Department of Transport and Main Roads

Evaluation of flashing school zone signs in Queensland

2013/14 Review

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Queensland Government

Contents

Executive summary

In response to community concerns about the safety of children going to and from school, the Queensland Government developed a $10 million program to install flashing school zone signs at over 300 risk-assessed school zones over a period of four years. These school zones are being selected based on a detailed risk analysis of all school zones in Queensland and nominations by schools and communities based on local knowledge of particular problem areas through their local Members of Parliament. Priority has been given to school zones with a significant crash history, a high level of vehicle and pedestrian traffic, higher speed limits or visibility problems. Flashing school zone signs are also installed at school zones on multi-lane roads and split campus schools.

A review of the literature identified a range of effects for flashing school zone signs in other jurisdictions: marginal (6 studies); ineffective (1 study); and detrimental (2 studies). Despite the mixed evidence, results suggest that flashing school zone signs typically provide a small beneficial effect on travel speeds; reductions of 1.3 – 3.8 km/h and 3.2 – 6.2 km/h in mean and 85th percentile speeds, respectively. Therefore, benefits appear slightly more pronounced for reducing higher levels of speeding.

The Queensland Department of Transport and Main Roads conducted an evaluation of the effectiveness of flashing school zone signs in assisting motorists to determine when reduced speed limits apply in school zones, and increasing compliance with these reduced speed limits. Two sources of data were examined: self-reported attitudes and behaviours of road users; and observations of vehicle travel speeds in and around school zones.

Do flashing school zone signs assist motorists to determine when school zones (and reduced speed limits) are in operation?

The 2014 Road Safety Perceptions and Attitudes Tracking Survey was conducted in April and May. A representative sample of 600 Queensland motorists completed the online survey. It was found that 98% of respondents agreed that flashing school zone signs help them determine when lower speed limits apply. The majority (91%) of respondents agreed that in their opinion, other road users are more compliant with speed limits in school zones with flashing school zone signs than standard school zone signs. Respondents were least likely to exceed the speed limit in a school zone where children are present (75% said they 'Never' do this), followed by school zones with flashing school zone signs (61%) and standard school zones (55%).

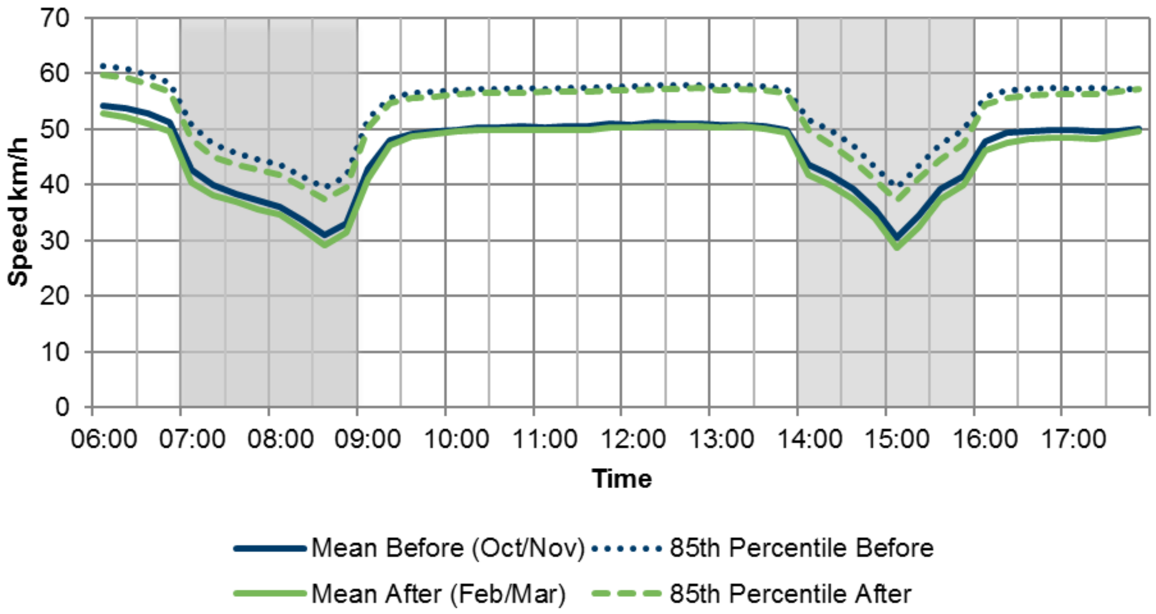
These results suggest that flashing school zone signs are considered a useful tool to alert motorists to when reduced speed limits apply. These cues may be particularly useful in encouraging compliance with reduced speed limits when motorists are not familiar with the road, or other cues (such as children) are not present.

Are flashing school zone signs effective in terms of increasing compliance with reduced speed limits in school zones?

Design options for the observational travel speed survey component of the evaluation were influenced by the time constraints of the project. Based on the time available to complete the evaluation, a before/after design with treatment (n = 39) and comparison (n = 3) groups was selected. This allowed comparison of travel speeds in school zones before and after installation of flashing school zone signs (treatment sites) to determine whether speeds were affected.

To control for general changes in travel speeds that may have occurred due to reasons other than the installation of the signs, travel speed data was collected at the same time periods for school zones that were similar to those in the treatment group in terms of road environment and risk assessment, but they did not have flashing school zone signs installed between the data collection periods. These sites were allocated to the comparison group.

It was encouraging to note that compliance with speed limits during school zone active and inactive times was already quite high during the "before" data collection period. Analysis of travel speeds at treatment sites in 15-minute bins (see the Figure below, which reports data for treatment sites with 60 km/h default speed limits [n = 26] – a similar figure for treatment sites with 50 km/h default speed limit is included in the report) showed that compliance with school zone speed limits was greatest during periods where the presence of children is greatest, which is consistent with previous research, and responses to the Road Safety Perceptions and Attitudes Tracking Survey, as presence of children was the most common signal to motorists that they were entering a school zone.



The effects of installing flashing school zone signs on travel speeds in existing school zones were estimated in a number of ways. Significant reductions in mean and 85th percentile speeds during school zone active times were observed at the "after" data collection period, for both treatment and comparison sites. Speeds also significantly reduced during school zone inactive times at treatment sites, whereas speeds significantly increased (by 0.15 km/h) at comparison sites. However, reductions during active school zone times at treatment sites exceeded those observed at comparison sites when a sub-sample of matched sites were compared.

Depending on the control variables used in the analyses, this study found that flashing school zone signs were associated with reductions in mean speeds of 0.50 – 2.95 km/h and reductions in 85th percentile speeds of 1.37 – 3.62 km/h during school zone active times, which is consistent with the reductions observed in previous studies. The reductions in the proportions of vehicles exceeding the school zone speed limits by large amounts (i.e. by 10 km/h or more) at both treatment and comparison sites were reduced by more than 45%. Thus the signs were particularly beneficial for reducing higher levels of speeding.

Research unrelated to travel speed around schools suggests that even small decreases of 1 km/h for mean travel speeds in 50 km/h zones are likely to result in 8.23% reductions in fatalities. Application of these estimates to results of the current study provided indicative estimates of 2.56% to 5.75% reductions in serious injuries and 6.13% to 13.43% reductions in fatalities due to reductions in mean speeds related to the installation of flashing school zone signs.

Therefore, installation of the flashing school zone signs at the surveyed sites appears to have been somewhat beneficial in Queensland. Further research involving cost-benefit analysis comparing this treatment with other treatments would maximise spending efficiency dividends. The majority of sites in this study were in the greater Brisbane area, and only a small number of sites did not receive flashing school zone signs and were able to be allocated to the comparison group. Research using regionally located schools, including non-urban, high speed (e.g. 80 km/h+) limit inactive zones, and using a larger sample of untreated sites for comparison, would increase confidence in the current findings. Investigation of the longer term effects of flashing school zone signs should also be conducted to determine whether the reductions in speeds observed in this study are maintained over time.

1 Introduction

The Queensland Department of Transport and Main Roads conducted an evaluation of the effectiveness of flashing school zone signs in increasing compliance with reduced speed limits in school zones. Two sources of data were examined: self-reported attitudes and behaviours of road users; and observations of vehicle travel speeds in and around school zones. This report describes the methods and results of the evaluation.

1.1 Background

Evidence suggests motorist speed compliance at school zones is poor (Transportation Research Board, 1998; Young & Dixon, 2003). In some cases, motorists have difficulty determining whether it is a school day or that the zone is in operation in the absence of other cues, such as the presence of children.

In response to community concerns about the safety of children going to and from school, the Queensland Government developed a $10 million program to install flashing school zone signs at over 300 risk-assessed school zones over a period of four years. These school zones are being selected based on a detailed risk analysis of all school zones in Queensland and nominations by schools and communities based on local knowledge of particular problem areas through their local Members of Parliament. Priority has been given to school zones with a significant crash history, a high level of vehicle and pedestrian traffic, higher speed limits or visibility problems. Flashing school zone signs are also installed at school zones on multi-lane roads and split campus schools.

Standard school zone signs (see Figure 1.1) alert motorists to the zone, and indicate the reduced speed limit and times at which it applies. Flashing school zone signs (see Figure 1.2) are also equipped with solar powered lights that flash when the school zone is in operation. School zones in Queensland typically operate between the hours of 7-9am and 2-4pm on school days; however, these times can vary.

Figure 1.1: Standard school zone sign

Figure 1.2: Flashing school zone sign

In 2013, the Minister for Transport and Main Roads announced that the Department of Transport and Main Roads would evaluate the effectiveness of these signs in increasing compliance with reduced speed limits in school zones. This evaluation would inform the future of the program, and discussions about whether further interventions are required to ensure the safety of school children in Queensland.

1.2 Objectives of the evaluation

The evaluation aimed to address the following research questions:

1) Do flashing school zone signs assist motorists to determine when school zones (and reduced speed limits) are in operation?
2) Are flashing school zone signs effective in terms of increasing compliance with reduced speed limits in school zones?

1.3 Structure of the report

The report includes a review of published evaluations of similar school zone signs in other jurisdictions (see section 2), as the methods and results of these studies informed the development of the methodology for this study. Section 3 addresses the first research question, as it describes relevant results from the 2014 Road Safety Perceptions and Attitudes Tracking Survey (RSPAT), which is an annual survey completed by a representative sample of Queensland motorists. Section 4 addresses the second research question by describing the results of an observational study of travel speeds. Travel speeds were measured before and after the installation of flashing school zone signs at 39 school zones. Speeds were also measured at the same time points at three school zones where flashing school zone signs had not yet been installed to control for any changes in speed that may have occurred over the study period that could not be attributed to the flashing school zone signs. The results of the evaluation are discussed in section 5, and concluding remarks are included in section 6.

2 Literature review

Transport injuries are the most common cause of child injury death for Australian children aged one to 14 (Henley & Harrison, 2009) and more generally, speed has been identified as a major contributing factor in crash causation and outcome severity (Global Road Safety Partnership, 2008). Pedestrians are particularly vulnerable in traffic situations that present conflicts with motorised vehicles, such as pedestrian crossings, due to their lack of protection. Accordingly, many jurisdictions regulate lower speeds in zones near schools at times when children are arriving and leaving (National Transport Commission, 2012).

However, evidence suggests motorist speed compliance at school zones is poor to negligible (Transportation Research Board, 1998; Young & Dixon, 2003). Factors identified as contributing to poor speed compliance include lack of enforcement, perceptions that the limit is unreasonably low, lack of children present, and distraction and forgetfulness of the limit when within the zone, especially after stopping (Hawkins, 2007; Osmers, 2002). One approach to increasing compliance with reduced speed limits in school zones is the treatment of the zones with signs equipped with lights that flash during active school zone times, the purpose of which is to remind motorists to reduce their speed, and reduce ambiguity about when the reduced speed limits apply (Simpson, 2008).

Evaluations of the effectiveness of flashing school zone signs have produced mixed results. Evidence for a degree of effectiveness includes a study by Zegeer, Havens and Dean (1976) which showed a statistically significant decrease in 85th percentile speeds. Aggarwal and Mortensen (1993) found similar effects; however, other treatments were simultaneously deployed making estimation of the proportion of the effect that is attributable to the flashing lights unclear. An evaluation of flashing school zone signs in New South Wales (NSW) showed a statistically significant decrease in both mean and 85th percentile speeds, by 1.3 km/h (from 45.0 km/h to 43.7 km/h) and 3.2 km/h (from 54.6 km/h to 51.4 km/h), respectively (Roper, Thoresen, Tziotis & Imberger, 2006). Despite these reductions, more than 50% of vehicles were exceeding the posted speed limit. Moreover, six of the 30 (20%) treated sites showed an increase in mean speed after adjusting for changes at matched control sites. The authors suggested that the high failure rate of the lights[1] to activate in school zone times may have contributed to their lack of effectiveness. Similarly, a study by Radalj (2004) into the effectiveness of flashing school zone signs in Western Australia, estimated up to 1.83 km/h mean speed reductions (seasonally adjusted; 2.62 km/h). However, consistent with other studies, the majority (75%) of vehicles were still found to be speeding.

Some evidence suggests that flashing school zone signs may be more effective in reducing speeding when the school zone speed limits are higher than 40 km/h, such as school zone speed limits of 50-55 km/h in rural high-speed environments where the normal speed limit is 15 km/h higher (e.g. Saibel, Salzberg, Doane & Moffat, 1999; Simpson, 2008) . However, compliance levels were still not considered high (Saibel et al., 1999; Simpson, 2008; Sparks & Cynecki, 1990). In contrast, evidence suggests that flashing school zone signs are ineffective at reducing speeds in urban environments. For example, two studies have found no effect (Sparks & Cynecki, 1990; Saibel et al., 1999) and two other studies have found that the signs were associated with statistically significant *increases* in speeding behaviour and/or traffic violations (Burritt, Buchanan & Kalivoda, 1990 as cited in Simpson, 2008; Roper et al., 2006).

The magnitude of speed changes associated with flashing school zone signs is typically small. For example, for 35 mph (~ 55 km/h) school zones, Simpson (2008) found a 1.8 mph (~ 2.9 km/h, 8%) reduction in mean speeds in zones with flashing school zone signs compared to those with standard (non-flashing) signs, and, in contrast, a 1.5 mph (~ 2.4 km/h, 5%) *increase* for flashing school zone signs in 25 mph (~ 40 km/h) school zones. The Roper et al. (2006) evaluation of flashing lights in NSW found, after controlling for other influencing factors, 1.3 - 3.8 km/h and 3.2 - 6.3 km/h reductions in mean and 85th percentile speeds, respectively. Similarly, a simple "before/after" evaluation of a small trial (four sites) of flashing school zone signs in Western Australia showed a reduction in mean speed of 1.32 km/h (Radalj, 2004). Simpson (2008) concluded that these small effect sizes are likely to have little practical significance. However, Cameron and Elvik (2008) developed estimates of expected reductions in casualties and fatalities as a function of lower mean travel speeds (originally developed by Nilsson, 1981, 2004, as cited by Cameron & Elvik, 2008). Their power estimates suggest that even small changes in mean travel speeds in urban 50 km/h zones are likely to produce practically significant changes. For example, a reduction in mean speed of 1 km/h is likely to result in an 8.23% reduction in fatalities.

To summarise, the studies reviewed here identified a range of effects for flashing school zone signs: marginal (6 studies); ineffective (1 study); and detrimental (2 studies). Despite the mixed evidence, results suggest that flashing school zone signs typically provide a small beneficial effect on travel speeds; between 1.3 – 3.8 km/h and 3.2 – 6.2 km/h reductions in mean and 85th

[1] There were 80 faults detected over the 18 month study period (about 2 faults/site). Faults included: non-function; continual flashing; and flashing at incorrect times. Reasons for the faults were not specified.

percentile speeds, respectively. Therefore, benefits appear slightly more pronounced for reducing higher levels of speeding, which is to be expected, given that the primary purpose of the lights is to remind motorists of the reduced speeds. For example, a motorist travelling through a 40 km/h school zone on an 80 km/h road who is not aware that the school zone is active could exceed the limit by as much as 40 km/h or 100%, assuming they are adhering to the default speed limit. Finally, it is acknowledged that flashing school zone signs are not intended to impact upon intentional speeding which is better addressed with other countermeasures (such as road treatments, enforcement, or, as technology develops, intelligent in-vehicle speed adaptation).

3 Self-reported attitudes and behaviours of road users

3.1 Method

In addition to objective measures of changes in travel speed behaviour, self-report measures investigating motorists' experiences of flashing school zone signs can provide additional insight into the effectiveness of these signs at alerting motorists to when reduced speed limits apply in school zones.

Since 1998, Department of Transport and Main Roads has conducted an annual survey of Queensland motorists focusing on road safety attitudes and behaviours, as well as support for road safety initiatives, the Road Safety Perceptions and Attitudes Tracking Survey (RSPAT). Up until 2007, the RSPAT survey was conducted using computer assisted telephone interview methodology. In a change in 2008, the fieldwork for the survey was migrated to an online panel, with this methodology now being utilised each year. The survey is conducted by Market & Communications Research.

The 2014 survey tracked many of the measures that have been taken in previous years. Additionally, some new measures were included across a range of subject areas, including school transport safety, where new items were included to measure attitudes towards flashing school zone signs.

These items asked respondents: which days school zones operate; how they recognise a school zone on a road they may be unfamiliar with; whether flashing school zone signs help them determine when lower speed limits apply; their perceptions of other road users' compliance with flashing school zone signs compared to standard (non-flashing) school zone signs; how often they slow down during school zone times in different circumstances; how often they exceed the speed limit in school zones in different circumstances; and where they think flashing school zone signs should be installed.

A total of 600 Queenslanders completed the 2014 survey. The sample was drawn from an online panel with more than 300,000 members, and was stratified so that it represented the Queensland licensed driver population in terms of gender, age and region. Only motorists (including riders of motorcycles, scooters and mopeds) aged 16 years and over who drive or ride for at least one hour per week were eligible to participate. The survey data was collected from 8 April to 23 May, 2014.

3.2 Results

Key results from the 2014 survey relevant to the first research question *"Do flashing school zone signs assist motorists to determine when school zones (and reduced speed limits) are in operation?"* include:

- 96% of respondents use school zone signs to recognise school zones on roads they are unfamiliar with.
- 98% of respondents agreed that flashing school zone signs help them determine when lower speed limits apply.
- 91% of respondents agreed that in their opinion, other road users are more compliant with speed limits in school zones with flashing school zone signs than standard school zone signs.
- Respondents were least likely to exceed the speed limit in a school zone where children are present (75% said they 'Never' do this), followed by school zones with flashing school zone signs (61%) and standard school zones (55%).

4 Observational travel speed survey

4.1 Method

4.1.1 Design

Design options for the observational travel speed survey component of the evaluation were influenced by the time constraints of the project. Based on the time available to complete the evaluation, a before/after design with treatment and comparison groups was selected. This allowed comparison of travel speeds in school zones before and after installation of flashing school zone signs (treatment sites) to determine whether speeds were affected.

To control for general changes in travel speeds that may have occurred due to reasons other than the installation of the signs, travel speed data was collected at the same time periods for school zones that were similar to those in the treatment group in terms of road environment and risk assessment, but they did not have flashing school zone signs installed between the data collection periods. These sites were allocated to the comparison group.

4.1.2 Site selection

As noted in section 1.1, school zones to be treated with flashing school zone signs in Queensland are selected based on a risk assessment process. It was therefore beyond the scope of this evaluation to change the installation schedule and select sites that were not on the installation program for inclusion in the treatment group of the evaluation. Thus treatment and comparison sites were selected based on the existing installation program. A large number of sites were sampled to ensure sufficient data would be available for analyses even if sites had flashing school zone signs installed earlier or later than expected, affecting the allocation of sites to the treatment or comparison group.

Thirty-nine of the sites where data was collected had flashing school zone signs installed between the data collection periods and were allocated to the treatment group. Only three sites did not have the signs installed and were allocated to the comparison group. The majority of sites were located in the greater Brisbane region. Details of the study sites are listed in Table 4.1 below.

As Table 4.1 shows, more than half of the treatment sites (n = 26, 62% of all sites) and all of the comparison sites (n = 3, 7%) were situated on roads with default speed limits of 60 km/h, with the remainder of the treatment sites on roads with 50 km/h default speed limits (n = 13, 31%). All school zone speed limits were 40 km/h.

Table 4.1: School zones included in the evaluation

School*	Default speed limit (km/h)	School zone limit (km/h)	Group**
Bethany Lutheran PS, Cascade St, Raceview	60	40	T
Birkdale South SS, Old Cleveland Rd East, East Birkdale	60	40	T
Camp Hill State and Infants PS, Wiles St, Camp Hill	60	40	T
Citipointe Christian College, Wecker Rd, Mansfield	60	40	T
Eagleby South SS, Fryar Rd, Eagleby	60	40	T
Elimbah SS, Beerburrum Rd, Elimbah	60	40	T
Faith Lutheran College, Link Rd, Victoria Point	50	40	T
Ferny Grove SS and SHS, McGinn Rd, Ferny Grove	60	40	T
Forest Lake State School, Woogaroo St, Forest Lake	60	40	T
Glasshouse Country Christian College, Roberts Rd, Beerwah	60	40	C
Good News Lutheran School & Jamboree Heights SS, Horizon Dr, Mt Ommaney	60	40	T
Grovely SS, Dawson Pde, Grovely	60	40	T
Hilder Rd SS, Kaloma Rd, The Gap	50	40	T
Hilliard SS, Alexandra Cct, Alexandra Hills	50	40	T
Holland Park SS, Abbotsleigh St, Holland Park	50	40	T
Holy Spirit School, Sparkes Rd, Bray Park	60	40	T
Indooroopilly SS, Russell Tce, Indooroopilly	60	40	T
Ironside SS, Swann Rd, St Lucia	50	40	T
Jindalee SS, Burrendah Rd, Jindalee	60	40	T
Logan Village SS, North St, Logan Village	50	40	T
Lourdes Hill College, Hawthorne Rd, Hawthorne	60	40	T
Manly SS, Ernest St, Manly	50	40	T
Mansfield SHS, Broadwater Rd, Mansfield	60	40	T
Meridan State College, Parklands Blvd, Meridan Plains	60	40	C
Minimbah SS, Walkers Rd, Morayfield	60	40	T
Morningside SS, Pashen St, Morningside	50	40	T
Nundah SS, Buckland Rd, Nundah	60	40	T
Our Lady of Assumption & Hillbrook Anglican College, Hurdcotte St, Enoggera	50	40	T
Oxley SS, Bannerman St, Oxley	50	40	T
Rainworth SS, Boundary Rd, Rainworth	50	40	T
Redland Bay SS, Gordon Rd, Redland Bay	60	40	T
Sherwood SS, Sherwood St, Sherwood	60	40	T
St Bernard SS, School Rd, Mount Tamborine	60	40	C
St Rita’s PS, Benfer Rd, Victoria Point	60	40	T
Tullawong SS & St Pauls Lutheran PS, Smiths Rd, Caboolture	60	40	T
Wamuran SS, D'Aguilar Hwy, Wamuran	60	40	T

School*	Default speed limit (km/h)	School zone limit (km/h)	Group**
Warrigal Rd SS, Warrigal Rd, Eight Mile Plains	60	40	T
Wellers Hill SS, Toohey Rd, Wellers Hill	60	40	T
West End SS, Hardgrave Rd, West End	50	40	T
Wilston SS, Thomas St, Wilston	50	40	T
Wondall Heights SS, Wondall Rd, Manly West	60	40	T
Yugumbir SS, Vansittart Rd, Regents Park	60	40	T

** PS = Primary School; SHS = State High School; SS = State School*

*** T = Treatment site; C = Comparison site*

For 27 (64%; 26 treatment, 1 comparison) sites the site-active times were the standard 7:00-9:00 and 14:00-16:00. A further 9 (21%; 8 treatment, 1 comparison) sites operated between the hours of 8:00-9:00 and 14:30-15:30. The remaining 6 (14%; 5 treatment, 1 comparison) sites operated at various other times; however, all sites operated at a minimum between the hours of 8:00-9:00 and 14:30-15:30.

The majority of sites were on collector roads (n = 26, 62%; 23 treatment, 3 comparison) with the minority of sites located on local (n = 11, 26%) and arterial (n = 5, 12%) roads. Most sites were on two lane roads (n = 38, 90%; 35 treatment, 3 comparison), with the remainder on four lane roads (n = 4, 10%). The majority of pedestrian crossings were supervised (n = 29, 69%; 26 treatment, 3 comparison), followed by signalised (n = 8, 19%), none (n = 3, 7%), refuge (n = 1, 2%) and unsupervised (n = 1, 2%). Most schools had over 500 pupils attending (n = 31, 74%; 30 treatment, 1 comparison), followed by 100-500 (n = 11, 26%; 9 treatment, 2 comparison) pupils.

4.1.3 Data collection periods

As the report describing the results of the evaluation was required by mid 2014, travel speeds were measured over three-week periods in Term 4 (14 October – 2 November), 2013 and Term 1 (24 February – 17 March), 2014. None of the sites had flashing school zone signs installed prior to or during the Term 4 data collection period, and all treatment sites had the signs installed prior to the Term 1 data collection period.

Speeds were not measured in the first or last weeks of the school year to minimise “atypical” travel patterns associated with these times. Neither period included public holidays or pupil free days. At sites where data was missing due to delays in installation, technical issues or vehicles parking on the detection tubes, extra days of data collection were conducted so that a full data set (defined as 14 days’ worth of data) was obtained for each site. Data was collected 24 hours per day, seven days per week.

4.1.4 Data collection procedure

Travel speed data was collected by Traffic and Transport Management using MetroCount 5600 Plus devices. This device logs data for every vehicle that passes over the detection tubes. As illustrated in Figure 4.1 below, tubes were placed as close as possible to the centre of the school zone, measuring both directions of traffic (SS2). Tubes were also placed outside the school zone for each approach direction (SS1 and SS3). Tubes were placed similarly in comparison zones where standard (non-flashing) school zone signs were present. Placement of the detection tubes was influenced by the road environment to maximise measurement of vehicles that would proceed through the school zone and minimise measurement of vehicles that may turn off the road without entering the school zone. Figure 4.2 shows an example of data collection points for a school zone in this study, and Figure 4.3 shows detection tubes on approach to a school zone.

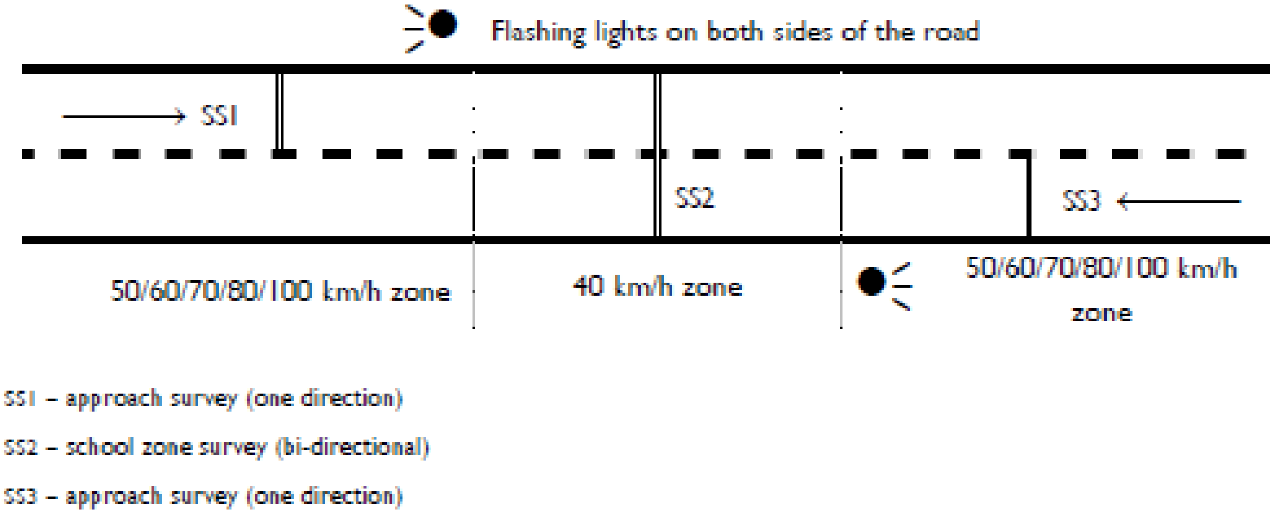


Figure 4.1: Placement of detection tubes (image source: Roper et al., 2006)

Figure 4.2: Example of data collection points

Figure 4.3: Example detection tubes on approach to a school zone

4.1.5 *Preparation of data for analysis*

The data were analysed by Department of Transport and Main Roads using Microsoft Excel and IBM Statistical Package for the Social Sciences software. There were more than 3.4 million vehicles observed during the two data collection periods. To make the dataset more manageable for analysis, some data were excluded (as described below), and remaining data were aggregated for analysis into 15-minute “bins”.

Data collected on weekends and between 6pm and 5:59am on weekdays was excluded. Vehicles with less than three seconds headway (defined as the distance between the front of a vehicle and the front of the vehicle preceding it) were also excluded, as this may indicate traffic congestion that does not give these vehicles the opportunity to speed, sometimes referred to as “free speeds”.

Data were not analysed by direction, as data for each direction at SS2, and for SS1 and SS3, in Figure 4.1 above were combined for analysis so there was one dataset each for travel within and outside of each school zone.

Where data for school zone active times were to be compared with data from inactive times, data from one hour either side of each school zone active period (i.e., 6-7am, 9-10am, 1-2pm and 4-5pm) were used. These time periods were selected as they were the closest to the school zone active times, and travel behaviour was expected to be similar but unaffected by the flashing school zone signs (which would not be operating). This also provided a similar number of observations as the school zone active time periods.

4.2 Results

4.2.1 *Descriptive statistics*

Table 4.2 shows the aggregate mean free speeds (for vehicles with at least three seconds headway) and 85th percentile speeds for the treatment and comparison groups in the before and after time periods. Changes between the two periods are highlighted in the shaded columns.

In the before period, 62.3% of vehicles travelling through treatment sites and 60.6% of vehicles travelling through comparison sites with at least three seconds headway were travelling at or below the reduced speed limit of 40 km/h. Less than two fifths of vehicles (37.7% and 39.4% respectively) were exceeding the speed limit.

In the after period, mean speeds reduced by 1.9 km/h at treatment sites and 2.6 km/h at comparison sites. The 85th percentile speeds reduced by 2.5 km/h at both treatment and comparison sites. Compliance with the reduced speed limit increased to 71.2% for both groups.

Table 4.2: Aggregate descriptive statistics for travel speeds during school zone times (when 40 km/h school zone speed limit applied)

	Treatment sites (*n* = 39)					
	Before (no flashing lights)		**After (flashing lights)**		**Change**	
	n	**value**	***n***	**value**	**difference**	**%**
Mean speed	637,132	35.9 km/h	588,721	34.0 km/h	-1.9 km/h	-5.3%
85th percentile speed		45.2 km/h		42.7 km/h	-2.5 km/h	-5.5%
Vehicles at or below limit	396,674	62.3%	419,118	71.2%	+8.9%	+14.3%
Vehicles > 40 km/h	240,458	37.7%	169,603	28.8%	-8.9%	-23.6%
Vehicles > 50 km/h	56,530	8.9%	28,942	4.9%	-4.0%	-44.9%
Vehicles > 60 km/h	5,734	0.9%	2,259	0.4%	-0.5%	-55.6%
Vehicles > 70 km/h	319	0.05%	109	0.02%	-0.03%	-60.0%
	Comparison sites (*n* = 3)					
	Before (no flashing lights)		**After (no flashing lights)**		**Change**	
	n	**value**	***n***	**value**	**difference**	**%**
Mean speed	39,550	36.8 km/h	41,238	34.2 km/h	-2.6 km/h	-7.1%
85th percentile speed		46.0 km/h		43.5 km/h	-2.5 km/h	-5.4%
Vehicles at or below limit	23,978	60.6%	29,365	71.2%	+10.6%	+17.5%
Vehicles > 40 km/h	15,572	39.4%	11,873	28.8%	-10.6%	-26.9%
Vehicles > 50 km/h	3,581	9.1%	2,075	5.0%	-4.1%	-45.1%
Vehicles > 60 km/h	619	1.6%	342	0.8%	-0.8%	-50.0%
Vehicles > 70 km/h	59	1.5%	28	0.07%	-1.4%	-95.3%

It was noted in section 4.1.2 that there was a mixture of 50 km/h and 60 km/h default speed limits at treatment sites, whereas all comparison sites had a default speed limit of 60 km/h. Figures 4.4 and 4.5 below separate the treatment sites into those with a 60 km/h default speed limit (*n* = 26; see Figure 4.4) and those with a 50 km/h default speed limit (*n* = 13; see Figure 4.5). Mean speeds (solid lines) and 85th percentile speeds (dotted lines) for each 15-minute “bin” between 06:00 and 17:59 are plotted for the before (blue) and after (green) data collection periods.

Standard school zone times of 07:00-09:00 and 14:00-16:00 are shaded; however, as noted in section 4.1.2, not all sites were active during these times. Only sites that were active school zones during these periods were used to plot these sections of the graphs.

Speed limit compliance outside school zone active times appears better in 60 km/h zones than in the 50 km/h zones, as the 85th percentile speeds for both before and after surveys are below the speed limit for the 60 km/h zones, but are slightly above for the 50 km/h zones. Regardless of the default speed limit, Figures 4.4 and 4.5 show distinct differences between the morning and afternoon school zone profiles. The morning school zone period shows a steady reduction in speeds across the school zone period until the lowest point at about 8:30am, whereas the afternoon peak period shows a shorter and sharper reduction in speeds around 3pm. School zone speed limit compliance appears best for the 8:00-9:00 and 14:30-15:30 periods, possibly due to an increased presence of children at those times, as these times coincide with start and finish times at most Queensland schools. As discussed in section 3.2, respondents to the 2014

Road Safety Perceptions and Attitudes Tracking survey were least likely to exceed the speed limit in school zones when children are present.

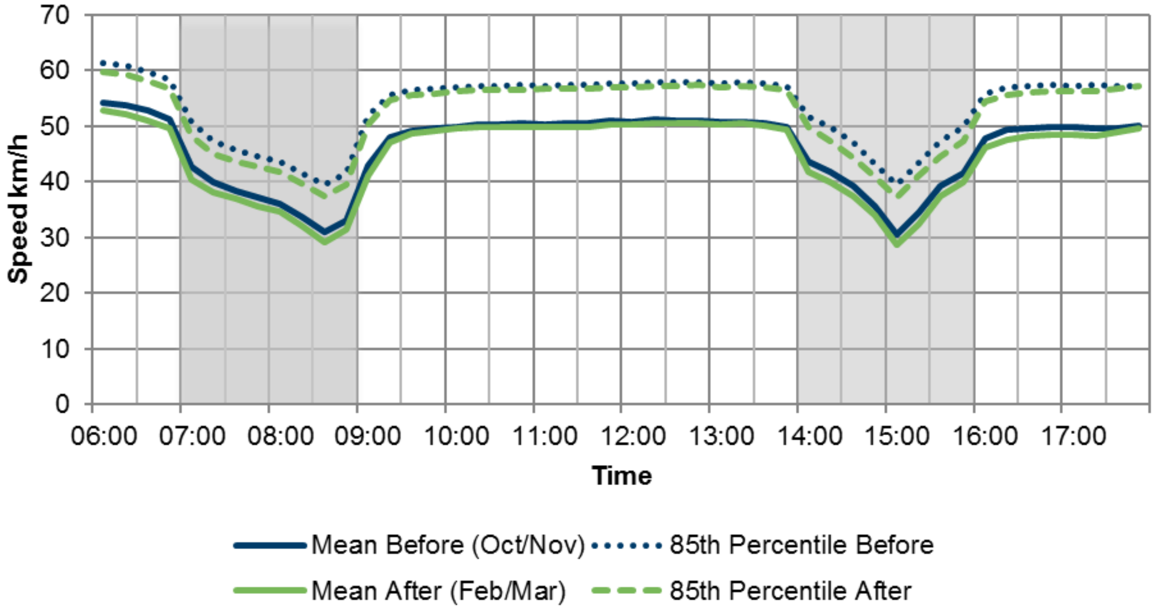


Figure 4.4: Mean and 85th percentile speeds before and after flashing school zone sign installation at treatment sites with a default speed limit of 60 km/h

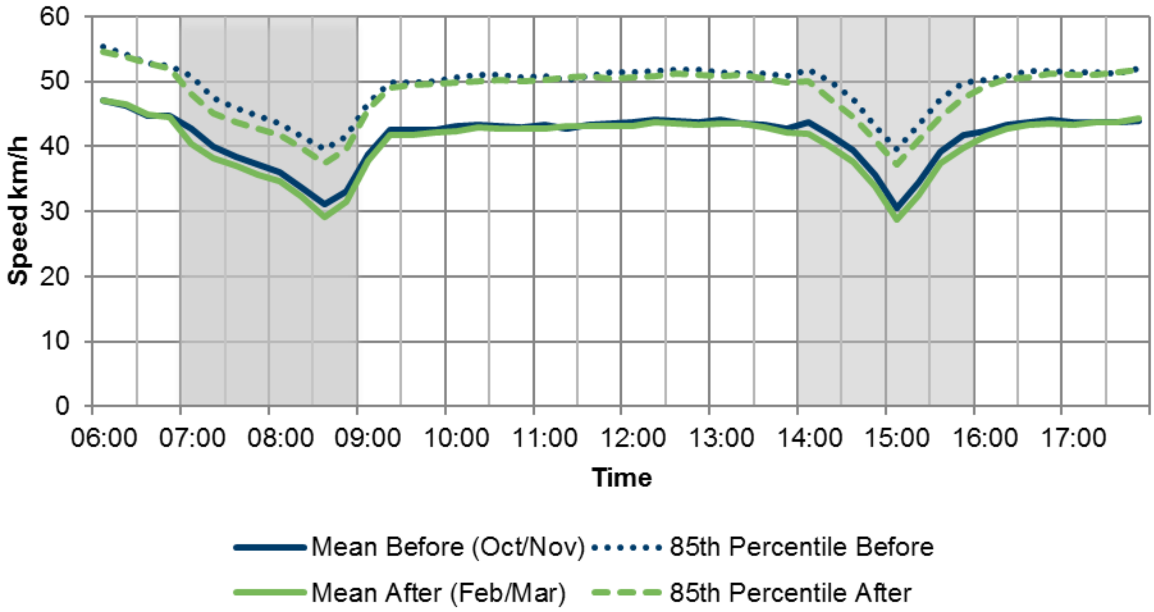


Figure 4.5: Mean and 85th percentile speeds before and after flashing school zone sign installation at treatment sites with a default speed limit of 50 km/h

When comparing mean and 85th percentile speeds before the installation of flashing school zone signs (blue lines) with the after installation speeds (green lines), both figures show slight reductions outside active school zone times (slightly greater for 60 km/h zones), but the reductions appear greater during school zone times.

Appendix A shows the aggregated mean, standard deviation and 85th percentile active school zone travel speeds for each site and collection period, as well as the percentage of vehicles travelling above the speed limit (during school zone active times), and at 10, 20 and 30 km/h intervals. Overall, reductions were seen between the two observation periods in not only mean speeds but also 85th percentile speeds and percentage of vehicles travelling over the speed limit. These reductions appear relatively uniform across all sites.

4.2.2 Statistical analyses

A number of statistical analyses were performed to address the second research question, *"Are flashing school zone signs effective in terms of increasing speed limit compliance with reduced speed limits in school zones?"* These analyses considered changes in two dependent variables: mean speeds and 85th percentile speeds.

The analyses were conducted by weighting the dependent variables by the number of vehicle observations (per observation period) to improve the statistical models and better reflect the travel behaviour of the majority of vehicles. To account for differences in approach speed as a result of the two default speed limits and other environmental factors, travel speed data were adjusted to provide better estimates of the effects of the treatment.

4.2.2.1 Changes in travel speeds at treatment sites

Table 4.3 below shows the mean and 85th percentile speeds within the school zone for the 39 treatment sites before and after the installation of flashing school signs during school zone active and inactive times, after adjusting for approach speeds in the before period. These data are based on 1,135,744 vehicle observations during inactive times, and 1,225,853 vehicle observations during school zone active times (when a reduced speed limit of 40 km/h applied). Only vehicles with three seconds headway distance were included. The table also shows the change over time in these statistics, which is graphically presented in Figure 4.6.

Table 4.3: Weighted mean and 85th percentile speeds within school zones for treatment sites (n = 39)

	Period		**Change**	
	Before (no flashing lights)	**After (flashing lights)**	**km/h**	**%**
Mean speed				
Inactive	46.16 km/h	45.09 km/h	-1.07 km/h	-2.32%
Active	38.68 km/h	36.52 km/h	-2.16 km/h	-5.58%
85th percentile speed				
Inactive	53.91 km/h	52.81 km/h	-1.10 km/h	-2.04%
Active	46.69 km/h	44.09 km/h	-2.60 km/h	-5.57%

Adjusting for zone approach speeds slightly increased the estimates of the reductions in speed between survey periods, for the active zone times. For example, the reductions in mean and 85th percentile speeds in Table 4.2 increased from 1.9 and 2.5 km/h respectively to 2.16 and 2.60 km/h in Table 4.3, where approach speeds were controlled.

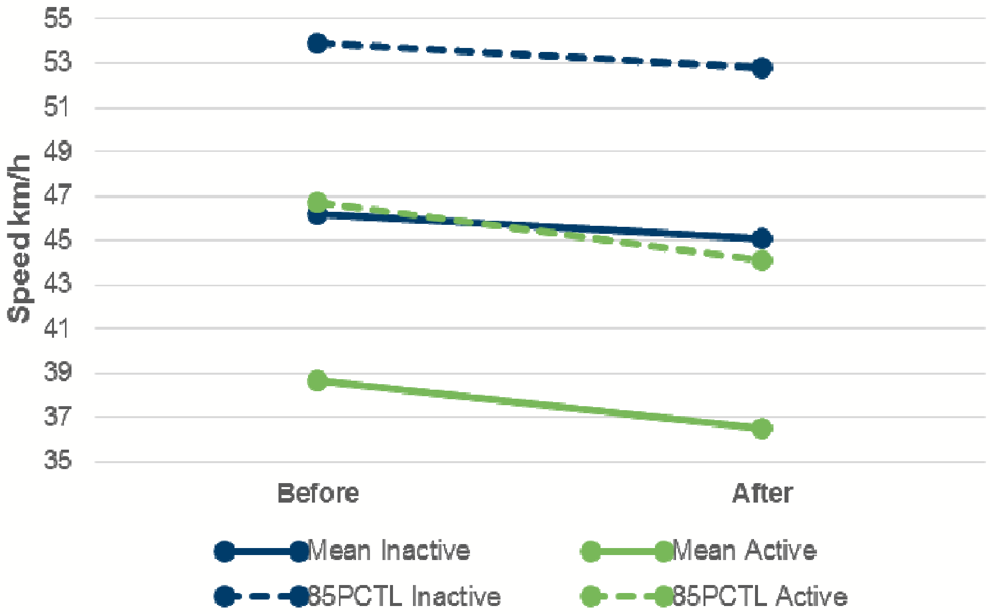


Figure 4.6: Weighted mean and 85th percentile speeds within school zones for treatment sites (n = 39)

Two analyses of covariance (ANCOVAs) were conducted to analyse changes in mean speeds and 85th percentile speeds within school zones, after controlling for speeds on approach to (i.e. outside of) the school zones. For mean speeds, it was found that speed significantly reduced over time during both school zone active and inactive times[2]. However, the reduction in mean speeds over time during school zone active times[3] was significantly[4] greater than the reduction over time during school zone inactive times[5]. A similar pattern of results was found for 85th percentile speeds, where speed significantly reduced over time during both school zone active and inactive times[6], but the reduction in 85th percentile speeds over time during school zone active times[7] was significantly[8] greater than the reduction over time during school zone inactive times[9].

Overall these results suggested an effect[10] on travel speeds over time, which was greater in the school zone active times than during the inactive periods. However, the reduction during inactive periods might suggest there was a general change in travel speeds across the network during the study, or that the effects of flashing school zone signs in reducing speeds extend beyond school zone active times.

Analysis of approach mean speeds (not reported in the Table or Figure) showed a similar reduction during both inactive (-1.18%) and active (-5.58%) times to the results reported above

[2] Wilks' Lambda = .98, F (1, 2361594) = 42,621.26, $p < .0005$
[3] Wilks' Lambda = .70, F (1, 2361594) = 1,008,438.61, $p < .0005$
[4] Time * Zone activity interaction F (1, 2361594) = 107,238.37, $p < .0005$
[5] Wilks' Lambda = .91, F (1, 2361594) = 228,223.31, $p < .0005$
[6] Wilks' Lambda = .97, F (1, 2361594) = 69,599.19, $p < .0005$
[7] Wilks' Lambda = .47, F (1, 2361594) = 2,103,731.62, $p < .0005$
[8] Time * Zone activity interaction F (1, 2361594) = 292,317.98, $p < .0005$
[9] Wilks' Lambda = .87, F (1, 2361594) = 348,121.93, $p < .0005$
[10] Given the large sample size, differences are likely to be statistically significant even when the differences are small and may be of limited practical significance. A number of measures of the strength of the effect can be calculated, but in this report, changes in speeds are described in km/h and as a percentage change only so the reader can form their own judgements about the practical significance of the results. For example, the effects of observed reductions on injuries and fatalities are discussed in section 4.2.4.

for speeds within the school zone, suggesting that motorists begin to slow down before entering the school zone. However, it is acknowledged that approach speeds were often measured in close proximity to school zone signs, and that in all cases, the signage was visible to motorists from the approach data collection points.

As flashing school zone signs are designed to improve compliance with reduced speed limits during school zone active times, changes in speeds during inactive times may represent a network-wide change in speeds. Thus the estimated reductions during school active times were adjusted to account for the changes observed during inactive times, giving a more conservative estimate of the effect of the flashing lights.

Table 4.4 below shows the changes in aggregate zone active times travel speeds after adjusting for changes in speeds during the inactive times. For example, the average mean speed when school zones were active was 38.68 km/h in the before survey period (column 1). The percentage change in mean speed within the school zone during inactive times (as reported in Table 4.3 above) between survey periods was -2.32% (column 2). If there was no effect of flashing school zone signs on travel speeds during times when the school zone was active, then we would expect the same reduction in speed during active school zone times. Column 3 applies this figure to the before survey active zone mean speed to provide an expected change (reduction in mean speed) without installation of the lights to 37.78 km/h. The actual after speed was 36.52 km/h (column 4). Column 5 calculates the adjusted effect of the flashing lights by subtracting the expected speed from what was observed. This figure shows that speeds during active school zones times were reduced by 1.26 km/h (column 5) or 3.34% (column 6), after taking into account reductions in speed outside school zone active times. After accounting for changes in 85th percentile speeds outside active school zone times using the same procedure, 85th percentile speeds during school zone active times were estimated to have reduced by 1.65 km/h or 3.60%.

Table 4.4: Weighted mean and 85th percentile speeds within school zones during active times for treatment sites, adjusted for changes during school zone inactive times

	Before speed	Inactive change %	Expected after speed (if no effect)	Actual after speed	Adjusted speed change	Adjusted % change
	1	2	3 = 1*(100%-2)	4	5 = 4 – 3	6 = 5 / 3
Mean speed	38.68 km/h	-2.32%	37.78 km/h	36.52 km/h	-1.26 km/h	-3.34%
85th percentile speed	46.69 km/h	-2.04%	45.74 km/h	44.09 km/h	-1.65 km/h	-3.60%

4.2.2.2 Changes in travel speeds at comparison sites

Similar to the results reported in Table 4.3 and Figure 4.6 which show data for the treatment sites, means and 85th percentile travel speeds were weighted by observations, and adjusted for approach travel speeds during the “before” data collection period for the comparison sites. As one of the three comparison sites (Glasshouse Country Christian College) did not have approach data for the before period, Table 4.5 and Figure 4.7 below only include data for the two remaining comparison sites. There were 77,917 observations during inactive times, and 50,076 observations during school zone active times (when a reduced speed limit of 40 km/h applied). Only vehicles with three seconds headway distance were included.

Table 4.5 and Figure 4.7 show little change (slight increases) in mean and 85th percentile speeds during school zone inactive times. In contrast, reductions were seen in the school zone active times for both dependent variables, the greatest of which was for mean speeds, despite there being no changes in these school zones between the two data collection periods.

Table 4.5: Weighted mean and 85th percentile speeds within school zones for comparison sites (n = 2)

	Period		Change	
	Before (no flashing lights)	After (no flashing lights)	km/h	%
Mean speed				
Inactive	46.13 km/h	46.28 km/h	+0.15 km/h	+0.33%
Active	41.03 km/h	38.62 km/h	-2.40 km/h	-5.85%
85th percentile speed				
Inactive	53.17 km/h	53.22 km/h	+0.05 km/h	+0.09%
Active	48.82 km/h	47.28 km/h	-1.54 km/h	-3.16%

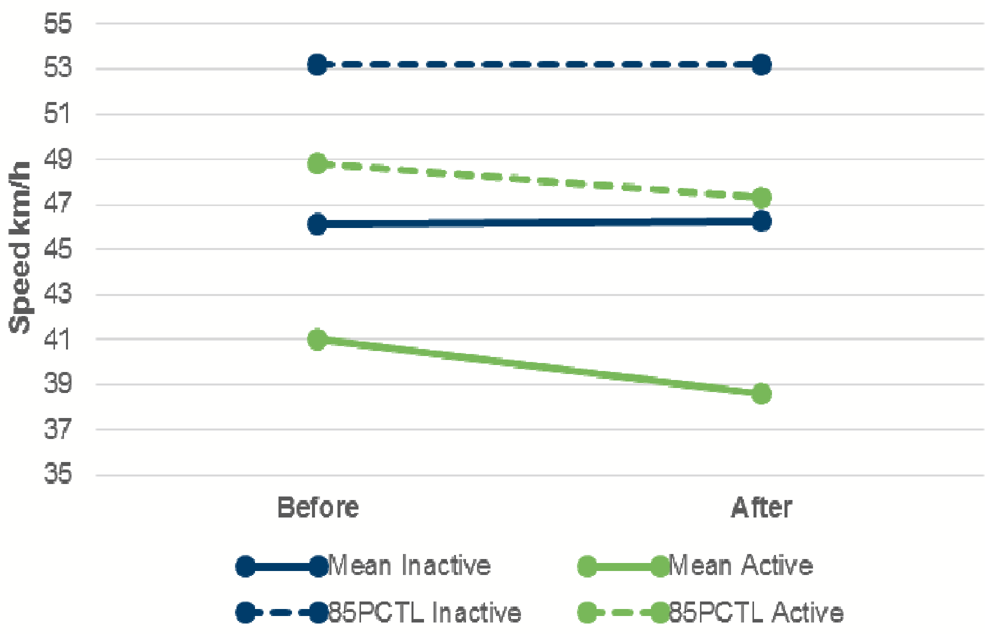


Figure 4.7: Weighted mean and 85th percentile speeds within school zones for comparison sites (n = 2)

Two ANCOVAs were conducted to analyse changes in mean speeds and 85th percentile speeds within comparison school zones, after controlling for speeds on approach to (i.e. outside of) the school zones. Similar to the results for treatment sites, it was found that mean speeds significantly reduced over time[11]. However, results differed depending on whether the school zone was active or not[12]. There was a significant reduction in mean speeds during school zone

[11] Wilks' Lambda = .99, F (1, 127990) = 913.90, $p < .0005$
[12] Time * Zone activity interaction F (1, 127990) = 37,548.07, $p < .0005$

active times[13], but a significant *increase* in mean speeds during school zone inactive times[14]. Similar results were found for 85th percentile speeds, where the significant reduction in speed over time[15] was a result of changes during school zone active times[16], while there was a significant *increase* in 85th percentile speeds during school zone inactive times[17].

Thus while mean and 85th percentile speeds reduced significantly over time during active school zone times at comparison sites, they *increased* during inactive school zone times. However, the increases were very small (0.15 and 0.05 km/h) and may therefore be of limited practical significance.

4.2.2.3 Comparing treatment and comparison sites

The results reported in sections 4.2.2.1 and 4.2.2.2 showed that there were significant reductions in mean and 85th percentile speeds during school zone active times in both treatment and comparison school zones over the study period. However, only the treatment sites also showed a significant reduction in speeds during inactive times over the study period.

Direct comparison of the treatment and comparison sites should be interpreted with caution as the small number of comparison sites may be systematically different to the treated sites in a meaningful way. For example, the comparison sites were located on the Gold and Sunshine Coasts, whereas the majority of the treatment sites were in the greater Brisbane region.

To ensure that treatment and comparison sites were similar with the exception of the installation of flashing school zone signs, a subset of treatment sites matched on zone inactive speed limit (60 km/h), crossing supervision (supervised), number of lanes (n = 2), school size (>500) and geographical location (regional – as close as possible) were selected. These sites were Minimbah State School, St Rita's Primary School, and Tullawong State & St Paul's Lutheran Primary Schools.

Due to the absence of approach speed data at one of the comparison sites, analyses were conducted without adjusting travel speeds for approach speeds during the before period so all three comparison sites could be included. The omission of the approach speed from the analysis was not considered a problem, as all six sites were located on roads with the same inactive speed limit, which was not the case in the previous analyses. Speeds were weighted by observations, with analyses based on 63,047 vehicle observations at treatment sites, and 80,788 observations at comparison sites.

Table 4.6 and Figure 4.8 show the mean and 85th percentile speeds for the sub-sample of treatment and comparison sites during active school zone times in the before and after data collection periods. Differences in these variables were compared to estimate the impact of flashing school zone signs versus standard school zone signs during school zone periods.

Two analyses of variance (ANOVAs) were conducted to analyse changes in mean speeds and 85th percentile speeds within school zones during active school zone times. Results revealed that the changes in mean and 85th percentile speeds over time were significant for treatment and comparison sites[18].

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[13] Wilks' Lambda = .53, F (1, 127991) = 114,333.11, $p < .0005$
[14] Wilks' Lambda = .99, F (1, 127991) = 1,001.63, $p < .0005$
[15] Wilks' Lambda = .92, F (1, 127990) = 11,371.17, $p < .0005$
[16] Wilks' Lambda = .69, F (1, 127990) = 58,661.98, $p < .0005$
[17] Time * Zone activity interaction F (1, 127990) = 30,596.89, $p < .0005$; effect of time on 85th percentile speeds during inactive school zone times Wilks' Lambda = .99, F (1, 127990) = 112.17, $p < .0005$
[18] Mean speed Wilks' Lambda = .30, F (1, 143833) = 341,780.93, $p < .0005$; 85th percentile speed Wilks' Lambda = .23, F (1, 143833) = 495,265.30, $p < .0005$

However, the reductions were significantly[19] greater for the treatment sites[20] compared with the comparison sites[21], particularly for the 85th percentile speeds.

Table 4.6: Weighted mean and 85th percentile speeds within school zones during active times for sub-sample of treatment and comparison sites (both n = 3)

	Period		**Change**	
	Before (no flashing lights)	**After (flashing lights*)**	**km/h**	**%**
Mean speed				
Treatment	36.31 km/h	33.36 km/h	-2.95 km/h	-8.12%
Comparison	37.16 km/h	34.65 km/h	-2.51 km/h	-6.76%
85th percentile speed				
Treatment	44.13 km/h	40.51 km/h	-3.62 km/h	-8.20%
Comparison	44.69 km/h	42.41 km/h	-2.28 km/h	-5.10%

** Only treatment sites had flashing lights installed by the after data collection period*

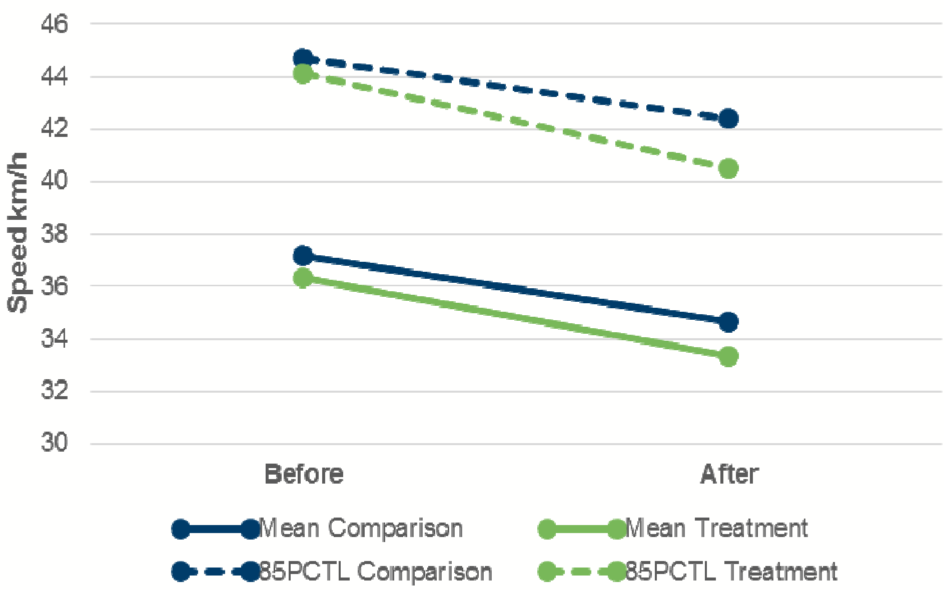

Figure 4.8: Weighted mean and 85th percentile speeds within school zones during active times for sub-sample of treatment and comparison sites (both n = 3)

Overall these results suggest significant reductions in mean speeds and 85th percentile speeds during school zone active times over the study period regardless of school zone sign type, which might suggest that the reductions are due to a network-wide reduction in speeds, or a factor that is influencing school zones generally (e.g. media attention given to school zone safety, police enforcement). However, the greater reductions at sites treated with flashing school zone signs suggests these signs are significantly contributing to the observed speed reductions.

[19] Time * Group interaction Mean speed Wilks' Lambda = .99, F (1, 143833) = 2221.37, $p < .0005$; 85th percentile speed Wilks' Lambda = .85, F (1, 143833) = 25,661.81, $p < .0005$
[20] Mean speed Wilks' Lambda = .45, F (1, 143833) = 177,644.04, $p < .0005$; 85th percentile speed Wilks' Lambda = .30, F (1, 143833) = 332,222.33, $p < .0005$
[21] Mean speed Wilks' Lambda = .47, F (1, 143833) = 164,770.39, $p < .0005$; 85th percentile speed Wilks' Lambda = .46, F (1, 143833) = 168,512.33, $p < .0005$

4.2.2.4 Adjusted estimates of observed changes in travel speed during school zone active times

Table 4.7 below shows the changes in travel speeds during school zone active times in the sub-sample of treatment sites (*n* = 3) after adjusting for changes in speeds at the comparison sites. For example, the average mean speed at the sub-sample of treatment sites when school zones were active was 36.31 km/h in the before survey period (column 1). The change in mean speed within the comparison sites (as reported in Table 4.6 above) between survey periods was -6.76% (column 2). If there was no effect of flashing school zone signs on travel speeds, then we would expect the same reduction in speed at treatment sites that was observed at the comparison sites. Column 3 applies this figure to the before survey active zone mean speed to provide an expected change (reduction in mean speed) without installation of the lights to 33.86 km/h. The actual after speed was 33.36 km/h (column 4). Column 5 calculates the adjusted effect of the flashing lights by subtracting the expected speed from what was observed. This figure shows that speeds during active school zones times at treatment sites were reduced by 0.50 km/h (column 5) or 1.38% (column 6), after taking into account reductions in speed at the comparison sites. After accounting for changes in 85th percentile speeds at the comparison sites using the same procedure, 85th percentile speeds during school zone active times were estimated to have reduced by 1.37 km/h or 3.10% at treatment sites.

Table 4.7: Weighted mean and 85th percentile speeds within school zones during active times for sub-sample of treatment sites (n = 3), adjusted for changes in comparison sites

	Before speed	Comparison change %	Expected after speed (if no effect)	Actual after speed	Adjusted speed change	Adjusted % change
	1	**2**	**3 = 1*(100%-2)**	**4**	**5 = 4 – 3**	**6 = 5 / 3**
Mean speed	36.31 km/h	-6.76%	33.86 km/h	33.36 km/h	-0.50 km/h	-1.38%
85th percentile speed	44.13 km/h	-5.10%	41.88 km/h	40.51 km/h	-1.37 km/h	-3.10%

4.2.3 *Consolidation of results*

The effects of installing flashing school zone signs in school zones were estimated by:

- Comparing speeds at treatment sites before and after installation of flashing school zone signs, during school zone active and inactive times (section 4.2.2.1, particularly Table 4.3).
    - It was found that mean and 85th percentile speeds at treatment sites were significantly lower after the installation of flashing school zone signs compared with speeds before installation during school zone active times.
    - This might suggest that the flashing school zone signs were effective in reducing speeds during school zone times. Alternatively, it is possible that there was a general (network-wide) reduction in speeds over time (e.g., a seasonal effect, impact of Christmas road safety campaign or other intervention), or some other factor (e.g. media attention, police enforcement) that reduced speeds at school zones generally over the study period.

    - The reduction in mean and 85th percentile speeds during inactive times might suggest that the effects of flashing school signs persist beyond school zone active times. However, this finding is also consistent with alternative explanations for the active school zone time results above, including a general (network-wide) reduction in speeds over time, or some other factor that reduced speeds at school zones generally over the study period.

- Comparing speeds at treatment sites before and after installation of flashing school zone signs, during school zone active times, controlling for changes observed during inactive times (section 4.2.2.1, particularly Table 4.4).
    - It was found that even after controlling for the changes in speeds during inactive times, there was a significant reduction in mean and 85th percentile speeds at treatment sites after the installation of flashing school zone signs.
    - While this doesn't rule out the alternative explanations for the results proposed above, the greater reductions during active school zone times compared with inactive times are consistent with the flashing school zone signs being responsible for at least some of the effect. Adjusting for the changes during inactive times provides a more conservative estimate of the effect of flashing school zone signs during school zone active periods.
- Comparing speeds in the before and after data collection periods, during school active times, between a sub-sample of treatment sites that were matched to comparison sites (section 4.2.2.3, particularly Table 4.6).
    - Section 4.2.2.2 showed that mean and 85th percentile speeds at comparison sites also reduced significantly between the two data collection periods, but only during school zone active (and not inactive) times. This result suggests that a general (network-wide) reduction in speeds is not a plausible explanation for the changes observed at treatment sites (as speeds increased at comparison sites during school zone inactive times), but it may indicate that the influence of other factors (e.g. media attention, police enforcement) reduced speeds at school zones generally (i.e. regardless of sign type) over the study period.
    - As the comparison sites were not representative of the full sample of treatment sites, a sub-sample of treatment sites that were matched to the comparison sites was identified. Comparing speed changes between these groups revealed that mean and 85th percentile speeds were significantly lower in the "after" period for the sub-sample of treatment sites, and to a lesser extent, comparison sites.
- Comparing speeds at treatment sites after installation to speeds before, during school zone active times, controlling for changes observed at comparison sites (section 4.2.2.4, particularly Table 4.7)
    - More conservative estimates of the benefits of flashing school zone signs in reducing speeds in school zones during active times were calculated by adjusting for the reductions observed at comparison sites for the sub-sample of treatment sites. It was found that treatment sites had a greater reduction in travel speeds than the comparison sites. However, this result should be interpreted with caution as it is based on a small sample of school zones that may not be representative of school zones across Queensland.

In summary, depending on the control variables used in the analyses, this study has found that flashing school signs were associated with reductions in mean speeds of 0.50 – 2.95 km/h and reductions in 85th percentile speeds of 1.37 – 3.62 km/h during school zone active times.

4.2.4 Expected effects on injuries and fatalities

It was noted earlier that although a number of analyses in this study revealed statistically significant changes in speeds, it was at the reader's discretion to determine how meaningful observed changes in speed were. While some may consider small changes in speed to be trivial, further calculations can be conducted to estimate the likely effects of speed reductions on injuries and fatalities.

Cameron and Elvik (2010) developed estimates of expected changes in casualties and fatalities due to changes in the average speeds of vehicles for different road environments, using exponential (power) estimates originally developed by Nilsson (1981, 2004). According to their calculations, the ratio of actual speeds to expected speeds after an intervention can be raised to the power of 1.746 for injuries and 4.251 for fatalities (in 50-60 km/h speed zones) to provide indicative changes in the number of expected injuries and fatalities related to the identified speed reductions. For example, using the results of the analysis presented in Table 4.4, the actual (36.52 km/h) and expected (37.78 km/h) mean speeds can be used to create a ratio of 36.52 / 37.78 = 0.966649. Raising this ratio to the power of 1.746 gives 0.9425. As a percentage, this figure is the percentage of persons injured before flashing school zone sign installation that would be expected after light installation (94.25%). Subtracting this figure from 100 means we would expect a reduction of 5.75% in persons injured as a result of the reduced speed. Applying similar calculations for fatalities produces an estimate of a 13.43% reduction in fatalities. Using the results in Table 4.7 (adjusting for the speed reduction observed at comparison sites when estimating the effect of the flashing school zone signs and a sub-sample of treatment sites), the same calculations provide estimates of a 2.56% reduction in persons injured and a 6.13% reduction in persons killed. Thus, results overall provide an estimated reduction of 2.56% to 5.75% in persons seriously injured and a reduction of 6.13% to 13.43% in fatalities due to reductions in mean speeds as a result of the flashing school zone signs estimated in this study.

However, results of these calculations are indicative only, since there is uncertainty about the actual changes in mean speeds, and the accuracy of the power factors used. Moreover, the power factors do not account for other important influential factors on injury rates, such as traffic volumes, police enforcement and general economic activity. Therefore, it would be unreasonable to expect the estimated effects to be directly observed in Queensland crash data.

5 Discussion

This evaluation addressed the following research questions:

1) Do flashing school zone signs assist motorists to determine when school zones (and reduced speed limits) are in operation?
2) Are flashing school zone signs effective in terms of increasing compliance with reduced speed limits in school zones?

These questions were addressed using data from an annual road user survey commissioned by the Department of Transport and Main Roads, and an observational travel speed survey.

5.1 Results relating to the research questions

5.1.1 Do flashing school zone signs assist motorists to determine when school zones (and reduced speed limits) are in operation?

Respondents to the 2014 Road Safety Perceptions and Attitudes Tracking Survey were very positive about flashing school zone signs, with 98% agreeing that they assist them to identify when lower speed limits apply. They also agreed that other road users were more likely to comply with these signs than standard (non-flashing) school zones.

These results suggest that flashing school zone signs are considered a useful tool to alert motorists to when reduced speed limits apply. These cues may be particularly useful in encouraging compliance with reduced speed limits when motorists are not familiar with the road, or other cues (such as children) are not present.

5.1.2 Are flashing school zone signs effective in terms of increasing compliance with reduced speed limits in school zones?

It was encouraging to note that compliance with speed limits during school zone active and inactive times was already quite high during the "before" data collection period.

The effects of installing flashing school zone signs on travel speeds in existing school zones were estimated in a number of ways. Significant reductions in mean and 85th percentile speeds during school zone active times were observed at the "after" data collection period, for both treatment and comparison sites. Speeds also significantly reduced during school zone inactive times at treatment sites, whereas speeds significantly increased (by 0.15 km/h) at comparison sites. However, reductions during active school zone times at treatment sites exceeded those observed at comparison sites when a sub-sample of matched sites were compared.

Depending on the control variables used in the analyses, this study found that flashing school signs were associated with reductions in mean speeds of 0.50 – 2.95 km/h and reductions in 85th percentile speeds of 1.37 – 3.62 km/h during school zone active times, which is consistent with the reductions observed in previous studies. The proportions of vehicles exceeding the school zone speed limits by large amounts (i.e. by 10km/h or more) at both treatment and comparison sites were reduced by more than 45%.

Analysis of travel speeds in 15-minute bins showed that compliance with school zone speed limits was greatest during periods where the presence of children is most likely, which is consistent with previous research, and responses to the Road Safety Perceptions and Attitudes Tracking Survey, as presence of children was the most common signal to motorists that they were entering a school zone.

The simple before/after design using treatment and comparison sites that were not directly comparable limits our ability to confidently assert that the observed changes in travel speeds were attributable to the installation of flashing school zone signs. There are a number of possible explanations for the study results, including:

a) Flashing school zones signs reduce travel speeds during school zone active times

b) There was a general (network-wide) reduction in travel speeds over the study period

c) There was an influence on school zones (regardless of sign type) over the study period, such as media attention or police enforcement

Explanation b) is not considered plausible as a significant increase in travel speeds was observed at comparison sites during school zone inactive times. Explanation c) is considered plausible, as speeds reduced at both treatment and comparison sites. However, the greater speed reductions at treatment sites during school zone active times compared with those observed at comparison sites suggests that the flashing school zone signs may have been responsible for a significant proportion of the overall reductions in travel speeds observed at treatment sites (explanation a). It is also possible that the effect of the flashing school zone signs, which are larger than standard school zone signs, persists beyond school zone active times, and contributed to the significant reductions observed during school zone inactive times at treatment sites.

5.2 Limitations of the research design

The results of this research should be interpreted in light of the limitations of the research design. Although the sampling technique for the Road Safety Perceptions and Attitudes Tracking Survey aims to recruit a sample that is representative of licence holders in Queensland, there may be differences in the attitudes and behaviours of individuals who volunteer to complete these types of surveys and those who do not. However, information about community perceptions of flashing school zones signs and road user behaviour at sites with these signs is not available from any other source at this time.

For the observational travel speed survey, constraints on the design of this study were noted in section 4.1. A naïve comparison of behaviour before and after installation or application of a treatment or intervention is generally not well regarded within road safety evaluation. This is because the road safety environment is dynamic, constantly changing due to many different changes in risk and exposure (such as weather, nature and amount of travel, mode of transport, etc.). Therefore, an attempt was made in the current study to account for these other changes. However, the data used to account for these changes were potentially contaminated with the effects of the treatment; that is, the new flashing school zone signs may have caused motorists to reduce their speed even when the signs were inactive. Thus the resulting estimates of changes in travel speed might be more conservative than necessary; the simple before/after unadjusted measures in travel speed might be more accurate. A better design would have been one that compared a similar number (or matched sets) of treated and untreated sites, before and after installation of lights at the treatment sites. This design, while originally proposed, was not possible due to the timing of flashing school zone sign installation, leaving just three untreated sites for the comparison group. Nevertheless, a strength of the evaluation was that a large number of sites and substantial number of observations were recorded.

As data in the “after” period were collected within three months of installation of the flashing school zone signs, it was beyond the scope of this study to determine whether the observed speed reductions persist over time, or are an initial response of motorists to a change in the road environment. Further, no attempt was made to compare the benefits of the installation of flashing school zone signs with the costs of the program, or to the benefits of other interventions designed to increase compliance with speed limits. These issues should be considered in future research projects.

6 Conclusion

Flashing school zones are considered a useful intervention to assist motorists to determine when reduced speed limits apply. This study found that these types of signs were associated with reductions in mean speeds of 0.50 – 2.95 km/h and reductions in 85th percentile speeds of 1.37 – 3.62 km/h. Thus the signs were particularly beneficial for reducing higher levels of speeding.

Research unrelated to travel speed around schools suggests that even small decreases of 1 km/h mean travel speeds in 50 km/h zones are likely to result in 8.23% reductions in fatalities. Application of these estimates to results of the current study provided indicative estimated reductions of 2.56 – 5.75% in serious injuries and 6.13% to 13.43% in fatalities due to reductions in mean speeds related to the installation of flashing school zone signs.

Therefore, installation of the flashing school zone signs at the surveyed sites appears to have been somewhat beneficial. Further research involving cost-benefit analysis comparing this treatment with other treatments would maximise spending efficiency dividends. Research using regionally located schools, including non-urban, high speed (e.g. 80 km/h+) limit inactive zones, and using a larger sample of untreated sites for comparison, would increase confidence in the current findings.

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Appendix A: Aggregate mean, standard deviation and 85th percentile speeds during active school zone times by observation period and percentage of vehicles observed speeding by 10, 20, and 30 km/h

School	Default speed limit (km/h)	No. of Vehicles		Mean Speed (km/h)		Standard Deviation (km/h)		85th PCTL (km/h)		% Above Limit		% >10km/h Above Limit		% >20km/h Above Limit		% >30km/h Above Limit	
		Period		Period		Period		Period		Period		Period		Period		Period	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Bethany Lutheran PS, Cascade St, Raceview	60	16,526	12,553	40.8	39.9	9.5	9.4	51.1	49.7	51.8	47.7	17.1	14.2	1.9	1.3	0.1	0.0
Birkdale South SS, Old Cleveland Rd East, East Birkdale	60	14,006	13,146	34.7	32.5	10.0	9.0	43.5	40.6	28.4	17.4	5.5	1.1	0.5	0.0	0.0	0.0
Camp Hill State Infant & PS, Wiles St, Camp Hill	60	19,421	17,916	37.4	35.8	9.6	9.5	46.1	44	38.1	31.5	8.0	4.6	0.9	0.5	0.0	0.0
Citipointe Christian College, Wecker Rd, Mansfield	60	20,679	14,863	33.2	33.6	9.9	9.7	42.4	42.4	22.3	23.8	4.1	3.3	0.4	0.4	0.0	0.0
Eagleby South SS, Fryar Rd, Eagleby	60	14,581	13,372	35.5	33.6	9.8	9.2	45.4	42.2	31.7	22.1	6.3	3.2	0.2	0.1	0.0	0.0
Elimbah SS, Beerburrum Rd, Elimbah	60	10,850	10,548	46.3	42.6	8.4	7.8	54.6	50.5	77.2	60.0	29.9	16.4	6.0	1.6	0.8	0.1
Faith Lutheran College, Link Rd, Victoria Point	50	10,383	7,073	33.7	31.9	9.9	9.9	42.9	41.2	24.3	19.2	3.4	2.1	0.3	0.1	0.0	0.0
Ferny Grove SS and SHS, McGinn Rd, Ferny Grove	60	21,865	20,323	39.2	37.1	7.2	6.5	45.7	42.7	44.4	29.6	6.1	2.2	0.4	0.1	0.0	0.0
Forest Lake SS, Woogaroo St, Forest Lake	60	24,781	22,965	39.7	37.4	11.2	10.7	51.5	47.8	51.4	42.0	18.6	11.2	2.0	1.1	0.1	0.1
Glasshouse Country Christian College, Roberts Rd, Beerwah	60	15,776	14,936	40.4	37.8	9.5	9.2	49.2	46	48.7	36.3	13.7	8.8	3.0	1.9	0.4	0.2
Good News Lutheran School & Jamboree Heights SS, Horizon Dr, Mt Ommaney	60	27,259	25,937	40.6	37.7	11.2	10.8	51.6	47.7	55.8	44.1	18.4	10.4	2.9	1.2	0.2	0.1
Grovely SS, Dawson Pde, Grovely	60	34,441	36,286	37.3	34.7	9.0	9.2	44.9	42.4	38.6	26.2	6.2	3.1	0.6	0.3	0.0	0.0
Hilder Rd SS, Kaloma Rd, The Gap	50	9,457	7,491	37.2	36.4	8.1	7.6	45.2	43.6	36.0	30.6	5.1	2.8	0.2	0.1	0.0	0.0
Hilliard SS, Alexandra Cct, Alexandra Hills	50	4,737	5,019	30.5	28.7	9.2	8.3	39.7	37.3	13.9	8.7	1.7	0.5	0.1	0.0	0.0	0.0

School	Default speed limit (km/h)	No. of Vehicles		Mean Speed (km/h)		Standard Deviation (km/h)		85th PCTL (km/h)		% Above Limit		% >10km/h Above Limit		% >20km/h Above Limit		% >30km/h Above Limit	
		Period		Period		Period		Period		Period		Period		Period		Period	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Holland Park SS, Abbotsleigh St, Holland Park	50	12,934	12,048	36.0	34.1	9.2	9.0	44.6	42.5	33.1	23.9	4.7	2.4	0.2	0.1	0.0	0.0
Holy Spirit School, Sparkes Rd, Bray Park	60	9,257	8,411	35.7	32.7	7.9	8.4	42.7	40.4	25.6	16.5	3.8	1.4	0.4	0.1	0.0	0.0
Indooroopilly SS, Russell Tce, Indooroopilly	60	18,778	16,544	29.3	27.9	10.8	10.0	40.6	37.9	16.3	10.4	2.7	1.7	0.2	0.1	0.0	0.0
Ironside SS, Swann Rd, St Lucia	50	15,996	11,023	35.8	34.1	8.1	7.9	43.5	41.0	28.6	19.2	2.7	1.2	0.0	0.0	0.0	0.0
Jindalee SS, Burrendah Rd, Jindalee	60	10,080	8,068	33.8	30.9	10.7	10.1	44.2	40.5	28.2	16.6	5.8	2.0	0.3	0.1	0.0	0.0
Logan Village SS, North St, Logan Village	50	5,110	4,564	25.1	23.9	8.9	8.3	34.0	32.4	5.2	3.4	0.7	0.2	0.0	0.0	0.0	0.0
Lourdes Hill College, Hawthorne Rd, Hawthorne	60	34,089	23,367	36.1	35.0	12.2	10.5	49.0	45.1	41.8	32.4	12.7	6.7	0.8	0.4	0.0	0.0
Manly SS, Ernest St, Manly	50	11,494	15,659	38.1	37.3	10.9	10.9	48.4	47.7	48.6	45.5	10.8	9.2	0.9	0.6	0.1	0.0
Mansfield SHS, Broadwater Rd, Mansfield	60	23,148	22,150	39.0	36.4	11.0	10.8	49.8	46.3	48.6	37.3	14.5	8.7	1.9	0.8	0.1	0.0
Meridan State College, Parklands Blvd, Meridan Plains	60	14,006	12,957	38.6	34.8	9.0	11.2	46.7	44.3	41.6	33.4	8.7	4.7	1.0	0.5	0.0	0.0
Minimbah SS, Walkers Rd, Morayfield	60	16,947	13,765	39.1	35.6	9.2	8.3	48.3	42.7	42.9	25.9	11.7	3.9	1.5	0.4	0.1	0.0
Morningside SS, Pashen St, Morningside	50	12,628	12,052	36.0	34.2	11.1	9.9	46.5	43	37.0	26.2	8.6	4.2	0.7	0.2	0.0	0.0
Nundah SS, Buckland Rd, Nundah	60	21,923	23,291	37.1	34.9	9.8	10.1	46.3	44.1	38.7	30.4	8.0	5.2	0.5	0.3	0.0	0.0
Our Lady of Assumption & Hillbrook Anglican College, Hurdcotte St, Enoggera	50	8,062	6,501	31.4	28.4	7.8	7.7	38.9	35.9	11.7	4.6	0.7	0.3	0.0	0.0	0.0	0.0
Oxley SS, Bannerman St, Oxley	50	6,320	5,948	29.8	29	9.2	9.0	39.4	38.1	13.1	10.7	1.3	0.9	0.1	0.0	0.0	0.0
Rainworth SS, Boundary Rd, Rainworth	50	24,374	17,171	36.4	36.0	8.5	8.2	44.2	43.2	31.4	28.7	4.4	3.5	0.2	0.2	0.0	0.0

School	Default speed limit (km/h)	No. of Vehicles		Mean Speed (km/h)		Standard Deviation (km/h)		85th PCTL (km/h)		% Above Limit		% >10km/h Above Limit		% >20km/h Above Limit		% >30km/h Above Limit	
		Period		Period		Period		Period		Period		Period		Period		Period	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Redland Bay SS, Gordon Rd, Redland Bay	60	6,997	6,938	36.1	34.6	8.2	8.3	43.8	42.5	29.3	25.2	4.8	2.2	0.3	0.1	0.0	0.0
Sherwood SS, Sherwood St, Sherwood	60	24,756	23,345	38.3	35.6	9.4	9.1	47.9	44.3	42.7	29.6	10.4	4.9	0.6	0.2	0.0	0.0
St Bernard SS, School Rd, Mount Tamborine	60	9,768	13,345	31.5	30.0	10.2	10.1	42.1	40.3	21.2	15.9	2.1	1.1	0.0	0.0	0.0	0.0
St Rita's PS, Benfer Rd, Victoria Point	60	10,603	8,950	37.3	35.2	10.0	9.4	46.5	43.7	38.4	30.0	9.4	4.0	1.4	0.4	0.1	0.0
Tullawong SS & St Pauls Lutheran PS, Smiths Rd, Caboolture	60	6,383	6,399	27.9	25.4	10.2	9.8	38.4	36.1	11.3	6.9	2.4	1.0	0.2	0.1	0.0	0.0
Wamuran SS, D'Aguilar Hwy, Wamuran	60	26,471	25,033	38.9	36.8	8.0	7.5	45.8	42.9	40.8	28.8	7.8	4.3	0.7	0.3	0.0	0.1
Warrigal Rd SS, Warrigal Rd, Eight Mile Plains	60	25,806	13,297	36.4	35.2	12.2	11.0	49.0	45.5	40.4	32.4	13.1	7.3	1.4	0.7	0.1	0.0
Wellers Hill SS, Toohey Rd, Wellers Hill	60	24,209	16,511	37.1	35.3	9.9	9.2	46.7	43.8	38.7	30.1	8.7	4.4	0.8	0.3	0.0	0.0
West End SS, Hardgrave Rd, West End	50	11,059	8,753	34.5	33.8	9.4	9.3	43.8	42.9	29.5	26.0	3.1	2.6	0.1	0.1	0.0	0.0
Wilston SS, Thomas St, Wilston	50	8936	6,972	33.4	32.3	9.5	9.0	42.9	41.3	23.7	18.6	3.6	2.3	0.3	0.1	0.0	0.0
Wondall Heights SS, Wondall Rd, Manly West	60	23,129	16,988	38.1	35.7	9.8	9.3	47.1	43.9	45.6	32.8	8.3	3.7	0.3	0.1	0.0	0.0
Yugumbir SS, Vansittart Rd, Regents Park	60	8,657	13,188	36.0	33.8	11.1	9.9	45.8	42.9	35.5	26.1	8.3	3.0	1.5	0.2	0.1	0.0

** PS = Primary School; SHS = State High School; SS = State School*