is anticipated to roll out the marking style to those parts of the SH1 pair that has been retrofitted with wide cycle lanes.

The marking trial is supplemented by measuring parking discipline, as it was anticipated that the changed road markings may result in drivers parking further out from the kerb. Parking discipline was measured in various locations, and this is further explained in section 3.1 and shown in Figure 12.

1.4 Reason for non-standard treatment

The primary purpose of the marking was to create a buffer that encourages cyclists to track clear of the door opening zone of parked vehicles. A secondary consideration was that the buffer markings be established without inducing a negative change in parking discipline, i.e. the application of a buffer should not cause drivers to park further from the kerb, as that would partially negate any safety gains due to cyclists riding further out.

There are currently no recognised[2] markings that could be used to highlight the zone where car door openings create a hazard for cyclists. Consequently, diagonal hatched “chevron” markings were installed on the left side of wide cycle lanes adjacent to parked cars as shown in Section 2.

1.5 Who needs this change

Two road user groups benefit from the change:

- The primary purpose is to reduce crashes where cyclists are hit by opening car doors, or crash because they are avoiding opening doors. Cyclists are thus the main beneficiary of the change.
- A secondary benefit would apply to those motorists who open their car door into the path of oncoming cyclists, or who collide with cyclists as a consequence. If the risk of hitting a cyclist can be minimised, the trauma experienced by drivers causing serious injury or death can be avoided.

1.6 National implication

A recent study undertaken by Weiss (2013b) of the University of Otago’s Injury Prevention Research Unit (IPRU) shows the prevalence of dooring crashes in midblock locations. A subsequent study by Weiss (2013a) gives an indication of the underreporting of this crash type by analysing ACC data and comparing them with the CAS data from the original study. Overall, the studies indicate the common nature of the car door crashes. Should the trial be shown to be effective, then we would expect it to become national policy.

[2] The NZ Transport Agency MOTSAM Part 2 Road Markings

2 Trial stages

There were three distinct stages during the trial as summarised in Table 2.

Stage 1 represented the existing road marking layout before the trial began (Figure 5),

Stage 2 represented the changed cross section (Figure 6), and

Stage 3 saw chevron markings added to the cycle lane in those sections where the video surveys were taken (Figure 11).

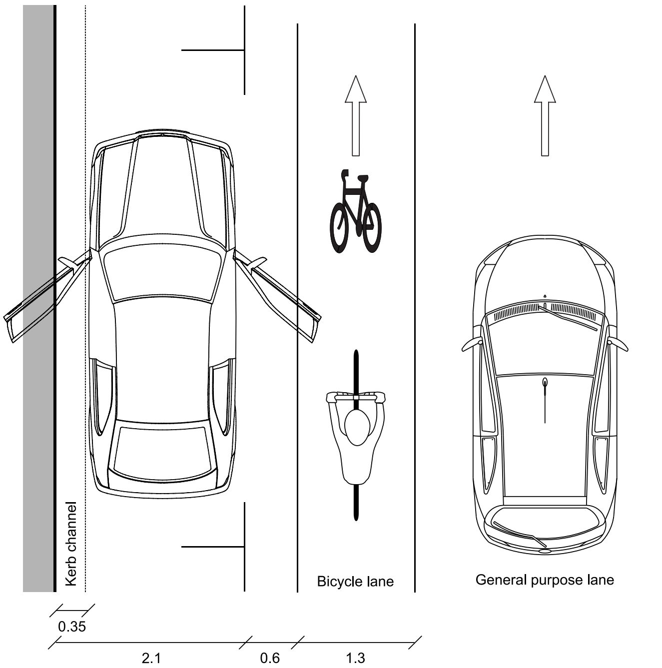

Figure 5: Stage 1 markings prior to the trial commencing

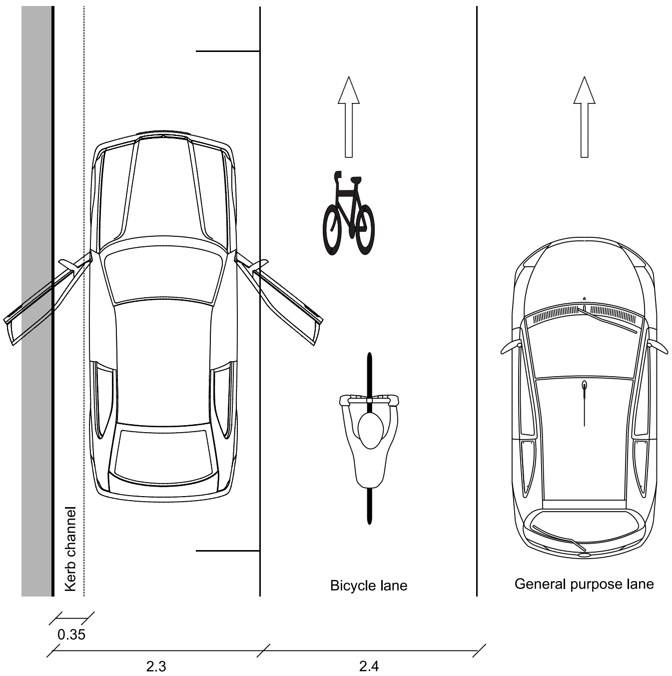

Figure 6: Stage 2 markings with widened cycle lane[3]

Table 2: Trial stages

Stage	Description
1	Unmodified cycle lanes
2	Widened cycle lanes
3	Buffer markings installed

The cross section shown in Figure 6 was implemented in this or a modified form along the entire SH1 one-way pair in Dunedin between Stuart and Duke Streets (3.6 km in total). The traffic lanes were narrowed, and the buffer between the right traffic lane and parking on the right hand side of the streets also reduced in width. In effect, the parking – cycle lane part of the carriageway was given an additional 0.7 m with the treatments. Note that the heads of the parking ticks were removed and the parking lines extended to a newly-placed edgeline. This change resulted in the left parking bays to increase in width by 0.2 m (Figure 7). The changed layout was achieved as part of reseals in some sections, and through water blasting in the remainder of the network. The water blasting technique is less effective, as traces of the original markings can still be seen (see Figure 7). The section where the video observations were carried out had the old markings removed through water blasting.

[3] Note that Figure 6 represents the layout that was implemented at zones 1 and 2; as discussed further down, the other sites were somewhat different.

Figure 7: Removal of parking ticks in zones 1 and 2

At the P5 time-restricted sites, individual car parks are not marked, but the whole parking area is demarcated with a continuity line, which was retained. This includes zone 3 which is directly downstream from the trial site (see Figure 12 for zone numbers) as illustrated in Figure 8.

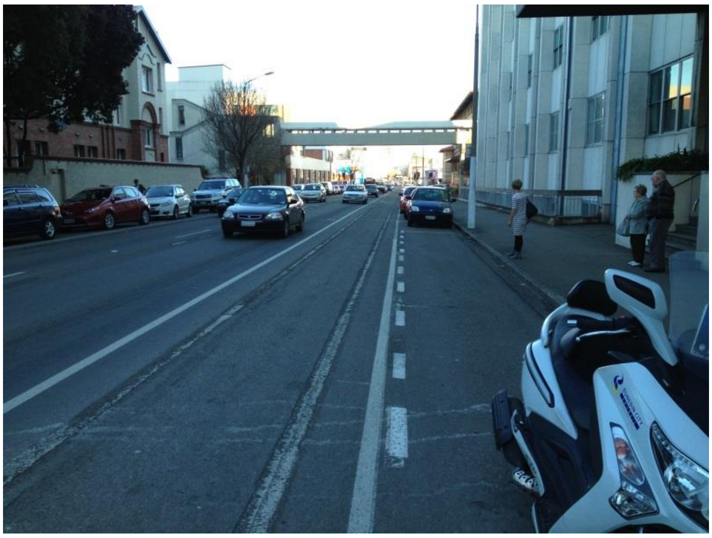

Figure 8: Continuity line demarcating the P5 parking area was retained

Figure 6 represents the markings that were installed at zones 1 and 2, the zones used for the video surveying. However what was actually intended for the sections that were not resealed, the existing parking ticks be left and the inner cycle lane edgeline be moved closer to the heads of the ticks. None of the other long-term parking zones used in the parking survey, i.e. zones 5,6 and 8, were resealed and thus they were marked differently to zones 1 and 2, as illustrated in Figure 9 and Figure 10. Figure 9 shows the section of the northbound section of the SH1 pair just south of Union Street; this area was zone 5 in the parking discipline survey. Figure 10 shows Castle Street south of Frederick Street; this area was zone 8 in the parking discipline survey.

Figure 9: Stage 2 cross section in zone 5

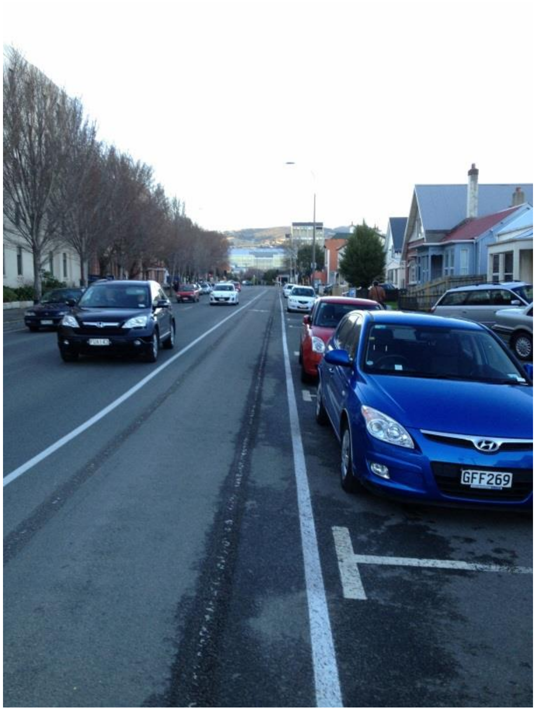

Figure 10: Stage 2 cross section in zone 8

In **Stage 3**, chevron markings were added to the car door opening zone of the cycle lane as shown in Figure 11. This was only implemented in the block where the video measurements were taken (i.e. zones 1 and 2 as shown in Figure 12).

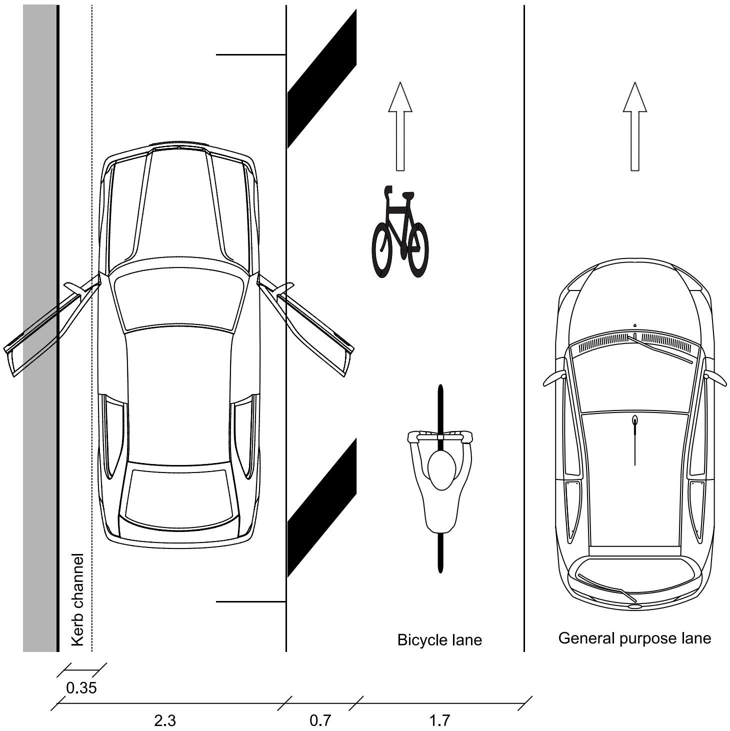

Figure 11: Stage 3 markings with buffers in the cycle lane

3 Parking discipline research

3.1 Parking discipline research – method

Parking discipline has been manually measured using a tape measure throughout the period between April and December 2013 in the eight zones identified in Figure 12. The northbound SH1 hospital bridge from which the video tracking survey was undertaken (see sections 4 and 4.2; Figure 22) is located between zones 1 and 2.

Figure 12: Parking discipline data collection zones

In zones 1 to 5, the one-way traffic moves in a northbound direction, and in zones 6 to 8, it moves in a southbound direction. As cycle tracking was measured from the over bridge, zone 1 is referred to as “upstream”, and zone 2 as “downstream”.

The eight zones had different characteristics. They differed in parking management, and there was either free short term parking (P5) or paid long term metered parking (M240). They also differed in the physical nature of the transition from carriageway to channel; in some zones, the transition was nearly flush (Figure 14), while in other areas, successive pavement overlays had created a distinct lip (Figure 13). This aspect was not measured, but visually assessed and categorised as 'flat' or 'lip'.

Figure 13: Lip at carriageway / channel boundary due to successive overlays

Figure 14: Flush transition from carriageway to channel

Table 3 shows a matrix of parking zone characteristics. None of the short term (P5) car parking zones had a lip, and there are thus three types of zones that have similar characteristics:

- Parking is short-term (P5) and there is no lip (three zones)
- Parking is long-term (M240) and there is no lip (three zones), and
- Parking is long-term (M240) and there is a lip between carriageway and channel (two zones)

A total of 56 car parks were located in the eight zones (where the "effective car parks" have been calculated in the P5 zones that did not have individual parking spaces marked). In addition, two short term car parks in zone 3 were for disabled parking, and the kerb was indented; these were not part of the survey.

Table 3: Matrix of parking zone characteristics[4]

	Parking management	
	P5	M240
No lip	3, 4, 7 (10)	1, 5, 8 (28)
Lip	n/a	2, 6 (18)

[4] The table shows the parking zone numbers, with the sum of the number of car parks given in brackets

The purpose of measuring parking discipline in zones with different characteristics was to test the following hypotheses:

1. Parking discipline improves with an increasing length of stay
2. Parking discipline is better where there is no lip between carriageway and channel
3. Installing the buffer markings will see a slight deterioration in parking discipline
4. Installing the buffer markings will result in cyclists tracking further to the right, which will more than compensate for the slight deterioration in parking discipline[5]

The first hypothesis is already known from overseas studies, and the real purpose of this research was to obtain data that reflect New Zealand driver behaviour and skills. The point of testing the second hypothesis was to determine whether there is economic justification to milling out lips to improve parking discipline. There were plans for some of the lips to be removed during the duration of the trial, which would have given direct before/after comparisons, but the physical works did not happen during the trial.

As it is known that widening parking lanes results in deteriorating parking discipline, it was anticipated that installing the chevron buffer markings would result in drivers parking further out from the kerb, but the expectation was that this would be more than compensated for by cyclists tracking further away from parked cars.

A total of 1,205 parking offset measurements were taken. Table 4 shows how the measurements distribute across the trial stages. All 211 measurements taken during Stage 2 also recorded the vehicle widths. This was done by two surveyors who measured the distance between the outside side walls of the rear tyres. Those measurements were taken by holding the tape shown in Figure 15 under the body of the car next to the rear tyres.

Table 4: Number of parking offset measurements

Stage	Description	No. of measurements
1	Unmodified cycle lanes	459
2	Widened cycle lanes	211
3	Buffer markings installed	535

Parking discipline was measured as the shortest distance between the kerb face and the side wall of the rear tyre of a car. Tyres were measured rather than the body of a car as the measurements were taken at footpath level, which required one horizontal measurement only. Rear tyres were chosen as front tyres might be turned, and in extreme cases, the shortest distance might thus not be a true reflection of where the body of a vehicle is located. Vehicles are also not necessarily parked parallel to the kerb, and agreeing on how to measure offset avoids surveyor bias. As the kerb face is not necessarily vertical, and the top of the kerb is often chamfered, the wooden angle[6] shown in Figure 15 was used for measuring parking discipline.

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[5] This hypothesis was tested through the video tracking study discussed in the next section of the report

[6] It was found that the vertical part of the survey instrument would ideally have been much shorter. Surveyors were instructed to place the horizontal part of the tool onto the kerb / footpath in such a way that it touched over its horizontal lengths, and where kerb faces were not horizontal, this left a short gap in the part of the tool where the two faces meet. If surveyors instead placed the tool so that the vertical part touched the kerb face over its length, this would have resulted in a difference of maybe 10 mm. Shortening of the vertical part of the tool would have avoided this potential survey bias.

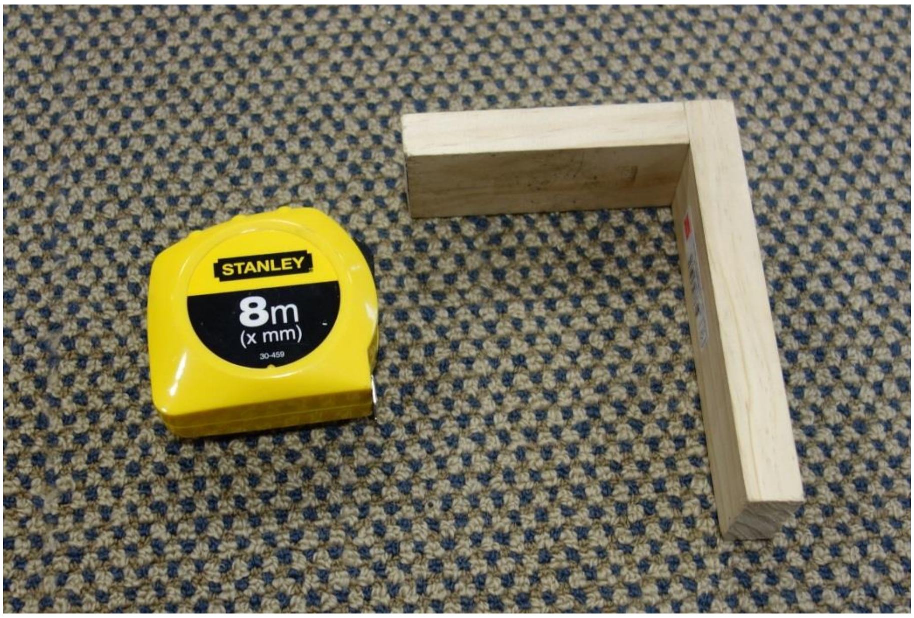

Figure 15: Survey equipment used for measuring parking discipline

The wooden angle was placed on top of the kerb, and the distance to the side wall of the tyre was measured from a datum marked on this tool to the nearest centimetre. The datum coincided with the back of the timber that touched the kerb face. Appendix D shows an example survey form, and as it can be seen, time of survey, zone number, number plate of the surveyed vehicle, and offset from the kerb were recorded along with notes where required. The data were transferred into a spreadsheet. Many cars remained in place between repeat surveys, and since number plates were recorded, it enabled the analyst to check the quality of the data collected, as offset measurements ought to have been the same in those cases. Very few inconsistencies were found, and it was thus concluded that all surveyors collected data of good quality.

3.2 Parking discipline research – results

The purpose of collecting data across different zones, i.e. within and outside of the video survey area, was to more easily reach sample sizes that achieve statistically significant results. This was based on the premise that data from zones with similar characteristics (Table 3) were comparable. The data analysis revealed some unexpected results. Analysing the results on a zone-by-zone basis showed correlation between some zones with the same characteristics, but no correlation with other zones with the same characteristics where good correlation was also expected. It was at this point in the analysis that it was discovered that going from Stage 1 to Stage 2 of the trial process, zones 1 and 2 had been road marked differently to how zones 5, 6 and 8 had been road marked.

The markings that had been specified for the research were as per Figure 9 and Figure 10. What was implemented in zones 1 and 2 was not as specified, but is as shown in Figure 6. The difference in layout is subtle, but it resulted in significantly different parking behaviour. Figures 8 and 9 show a layout where the existing parking ticks remained and the edgeline (i.e. the left hand side of the cycle lane) moved closer towards the kerbs. Drivers perceived that space for parking was more confined, and parking discipline improved, i.e. they parked closer to the kerb. In the layout shown in Figure 6, the edgeline was placed at the same offset from the kerb, but the parking ticks were removed, and the parking lines extended to the relocated edgeline. Drivers perceived that space for parking was less confined, and parking discipline declined, i.e. they parked further away from the kerb. Table 5 below summarises the situation.

Table 5: Two types of stage 2 road markings

	
Stage 2 markings for P240 areas as specified	Alternative Stage 2 markings for P240 areas
Implemented in zones 5, 6, and 8	Implemented in zones 1 and 2
Parking ticks kept	Parking ticks removed and parking lines extended to edgeline
Improved parking discipline	Declined parking discipline

This had major implications for the research. As Table 3 showed, the intention was to analyse parking discipline data consolidated for zones with similar characteristics to test various hypotheses, but the subtle differences that were introduced during the Stage 2 marking changes made this impossible to compare because it introduced another variable that had significant impact on parking behaviour. Consequently, the resulting datasets that were available did not have sufficient sample sizes for the results to be statistically significant.

Table 6 shows data consolidated for zones with similar characteristics the way the survey was designed, differentiating the zones with and without lips between the carriageway and the channel. As per Table 3, the data for 'M240 no lip' were collected in zones 1, 5, and 8. The results suggest that parking discipline improved from 34.7 cm offset from the kerb to 30.7 cm. Given that the available width for parking had increased by 20 cm in zone 1, due to the road marking configuration that was different than requested, the expectation was to see a decline in parking discipline and not an improvement. Clearly, there was an unanticipated factor influencing the situation.

Table 6: Unexpected results of consolidated parking discipline data for 'similar zones'

	Stage 1			Stage 2		
	sample	average (cm)	St Dev	sample	average (cm)	St Dev
M240 no lip	242	34.3	15.2	225	30.7	15.5
M240 lip	154	37.5	19.1	124	36.5	16.3

It was found that to consolidate the data is not valid, as the zones showed different parking behaviour. Table 7 shows the above data by zone, and here driver behaviour is as expected. For example, drivers in zone 1 had their parking bay increased in width by 20 cm, and this led to an average increase of offset from the kerb by 6.9 cm (from 38.0 cm to 44.9 cm). The same condition was applied to drivers in zone 2, and this led to an average increase of offset from the kerb by 10.4 cm (from 35.7 cm to 46.1 cm).

These observed increases in parking distance from the kerb were consistent with the expectation based on the research by Furth et al. (2010) who found in their field work in Boston, Massachusetts, that 30% of a widened parking lane will be taken up by decreased parking discipline, regardless of other factors such as the presence of an adjacent cycle lane. A widening of 20 cm would thus result in drivers parking, on average, 6 cm further out from the kerb. Their findings correspond well with the measurements from zones 1 and 2.

The parking tick markings were retained in zones 5, 8, and 6, and thus the parking width remained unchanged, but drivers evidently perceived less width available to them for parking, as the edgeline had shifted closer to the parking ticks in stage 2; this is shown in Figure 9 and Figure 10. The measured parking discipline consequently improved from between 1.6 cm (zone 5) and 8.3 cm (zone 6), as can be seen in Table 7.

Data are also given for P5 parking areas. Given that sample sizes are small, data for zones 4 and 7 have been consolidated; zone 3 is not included in this analysis, as it was marked in a different way to the other two zones in stage 2. The sample sizes for the individual zones are too small for the results to be statistically relevant at the 5% confidence level. Sampling was done for consolidated data as shown in Table 6, but as this discussion shows, consolidating the data for zones with similar characteristics is not valid.

Table 7: Parking discipline data by zone

		Stage 1			Stage 2		
	zone	sample	average	St Dev	sample	average	St Dev
M240 no lip	1	55	38.0	15.5	28	44.9	19.1
	5	77	32.5	15.5	82	30.9	15.6
	8	110	33.6	14.6	115	27.2	12.0
M240 lip	2	99	35.7	20.9	37	46.1	18.0
	6	55	40.7	14.8	87	32.4	13.5
P5	4&7	41	41.9	19.0	28	39.4	15.3

it is recommended to reinstate the former parking ticks in the section along the hospital

What is consistent across all zones is that from stage 1 to stage 2, the inner edgeline of the cycle lane was shifted to the left, 2.3 m from the kerb face. In zones 1 and 2, the heads of the parking ticks were then removed, and the parking bay markings extended to the inner edgeline. This treatment resulted in a reduced parking discipline, and it is recommended to reinstate the former parking ticks in the section along the hospital frontage. In the other zones, where the parking ticks remained, parking discipline has improved.

The data shown in Table 7 do not support the expectation that drivers park further out from the kerb in those zones where a lip exists between the carriageway and the channel, as stage 1 data for zone 1 (no lip) fall within the range of data recorded for zones 2 and 6 (lip). As the sample sizes are not high enough for the results to be statistically significant, this is not to say that such a relationship does not exist; it merely means that the data as collected cannot confirm the hypothesis.

As the parking ticks were kept in zones 4 to 8, it is relevant to compare short and long term parking behaviour across those zones for stages 1 and 2 in Table 7. It can be seen that parking offset from the kerb in the short term parking areas is always more than the long term areas. This seems to support the notion that parking discipline is a function of the length of stay, with drivers parking vehicles for longer taking more care to park closer to the kerb. The same effect is evident of drivers presumably experiencing less room for parking with the stage 2 markings having improved parking discipline. Once again, though, the sample sizes are too low for the results to be statistically significant.

From the results for zones 1 (M240 no lip) and 2 (M240 lip) for all project stages (Table 8), it can be seen that adding the diagonal bars in stage 3 appears to have resulted in a slight improvement in parking discipline. Due to the low zone 1 and 2 sample sizes during stage 2, however most of the results are not statistically significant. This is further demonstrated in Figure 16.

Table 8: Parking discipline data for zones 1 and 2 (cm)

	Stage 1			Stage 2			Stage 3		
zone	sample	avg	St Dev	sample	avg	St Dev	sample	avg	St Dev
1	55	38.0	15.5	28	44.9	19.1	130	40.1	15.9
2	99	35.7	20.9	37	46.1	18.0	128	41.1	18.2
1 & 2	154	36.5	19.2	65	45.6	18.5	258	40.6	17.6

What is shown as ‘Upstream’ in Figure 16 refers to zone 1, and ‘Downstream’ refers to zone 2. ‘Combined’ refers to the data for both zones 1 and 2 evaluated together.

If the difference between two samples is statistically significant, the respective confidence intervals will not overlap. The confidence intervals for the parking offset from kerb for the three stages are represented on Figure 16 by the span of the vertical lines. Thus, for the upstream site, none of the changes produced a statistically significant difference. For the downstream site the confidence intervals for stage 1 and stage 2 do not overlap so the lane widening produced a statistically significant increase in vehicle offset from the kerb, however there was no statistically significant change brought about by the buffer marking introduced in stage 3. The combined data show the same trends as for the downstream site, i.e. a statistical difference between stage 1 and stage 2.

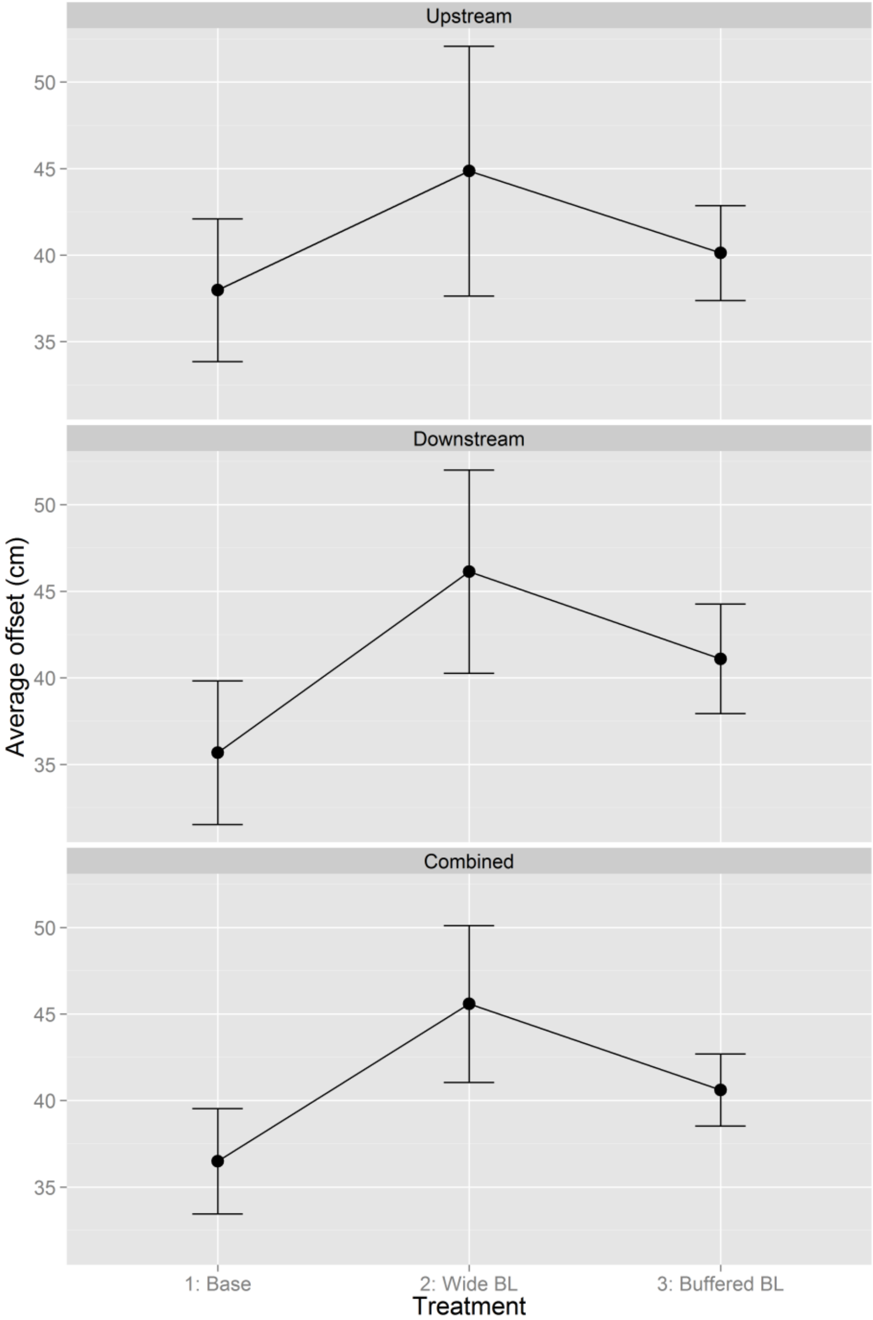

Figure 16: Average parking offsets from the kerb and 95% confidence intervals

The results of the vehicle width measurement are as per Table 9; the average vehicle width is 167 cm, with a standard deviation of 7.5 cm. For simplicity, it is assumed that the outside tyre side wall corresponds to the body of a car; the additional width of rear vision mirrors is not considered relevant, as the danger to passing cyclists is caused by opening car doors and not the mirrors.

Table 9: Vehicle width measurements (cm)

sample	average	St Dev
211	167	7.5

4 Video tracking study

4.1 Video tracking study – method

The methodology utilised digital a video camera positioned above the roadway on an enclosed pedestrian overpass that links the hospital buildings on either side of the survey site. The survey recording hardware was in a locked cage so that it could not be tampered with (Figure 18), and the camera was fixed to the outside of the building (Figure 17) and alternated between the two sites (upstream and downstream) meaning that the datasets for the two sites do not contain any data from the same period.

Figure 17: Camera setup

Figure 18: Survey hardware in locked cage

The cameras were positioned approximately overhead the centre of the cycle lane and looked directly upstream or downstream. From these videos the analyst staff measured the lateral position of parked cars and bicycles. The method used was as follows:

- Record the pixel coordinates of the inner cycle lane line and outer cycle lane at a fixed longitudinal datum.
- For each bicycle event, record the position where the front wheel (for the upstream view) or rear wheel (for the downstream view) touches the roadway when the bicycle crosses the datum. Record also the position of the outer face of parked cars at the datum when a bicycle is observed.
- For each parking event, record the position of the outer face of cars parked directly adjacent to the datum (bay 2), immediately upstream of the datum (bay 1) and downstream of the datum (bay 3).
- Apply trigonometric transformations to adjust for minor offsets in the azimuth and elevation of the camera.

Example screenshots are provided in Figure 19, Figure 20 and Figure 21 for each of the three trial stages at the upstream (zone 1) location. The lateral tracking of the cyclist could be reasonably confidently recorded using this method to within a few centimetres. The position of parked cars was somewhat more difficult to measure with accuracy; however, neither measurement is likely to be subject to significant bias. Appendix B discusses the repeatability of the method in further detail.

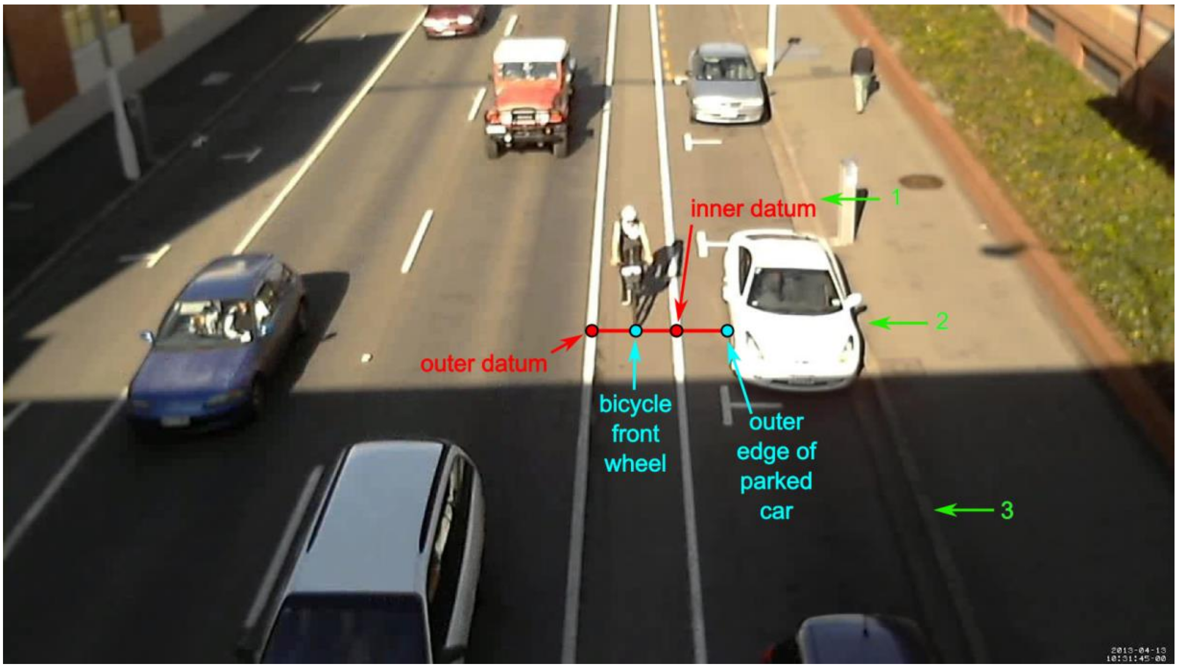

Figure 19: Sample screenshot before treatment

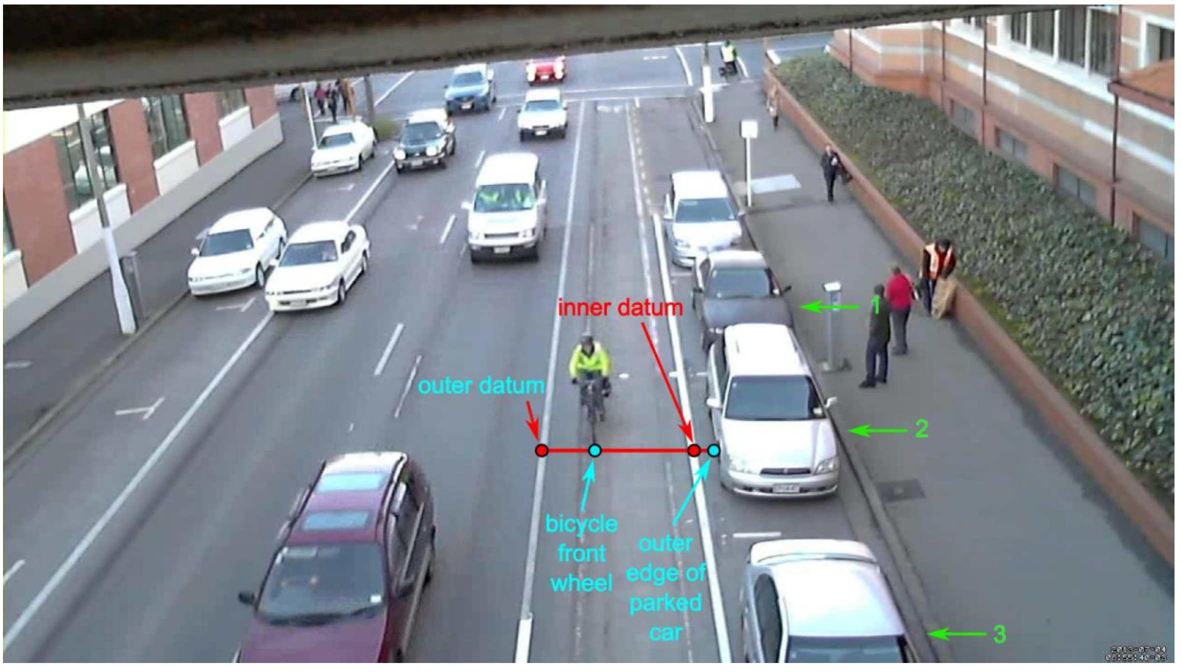

Figure 20: Sample screenshot with wide cycle lane

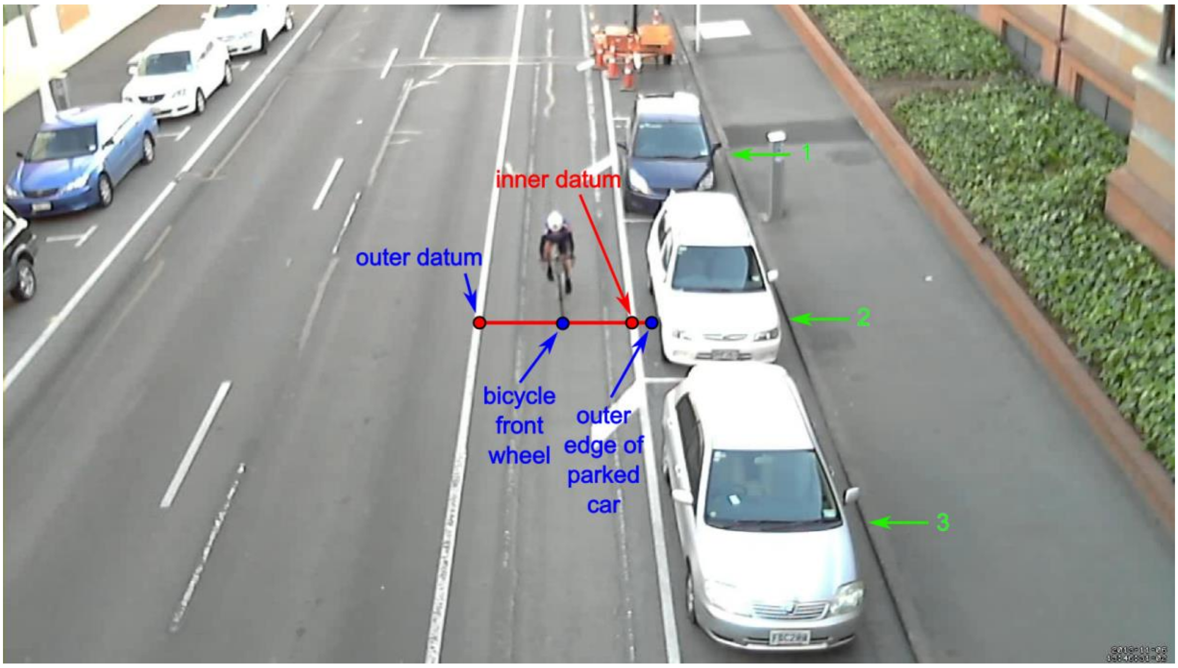

Figure 21: Sample screenshot with wide cycle lane and buffer

Cyclist lateral tracking was not recorded where the cyclists' path was either impeded by cars stopped in the cycle lane (usually as a result of waiting to manoeuvre into kerbside parking) or where the cyclist was riding outside the cycle lane (usually to travel to a destination on the opposite side of the roadway). These situations applied to only a minority of records (27 cyclists, or 1.8% of all bicycle records).

4.2 Video tracking study – results

In considering the implication of the results presented in this section, and their wider applicability to other sites, a number of factors specific to this site and trial should be noted:

- The trial included the realignment of the centreline between two one-way traffic lanes, and of the edgeline on the right side of the carriageway. This may have had some effect on motorist tracking, which in turn may have affected cyclist tracking.
- More critically, the old line markings remained clearly visible (in particular, the old dashed centreline and inner and outer edgelines of the original cycle lane; see Figure 21). It was observed that a significant proportion of motorists in the kerbside lane tracked to the left of the new lane after treatment; it is plausible that the visibility of the old centreline marking in particular may have influenced this behaviour. In turn, this may have tended to encourage cyclists to travel farther to the left in the cycle lane than they otherwise would have done.
- During Stage 3 (i.e. wide cycle lane with buffer), a large variable message sign (VMS) was present at the upstream end of the observed area during the observations (Figure 22). This may have had some influence on cyclist lateral tracking, at least at the upstream position. If it did have any impact it most probably would have been to encourage cyclists to travel farther out that they otherwise may have done.

Figure 22: Temporary sign present during stage 3 surveys

4.2.1 Cyclist lateral tracking

A total of 1,479 cyclist observations were made during the three trial periods across the two sites. In the majority of cases (86%) at least one parked vehicle was present either adjacent or immediately upstream or downstream of the datum. In 66% of cases at least two bays were occupied and in 36% of cases all three parking spaces were occupied. It is likely that cyclists will differ where they ride on the roadway depending on the presence of parked cars. In the analysis in this section only those cyclist observations where the adjacent parking bay is occupied (and perhaps also the upstream and/or the downstream space) are considered. This represents 63% of the cyclist observations.

Table 10 presents the summary statistics for the cyclist observations. The number of observations obtained were roughly even between the two sites, however while the downstream data involved very similar sample sizes between the three stages, for the upstream site stage 2 had significantly fewer observations that stage 1 and stage 3 even fewer again. These differences are most likely associated with temporal variations such as weather, and possibly the appearance of the VMS at the upstream site during stage 3.

Widening the cycle lane to 2.4 m in stage 2 had a statistically significant effect ($p<0.00$) on the average lateral tracking; at both sites the average lateral cyclist position moved between 0.45 and 0.54 m farther away from the inner edgeline (Table 10). However, there was no statistically significant difference in average lateral cyclist tracking with and without the buffer.

The proportion of cyclists who rode within 1.0 m of the inner cycle lane edgeline was much reduced once the lane was widened; between 81% and 90% of cyclists travelled within 1 m of the inner edgeline with the 1.3 m cycle lane, reducing to around 23% afterwards. This difference is statistically significant ($p<0.00$). However, taking into account the 0.6 m gap between the inner edgeline and parking tick in the 1.3 m cycle lane scenario, the differences relative to kerbside parking are much lower after the treatment. In other words, the wider cycle lane encourages cyclists to travel farther away from the inner edgeline, but on average they do so by no more than 0.6 m – the net result of which is an overall statistically significant reduction in lateral clearance to kerbside parking[7]. However, the magnitude of this change in average distance is fairly small; between 0.01 and 0.16 m.

What is perhaps more meaningful than the changes in average lateral tracking is the change in the proportion of cyclists travelling in the dooring zone. At the downstream site this increased from 7% to between 23% and 27%, and at the upstream site from 11% to

---

[7] The difference in the means is only statistically significant at the downstream site, and then only for the 2.4 m vs 1.3 m lane ($p<0.00$), and for the 2.4 m lane with buffer vs 1.3 m lane ($p<0.00$).

between 13% and 24% with the 2.4 m lane treatments. The differences are all statistically significant aside from the upstream 1.3 m lane compared with 2.4 m lane with buffer and the downstream 2.4 m lane compared with 2.4 m lane with buffer. In other words, the treatments appear to have had the effect of either not altering the proportion of cyclists travelling within the dooring zone or increasing the zone proportion. This runs contrary to the design intent.

The effect of the buffer is more difficult to determine. At the downstream site the proportion riding within the door zone without the buffer (23%) was essentially unchanged after treatment (25%). At the upstream site the effect was in line with our expectations; the proportion decreased from 24% to 13% (p=0.034).

Table 10: Cyclist lateral tracking summary statistics[8]

Site	Upstream			Downstream		
Treatment	1.3m lane	2.4m lane	2.4m lane with buffer	1.3m lane	2.4m lane	2.4m lane with buffer
No. of observations	224	160	99	151	196	148
Relative to inner edgeline						
Average	0.74	1.28	1.34	0.78	1.23	1.22
Median	0.74	1.26	1.32	0.78	1.17	1.15
Std. deviation	0.28	0.51	0.60	0.11	0.49	0.25
% within 1 m	90%	24%	13%	81%	23%	27%
Relative to parking bay						
Average	1.34	1.28	1.34	1.38	1.23	1.22
Median	1.34	1.26	1.32	1.38	1.17	1.15
Std. deviation	0.28	0.37	0.32	0.26	0.36	0.39
% within 1 m	11%	24%	13%	7%	23%	27%

The change in the cyclist lateral tracking in each of the treatments is illustrated in Figure 23. This figure illustrates the fairly tight lateral range within which cyclists travel (particularly at the downstream site), and the shift in the distribution closer to the parking bay in both of the 2.4 m lane cases.

The data for the two sites have not been combined as they display sufficiently different results to indicate different influences at the two locations. This may be due to the fact that the upstream site is directly after an intersection followed by a long bus-stop with low occupancy rates and the parking occupancy rates are somewhat lower at than for the downstream site. Thus, even though the methodology attempted to account for parking occupancy by selecting only the observations where at least the park adjacent to the datum was occupied, cyclists passing through the upstream site may in general perceive themselves to be less restrained by parked vehicles. The downstream site more "established" as a true mid-block situation, with more uniformity in terms of parking provision. The results seem to display a "signal to noise" ratio problem, meaning that a small change in a variable can generate a lot of disturbance in the data and produce less-meaningful results.

From this analysis, we conclude the following:

[8] Note: distances are in metres, positive values are away from the kerb. Only observations where a vehicle was parked directly adjacent to the datum are presented.

- Widening the cycle lane increased the lateral offset of cyclists from the inner edgeline in the range of 0.45 to 0.54 m.
- However, this was not sufficient to compensate for the loss of the 0.6 m buffer between the parking ticks and inner edgeline before treatment. The result is that the average cyclist cycles 0.01 to 0.16 m closer to the parking zone after treatment.
- The buffer does not seem to have a significant effect on cyclist lateral tracking positions.
- The proportion of cyclists travelling within the dooring zone has significantly increased after widening the cycle lane in most cases, roughly doubling from 10% to 20-25%. The effect of the buffer is inconsistent; it appears to have reduced markedly the proportion riding within the dooring zone at the upstream site but has had no effect at the downstream site (compared to the 2.4 m lane without buffer).

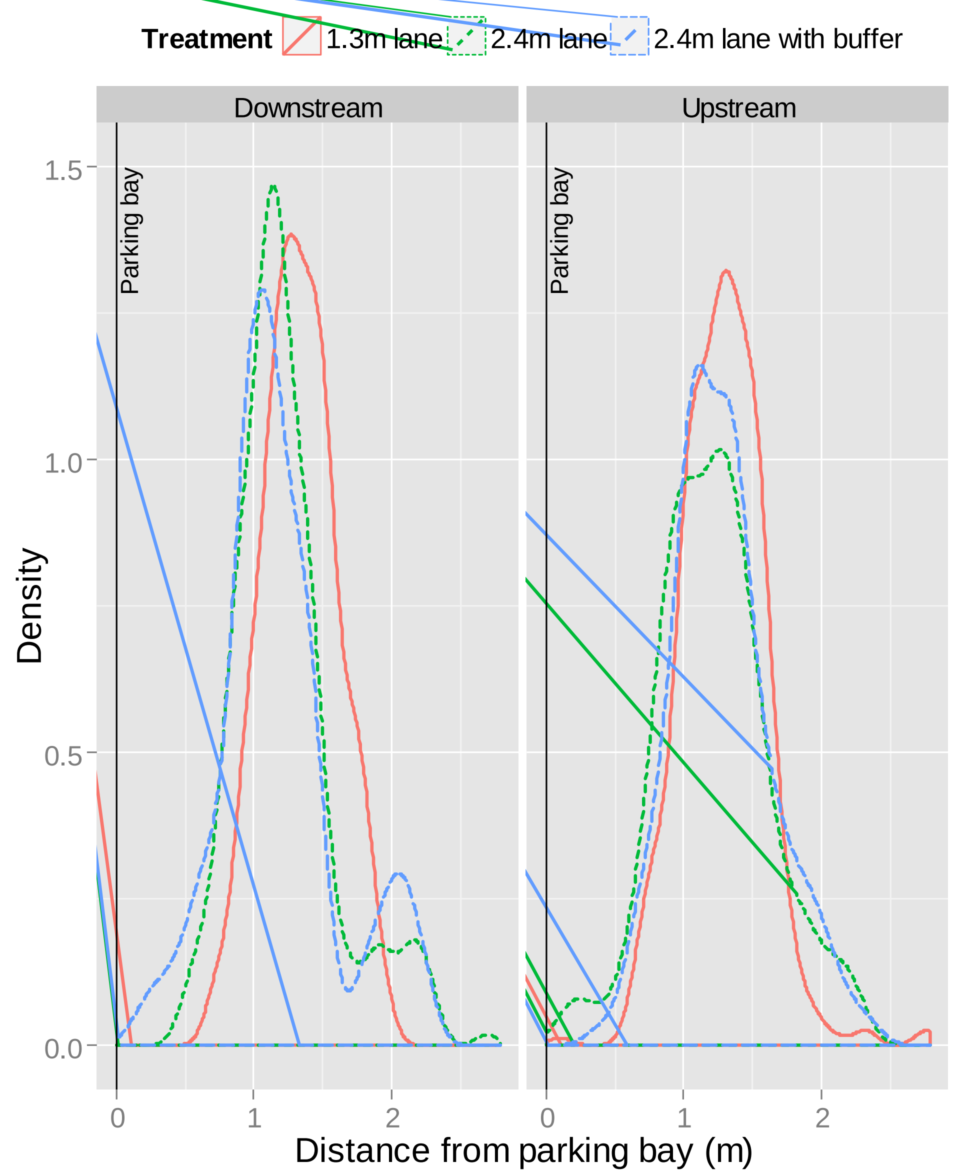

Figure 23: Cyclist lateral tracking by site and treatment

4.2.2 Parking

As explained in Section 2, the parking bays were increased in width from 2.1 m to 2.3 m along with widening the cycle lane. In each direction the position of parked vehicles at three parking bays was measured (adjacent to the datum – bay 2, immediately upstream (bay 1) and immediately downstream (bay 3)). The number of parking events observed through the video survey was relatively low at each site (between 37 and 181 at each site) and for each condition. This sample size, in combination with the inherent limitations in the video-based measurement method, limits the comparisons that can be drawn. Nonetheless, Table 11 suggests that the average distance of the outer face of parked cars did not change markedly with either of the treatments. Only in the downstream direction was a statistically significant change in average parking offset detected, and only between the 1.3 m lane and 2.4 m lane without buffer (M=-0.07 m, p=0.049) and 2.4 m lane with buffer compared to the 2.4 m lane without buffer (M=+0.062 m, p=0.024). The magnitude of these differences (around 6-7 cm) is of little material importance, and is likely to be within the measurement uncertainty. As such, we conclude that from this data we cannot conclude that parking offsets have changed in any of the treated cases.

There does not appear to be any clear trend (nor significant difference) in the variability of lateral parking position at the upstream site; the standard deviation of parking position of 0.21 to 0.25 m between treatments is not significantly different. However, at the downstream site a significant reduction in the variability of parking position is evident after treatment; the standard deviation reduces from 0.23 m to 0.15 m (2.4 m lane without buffer) and 0.11 m (2.4 m lane with buffer). Why this would be the case is not clear; given the parking bays were widened by 0.2 m after treatment we would expect variability to increase rather than decrease. Given this result is counterintuitive, and is not replicated at the upstream site, we are of the view that this result is more likely to be an artefact of the measurement method than a true outcome of the study. Furthermore, this finding is not replicated by the more accurate measurements made of inner parking offset described in Section 3.2.

Table 11: Parking position summary statistics[9]

Site	Upstream			Downstream		
Treatment	1.3m lane	2.4m lane	2.4m lane with buffer	1.3m lane	2.4m lane	2.4m lane with buffer
No. of observations	181	77	37	46	99	78
Average	2.01	2.00	2.03	2.19	2.13	2.19
Median	2.02	1.98	2.06	2.17	2.14	2.20
Std. deviation	0.24	0.21	0.24	0.23	0.15	0.11

Figure 24 is a box-and-whiskers plot showing the parking data obtained from the video survey, and illustrates the insignificant changes in mean and median parking offsets but the significant reduction in parking offset variability at the downstream site after treatment.

[9] Note that distances are in metres, relative to the inner edgeline. Positive values are towards the kerb face.

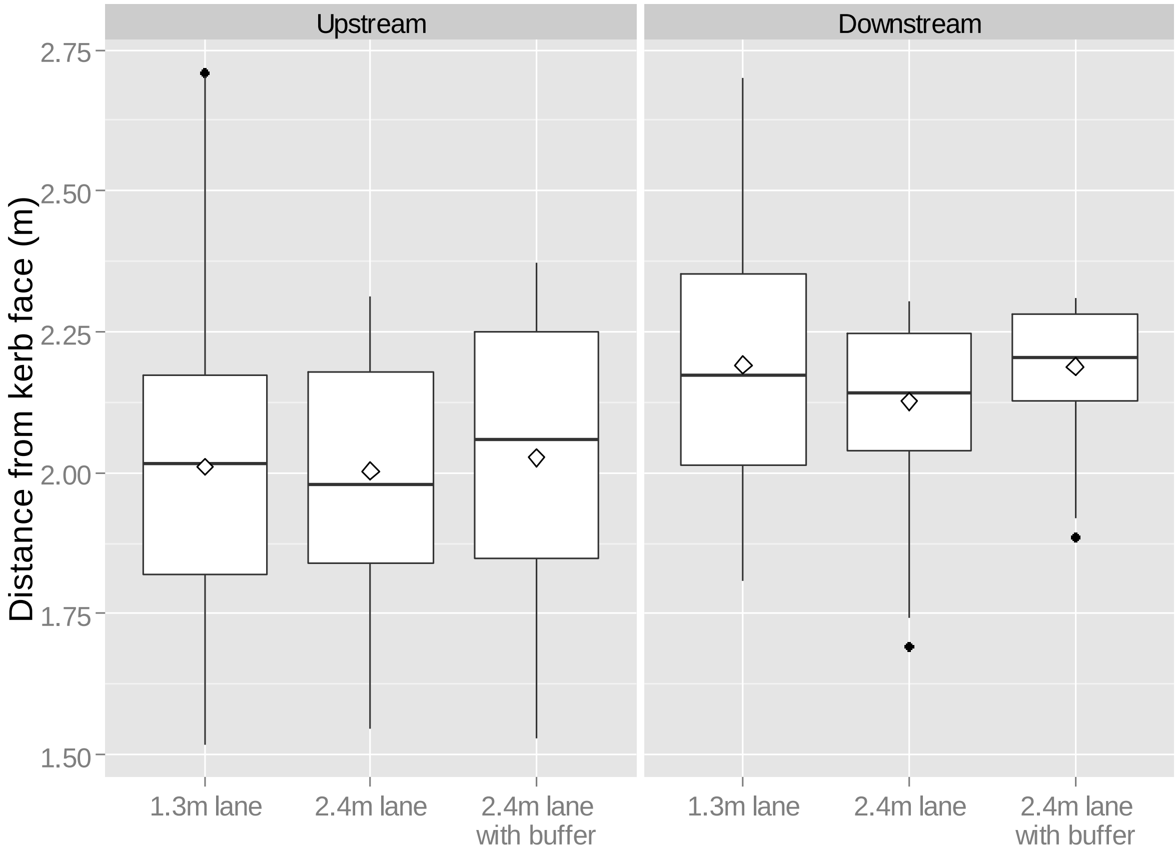

Figure 24: Lateral parking positions by site and treatment from video survey[10]

In descriptive statistics, a box-and-whiskers plot is a convenient way of graphically depicting groups of numerical data through their quartiles.

The horizontal line within the box is the median. The upper and lower hinges of the box represent the first and third quartiles (the 25th and 75th percentiles). The spacing between the different parts of the box thus help indicate the degree of dispersion (spread) and skewness in the data. The diamond within the box is the average, and especially when the data are skewed, the mean and the average may be quite different.

The lines extending vertically from the boxes are called whiskers, which indicate variability outside the upper and lower quartiles. The whiskers extend to within 1.5 times the inter-quartile range. The interquartile range (IQR) is a measure of statistical dispersion, being equal to the difference between the upper and lower quartiles, IQR = Q3 − Q1. In other words, the IQR is the first quartile subtracted from the third quartile.

If there are data points present that extend beyond the end of the whiskers, those outliers are plotted as individual points.

As can be seen in Figure 24, drivers park further away from the kerb in the downstream location. There is a larger spread in the parking positions in the upstream location.

There is no discernible relationship between parking position and cyclist lateral tracking. It would seem reasonable to expect that cyclists will track farther out if parked cars are positioned farther out from the kerb. However, as shown in Figure 25 no effect was discernible at either the upstream or downstream locations for any of the treatments. In

[10] Note that the datum for the data is the kerb face

this figure the maximum car position of the three bays at each location is presented. Similar results are obtained if only the parked vehicle directly adjacent to the datum is considered.

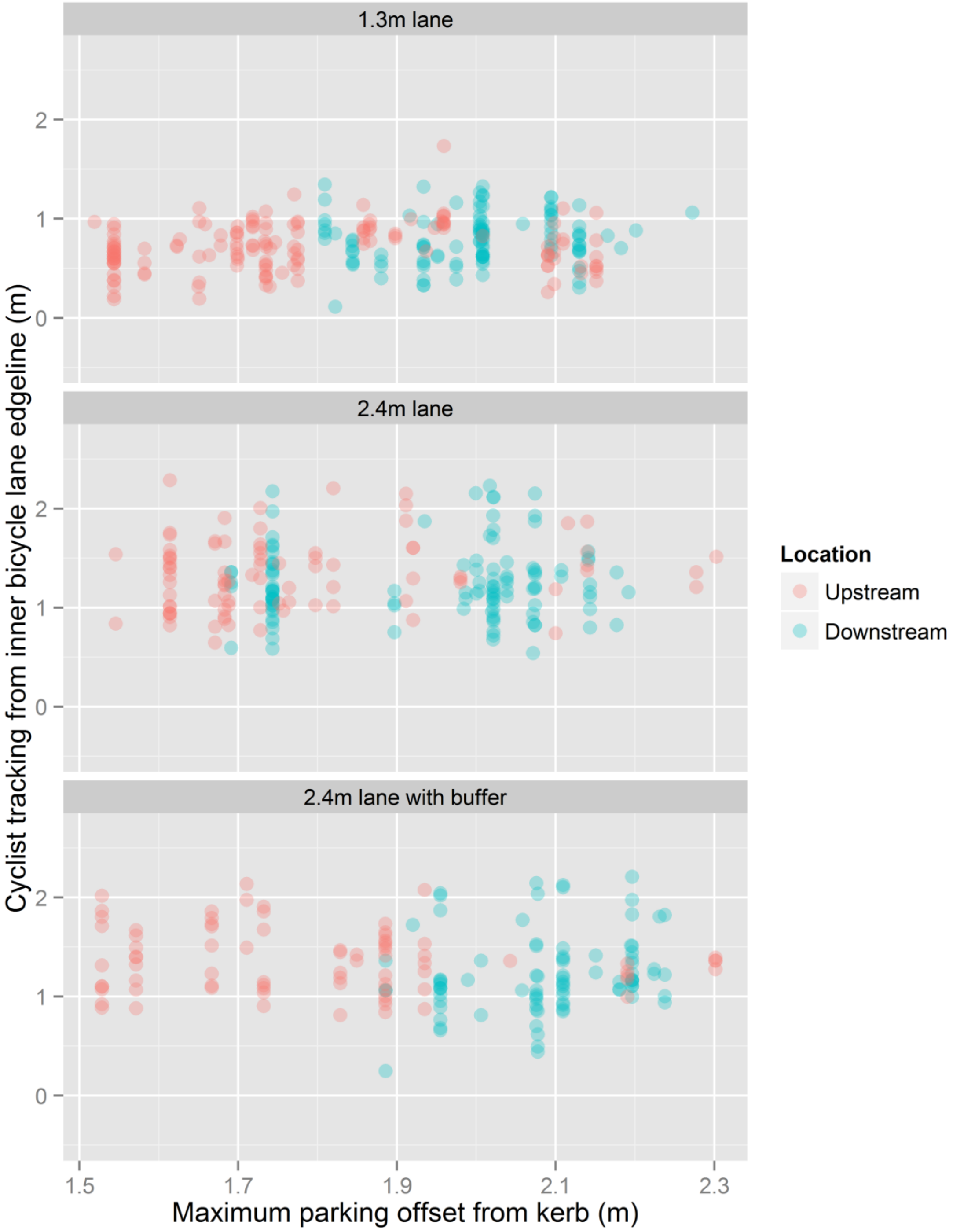

Figure 25: Lateral parking positions and cyclist tracking by site and treatment from video survey

5 Discussion of overall results

Two independent studies have been undertaken, a parking study to measure parking discipline, and a video tracking study to measure cyclist positioning. Sub-studies were measurements of vehicle widths, and parking discipline has to a limited extent also been recorded through the video survey. The overall purpose of the trial was to establish to what extent road markings influence the relative positioning of parked vehicles and cyclists in an adjacent cycle lane. The core issue is whether the separation between cyclists and parked vehicles increases as a consequence of road marking layout. That might be achieved by cyclists changing their tracking, or by drivers parking closer to the kerb, but ideally both these effects should happen simultaneously and the outcomes compounded.

Parking study data have previously been discussed in section 3.2. Figure 16 presented average offsets from the kerb, with 95% confidence intervals around the given averages. Figure 27 below gives a box-and-whiskers plot of the same dataset, with the kerb as the datum. As explained before, the box-and-whiskers plot is based on medians (i.e. the horizontal line within the box) and averages (the diamond within the box).

Bike tracking data have previously been discussed in section 4.2.1. Figure 23 gave a histogram of the tracking data, with the inner edgeline as the datum. Figure 26 below gives a box-and-whiskers plot of the same dataset, with the kerb as the datum.

The two box-and-whiskers plots below allow a more direct comparison of the change in road user behaviour. It must be stressed that the surveys are not related, and that tracking was recorded at a different time than parking discipline, and there is thus no direct correlation between the data. What further complicates the analysis is that the parking discipline data record the offset of the rear left tyre from the kerb, but what really matters is where the right side of the car is in relation to cyclists. For this reason, vehicle widths have also been recorded, and the average (167 cm) and Standard Deviation (7.5 cm) are given in Table 9. Nevertheless, if it is assumed that parking discipline as measured is representative, that tracking in turn is also representative, and that vehicle widths are also evenly distributed, it is reasonable to analyse the parking discipline and bicycle tracking datasets simultaneously for the core issue that the study intended to reveal, and that is whether the road marking changes applied in Dunedin result in cyclists increasing their separation from parked vehicles. Most of the changes in parking offset are not statistically significant, though, as explained previously.

However, while the differences in means are insignificant, the change in proportion riding within the dooring zone is significant. This is a profound and important finding. At the downstream site this increased from 7% to between 23% and 27%, and at the upstream site from 11% to between 13% and 24% with the 2.4 m lane treatments. The differences are all statistically significant aside from the upstream 1.3 m lane compared with 2.4 m lane with buffer and downstream 2.4 m lane without buffer compared with 2.4 m lane with buffer. In other words, the 2.4 m lane without buffer appears to have had the effect of increasing the proportion of cyclists travelling within the dooring zone. This is not an unexpected result; in the 1.3 m lane configuration there was a 0.6 m space between the parking bay and the cycle lane inner edgeline which was removed in the 2.4 m cycle lane design. Although the final configuration included a painted buffer this has had contradictory results at the two sites.

This increase in the proportion of cyclists travelling within the dooring zone runs contrary to the design intent and is the part that really matters. A small change in mean is irrelevant, since as long as that change happens within the dooring zone, the outcome in either case is that a cyclist is likely to be hit by an opening door or forced into the live traffic lane. The pertinent issue is the proportion of cyclists who track outside the dangerous ‘door opening’ position, and that proportion has decreased.

It is thus necessary to hold further discussions about marking changes that could help achieve the design intent, and that is to reduce risk by minimising the proportion of cyclists tracking within the door opening zone.

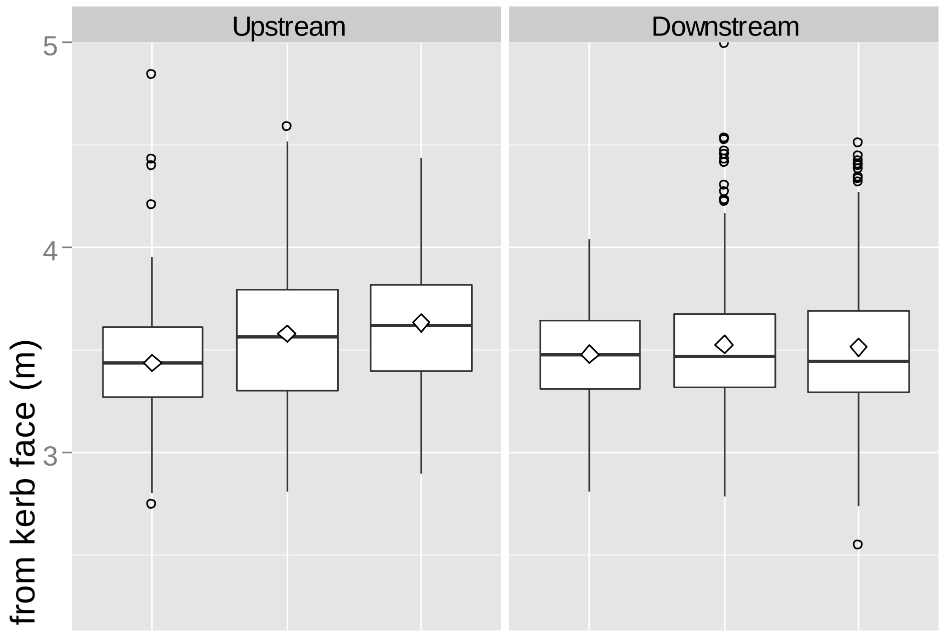

Figure 26: Cyclist lateral tracking

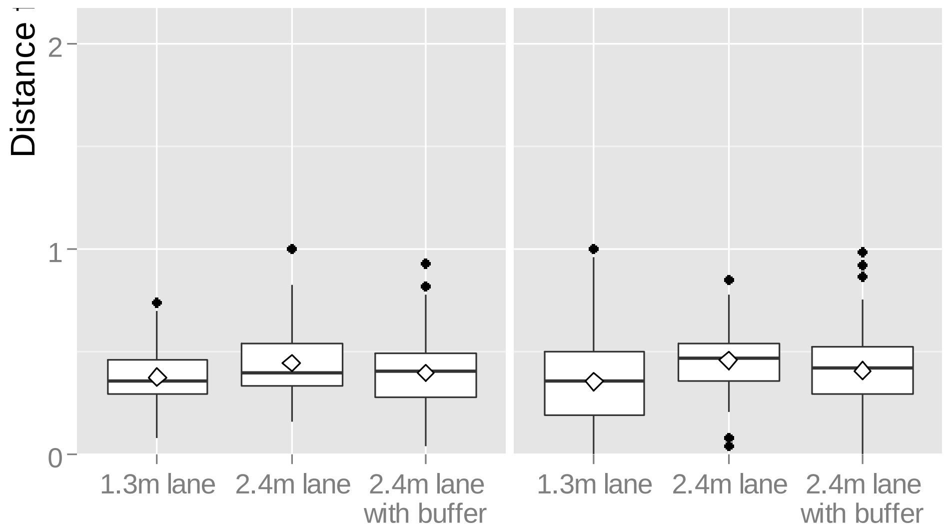

Figure 27: Parking offset from manual surveys

6 Conclusions and recommendations

- Different marking styles were implemented in the two zones where tracking videos were taken compared to the six other parking survey zones. In the video zones, parking ticks were removed and parking lines extended to a relocated inner edgeline, effectively increasing the width of the parking lanes. In all other zones, parking ticks were kept, and together with the relocated inner edgeline, the data show that motorists perceived the parking lane as having been narrowed which resulted in better parking discipline. This has had a significant impact on this study, as the data collection strategy had been designed around survey zones with similar characteristics to be comparable. As a consequence, most of the sample sizes from the parking discipline surveys are too low for the results to be statistically significant.
- The findings from an American study on parking discipline (Furth et al., 2010) that 30% of a widened parking lane will be taken up by decreased parking discipline (i.e. drivers will park further out from the kerb) correspond well to Dunedin data.
- The reverse is also the case, as when drivers perceived a narrower parking lane (even though, in reality, the width had not changed) they parked closer to the kerb. It is thus advisable to use parking ticks, with a small gap between the parking tick heads and the cycle lane edgeline.
- The data confirm the hypothesis that rivers tend to park closer to the kerb when the length of their stay increases.
- The data as collected do not support the hypothesis that a lip between the carriageway and channel results in reduced parking discipline.
- Vehicle widths (excluding mirrors) have been recorded and found to be 167 cm on average, with a Standard Deviation of 7.5 cm.
- It is recommended to reinstate the former parking ticks in the section along the hospital (note that their removal was contrary to the implementation instructions).
- It was found that the marking changes resulted in an overall increase of the proportion of cyclists tracking within the dooring zone, and with one exception, these changes were all statistically significant. This runs contrary to the design intent.
- Consequently, discussions should be held as to what further actions or changes should be tried that may help to achieve the design intent. Such approaches could include:
    - Coloured surfacing in the “riding zone” of the cycle lane, i.e. the non-dooring part where it is intended for cyclists to ride.
    - Realignment of the cycle symbol to coincide with the centre (or even slightly right of the centre) of the riding zone of the cycle lane.
    - Physical elements in the buffer zone (e.g. small protrusions or a rougher surface) that do not prohibit cycling but decrease the attractiveness to cycle there.
    - Stronger delineation of the buffer zone – e.g. a dashed line between the chevrons and the riding zone.
    - Stronger delineation of the cycle lane with respect to the adjacent live traffic lane – e.g. a green dashed line in the cycle lane besides its outer edgeline, as per current practice in Hastings. The aim of this is to increase the visibility of the cycle lane to motorists and, more importantly, increase cyclists’ perceptions of this – if they consider that motorists are more likely to recognise the cycle lane and respect its boundaries they will feel less threatened by the risk of collision from behind and thus more comfortable cycling closer to the traffic lane.

7 References

FURTH, P. G., DULASKI, D. M., BUESSING, M. & TAVAKOLIAN, P. 2010. Parking Lane Width and Bicycle Operating Space. *Transportation Research Record: Journal of the Transportation Research Board,* 2190**,** 6.

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WEISS, H. 2013b. NZ Cyclist/Dooring Map Released by IPRU. Dunedin: IPRU.

Appendix A Trial application

Appendix B Repeatability of the method

The accuracy of the video-based lateral tracking method has been tested for repeatability using independent analysts (i.e. the technical staff member charged with extracting the data from the video survey) on a sample of records. A sample of 40 records was examined independently by two analysts and the data compared. The differences in the average tracking position from this sample was statistically insignificant (M=0.04 m, p=0.08) and at the individual level most records closely aligned (Figure 24). This analysis suggests the method is reliable, at least insofar as it is not subject to undue variation between analysts.

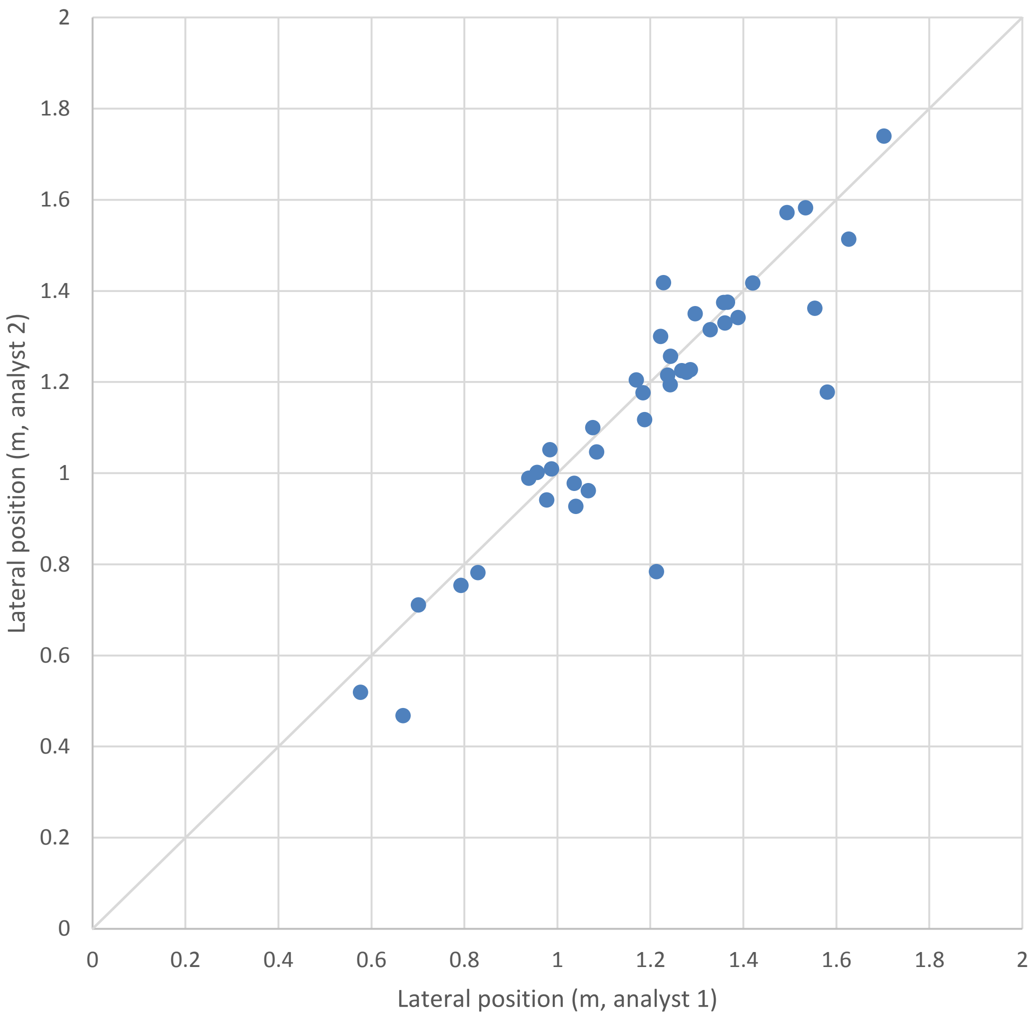

Figure 28: Repeatability of measured lateral tracking positions

Appendix C Timeline

Date	Item
Mar 2013	Trial application submitted to NZTA head office
Early Apr 2013	Collection of before parking data (3–11 April)
Mid-Apr 2013	Video survey of unmodified cycle lanes (10–13 April)
Jun 2013	Trial gazetted
Jun 2013	Cycle lanes widened in hospital block
Jul 2013	Video survey of widened cycle lanes (3–9 July)
Jul/Aug 2013	Collection of parking data after cycle lane widening (19 Jul – 14 Aug)
Mid-Sep 2013	Buffer markings installed
Nov 2013	Video survey of cycle lanes with buffers (6–13 Nov)
Nov/Dec 2013	Collection of parking data with buffers (6 Nov – 13 Dec)

Appendix D Example survey form

Time	Zone	No plate	offset (cm)	Notes
10.08	8	FFT525	31	
	8	JARVIS	25	Transit Van
	5	ZUZ535	59	
	8	ETK47	40	
	8	US9297	43	
	8	CPJ442	23	
	8	AKM893	30	
	8	KFS796	56	
	8	GGL59597	56	
	1	FYL415	20	
10.14	1	DTW960	43	
	1	WA2262	45	
		OLS212	41	
	2	DGT130	56	
		CHH252	43	
		ASP949	35	
		SK7515	53	
		BEL114	58	
		YHG178	77	
		ASJ696	96	
10.20	3	CPA415	58	
		X FTOR	53	
		BNT660	62	
	4	ABY139	35	
		BZR172	52	
		UK6542	4	
		ERG907	35	
		DGE995	41	
	5	DCT970	34	
		AEG496	32	

Surveyor: Simon Tomkins

Date: 10/4

record things like:

* anything other than a car is parked
* a zone is empty
* anything unusual going on

Appendix E Parking data collection timeline

Week	date	sample size	stage	surveyor(s)	width
12	Friday, 22 March 2013	36	1	Axel	
14	Tuesday, 2 April 2013	14	1	Axel	
14	Wednesday, 3 April 2013	83	1	Simon & Axel	
14	Thursday, 4 April 2013	135	1	Simon	
14	Friday, 5 April 2013	71	1	Simon	
15	Wednesday, 10 April 2013	86	1	Simon	
15	Thursday, 11 April 2013	34	1	Simon	
29	Friday, 19 July 2013	93	2	Simon & Jesse	yes
30	Thursday, 25 July 2013	36	2	Simon & Jesse	yes
30	Saturday, 27 July 2013	36	2	Simon & Jesse	yes
33	Wednesday, 14 August 2013	46	2	Simon & Jesse	yes
45	Wednesday, 6 November 2013	40	3	Isabelle	
45	Thursday, 7 November 2013	22	3	Isabelle	
46	Wednesday, 13 November 2013	37	3	Isabelle	
46	Friday, 15 November 2013	20	3	Isabelle	
47	Monday, 18 November 2013	38	3	Isabelle	
47	Tuesday, 19 November 2013	28	3	Isabelle	
47	Wednesday, 20 November 2013	41	3	Isabelle	
47	Thursday, 21 November 2013	33	3	Isabelle & Aron	
47	Friday, 22 November 2013	37	3	Aron	
48	Monday, 25 November 2013	41	3	Aron	
48	Tuesday, 26 November 2013	23	3	Aron	
48	Wednesday, 27 November 2013	21	3	Aron	
48	Thursday, 28 November 2013	23	3	Aron	
48	Friday, 29 November 2013	12	3	Aron	
49	Monday, 2 December 2013	17	3	Aron	
49	Tuesday, 3 December 2013	22	3	Aron	
49	Wednesday, 4 December 2013	14	3	Aron	
49	Thursday, 5 December 2013	12	3	Aron	
49	Friday, 6 December 2013	10	3	Aron	
50	Monday, 9 December 2013	15	3	Aron	
50	Tuesday, 10 December 2013	15	3	Aron	
50	Wednesday, 11 December 2013	9	3	Aron	
50	Friday, 13 December 2013	5	3	Aron	
	total	1,205			width
		459	1	Stage	211
		211	2	Stage	
		535	3	Stage	