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High occupancy vehicle lane enforcement: a successful trial in Brisbane by adding a splash of magenta*

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The views expressed in this paper are those of the authors and do not necessarily represent those of the Queensland Department of Transport and Main Roads or the Queensland Government.

* *Magenta - comprised of equal amounts of blue and red, and the official enforcement colour of the Transport Inspection Service of the Queensland Department of Transport and Main Roads.*

Abstract

High occupancy vehicle (HOV) lanes (such as bus lanes and transit lanes) are designed to encourage more efficient use of road space. HOV lanes have the potential to move more people with fewer vehicles, encourage modal shift from single occupant vehicles to high occupancy vehicles and provide travel time savings and reliability to users.

The unlawful use of HOV lanes prevents these outcomes being achieved and reduces the benefits to those people making a sustainable travel choice. Work undertaken for the Queensland Department of Transport and Main Roads showed rates of violation were as high as 89% of vehicles travelling in some HOV lanes.

One of the challenges in any enforcement regime is finding the optimal level of enforcement for a desired outcome.

The department undertook the High Occupancy Vehicle Lane Enforcement Trial (HOVLET) which was a 6 month trial during 2010 across four typical arterial corridors in Brisbane to test the efficacy of using its own Transport Inspectors to make the road network more efficient without imposing any additional burden on the ability of Police to undertake their vital work in policing other offences.

This paper examines the issues involved in enforcement of transit and bus lanes, the conduct of the trial and its success in increasing HOV lane efficiency.

1. Introduction

From May to October 2010 the Queensland Department of Transport and Main Roads (DTMR) undertook a 6 month trial of scheduled, on-road enforcement of high occupancy vehicle (HOV) lanes. This enforcement, across bus and transit lanes in Brisbane, was designed to test the capabilities of DTMR Transport Inspectors to deliver the enforcement, and to measure the impacts on the transport efficiency and traffic behaviour in the targeted corridors without compromising officer and public safety. A regime of traffic surveys undertaken between March and November 2010 allowed for the evaluation of the trial and its impact.

1.1 Objectives of this paper

This paper will:

- outline the basic transport challenge and congestion problem in Brisbane,
- consider some key factors in the operation and use of HOV lanes in Brisbane and other jurisdictions,
- report on the High Occupancy Vehicle Lane Enforcement Trial (HOVLET), and
- discuss the likely influence of a range of demographic and travel behaviour patterns in the success of the trial during 2010.

1.2 Congestion: a growing problem for Brisbane and its CBD

Brisbane, like many cities around the world, is facing a growing problem with congestion. The Australian Bureau of Transport and Regional Economics (BTRE) estimated that the avoidable cost of congestion in Brisbane in 2005 was $1.2 billion and that this would increase to $3.0 billion in 2020 (BTRE 2007, p. 13-14).

As highlighted by Marinelli et al, (2010 p. 2), the last decade in Brisbane has seen the Queensland Government and Brisbane City Council invest significant resources into new road, public and active transport infrastructure and services across Greater Brisbane, particularly in and around the Central Business District (CBD) and its surrounding suburbs.

A particular focus was given to congestion management by the Queensland Government through a range of solutions around land use and planning, travel demand, travel options, efficiency gains and capacity enhancements (Nolan 2009).

One project funded under the congestion management program was an initiative to test the contribution that better compliance in existing HOV lanes could make to congestion management. In 2010, a trial was undertaken in Brisbane that included surveys and 6 months of scheduled, on-road enforcement that commenced in May.(Wallace 2010).

2. The Brisbane CBD — a commuter drawcard

2.1 An employment hot spot

The resident population in the Brisbane City Council area in 2010 was 1.07 million while the resident population in Greater Brisbane (the Brisbane Statistical Division) was 2.04 million. All of the largest and fastest growing suburbs were located within 15 to 20 kilometres (km) of Brisbane's CBD. The three fastest-growing local government areas within south-east Queensland (SEQ) in 2009-10 all adjoin Brisbane City Council (ABS 2011).

Like many other cities, Brisbane’s CBD and surrounding frame of suburbs is the economic and employment centre of the city and the region. The CBD Frame comprises the CBD and eight nearby suburbs. It has a radius approaching 3km from its centre and contains the majority of CBD type functions, institutions, related activities and employment..

The total number of people working in the CBD Frame in 2006 was 193,335 (ABS 2006). It has the highest concentration of employment for both Brisbane City Council and Greater Brisbane (DTMR 2010a). This employment is heavily skewed to occupations that tend to follow a standard 'Monday to Friday '8 til 6' work week. Managers, administrators, professionals, clerical, sales and service workers comprised about 85% of stated occupations (ABS 2006).

2.2 Work trips and the super peak

As is typical for most Australian capital cities, the Brisbane CBD is the radial focal point for most major road and public transport corridors and services in Greater Brisbane.

Although only comprising one quarter of one percent (0.25%) of the area of Greater Brisbane, in 2007 the CBD Frame generated about 9% (580,000) of the 6.5 million private person trips a day in Greater Brisbane across all modes. Trips taken by private vehicle dominated at 47.0% followed by public transport at 43.6% (DTMR 2010b).

Looking at all trip types with an origin or destination in Greater Brisbane, the CBD Frame 7:00-9:00am morning peak accounts for almost 190,000 (33%) of around 580,000 CBD Frame arrivals for the 24 hour period. Within the peak, 114,000 or almost two thirds of the arrivals occur between 7:30 and 8:30am, meaning 20% of total daily arrivals are in a one hour “super peak”. Within this super peak, work trips contribute 75%, with education or serve passenger trips (mostly school drop offs) combining for another 13% (14,800) of total trips. The situation in the afternoon is similar but, in line with the Greater Brisbane wide pattern,, not as acute (DTMR 2010b).

It is within this context that the HOV Lane Enforcement Trial was positioned to test if enhanced enforcement of existing HOV facilities on Brisbane's urban arterial network could improve the overall efficiency and person throughput of the Brisbane arterial network.

3. HOV solutions: international and local studies

3.1 Some international experiences

Many jurisdictions around the world prioritise HOV facilities during peak periods as part of an overall peak hour traffic and congestion management regime. Following the introduction of a T2 transit lane (vehicles carrying 2 or more people) inbound to the city centre on a 1km section of a 4 lane urban arterial in Trondheim, Norway in 2001, car occupancy increased from 1.33 persons per vehicle (ppv) to 1.38 ppv in the morning peak. Single occupant cars decreased by almost 4% but total traffic volume stayed the same. Travel time in the HOV lane also decreased (Haugan 2004, pp. 5-7, Figures 3 and 4).

It had been expected that the introduction of the HOV lane would transfer traffic to other streets however no significant changes in traffic volumes in nearby streets were measured. An interesting phenomenon was the transposing of travel experience between the HOV and general purpose lanes following the introduction of the scheme.

Following the HOV lane's introduction, average travel time dropped by about 35 seconds during the morning 7:00-9:00am period with the maximum travel time dropping almost 2 minutes. The general purpose lane on the other hand saw travel times increase (by over 3 minutes at the 7:40 am time slot). The peak also started earlier and lasted longer (Haugan 2004, pp 7-8, Figures 5 and 6). It was also found that after the HOV lane introduction, up to 50% of vehicles in the lane were non compliant, dropping to about 20% post police enforcement (Haugan 2004, p. 9, Figure 7).

In 1999 in Leeds in the United Kingdom, the introduction of a T2 lane inbound to the city on a 2km section of a 4 lane urban arterial (the A647) saw similar results to that in Trondheim. Travel time in the general purpose lane remained unchanged at an average of 11 minutes during morning peak for a 5km section that included the HOV scheme. The T2 lane however was generating average travel time savings for vehicles of over 3.5 minutes, with the local bus operator reporting travel time savings of 3 and 6 minutes (Quinn et al, 1998 p. 190).

Car occupancy on the A647 over the 3 hour morning peak (7:00-10:00am) rose from 1.31 ppv to 1.45 ppv, while car occupancy in the T2 lane reached 2.19 ppv. Bus operators reported slight increases in patronage on services using the A647 (Quinn et al, 1998 p. 191). Surveys of 102 local commuters indicated that almost 60% perceived a benefit from its introduction, with 26% stating it encouraged them to form car pools (Quinn et al, 1998 p.192).

In 1995 in Madrid, Spain, after the introduction of T2 and bus lanes in a 16km stretch of the N-V1 Freeway (6 lanes each way), travel time decreased for both HOV and general purpose lane users in the 7:00-9:00am peak. Total person throughput along the freeway almost doubled for both car and bus users in the 7:00-9:00am peak. Average occupancy rates rose from 1.36 ppv in 1991 to 1.47 ppv in 1996 (Monzon and Cristobel, 1997 pp. 91-91 Tables 5-8).

3.2 Previous reviews in Brisbane

A 2005 paper sponsored by the local motoring advocacy group, RACQ, questioned the effectiveness of transit lanes in Brisbane and suggested that HOV facilities should be subjected to an evaluation framework (Bauer et al, 2005). The paper noted the role of enforcement in reducing violation rates to ensure the effectiveness of transit lanes.

In 2009 DTMR commissioned a review of existing HOV facilities to examine their effectiveness (Sinclair Knight Merz 2009). This review noted that despite the high rates of violation across the network, there were a range of benefits from the existing HOV network.

4. The Brisbane HOV network - a violator's drawcard

4.1 Brisbane's HOV network - an early travel demand management measure

A network of 76 HOV facilities covering a combined total of 68 kilometres exists within Brisbane and the surrounding local government areas that make up the south-east Queensland (SEQ) region. These facilities are a mix of bus and transit lanes, pull in bays and bus jump signal priority facilities, with the majority being less than 400m in length. The number of facilities has varied over time with a range of changes to the network of state and local government controlled roads (DTMR 2010c).

4.2 HOV Violation on the rise: the need for action

DTMR identified that violation rates in HOV lanes were an impediment to achieving desired HOV lane efficiency outcomes. Surveys undertaken for DTMR confirmed that violation rates were as high as 89% on some HOV facilities (Sinclair Knight Merz 2009).

Prior to 1 January 2010, only the Queensland Police Service (QPS) had the legislative powers to undertake the enforcement of HOV lanes. This required a commitment from QPS in both the time of officers and resources away from other tasks. Enforcement of HOV lanes must be balanced against other high priority tasks for the QPS (often life threatening offences) including other road-related offences such as drink driving and speeding.

DTMR analysis of statistics showed that the number of infringements issued declined from 5,319 in 2003 to less than 3,000 in 2008. QPS were not able to undertake increased enforcement of HOV facilities for DTMR's program, so a range of options were examined.

Options included Transport Inspectors being given the equivalent powers of enforcement for HOV offences, the use of technology and automated camera-based solutions. However the departmental view was that no existing technology (e.g. thermal imaging) would allow for the remote enforcement of T2 or T3 lanes sufficiently to meet Queensland Government requirements for evidentiary purposes.

It was proposed that DTMR undertake a trial of enforcement of HOV lanes by DTMR Transport Inspectors and appropriate legislation (*Transport and Other Legislation Amendment Bill 2009*) granting the powers from 1 January 2010 to 31 March 2011 (with a possible 12 month extension) was passed by Parliament in November 2009.

The Queensland Road Rules (QRR) make it an offence to drive a vehicle other than a bus, taxi or bicycle in a bus lane or to drive in a transit (T2/T3) lane without the specified minimum number of persons in the vehicle unless the vehicle is a bicycle, bus, taxi or motorcycle. Driving in a bus or transit lane is permitted for a distance of up to 100 metres for such things as entering or exiting the roadway, making a turn and avoiding an obstruction.

5. HOVLET - designing a dash of magenta

5.1 Trial objectives

DTMR set four objectives for the trial:

- demonstrate the ability of Transport Inspectors to effectively and safely undertake enforcement of HOV lanes;
- maintain a high level of safety for the public and Transport Inspectors;
- decrease the violation rate in HOV lanes; and
- increase transport efficiency.

5.2 Overview of trial design and implementation

The trial design was based around:

- two sets of pre enforcement traffic surveys on each corridor in late March and again in May 2010 under normal road conditions for the year (i.e. schools and universities had returned from holidays)
- an enforcement period of 6 months from May to October 2010 with traffic surveys at 1, 2 and 4 weeks after the initial intense enforcement
- surveys the week after each period of random enforcement
- final post enforcement traffic surveys 5 weeks after the last enforcement (4 weeks after the final survey of the random enforcement period) for each corridor and before school and universities finished for the year.
- Transport Inspector enforcement was scheduled across 4 selected corridors for 14 days each, for approximately two hours during the AM or three hours during the PM peak period. Enforcement and surveying dates were scheduled to occur in normal traffic conditions, avoiding school, university and public holidays.

5.3 Corridor selection

The 4 corridors selected for the trial are displayed in Figure 1 below. A range of filters were used in the selection of the trial corridors from the 76 HOV facilities in the region. The project team sought facilities greater than 1km in length, evaluated the significance to bus operations and set a criteria for a safe speed environment for static enforcement (<80km/hr). The remaining facilities were categorised against the mix of facility types and hours of operation and conformance to requirements for the presence of safe enforcement sites and the capacity of trial resources.

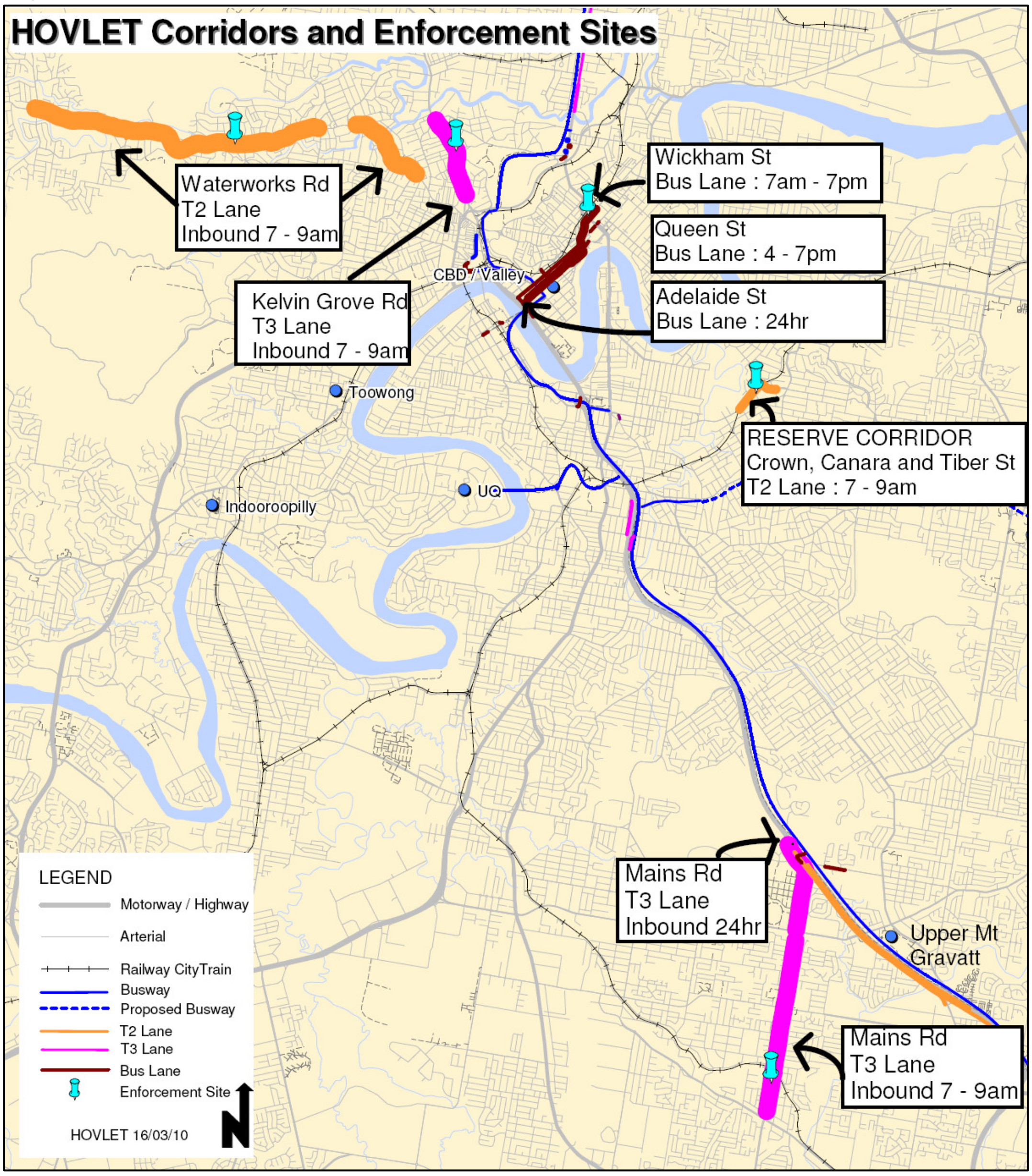
A subset of corridors were identified for the trial based upon vehicle mix, traffic volumes, non-compliance rates and ability to safely and appropriately enforce the HOV lanes during a trial period. A reserve corridor (Crown, Canara and Tiber Street in Norman Park) was also assessed but not used during the trial.

All the HOVLET corridors were 4 or 6 lane urban arterials with a designated speed limit of between 60 and 70km/hr. Mains Road is a 70 km/hr arterial road linking southern suburbs to the Pacific Motorway and has a kerbside T3 lane and two general purpose lanes. Waterworks Road is a 60km/hr arterial linking The Gap in the west with the CBD and has a kerbside T2 lane and a single general purpose lane. Kelvin Grove Road is a 60km/hr arterial road linking the north western suburbs with the Brisbane CBD and has a kerbside T3 lane and two general purpose lanes.

The Adelaide/Queen/Wickham Streets corridor is a centrally located route running outbound from the CBD varying from 40km/hr to 60km/hr. The Wickham St location used in the trial has a kerbside bus lane and three general purpose lanes.

It is worth noting that most of the bus stops along the trial corridors are in the kerbside lane and not indented. This leads to delays as other vehicles including express running buses become caught behind stopping buses and are unable to pass.

Figure 1: HOVLET corridors and sites 2010



Source data: Queensland Department of Transport and Main Roads (DTMR) 2010c.

5.4 Survey design

DTMR developed a program of surveys, data collection and analysis to gather information on the impacts of enhanced enforcement by the Transport Inspectors. A contractor and traffic survey sub-contractor undertook survey data collection and analysis.

Each corridor had pre enforcement surveys in March 2010, a survey 1 week before first enforcement on that corridor, surveying during the first week of enforcement on the corridor, surveying 1, 2 and 4 weeks after first week of enforcement, 3 surveys during the random enforcement period and a follow up survey 4 weeks after the last enforcement on each corridor. The final survey was undertaken in November 2010.

Data collection was designed to allow DTMR to make an evidence based assessment of the trial. The trial was measured against criteria developed for the trial objectives through the use of classified counts (vehicle numbers, by type, by lane), vehicle occupancy surveys (by lane, vehicle type, including on bus surveys), travel time surveys (using floating car method, by lane, including on bus surveys, multiple runs) and administrative and operational metrics.

Prior to the commencement of the trial contact was made with the joint DTMR and Brisbane City Council, Brisbane Metropolitan Traffic Management Centre (BMTMC) which monitors the performance of the road network in real time. The BMTMC was to contact officers responsible for the trial in the event of traffic disruption on trial corridors on enforcement days whether due to enforcement or unrelated traffic incidents.

For the transport efficiency criteria volume of traffic, average vehicle occupancy, person throughput, average travel time and vehicle speed, and travel time reliability and variation were measured. The rate of violation was calculated from vehicle occupancy and classification measures in the HOV lane.

To optimise comparability of the results, all surveys for each corridor were undertaken on the same day of the week (either a Wednesday or Thursday) with one exception due to overlap with surveying on another corridor at the same time.

5.5 Enforcement design

Enforcement was designed to minimise the impact on motorists and the regular flow of traffic. A detailed operational plan was prepared for each site selected, with requirements including the ability for Transport Inspectors to direct drivers into a side street for processing to ensure safety and to minimise the impact upon traffic flow.

The trial was based upon the static interception of vehicles by a team of Transport Inspectors. One Transport Inspector acted as a spotter observing violating vehicles in the HOV lane at a location greater than 100m from the interception point (i.e. to allow for the 100m provision in the road rules). The spotter relayed vehicle details to the intercepting officer by radio. The intercepting officer directed the violating vehicle into a side street where other Transport Inspectors questioned the driver and issued an infringement notice if required.

The trial methodology focussed enforcement activities on each corridor for an “intense” period of one week initially (4 to 5 days), followed by a four week break before further random enforcement over the remainder of the enforcement period. This allowed for testing of the impact of the different enforcement intensities.

On Monday 10 May 2010, Craig Wallace, Minister for Main Roads announced the trial's commencement on Waterworks Road, Ashgrove and issued a media release. This led to some television, radio and newspaper coverage about the trial in its early stages.

6. Trial results

This paper is focussed on the last two objectives of the trial, related to compliance and transport efficiency improvements from enforcement activities. However the results and information related to the trial's capability and safety objectives are briefly discussed below.

6.1 Capability

Transport Inspectors utilised existing on-road experience and operational procedures to implement the project. Over the 55 'enforcement days' a total of 1,041 HOV lane violation infringements were issued across the four corridors. Waterworks Road had less intercepts and infringements issued than other corridors through a lower underlying violation rate (due to existing police enforcement presence), lower vehicle numbers and the lower occupancy requirement to qualify for the T2 lane.

6.2 Operational and public safety

The second objective of the trial was to maintain a high level of safety for the public and for Transport Inspectors. There were zero Workplace Health and Safety (WH&S) incidents, deaths or injuries, and no incidents related directly to the enforcement activities of the trial.

6.3 Violation rates

The HOV lane violation rates for the four HOVLET corridors are shown in Figure 2. In the initial phase, violation rates reduced by between 12% and 16% for the three transit lane corridors, and by between 6% and 10% over the trial. The violation rate at the Wickham Street Bus lane in the PM peak fluctuated between 38% and 44% before, during and after the trial. Figure 2 below provides more detail.

Figure 2: Violation rates at HOVLET corridors – March to November 2010

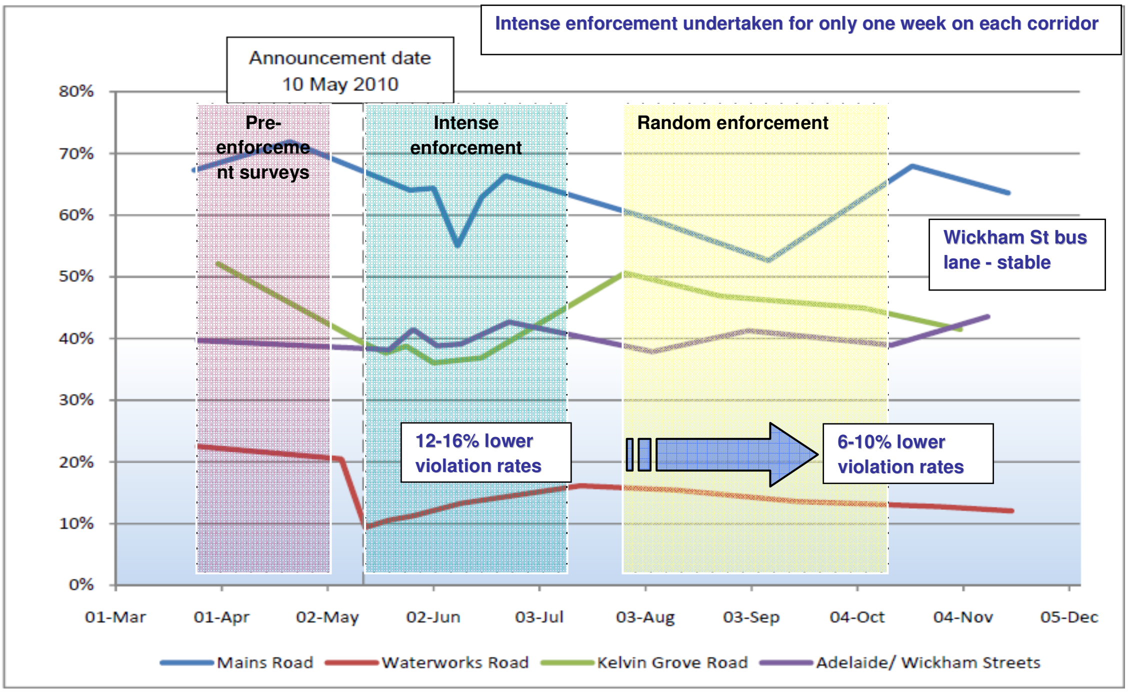


Figure 2 modified from Figure 7, p. 120 in Sinclair Knight Merz 2011a.

Illegal vehicle numbers in the HOV lane reduced in all HOVLET corridors, although the reduction on the Wickham Street bus lane was not significant. Illegal vehicle numbers peaked in the Wickham Street bus lane in June 2010 when no enforcement was being carried out (intense enforcement on Wickham Street was undertaken the week of 24-28 May 2010). The lowest number of illegal vehicles in the HOV lane at Kelvin Grove Road occurred directly after the initial intense enforcement period on Kelvin Grove Road which was from 17-21 May 2010. Although they both saw decreases following the intense enforcement period, the Mains Road and Waterworks Road HOV lanes had the lowest number of illegal vehicles using the HOV lane during the second stage when random enforcement was undertaken.

6.4 Transport network efficiency

One measurable benefit of HOV lanes is improving transport network efficiency during peak periods, i.e. more efficient person throughput, whilst utilising existing infrastructure. The individual HOVLET corridors are diverse, with varying numbers of vehicles, general purpose lanes, HOV facility length and type, and modal trip breakdowns. A suite of transport network efficiency data was collected to provide a holistic picture of the contribution of each HOV lane, and the impact of enforcement and other factors in each HOVLET corridor.

In addition to surveying undertaken for the trial, the Brisbane Metropolitan Traffic Management Centre reported that they did not observe any change in traffic performance for the trial corridors.

6.4.1 Travel time and reliability/variability

Travel times for bus, HOV lane private cars and general purpose lane cars during the trial are presented in Figures A1-A4 in the Appendices.

General purpose lane travel times varied to a larger extent than travel times for both private vehicles (legal and illegal) in the HOV lane and for buses.

Waterworks Road was the most consistent corridor with travel times across all modes maintaining reliability across the trial period. Mains Road was less reliable as demonstrated by the result on 25 March 2010 when travel time increased dramatically. Although the authors assumed that this would be due to an incident, further investigation was unable to identify an incident on this corridor on that date or establish the cause of this delay.

6.4.3 Vehicle occupancy and mode share

At the Wickham Street bus lane, private vehicle occupancy (for illegal vehicles in the bus lane and private vehicles turning left) remained relatively similar throughout the trial. Vehicle occupancy improved on all three transit lane corridors, with the most significant increase being seen on Waterworks Road (see Figure 3 below).

Figure 3: Vehicle occupancy in HOV Lanes across the HOVLET corridors

Location	Pre Enforcement (PPV)	Highest during Trial (PPV)	Average across the Trial (PPV)
Waterworks Road T2 lane	1.80	2.13	2.02
Kelvin Grove Road T3 lane	1.78	2.01	1.89
Mains Road T3 lane	1.73	1.97	1.82
Wickham Street Bus lane	1.51	1.51	1.47

PPV: Persons per vehicle
Pre Enforcement: Average of the surveys carried out prior to actual enforcement commencing
Highest During Trial: Highest record on any single survey day for that corridor before, during or after enforcement
Average During the Trial: Average of all survey days for that corridor before, during or after enforcement

Figure 3 calculated by manual traffic and occupancy counts taken for a 2 hr period during the relevant peak times for each corridor (7:00-9:00am for Waterworks, Mains and Kelvin Grove Roads and 4:30-6:30pm for Wickham St). Counts include all vehicles (legal and illegal) excluding, buses, motor bikes and cycles. Source data: SKM (2011a) p. 28; p. 52; p. 79; p. 105.

The average vehicle occupancy rate increased in the three transit lane corridors during the trial by between 0.09 and 0.22 persons per vehicle. The best result was achieved on Waterworks Road, reaching a peak of 2.13 ppv after intense enforcement and maintaining vehicle occupancy above 2 ppv in the T2 lane for the remaining time. It should be noted that the Queensland Road Rules do allow certain vehicles (e.g. limousines, taxis, motorcycles) to legally travel in a transit lane without the minimum number of occupants.

Most corridors achieved highest occupancy after enforcement with the exception of Wickham Street which showed little variation.

Mode share for public transport increased at Kelvin Grove Road, Mains Road and Wickham Street corridors over the enforcement period and remained steady on Waterworks Road.

6.4.4 Person throughput and vehicle numbers

Person throughput refers to the number of people that travel through each corridor in a set time period. The analysis below highlights the percentage of that throughput that the HOV lane carries, compared to the general purpose lanes of each corridor. The combined effect of improved travel time, enhanced reliability, increased travel speeds and average vehicle occupancy and mode shift has an effect on the person throughput of a HOV lane and the entire corridor.

As can be seen in Figure 4 below, intensive enforcement has noticeably improved the HOV lane share of person throughput of each corridor. After enforcement concluded, however, the HOV lane share of person throughput had dropped on 2 of the corridors when compared with the pre-enforcement results. The reason for these results is not clear from the data available.

Figure 4: HOV lane contribution to person throughput in each HOVLET corridor

Corridor HOV share of lanes – i.e. 1 in 3 lanes =33%	Pre Enforcement	During Trial (High Intensity Enforcement Phase)	Post Enforcement
Waterworks Road T2 lane (50%)	50.25%	53.79%	47.30%
Kelvin Grove Road T3 lane (33.33%)	37.58%	43.98%	40.91%
Mains Road T3 lane (33.33%)	46.96%	49.64%	44.91%
Wickham Street Bus lane (25%)	49.23%	55.69%	49.35%

Pre Enforcement: Average surveys carried out prior to actual enforcement commencing.
During Trial (High Intensity Enforcement Phase): Average of the 4 surveys carried out during and immediately after the initial high intensity week of enforcement for that corridor.
Post Enforcement: Average of all survey days for that corridor after enforcement concluded.

Figure 4 calculated from classified traffic counts taken for a 2 hr period during the relevant peak times for each corridor (7:00-9:00am for Waterworks, Mains and Kelvin Grove Roads and 4:30-6:30pm for Wickham St). Counts include all vehicles (legal and illegal) excluding, buses, motor bikes and cycles. Source data: SKM (2011a) p. 28; p. 52; p. 79; p. 105.

7. Discussion: magenta rising

7.1 A whiff of magenta: immediate results

There was a noticeable decrease in the violation rate on three of the four corridors following the announcement of the trial. This is consistent with the “announcement effect” as noted in Benedettini and Nicita (2009).

This result was achieved through a relatively soft announcement consisting entirely of the announcement by Minister Wallace on 10 May 2010 and the subsequent media coverage. There was no advertising or education campaign in this period to support this announcement.

Analysis of the results indicates that the initial intense enforcement derived the greatest reductions in violation rates and illegal vehicle use of the HOV lane and improvements in travel times. The announcement and media coverage at the start of the trial may have been an influencing factor in these immediate results at locations, particularly Kelvin Grove Road (which commenced enforcement the week after the announcement). This leads to suggestions that future enforcement campaigns at new locations could be more effective if accompanied by similar announcements or a communication campaign.

7.2 Concentrated magenta: now we're moving

With the exception of continued improvements after the return of enforcement in a couple of instances, the initial high intensity concentration of enforcement (4 to 5 days in a week) generally produced the greatest results across the trial parameters at all corridors. The initial, intense enforcement delivered the sharpest reductions in violation rates and quickest HOV lane travel times.

In most cases the follow up enforcement activities did not sustain or go beyond the initial results. However violation rates at Mains Road actually reached their lowest level during the second round of lower intensity, randomised enforcement. This may indicate that Mains Road (with the highest initial violation rate and highest reduction in illegal vehicle numbers) has a much greater capacity to respond to a “whiff” of any HOV enforcement. That is, the mere presence of officers at the roadside and the belief that 'some enforcement is happening' is enough to influence those casual violators (those whom occasionally violate and/or are most worried about being caught) to shift behaviour. Corridors with a high violation rate and limited history of enforcement may have more of these less-committed violators.

Kelvin Grove Road responded the best to initial enforcement activities, though reduced violation rates, quicker bus travel times and illegal vehicle number reductions were not maintained.

Waterworks Road, with a history of police enforcement and a much lower initial violation rate, also produced its best results after the initial enforcement, including its highest vehicle occupancy levels. In contrast with Mains Road, the enforcement history at Waterworks Road seems to have set the driver expectation and behaviour to limit illegal use of the HOV lane, and to have reinforced this message more strongly over the months of the trial. Although violation rates and illegal vehicle numbers at Waterworks Road were the lowest of all corridors, both of these indicators reduced by the largest proportion at Waterworks Road.

7.3 Bus: a big winner

The initial stage of enforcement coincided with bus travel time savings on three of the corridors. This intense burst of enforcement, at some locations the first time enforcement had been undertaken, appears to have influenced the smoother running of the HOV lane with reduced illegal vehicle numbers in HOV lanes also occurring at these times. However this may also be influenced by a number of other factors on the days surveys were undertaken. It is suggested that a larger dataset would provide more opportunity to further analyse any relationship of influences given that the initial bus travel time savings of between 10% and 19% on three corridors were not fully sustained. The authors are aware of bus timetable and route changes during the trial at both Wickham Street and Waterworks Road which would influence the data collection and results.

Beyond this study of enforcement of HOV lanes, there are other influences that can impact on vehicle travel times, such as clogged intersections, major and minor accidents, vehicle lane swapping and the lack of indented bus stops. The understanding of the impacts of these factors on travel in a HOV lane against HOV lane enforcement and a suite of other treatments would benefit from further data and study.

7.4 Car poolers in the fast lane

The data suggests that HOV lane private car users also benefit from the actual or possible enforcement with quicker, less variable travel times compared to general purpose lanes. In the case of Kelvin Grove Road and Mains Road, a travel time disadvantage for the HOV lane users compared to general purpose lanes at the beginning of the trial was turned into small travel time advantages by the end of the trial. On Waterworks Road the travel time advantage for cars in the T2 lane was largely maintained through the course of the trial. Travel time for HOV lane users was more reliable over the trial period.

As noted in Section 6.4.3 and Figure 3 above, vehicle occupancy increased on three of the four corridors. These vehicle occupancy increases were higher than the authors had thought likely from the impact of the trial given its relatively limited intensity and short duration. This suggests that if commuters believe that they can gain an advantage by using the T2 and T3 transit lanes, then they may be more willing to make a change than had been anticipated and in a much shorter timeframe.

Analysis carried out into trip choice changes as a result of a two month lane restriction on Coronation Drive (a major urban arterial) in Brisbane during 2009-10 showed that of those that made travel behaviour changes, 74% said they made these changes on either the first day or first week of the lane restriction and the vast majority maintained the changes for the entire lane restriction period (*Enhance 2010a, p 28).*

In total 5% shifted mode. The major reasons stated by respondents for their changed behaviour were because it was quicker (35%) or cheaper (22%). Of those 5% of people whom changed mode, 40% switched to train, 28% to bus, 12% to CityCat (ferry) and 8% to shared car (car pooling) (*Enhance 2010b, p 39).*

Based on these results, it is reasonable to argue that mode shift to both public transport and car pooling could have been achieved during the trial.

Given the willingness of some people to make changes when confronted with the need to make a new trip choice decision (lane restriction; HOV lane enforcement), an opportunity exists to achieve sustained increases in average vehicle occupancy in HOV lanes. In some cases in general purpose lanes, this can also be achieved by coupling with other activities and programs such as car pooling and the introduction of public transport services that utilise the corridor’s HOV lanes.

7.5 The general purpose lanes: no losers here

General purpose lane travel times and speeds fluctuated during the six months of the trial. However directly relating this to enforcement days or the overall influence of the enforcement activities does not seem reasonable. The worst results in general purpose lane travel times do not appear related to HOV lane enforcement, or have a clear relationship with changes in violation rates or illegal vehicle numbers.

It is more likely, based on the Kelvin Grove Road data where general purpose lane travel times were highly variable on a relatively short trip length that the dominant influence on general purpose lane traffic is – *itself!*

Increased or decreased vehicle numbers of the order of 200 plus vehicles coincide with fluctuations in general purpose lane travel times at Kelvin Grove Road. This increase in vehicles is beyond the magnitude of illegal HOV lane vehicles that may be re-entering the general purpose lanes. While there may have been some connection between the initial enforcement and the increase in general purpose lane travel time, the reduction in violators in the HOV lane is not the determining factor. Four weeks after the initial enforcement when violation was almost at its lowest point, general purpose lane travel time was below pre-enforcement levels.

7.6 Across the corridors

Only Mains Road's initial bus travel time improvements (19%) drove a whole-of-corridor (HOV and numerous general purpose lanes) transport efficiency gain, which was not sustained over the trial's duration. For increased enforcement of a HOV lane to deliver this does not appear sustainable – as behavioural responses to increased HOV lane enforcement do not appear to be able to overcome the many other factors controlling the flow of traffic in the corridor.

Increased enforcement combined with other transport management measures, such as infrastructure improvements or travel demand management initiatives (e.g. carpooling schemes), may be more effective at delivering sustained transport efficiency improvements.

7.7 Future options for investigation

Future research needs to focus on determining the correct intensity and frequency required to achieve sustained reductions in violation and to drive efficiency outcomes such as reduced travel time, improved person throughput and higher vehicle occupancy. An ongoing HOV compliance program provides the opportunity to test the continued surveying of the corridors.

Although it is not possible to know with certainty from the information gathered for the purposes of this trial, the advice from the Brisbane Traffic Management Centre that they were unable to detect any adverse impact of the trial upon traffic suggests that any unintended impacts were not significant. Future surveying could be extended to include more upstream and downstream sites on the enforced corridor as well as alternate routes to also better understand any redistributive impacts on the network.

As indicated in Section 7.6, the potential for enhanced enforcement to help achieve the prime function of HOV facilities in achieving greater network efficiency could be considered as part of a travel demand management program in which it is combined with other initiatives such as infrastructure changes and travel behaviour campaigns.

8. Conclusion: a dash of magenta helps you on your way

The trial successfully met its four key objectives, safely delivering effective enforcement of HOV lanes that improved transport efficiency of the HOV lanes. The trial's results support the findings of international studies discussed earlier in Section 3.1 that found decreased travel times for HOV users, increased person throughput and limited, if any impacts on other travellers in the network. On the basis of the trial outcomes and success in reducing violation, the Queensland government made the powers for Transport Inspectors permanent in April 2011 (Palascszuk 2011).

Traffic changes at some locations such as the Wickham Street bus lane's altered public transport services and growth in traffic numbers at Kelvin Grove Road highlight that HOV lane enforcement may not be able to compensate for other changes also occurring on the network. This suggests that HOV lane enforcement could be coordinated with other programs to deliver the most effective outcome and the efficient use of resources.

The results highlight that the intense enforcement technique used in the initial part of the trial appears the best selection for focussing the majority of resources to deliver desired outcomes, particularly in the developmental stages of a program of enforcement. As an understanding of individual corridor characteristics is developed, the approach to enforcement can be tested and customised for each corridor. Importantly, as the dataset builds it may be possible to evaluate the corridors that do not respond to HOV lane enforcement, or do not require significant enforcement to maintain a required level of performance and operation.

The intense enforcement approach appears to ensure driver behaviour change in the majority of cases, resulting in HOV lane occupancy increases and improved travel times and reliability in the HOV lane compared to general purpose lanes. The trial results suggest that enforcement delivers these benefits without detracting from the journey of other road users.

Public awareness before the trial was limited to low-key campaigns and information provided by the relevant Ministers. Warnings and education were only undertaken at the roadside by Transport Inspectors in the early stages of the trial. Further testing of public awareness about HOV lane road rule requirements and understanding driver views about HOV lanes may enable enhancements of enforcement activities and broader HOV network and transport management programs.

Drivers make individual choices for their journey each day and these personal choices along with variations in traffic make it difficult to claim with absolute certainty that the results measured as part of the trial can be fully apportioned to the enforcement undertaken. However the trial results do strongly suggest that HOV lane enforcement improves the operation of HOV lanes and corridors by producing lower HOV lane violation rates that provide advantages to users without causing significant detriment to users in other lanes.

The trial of increased enforcement of HOV lanes in Brisbane by DTMR Transport Inspectors has shown that it is possible to achieve reductions in violation and to improve the network efficiency. It seems likely that when combined with other complementary measures such as infrastructure improvements, signal priority and travel behaviour change campaigns, even greater results could be achieved.

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Appendices

Figure A1: Violation rate and travel times for vehicles at Kelvin Grove Road

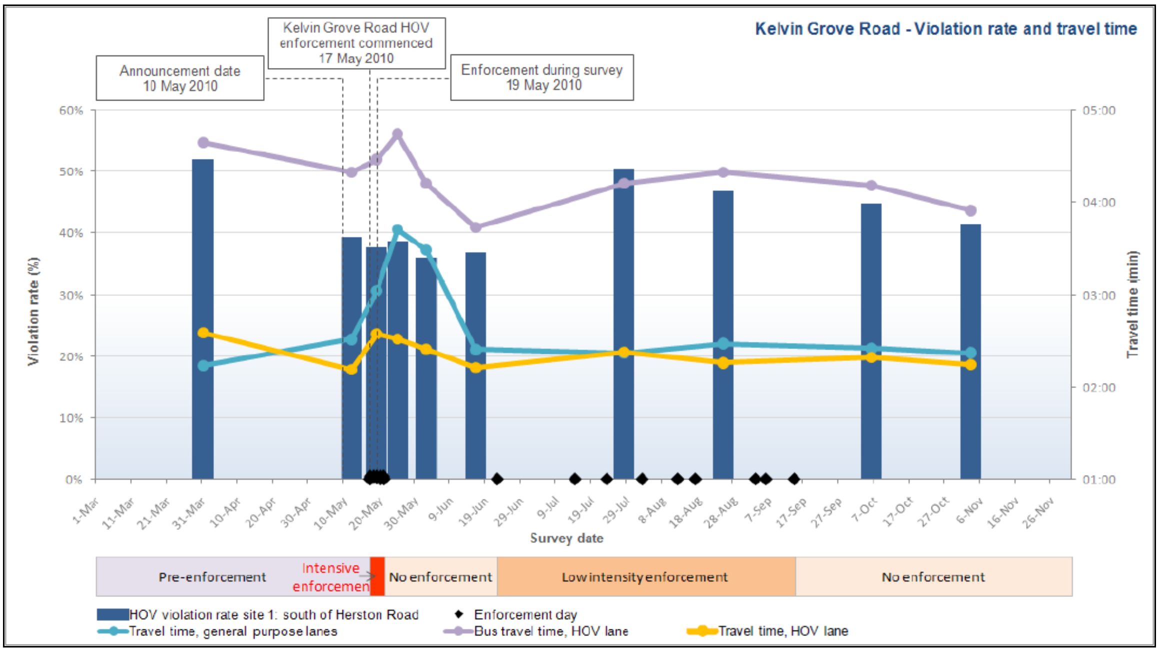

Figure A1 modified from Figure 5.3, p. 75 in Sinclair Knight Merz 2011a.

Figure A2: Violation rate and travel times for vehicles at Waterworks Road

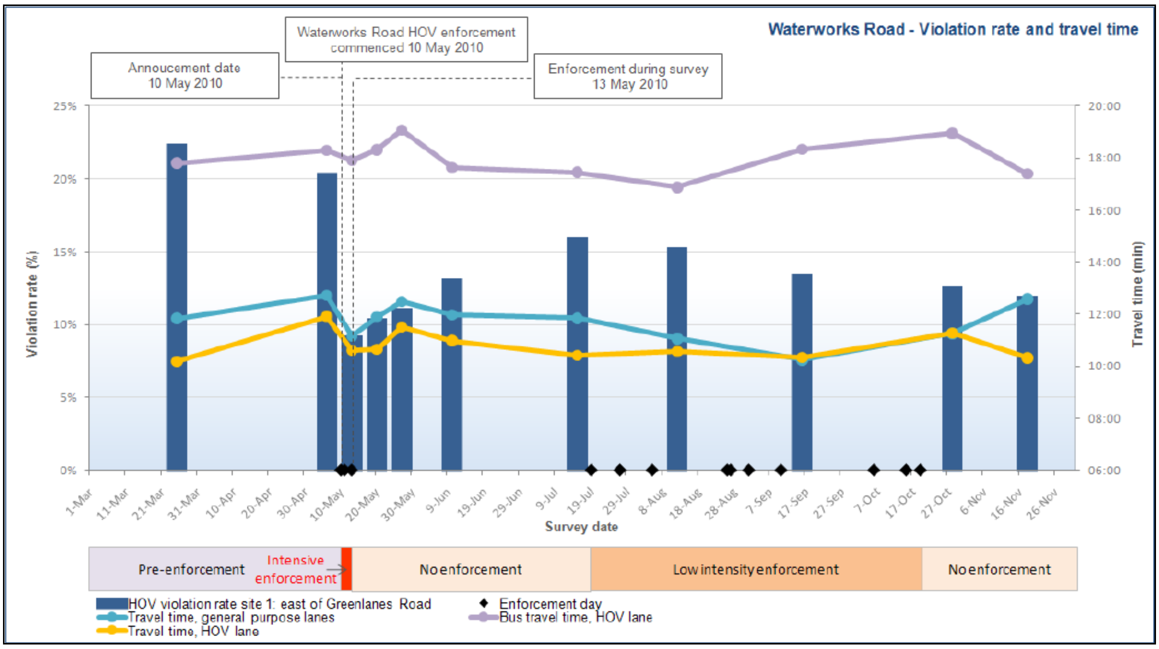

Figure A2 modified from Figure 4.3, p. 49 in Sinclair Knight Merz 2011a.

Figure A3: Violation rate and travel times for vehicles at Mains Road

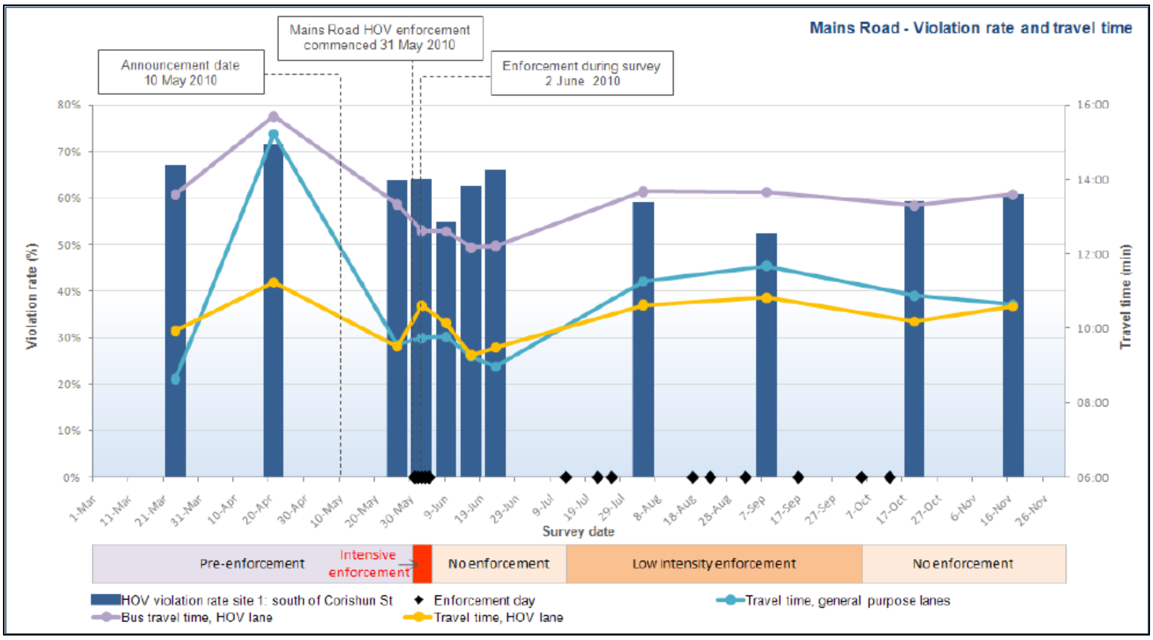

Figure A3 modified from Figure 3.11, p. 38 in Sinclair Knight Merz 2011a.

Figure A4: Violation rate and travel times for vehicles at Wickham Street

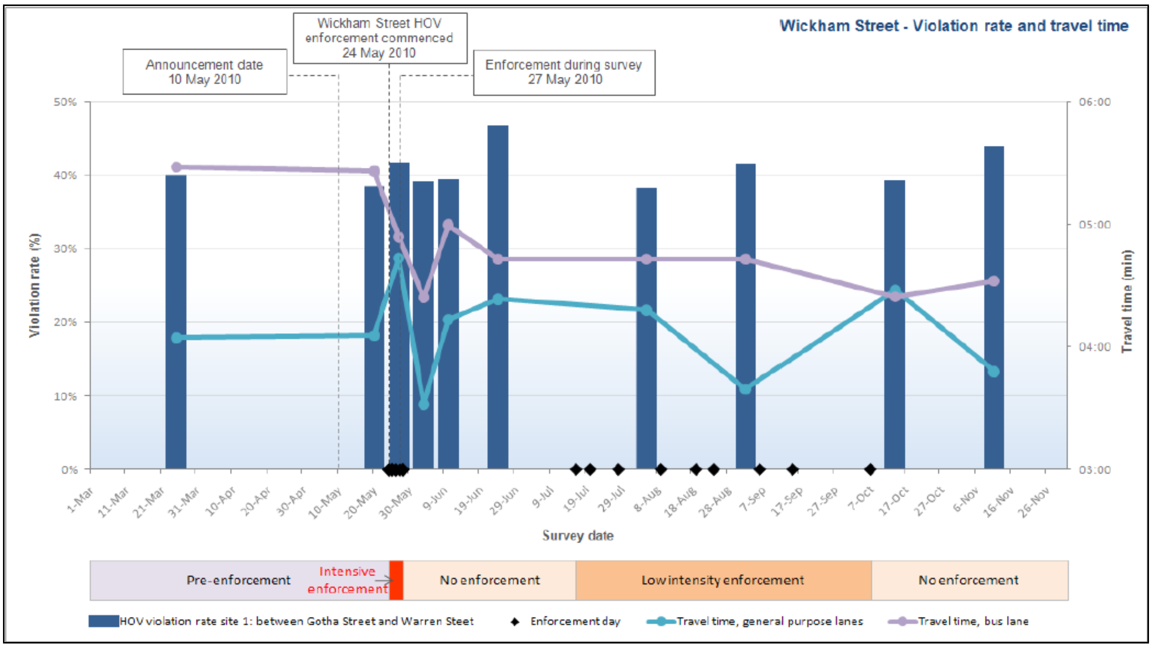

Figure A4 modified from Figure 6.3, p. 102 in Sinclair Knight Merz 2011a.

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