Rural regional roads – improving the system

Beer[a], K., Moon[b], W., Riess[b], A.

[a]Safe System Solutions Pty Ltd, [b]VicRoads Eastern Region

Abstract

In rural Victoria the casualty crash rate is over twice that of metropolitan Melbourne (VicRoads Road Crash Information System (RCIS) 2014). While many factors contribute to these crashes, vehicle speed dominates.

Victoria's traditional approach to treating high speed rural roads has been to invest in infrastructure treatments such as safety barriers, delineation and shoulder sealing, where worthwhile, and to leave the default 100 km/h speed limit. This approach has proven very successful for high volume roads where the investment can be justified because a reduction in speed limit would be socially undesirable with the significant impact on mobility. Unfortunately the same cannot be said for low volume roads with high crash rates. The cost of treating these roads with expensive infrastructure treatments is difficult to justify.

VicRoads Eastern Region identified 11 sections of low volume roads with higher than average crash rates. In these sections in a five year period there were 56 fatal and serious injury crashes (2008-2012). The major crash type was single vehicle run-off-road and motorcyclists were the most involved (80%). Inappropriate speeds and speeding were identified as major contributing factors in the majority of these crashes.

In 2012 VicRoads reduced the speed limit from the default 100 km/h to 80 km/h in these sections (covering 225 kilometres of arterial road network). This was to be complemented by delineation, strategic enforcement, advertising and behavioural change initiatives.

This paper details the process involved in identifying the sites, developing the treatments, gaining public acceptance for the speed limit changes, the proposed strategic enforcement, behavioural change initiatives and the early results of the project.

The project, which included some minor infrastructure improvements, was funded by the TAC under the Safer Roads Infrastructure Program with an estimated Benefit Cost Ratio of 17.4.

Introduction

Australia has adopted the Safe System approach to road safety (Australian Transport Council 2011). This approach represents a significant change in the way that road safety is managed and delivered. This approach accepts that humans will make errors and so crashes will continue to occur. In addition, humans are physically vulnerable and are only able to absorb limited kinetic energy, during the rapid deceleration associated with a crash, before injury or death occurs. What is required is infrastructure that takes account of these errors and tolerances so that road users are able to avoid serious injury or death in the event of a crash. The Safe System aims to manage vehicles, road and roadside infrastructure and speeds to eliminate death and serious injury as a consequence of a road crash. If a "Safe System" is to be achieved in the absence of appropriate infrastructure protection, effective speed management strategies are essential to ensure that threshold impact speed values are maintained with the road network system (Oxley, Langford & Fildes, 2007).

It is well established in literature that increasing travel speed increases the likelihood of crashes because of an increased likelihood of the driver or rider losing control of the vehicle, reduced ability to observe and process important hazard cues, increased distance the vehicle will travel once the brakes are applied and overall increased unpredictability. In addition to this, the severity of injuries as a result of a crash is also directly related to the pre-crash speed of the vehicle. Higher speeds invariably mean higher impact speeds and consequently, more severe injuries for those involved in the crash (see Oxley et al., 2007).

The central factor in the relationship between speed and both crash frequency and crash severity is stopping distance. There are two components to stopping distances: the distance travelled by the vehicle during the reaction time of the driver or rider, and the distance travelled once the brakes are applied. For example, (assuming normal reaction times and typical road and vehicle braking capabilities) a vehicle travelling at a speed of 30 km/h could come to a halt in approximately 15 metres, whereas a vehicle travelling at a speed of 40 km/h would come to a halt in approximately 22 metres. At 15 metres, this vehicle would still be travelling at approximately 37 km/h (Oxley et al., 2007). This highlights the non-linear relationship between speed and stopping distance that needs to be considered when determining appropriate speed limits for roads.

Within the Safe System approach, the level of safety required should determine speed. This conflicts with traditional mobility philosophies wherein safety is traded off against rapid transport functioning. The Safe System approach stems from an ethical stance with the notion that it is unethical to consider trading lives for the benefit of fast travel (Oxley et al., 2007). It is important to recognise that this approach also recognises that higher speeds can be justified if optimum levels of road and roadside infrastructure are provided and maintained.

In summary, the Safe System approach to operating a road network requires that all forms of speeding be comprehensively addressed. Illegal, excessive or inappropriate speeds need to be targeted through the setting of appropriate speed limits, enforcement of these limits, as well as education, publicity and promotion of the critical nature associated with speed, in terms of understanding crash and injury risk.

A change in the current "speed culture", societies' acceptance of high speeds, may be vital not only to recognising the significance of the problem, but to offer a change in future speeding behaviour observed on Victorian roads.

Aim of this paper

The aim of this paper is to illustrate how recent research can be applied to assist decision-making concerning changes in speed limits to obtain safety benefits. Such decision-making is not merely the province of the road-safety experts who determine the posted speed limits in particular localities, but also includes the decision-making of the drivers and riders of vehicles who need to make judgements as to their desire to adhere to the posted limits. The paper will show that, in some cases, infrastructure treatments on their own may be insufficient and may require further treatment, such as speed-limit reduction, education and enforcement to reduce the likelihood of a crash occurring and the kinetic energy absorption to within Safe System levels when a crash occurs.

Issue

The posted speed limit is considered to be one of the most powerful road feature that determines speed choice and therefore plays a pivotal role in determining overall crash and injury risk (Nilsson, 1993). The primary reason for setting speed limits is to provide safety and mobility, with the aim of identifying an appropriate balance between both travel time and crash risk for specific roadway sections. Posted speed limits are designed to inform drivers and riders of maximum driving speeds that authorities consider reasonable and safe (Corben & Oxley, 2002). There is controversy however surrounding political influences that are believed to impact on the selection of these posted speeds (Mannering, 2009). It is important to note that the posted speeds, as determined, do not take into account altered environmental and situational factors. Hence, they provide a maximum regulatory travel speed that may need to be reconsidered during altered circumstances; this is supported by the Victorian Road Safety Act which obliges drivers, legally, to drive up to the speed limit only if safe to do so.

Examination of the set speed limits rely on determining the 85th percentile speed of traffic, based on the perception that speed limits need to be 'credible' to the road-users for them to adhere to the posted limit. Another excuse for examining speed limits with this process is to ensure that enforcement remains manageable and affordable. Issues associated with examination of speed limits using this procedure include the inability adequately to account for some factors that influence road-user speed choice, the limitations of human factors and the fact that these speed limits are often far from Safe System speeds for the road infrastructure. There is a debate as to whether this process can be used to set what drivers believe to be acceptable travel speeds (via the 85th percentile process) with a general belief that such a travel speed is arguably unsafe.

There is research that suggests that drivers and riders have limited ability to relate individual risk to collective risk (Beer, 2011). As a consequence, allowing drivers to determine speed limits (by an 85th percentile method) means that speed limits will often be in excess of what is inherently safe for the road conditions. It is, however, clear that public understanding and belief is that set posted speed limits will contribute to increased road safety is crucial to speed compliance. Therefore, setting speed limits needs to be accompanied with public education and promotion to ensure that the public understands why speed limits are set at their respective level, and the factors considered in the process. In education and promotion campaigns, it should be communicated to the public that:

• Posted speed limits are set at a maximum, and that different situational or environmental circumstances may require the individual road-user to alter their speed;

and

• The public should also be educated about the impact of speed and how small reductions are proven to lower rates of serious trauma each year.

A motivation for the work in this paper is that within Gippsland there is evidence to show that the currently available infrastructure improvements on relatively tight geometry roads may not effectively address crashes. Thus this paper examines the following issues/ideas:|

- Because infrastructure improvements are expensive, roads with low numbers of vehicles, but a high crash rate should have a speed limit reduction.
- Economic analysis (Cameron, 2003) shows that the optimum speeds for low volume rural two-way undivided roads is between 80 and 90 km/h for light vehicles.
- Individual drivers are unable to determine this as shown by Beer (2011).
- VicRoads Eastern Region analysed their road crash statistics to identify 11 roads that required risk treatment. Then the speeds of vehicles on these roads were examined.
- In addition, time comparisons of a speed limit of 100 km/h and 80 km/h were undertaken resulting in little difference because of the relatively tight geometry of the roads which combine speed with curves.
- Motorcyclists are over-represented in the casualty crash statistics.
- Most fatal crashes on these roads involve inappropriate speeds.

Methodology

Initially, a review of literature was undertaken to understand more about the relationship between speed limits, road safety, travel time, driver and rider behaviour and the tortuosity of the road.

VicRoads Eastern Region regularly monitors, analysed and addresses crashes on the 3400 kilometres of arterial roads in this part of the state. Throughout this analysis 11 roads with 100 km/h default speed limits were identified that had high crash rates, low volumes and semi mountainous environments with winding roads. Infrastructure countermeasures had previously been installed on these roads with varied success.

The requisite data collection involved determination of the crash statistics along the 11 roads in Gippsland. On these roads there was an examination of the speeds of vehicles in straight sections of the road, on the approaches to curves, and whilst driving or riding through the curves. This data collection was undertaken for trucks, cars and motorcycles.

Between January and May 2013, eleven 80 km/h speed zones were implemented on targeted sections of these roads. There was a total of 225 kilometres of arterial road network that was speed zoned to 80 km/h.

Speed limits are strong regulatory treatments that support the Safe System approach to influence speed, however there is still a requirement for a level of enforcement. This is predicted to contribute significantly to driver and rider compliance and hence lower speeds. Due to the rural location and tight geometry generally evident in these crash cluster areas with new 80 km/h limits, motorists would not expect enforcement, and resultantly the probability of being issued with traffic infringements for speeding would be considered low by motorists. Thus the project has included enforcement in its planning and evaluation. Victoria Police has been briefed on the project and is considering enforcement which, if undertaken, can be evaluated with ongoing speed data and the use of ‘controls’ within the data set to establish the additional effect of further compliance in speed reduction and subsequent crash reduction.

The evaluation is well positioned to provide meaningful data with speed and crash data collected before the speed reductions were introduced. The project evaluation will continue to gather speed and crash data throughout the duration of the project.

Education, as a key component of the Safe System, has been undertaken through: (1) engagement with the Eastern Region Motorcycle Working Party, who were kept informed and assisted with education projects; (2) site specific print material, such as the Lang Lang-Poowong Road brochure and the Map and Guide to Motorcycling in Gippsland; (3) installation of unique 'High Risk Motorcycle Area' signage; (4) motorcycle and speed themed roadside banners and billboards; (5) deployment of variable message signs; (6) Gippsland specific television and radio commercials; (7) newspaper articles stating – “It's a limit, not a target”; and (8) Gippsland Motorcycle Safety Trailer attendance at events such as the motorcycle Grand Prix, Superbikes, Toy Runs.

Findings

A direct causal link between speed and crash risk was firmly established by Nilsson (2004) and has been reviewed a number of times since. Elvik et al. (2004) reaffirmed the causal relationship between speed and road safety based on a number of arguments, including:

- The consistency of the statistical relationship between speed and road safety. When speed is reduced, the number of crashes and injuries falls in 95% of the cases. When speed is increased, the number of crashes and injuries increases in 71% of the cases.
- Most of the evidence came from before-and-after studies, where there was no doubt that the reduction in crashes occurred due to reduction in speeds.

In a seminal Australian study on rural speed, Kloeden et al. (2001) identified that the risk of involvement in a casualty crash more than doubles when travelling 10 km/h above the average speed of non-crash involved vehicles and that it is nearly six times as great when travelling 20 km/h above that average speed.

There is further empirical evidence for the causal link between increases in speed and a subsequent increase in risk from a study by Sliogeris (1992). In the late 1980s, the speed limit for outer-metropolitan freeways in Victoria, Australia was increased from 100 km/h to 110 km/h, but was then reduced again to 100 km/h due to safety concerns. This offered an opportunity to study the safety effect of increases in speed limits for these types of roads. A ‘before’, ‘during’ and ‘after’ study was conducted on these roads spanning a 2½ year period.

When the speed limit was increased to 110 km/h the casualty accident rate increased by around 25% and when the speed limit was decreased back to 100 km/h the casualty accident rate decreased by almost 20%.

Bhatnagar et al. (2010) examined changes to speed limits and crash outcomes on the Great Western Highway of NSW and noted that travel speeds are indeed reduced following a speed limit reduction with a 26.7% reduction in casualty crashes. They noted that this is consistent with the power model of Nilsson (1984) and Elvik et al. (2004) though the actual safety outcome of 26.7% was greater than the 16% predicted by the power model because the actual mean speed reduction was greater than that predicted by the power model.

Roads with low numbers of vehicles but with a high crash rate, especially windy roads in alpine areas, should have a speed limit reduction. This is illustrated in Figure 1, which plots casualty crashes per 100 million vehicle kilometres travelled (VKT) versus annual average daily travel (AADT) for some of Gippsland's roads.

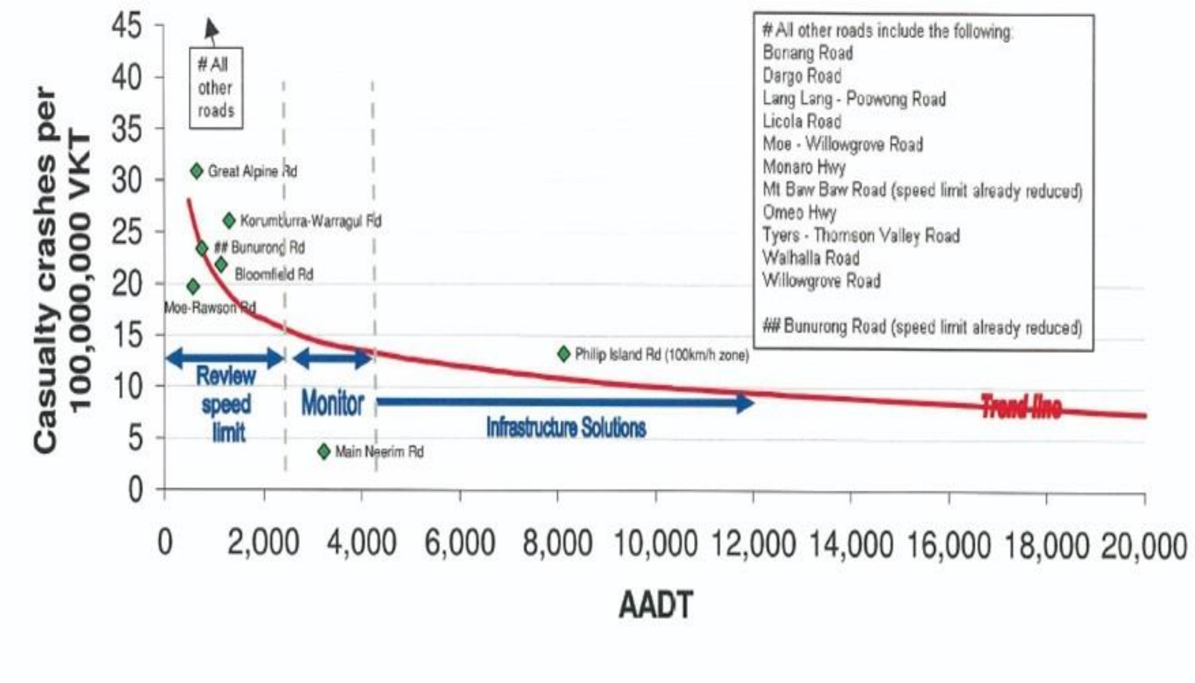


Figure 1 – The relationship between crash rate and annual average daily traffic (AADT) can be used to determine roads with low numbers of vehicle and high crash rates so as to determine their suitability for reduced speed limits.

As indicated in the side bar of Figure 1, there are 11 other low volume arterial roads with crash rates exceeding 30 casualty crashes per hundred million VKT that have been examined in detail, with the crash data being depicted in Table 1. It may be noted that motorcycles comprise the vast majority of the vehicles involved in the crashes. Speed survey data for motorcycles and cars shown in Table 2, highlighted that inappropriate speeds were predominantly those of motorcycles. In particular the top 10% of motorcycle speeds on curves exceed 92 km/h, a value that is nearly double the curve warning advisory signs that average 53 km/h.

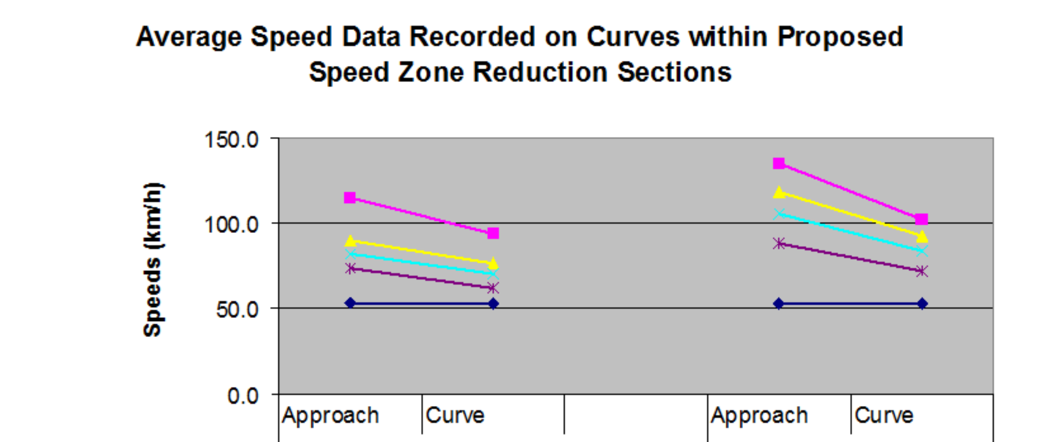
Table 1 – Eastern Region crash data for all vehicles, and for motorcycles for a five year period starting July 2007

EASTERN REGION - MOTORCYCLE STRATEGY 80 SPEEDS
CRASHES WITHIN PROPOSED 80 ZONES.
ALL CRASHES (1/7/07 - 30/6/12)
RCIS REPORTS GENERATED 16/8/12

Route	AADT	Start Ch	End Ch	Length	FATAL	SERIOUS	OTHER	TOTAL	Crashes per 100M VKT #	FATAL	SERIOUS	OTHER	TOTAL	Crashes per 100M VKT #	M/C % OF ALL CRASHES
8 ROUTES WITH PROPOSED SPEED REDUCTIONS (11 SECTIONS)															
Licola Rd - Sth Section	56	16.13	27.62	11.49	0	4	1	5	426	0	4	1	5	426	100%
Walhalla Rd	129	0	9.21	9.21	0	4	4	8	369	0	4	4	8	369	100%
Lang Lang-Poowong Rd	464	4.58	9.14	4.56	0	3	5	8	207	0	1	2	3	78	38%
Bonang Rd	77	5.67	113.85	108.18	1	13	4	18	118	1	13	3	17	112	94%
Licola Rd - Nth Section	56	34.24	43.11	8.87	0	1	0	1	110	0	0	0	0	0	0%
Omeo Hwy	174	4.11	12.95	8.84	0	2	1	3	107	0	2	1	3	107	100%
Willowgrove Rd	317	32.39	42.68	10.29	1	1	3	5	84	1	1	3	5	84	100%
Great Alpine Rd - Part 2 Sth of Ensay	577	230.72	270.49	39.77	3	14	8	25	60	3	9	5	17	41	68%
Korumburra-Warragul Rd Nth Section	581	14.49	28.05	13.56	1	1	6	8	56	1	2	2	5	35	63%
Great Alpine Rd - Part 1 Nth of Omeo	830	173.31	184.09	10.78	1	5	3	9	55	1	5	3	9	55	100%
Korumburra-Warragul Rd Sth Section	1321	0.69	3.1	2.41	0	1	2	3	52	0	1	1	2	34	67%
Total					7	49	37	93		7	42	25	74		80%
8 ROUTES WITH NO SPEED REDUCTION TREATMENT PROPOSED															
Dargo Rd	71	54.73	63.24	8.51	0	0	0	0	0	0	0	0	0	0	0%
Tyers-Thomson Valley Rd	1344	0	40.02	40.02	0	8	9	17	17	0	4	3	7	7	41%
Monaro Highway	363	0	43.92	43.92	1	10	7	18	62	0	4	1	5	17	28%
Moe-Willowgrove Rd	950	0	12.66	12.66	0	6	3	9	41	0	4	1	5	23	56%
Moe-Rawson Rd	1129	0	34.8	34.8	1	6	20	27	38	0	4	2	6	8	22%
Bloomfield Rd	1194	0	15.82	15.82	1	5	7	13	38	1	0	2	3	9	23%
Phillip Island Rd (100km/h section Ch.0 to 5.9km)	7668	0	13.2	13.2	2	3	6	11	6	1	1	3	5	3	45%
Main Neerim Rd	3733	0	33.56	33.56	0	10	21	31	14	0	3	3	6	3	19%
					5	48	73	126		2	20	15	37		29%

VKT = Vehicle Kilometres Travelled
Crashes per 100M VKT = Total crashes (5 year period) x 100,000,000 / [Annual Average Daily Traffic (AADT) x Length (km) x 365 days x 5 years]

Table 2 – Speed distribution data on 11 Eastern Region roads (with a default 100 km/h speed limit) indicating speeds on approaches to curves and within curves for cars and motorcycles



	Approach (Car)	Curve (Car)		Approach (Motorcycle)	Curve (Motorcycle)
Max	114.7	93.4		134.8	102.3
Top 10% Average	89.9	76.2		118.1	92.3
85th Percentile	81.9	70.2		105.3	83.5
Average	73.5	62.1		88.3	71.9
Advisory	53.2	53.2		53.2	53.2

Note: Data is for 9 out of the 11 roads

Post 80 km/h evaluations are planned for all routes, however at the time of this paper, the speed data collection had not yet been completed. A preliminary review of the crash data for the 18 months post the introduction of the 80 km/h speed limits, in comparison to the previous five year crash history, is indicating very encouraging trends.

Discussion

Following the Safe System approach, setting of appropriate speed limits combined with future strategic enforcement has a high potential to reduce risks for both normal errors and extreme behaviour errors. This is based on the assumption that the drivers contributing to the upper decile of vehicle speeds will modify their behaviour and decrease their speed in response to lowered speed limits, especially if those lowered speed limits are accompanied by an enforcement campaign focused on the remote areas (where drivers and riders believe that they will not be caught speeding) and in those winding sections where crashes are occurring.

The benefit-cost ratio of such a program is extremely favourable. Table 1 indicates that there are 93 casualty crashes in the roads for which the Eastern Region speed limit reduction program is underway. Using actuarial estimates of the lost value of such crashes as $2.3M for each of the 7 fatal crashes, $542k for each of the 49 serious crashes and $22k for the 37 other crashes – the total lost value of all these crashes is $43.5M over 5 years. It is anticipated that the speed limit reduction program will lead to a 20% crash reduction over 15 years. Assuming that the crash reduction is linear in time, the benefit (or saving) is $17.4M, with an estimated cost of approximately $1M. This leads to a favourable benefit-cost ratio of 17.4.

Also, the travel time changes have been relatively small. Providing this information to the driving and riding public can alleviate some of the concerns.

According to the theory of planned behaviour, people's attitude towards the behaviour, their subjective norms and their perceived behavioural control determines their behaviour (a defined action) indirectly via their intention (willingness to try to perform the behaviour) (Ajzen, 2005). More specifically (Warner, 2006), each component can be broken down to:

1. Behavioural beliefs where the subject undertakes an implicit risk assessment.
2. Normative beliefs where the subject undertakes an implicit assessment of what they believe is 'normal'.
3. Control beliefs where the subject undertakes an implicit assessment of controls that may be on their behaviour

The theory of planned behaviour provides a good structural and reliable conceptual framework for understanding the motivations for speeding behaviour, as well as how various factors can influence choice of travel speed for drivers and for motorcycle riders. It also shows that individuals will vary their assessment of appropriate speeds based on a variety of factors.

The installation of a lower speed zone on its own will not address all of these factors. This shows that it needs to be complemented with information on the risks associated with exceeding the speed limit, information about enforcement (backed up with actual enforcement) and trying to instil a culture of speed compliance to influence the normative beliefs.

In a pure Safe System, where infrastructure improvements are not viable for low volume, lower standard roads, the speed limit would be very low to fully mitigate risks of serious and fatal injury. However, in terms of a compliant driver who should be selecting an appropriate speed for the conditions and in a transition to a Safe System, the balance between mobility and safety is still a reality in today's society. Hence, even these reductions to 80 km/h are just a step towards a true Safe System and the ultimate vision of achieving zero serious and fatal injury crashes. In stating this, the culture change for drivers and riders to be compliant in terms of selecting an appropriate speed relative to the conditions and up to a maximum of the speed limit is one of the most critical factors in these environments that is yet to be achieved. This project had components of education, behaviour and will potentially have enforcement to reinforce this message. There were a variety of other ideas for reinforcing this message, including a modified speed limit sign (see Figure 2). On this occasion the sign was not used, however it is felt that there is potential for the use of this, or similar signs.

Figure 2 – An illustration of a possible speed zone sign reinforcing Safe System principles

Conclusion

Speed limits should reflect the nature of the crash risk. In particular, for a low standard road with a low volume of traffic and a high crash rate then infrastructure improvement is not warranted (because of the high cost and low traffic volume) but speed limit reduction, combined with consistent and basic delineation, behavioural change programs and enforcement programs, provides a cost-effective risk treatment.

Stage 2 of the project comprises further evaluation of speed and crash data, as well as any enforcement activities. This stage is scheduled for 2015 and is expected to further inform road safety practitioners of a potentially achievable step towards the Safe System on rural roads.

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