TS 00142:1.0

Standard

Rural Intersection Speed Zones

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Preface

This document is a first issue.

This standard was developed to enable implementation of Rural Intersection Speed Zones on the NSW road network as a mass action road safety treatment. Rural Intersection Speed Zones is an innovative treatment used to improve safety at priority-controlled or uncontrolled intersections on high-speed rural roads.

The intention of the document is to provide road safety managers and practitioners with authoritative guidance and requirements on planning and designing RISZ, so the treatment can be planned at the most optimal locations to maximise safety benefits, designed to ensure reliable operations and delivered to a consistent standard across the statewide road network.

Intersections on rural roads continue to be a significant road safety challenge with crashes often resulting in high severity outcomes. While Safe System aligned treatments such as roundabouts are highly effective at reducing fatal and serious injury crashes at intersections, they can usually be economically unviable at most locations. RISZ is a technology based, relatively cost-efficient treatment that has proven to significantly improve safety performance at rural intersections. As a non-transformational treatment, RISZ also has the benefit of being able to be designed and implemented in a short timeframe.

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1 Scope

This standard specifies the key planning and design principles for RISZ, which is an emerging and innovative form of ITS used to reduce high severity crashes at rural intersections.

This document is not an exhaustive design and implementation guide for RISZ. Detailed requirements such as technical specifications of ITS components, installation guidance (including power supply, cabling and configuration of individual components to formulate the system), and ongoing operations and maintenance needs are not covered within this document.

It is expected that suitably qualified professionals in their respective fields, combined with specific technical guidance provided through other relevant TfNSW and Australian standards and guidelines, will determine these specific requirements at a project level to satisfy the planning and design principles of RISZ outlined in this document. This document also does not cover requirements, recommendations, or other information on funding sources to implement or maintain RISZ.

2 Application

This document is intended for use by road safety managers and practitioners who are seeking ways of improving road safety at intersections on the rural road network in NSW. As a road safety intervention, RISZ can be applied on roads of all hierarchies. Therefore, this document is applicable to practitioners at TfNSW as well as local government road management agencies.

3 Referenced documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS 1742.2 *Manual of uniform traffic control devices – Part 2: Traffic control devices for general use*

AS 1742.15 *Manual of uniform traffic control devices – Part 15: Direction signs, information signs and route numbering*

AS 5156 *Electronic Speed Limit Signs*

Transport for NSW standards

TS 03631 *NSW Speed Zoning Standard*

Other referenced documents

Austroads Guide to Road Design – Part 3 Geometric Design

Bradshaw C.L., Bui B., and Jurewicz C., 2013, *Vehicle Activated Signs: An emerging treatment at high risk rural intersections*, ARRB Group. VicRoads

Mackie H., Holst K., Brodie C. and Tate F., 2014, *New Zealand's Rural Intersection Active Warning System*, Mackie Research and Consulting Ltd. NZ Transport Agency

Meuleners L., Chow K., and Fraser M., 2018, *Rural Intersection Active Warning System (RIAWS): A Driving Simulator Study,* Curtin-Monash Accident Research Centre, Faculty of Health Sciences, Curtin University

Mongiardini M., Stokes C., and Wolley J., 2022, *Preliminary evaluation of Rural Junction Activated Warning System (RJAWS) in rural South Australia*, CASR 168, Centre for Automotive Safety Research, The University of Adelaide

Queensland Government Department of Transport and Main Roads, April 2021, *Vehicle Activated Signs (VAS),* Technical Note TN160

Stephens A., Mitsopoulos-Rubens E., Candappa N., Lenné M., and Beanlanda V., 2021, *A Simulator Evaluation of Driver Responses to Dynamic Warning Signs at Rural Intersections*, The Australian National University

TfNSW Traffic Signs Register

Thorne R., and Mackie H., 2020, *Intersection Speed Zones – Long-term Operational and Safety Performance.* Prepared by Mackie Research for Waka Kotahi NZ Transport Agency, Auckland

4 Terms, definitions and abbreviations

AADT average annual daily traffic; the total volume of traffic passing a roadside observation point over the period of a calendar year, divided by the number of days in that year (365 or 366 days)

carriageway the portion of a road devoted particularly to the use of vehicles, inclusive of shoulders and auxiliary lanes

FSI fatal and serious injury

ITS intelligent transport system

operating speed for the purpose of this document, refers to the 85th percentile speed of cars under free-flowing conditions. For further details on operating speed, refer to Austroads *Guide to Road Design – Part 3 Geometric Design*

practitioner for the purpose of this document, the TfNSW or NSW local government employees, or employees of other organisation representing or undertaking work for TfNSW or NSW local government agencies who has a primary role of maintaining and improving road safety performance on NSW road network

RISZ rural intersection speed zones

RUM road user movement; code identifies the principal movement(s) of the vehicle or vehicles involved in the first impact of the crash

VAS vehicle activated sign

VRU vulnerable road users; road users that are not within a vehicle, generally considered to include pedestrians, cyclists, motorcyclists, riders of other micro mobility devices such as scooters and skateboards and the users of mobility devices

VSLS variable speed limit signs

TfNSW Transport for NSW

5 Introduction

5.1 Rural intersection speed zones

RISZ is an innovative treatment used to improve safety at priority-controlled or uncontrolled intersections on high-speed rural roads. RISZ employs VSLS to temporarily reduce the legal speed limit for vehicles travelling along the priority road in case of a potential for conflict. RISZ comprises a series of radar or ground sensors that detect a vehicle approaching the intersection from a minor road or slowing down on a major road to turn right onto the minor road, at which point the VSLS are activated deploying a lower speed limit on the major road. A set of secondary sensors (typically located at the minor road and the right turning lane limit line) detect waiting traffic and trigger the end of sign activation once the turning manoeuvre is complete.

Although a relatively novel treatment, RISZ has been in use in other Australian jurisdictions and internationally. They are identified as Side Road Activated Speeds (SRAS) in Victoria, Rural Junction Active Warning System (RJAWS) in South Australia and Intersection Speed Zones (ISZ) in New Zealand. Monitoring and evaluation of sites already treated with RISZ in South Australia and New Zealand have provided robust evidence of their potential to reduce high severity crash risk at rural intersections. (Refer Mongiardini et al., 2022, *Preliminary evaluation of Rural Junction Activated Warning System (RJAWS) in rural South Australia* and Thorne et al., 2020, *Intersection Speed Zones – Long-term Operational and Safety Performance* for further details). Figure 1 shows a RISZ site in operation in New Zealand.

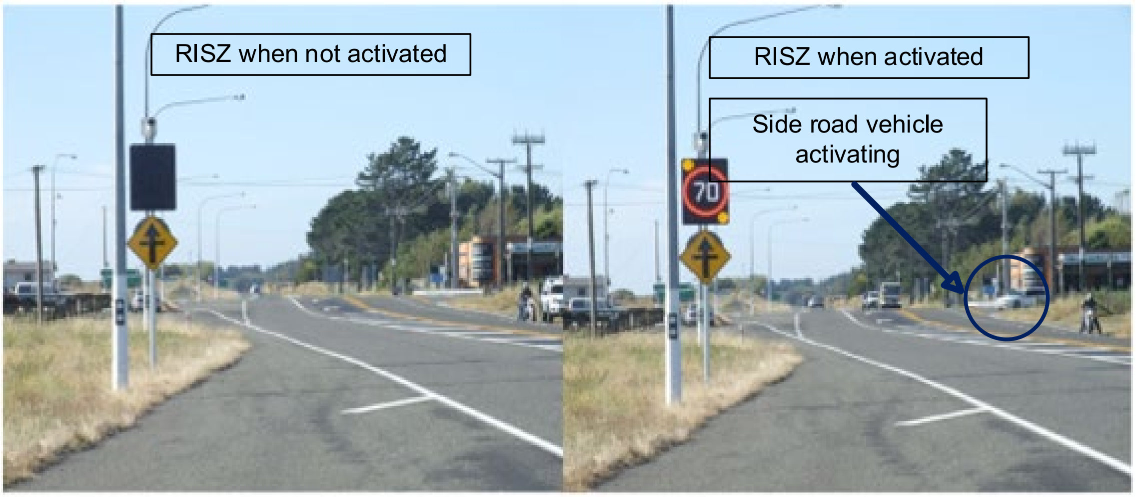

Figure 1 – RISZ site in operation (Source: Mackie et al., 2014, *New Zealand's Rural Intersection Active Warning System*)

5.2 Safe Systems context

The NSW government has made a commitment to achieve zero fatalities and serious injuries (Vision Zero) on our road network by 2056, with an interim target to halve deaths and reduce serious injuries by 30% by 2030. The Safe System approach underpins Vision Zero and is formally adopted in NSW as the primary enabler for achieving Vision Zero.

The Safe System approach is regarded as an international best practice in road safety and aims to provide an outcome whereby death and serious injury are virtually eliminated amongst users of the road system. Safe System approach acknowledges the physiological and psychological limitations of humans and puts ultimate responsibility on the designers and operators of the system to accommodate these human limitations. The approach is derived from an understanding that people make mistakes, and from an ethical standpoint no-one should be killed or seriously injured on roads due to a mistake. The focus is to adapt the road system to humans, rather than human behaviour to the roads.

Central to the Safe System approach is managing and designing the road system such that impact energy on the human body is firstly avoided and secondly managed at tolerable levels by manipulating speed, mass or crash angles to reduce crash injury severity. RISZ contributes to a Safe System aligned road network by managing vehicles' speeds at rural intersections.

5.3 Safe System alignment and benefits of RISZ

RISZ provides a multifaceted approach to minimising crash risk at intersections as follows:

- Reduces the likelihood of a crash occurring – slowing down motorists on a major road means they need a shorter distance to come to a complete stop and avoid a collision if a vehicle turning to or from the minor road reaches a conflicting position.

- Reduces the severity outcome if a crash was to occur – lower speeds correspond to less energy transfer, which is the primary determinant of the severity outcome in the event of a crash.
- Activated signs increase driver awareness and alert drivers who are already prone to fatigue, therefore preparing for a possible event (effectively reducing the driver reaction time).
- With low vehicle speeds on a major road, gap judgement of the motorists turning to and from the minor road will likely improve.

RISZ is a safety intervention that is fully aligned with the Safe System principles. However, RISZ is a Supporting – Towards Safe System treatment rather than a Primary Safe System treatment. This means whilst RISZ is proven to provide significant road safety benefits, it does not eliminate the possibility of death or serious injury. The system relies on the road user to manage the vehicle speeds rather the infrastructure itself offering a mechanism of managing the energy transfer to survival limits in the event of a crash. As such, RISZ should not be considered a permanent alternative to Primary Safe System treatments such as roundabouts, raised intersection platforms and grade separated interchanges. Despite not being a Primary Safe System treatment, RISZ still presents a highly effective means of reducing crash risk at rural intersections given its:

- relatively low design and implementation cost, making it an effective treatment at locations where generally cost and space intensive primary treatments are deemed economically unviable
- minimal impact on other competing transport demands such as accessibility, travel time efficiency, heavy vehicle operations and so on
- shorter implementation timeframes, making RISZ an interim solution for high-risk intersections until a Primary Safe System treatment is planned, designed and constructed which can often be time consuming
- possibility of reducing risk arising through design deficiencies (for example, substandard sight distance availability).

  Note: RISZ is not a replacement for good intersection design. Directly addressing any design deficiencies should always take precedence over implementing RISZ. Only when doing so is cost prohibitive due to the levels of physical works involved should RISZ be considered a permanent solution in its own right.

6 Planning of rural intersection speed zones

6.1 Site selection

Appropriate site selection is critical for all road safety interventions to ensure that their benefits are maximised and any unintended adverse impacts on safety itself or other operations of the transport system are avoided. This section of the document aims to provide guidance and requirements on selecting sites that are most suitable to be treated with RISZ.

6.1.1 Optimal intersection characteristics for rural intersection speed zones

6.1.1.1 Speed limits

RISZ are recommended only for intersections where the major road speed limit is 80 km/h or above. For speed limits any lower, the benefits of the treatment will likely be insignificant. The speed limit on the minor road approach or approaches is generally irrelevant for the purpose of selecting suitable sites for RISZ.

6.1.1.2 Traffic volumes

Driver responsiveness to vehicle activated signs tend to deteriorate when they are continuously activated for extended periods of time as the dynamic nature of the sign is essentially lost in this case. As such, RISZ are likely to be less effective at intersections where minor road approaches frequently have long delays or queues of multiple vehicles. RISZ are best suited for locations where the side road traffic volumes are low relative to the major road volumes. At high-risk intersections with relatively high minor road traffic volumes, the form of intersection control itself may need to be revisited with consideration to more transformational treatments such as roundabouts, signalisation or banning selected movement types.

RISZ are also not suitable for locations where the major road traffic volumes are very high. This will likely result in extended sign activations even at relatively low side road traffic volumes. A VAS trial undertaken in Queensland (refer to *Department of Transport and Main Roads Technical Note TN160 Vehicle Activated Signs* for further details) found that on high volume roads, when traffic travels past the sign in a platoon formation, the speed of the driver is set by the vehicle in front and drivers are more inclined to continue travelling at speeds consistent with the platoon, therefore making the VAS less effective. Accordingly, RISZ should not be used on roads where the major road AADT exceeds 12,000 vehicles per day.

6.1.1.3 Road geometry

RISZ will deliver maximum benefits when used on straight rural roads. A part of the treatment's benefits is attributed to electronic sign activation increasing driver awareness. Driver awareness tends to be lower when the demand placed on the driver by the task of driving itself is low, such as when driving on straight low volume roads. In contrast, drivers are likely to be intrinsically more attentive and conscious of their surroundings when driving through more challenging road alignments. Additionally, the vehicle operating speeds are also likely to be lower on roads with continuous winding alignments regardless of the posted speed limit, which can further diminish the value of RISZ.

If RISZ are used on roads with winding road alignments with curves leading up to the intersection, the VSLS shall be located so that motorists have sufficient advance visibility of them.

6.1.1.4 Proximity to other intersections

RISZ should be avoided at intersections that are located close to other priority-controlled or uncontrolled intersections. The drivers on the major road that are accelerating back up to the regular operating speed (after passing a RISZ) can adversely impact gap judgement of vehicle waiting to turn at the adjacent intersection. To minimise this, RISZ should be considered only at intersections that are at least 500 m away from the adjacent intersections on 110 km/h or 100 km/h roads, and 400 m on 80 km/h roads. However, if a more closely located adjacent intersection only has very low and infrequent traffic movements, the potential increase in any risk is likely to be minor, and that in itself should not be a reason to discount RISZ as a treatment option. When determining treatment viability in such situations, good professional judgement should be applied to evaluate potential minor increases in risk relative to the wider safety befits RISZ can deliver.

6.1.2 Risk-based site prioritisation

RISZ would improve safety performance at most rural intersections. However, targeted safety improvements such as RISZ should be prioritised at high-risk locations where they are most likely to prevent fatalities and serious injuries. This will enable a more optimal path for achieving our road safety targets by maximising the benefits that safety treatments can deliver.

As such, practitioners are encouraged to undertake a systematic networkwide assessment in selecting treatment sites rather than purely reacting to perceptions or isolated events such as recent crashes. Statewide intersection risk assessment data such as intersection collective risk and personal risk (see Appendix A for intersection risk metrices) are calculated based on the most recent five-year crash period and are readily held within the Safer Roads Risk Assessment (SRRA) spatial application managed by the Safer Roads team at TfNSW. Practitioners undertaking networkwide risk assessments to identify suitable sites for RISZ are encouraged to contact the Safer Roads team at safer.roads@transport.nsw.gov.au to discuss how these already available intersection risk profiles can assist in identifying suitable sites for RISZ.

RISZ is primarily aimed at reducing the risk of side impact, also known as T-bone crashes and side road merge (collision between a turning vehicle from the minor road and a vehicle traveling in the same direction on the major road) crashes. Accordingly, RISZ should be prioritised at locations where the crash history is dominated by either or both of the following:

- side impact crashes (RUM codes – 10, 13, 21)
- side road merge crashes (RUM Codes – 11, 16).

Side impact crashes are more susceptible to high severity outcomes given the high impact angle. Comparatively, side road merge crashes have a low impact angle resulting in a relatively low possibility of fatalities or serious injury. Accordingly, when prioritising treatment sites, side impact crashes should be given more weighting than side road merge crashes.

Risk of other crash types such as rear end, loss of control, side swipe and vulnerable road user related crashes are not directly influenced by RISZ. If such crash types are overrepresented at an intersection identified as high risk, it is likely that there are other interventions that can more directly address the predominant crash risk at the location. For example, if ‘overshooting’ an intersection (vehicle approaching from the minor road failing to stop, likely due to not having noticed the presence of an intersection and continuing through the intersection) is overrepresented at a T-intersection, improving the conspicuity of the intersection and the intersection control are likely to address the crash problem more directly than RISZ.

Overall, when analysing the existing risk at intersections to determine suitable sites for RISZ, only side impact and side road merge crashes should be considered with a higher weighting placed on side impact crashes. This approach will ensure that site selection is not influenced by crash types which cannot be effectively addressed through the treatment.

Whilst systematic assessment of past crashes provides a robust framework to prioritise sites for RISZ, proactive risk identification is also integral in reducing serious road trauma under a Safe Systems approach. If an elevated risk of side impact or side road merge crashes has been identified through a methodical risk assessment process such as road safety audits, Safe System assessments, crash prediction modelling or emerging technologies for near miss identification, RISZ can be considered as a means of mitigating risk at such locations.

6.1.3 Existing intersection design

For intersections identified as high risk and suitable to be treated with RISZ, a thorough assessment of the existing intersection design should be undertaken before deciding to install RISZ. Resolving any major existing design flaws or safety considerations, such as suboptimal sight distance or visual deceit at crossroad intersections should take precedence over installing a RISZ. Visual deceit is a see-through effect when viewed from the minor road approaches of a crossroad intersection which often results in drivers not recognising the presence of an intersection that they should give way or stop sufficiently in advance. Along with poor signage and road marking conspicuity, continuation of roadside features such as lighting poles or high grown vegetation across an intersection can contribute to visual deceit.

Major design issues of this nature are likely to be the key cause of an existing crash problem, and without them being rectified, the benefits of any non-transformational safety treatments are likely to be minimal. The exception to this would be where the level of physical works required to address the existing design or safety considerations are significantly cost prohibitive, in which case RISZ can be used as a step reduction in the safety risk.

6.2 Rural intersection speed zones - variable speed limit

Under a Safe System approach, principles which guide infrastructure are derived from human tolerance to injury in the event of a crash. In the case of side impact collisions at or near 90 degrees, the survivable impact speed is generally considered to be no more than 50 km/h. Based on this principle and considering the need to achieve a good level of compliance, the variable speed limit activated by RISZ should be 60 km/h to 80 km/h. With braking, impact speed in the event of a collision should then be at or close to the 50 km/h Safe System critical impact threshold for side impact crashes. Table 1 outlines the variable speed limits that shall be used for all RISZ installations in NSW. The variable speed limit activated through RISZ shall be a regulatory speed that is enforceable, and not an advisory speed.

Table 1 – RISZ variable speed limit

Major road operating speed (km/h)	RISZ variable speed limit (km/h)
110	80
100	70
80	60
Lower than 80 km/h	Benefits of RISZ is likely to be minimal. Consider alternative treatment options.

Prior to determining the suitable variable speed limit for RISZ, the vehicle operating speed on the major road through the intersection should be measured for a period of no less than two weeks. The period chosen should be representative of the normal operating conditions.

> Note: Vehicles decelerating to turn at the intersection or accelerating having just turned from the minor road can skew the operating speed measurements on the major road. Therefore, the set up used for measuring operating speeds should be made capable of identifying vehicles that are turning at the intersection. Alternatively, the location chosen for measuring operating speeds can be sufficiently offset from the intersection, so the turning vehicles as well are at the regular operating speed.

6.3 Implementation on trial basis

The relatively low implementation cost and short timeframes of RISZ, when combined with the possibility to repurpose majority of the system components, lends itself to being an excellent choice for implementing on trial basis. A trial implementation may be preferred in the first instance over a more permanent set up for a variety of reasons, including lack of initial stakeholder support, the site not meeting all selection criteria recommended in Section 6.1 and so on. RISZ is also generally a low-risk treatment as it only involves deploying a lower speed limit for a short section of a road without any form of physical interference to moving traffic or directly influencing gap judgement of turning vehicles. This means it is highly unlikely that RISZ will worsen the safety performance at any location beyond the already existing level of risk (provided that the system components such as the VSLS are appropriately placed so they do not pose a roadside hazard risk).

Despite the low risk and relative ease of implementation on a trial basis at most sites, it is still important that due consideration is given to site selection and prioritisation criteria specified in Section 6.1. While the intention of implementing a treatment on a trial basis is the ability to discontinue if shown to be unsuccessful, it is important to recognise that having to curtail a trial is not an optimal outcome. In addition to the non-recoverable monetary costs of implementation (albeit most system components being able to be repurposed), the same resources if planned well and used elsewhere on the network may have yielded better safety outcomes. As such, the site selection and prioritisation criteria recommended in Section 6.1 should be considered regardless of whether the implementation is a permanent set up or a trail to ensure the treatment is used at locations with maximum potential to reduce high severity crashes.

Any RISZ implemented on a trial basis should be monitored for the entire duration of the trial period to determine its effectiveness prior to determining whether to continue or curtail its operations. High level guidance on monitoring and evaluation of RISZ is provided in Section 9.

7 Design and operation of rural intersection speed zones

7.1 Overview

RISZ is designed to activate a lower speed limit when there is potential for a side impact or a minor road merge collision. Accordingly, the system should activate when either of the following scenarios occurs:

a. a vehicle approaching from the minor road turning onto the major road, and if at a crossroad intersection, crossing the major road

b. a vehicle is turning right from the major road to the minor road.

RISZ employs a series of vehicle detector sensors to identify these movements and deploy a reduced speed limit on the major road while the conflict lasts. Each vehicle detection is registered by a central RISZ control system, which then manages sign activation and deactivation. RISZ requires two types of detector functions which are:

- Advance detection – detects vehicles that will be undertaking a conflicting turning manoeuvre (turning from the minor road or turning right from the major road) as it passes a specified point in advance of the intersection. This triggers the initial activation of VSLS for a specified time period (activation period). Advance detection sensors can either be above ground radar sensors or underground vehicle detection options such as inductive traffic loops. However, above ground radars are preferable than underground detection options due to low maintenance requirements.
- Stop line detection – detects vehicles waiting at the intersection to complete a turn and keeps extending the initial VSLS activation by a specified time period (extension period) for as long as vehicles are detected. Once the waiting vehicles have cleared, the sensor will trigger the end of sign activation followed by a delay.

  Unlike advance detectors that detect vehicles going past a specified point, stop line detectors should detect the presence of a vehicle for as long as it is in the detection zone. For appropriate functioning of RISZ, the stop line sensors should be able to differentiate between passage (vehicles that simply traverse the sensor as they are travelling through or turning at the intersection) and presence (vehicles waiting at the intersection to find a suitable gap in the opposing traffic streams) of vehicles. Extension of the initial VSLS activation shall only be triggered by vehicle presence, and not passage.

  Stop line detection is typically done through underground sensors. However, a suitable above ground detector placed at the intersection closer to the limit line may also be used for stop line detection, provided that it is capable of differentiating vehicle presence and passage. This is particularly useful for low volume side roads where the quality of the seal may not be suitable for installing underground detection options.

RISZ operates in the following three key steps:

1. Activate – advance detector detects a vehicle and activates VSLS for a specified time period (activation period).
2. Extend – once the initial activation period ends, if a vehicle is detected by the stop line sensor, the initial activation is extended by a specified time period (extension period). Extension continues at the end of each cycle for as long as the presence of a vehicle is detected by the stop line sensor.
3. Cancel – when a vehicle is no longer detected by the stop line sensor (when an extension period is active), a brief cancellation period is activated. At the end of the cancellation period VSLS are deactivated.

7.2 Standard layout and operations

Figure 2 shows the standard RISZ components and their placement at a typical crossroad intersection, where the major road is median divided and has right turning lanes. This intersection layout presents the most complex sensor arrangement and operational requirements for RISZ, and therefore has been used as an example to illustrate the key operating principles of the system. The same overarching principles should be applied to other intersection configurations such as T-intersections and crossroad intersections without wide medians to accommodate staged right turns.

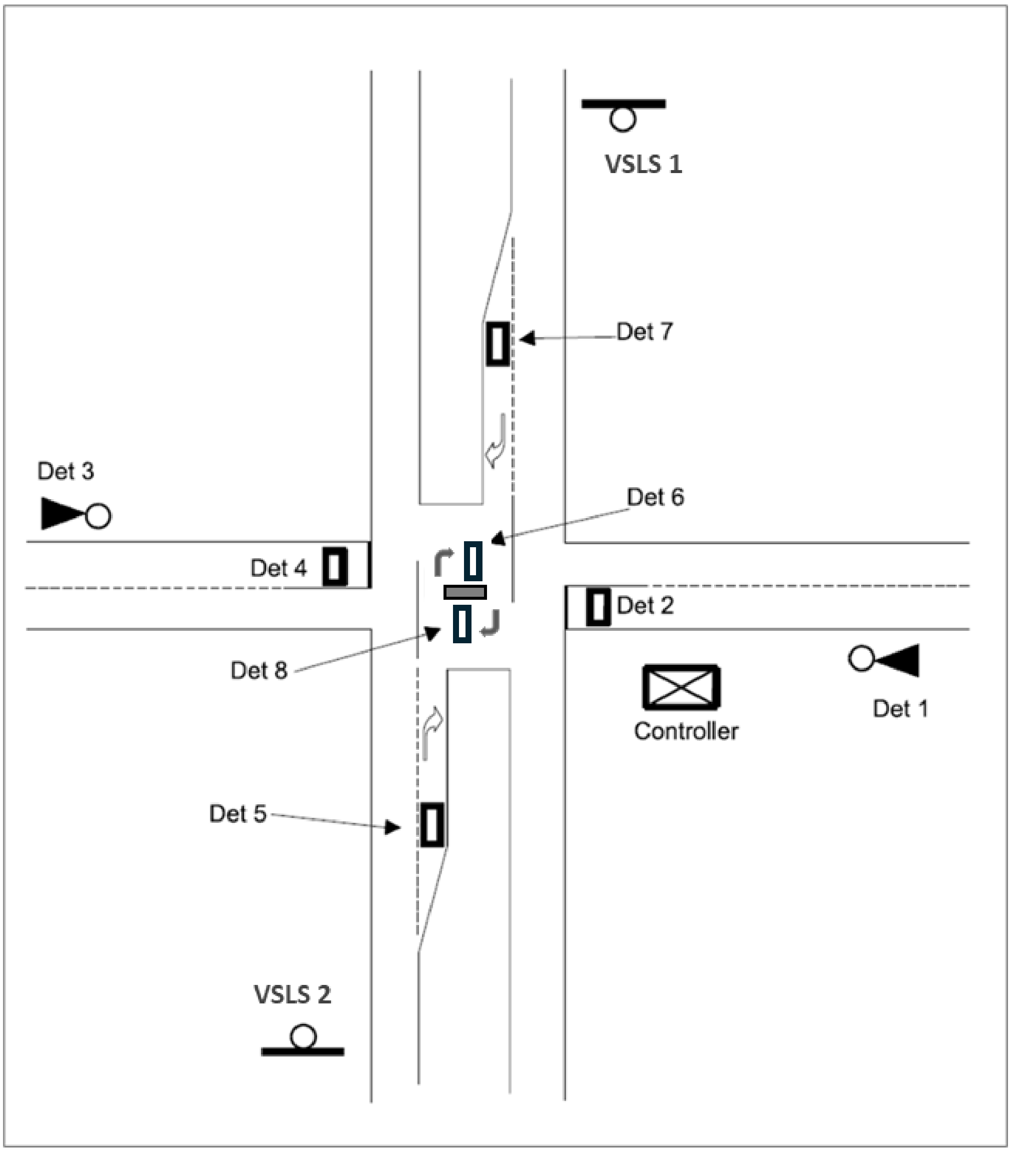

Figure 2 – Standard layout of RISZ components

RISZ operations for the key movements are described as follows:

1. vehicles turning left from the side road:

   a. Detector 1 (or 3) detects a vehicle, and the controller activates VSLS 1 and 2 for a preset time (activation period)

b. as Detector 2 (or 4) detects a vehicle, the controller restarts the timer (extension period). Detector 2 (and 4) are presence detectors that hold the VSLS 1 and 2 active for as long as a vehicle is present by recurring the extension period

c. once the vehicle departs Detector 2 (or 4), the countdown timer expires, and a cancellation timer is activated. At the end of the cancellation timer, the controller will deactivate the VSLS

2. vehicles turning right from the side road or crossing through the intersection:

   a. Detector 1 (or 3) detects a vehicle, and the controller activates VSLS 1 and 2 for a preset time (activation period)

   b. as Detector 2 (or 4) detects a vehicle, the controller restarts the timer. Detector 2 (and 4) are presence detectors that hold the VSLS active for as long as a vehicle is present

   c. once the vehicle departs Detector 2 (or 4),the countdown timer expires, and the cancellation timer is activated

   d. if the vehicle is undertaking a staged manoeuvre, that is, stopping at the gap in the median, it will be detected by Detector 8 or 6, which then deactivates the cancellation timer set by Detector 2 (or 4) and hold the VSLS 1 and 2 active for as long as the vehicle is present

      Note: The ability of stop line detectors to differentiate between vehicle passage and presence means that if the turn or crossing is done in a single manoeuvre (that is, without stopping at the median gap), Detectors 6 or 8 will not trigger any further extensions and VSLS will be deactivated at the end of the cancellation period triggered by Detector 2 or 4.

   e. if the turn or crossing is done in a staged manner, the cancellation timer will be activated once the vehicle departs Detector 8 (or 6). At the end of the cancellation timer, the controller will deactivate the VSLS

3. Vehicles turning right from the main road:

   a. Detector 5 (or 7) detects a vehicle, and the controller activates VSLS 1 (or 2) for a preset time

   b. as Detector 6 (or 8) detects a vehicle, the controller restarts the timer. Detector 6 (and 8) are presence detectors that hold the VSLS active for as long as a vehicle is present

   c. once the vehicle departs Detector 6 (or 8) the countdown timer expires, and a cancellation timer is activated. At the end of the cancellation timer, the controller will deactivate the VSLS.

Figure 3 and Table 2 further summarise the RISZ operations.

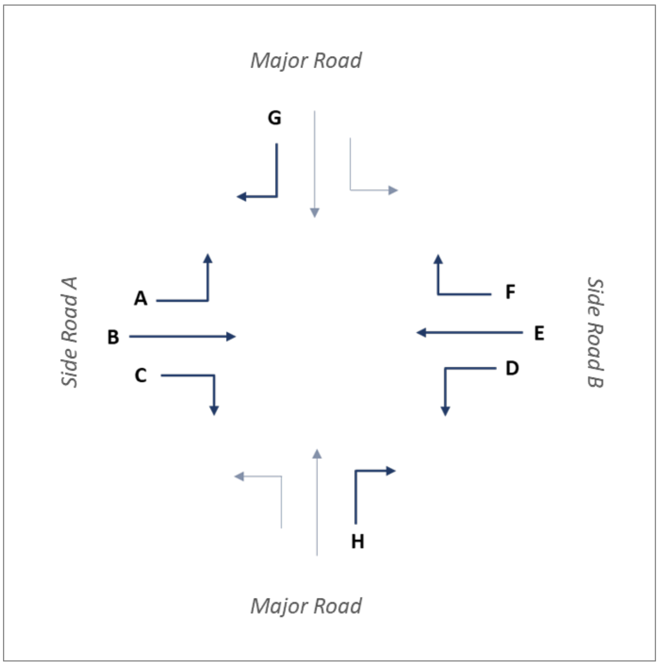

Figure 3 – Intersection movements that activate RISZ

Table 2 – Summary of RISZ operations by movements

Movement	Movement description	Activation detector	Extend or deactivation detector	Activated VSLS
A	Left turn from Side Rd. A to Major Rd.	3	4	1 and 2
B	Cross intersection (from Side Rd. A to Side Rd. B)	3	4 and 6	1 and 2
C	Right turn from Side Rd. A to Major Rd.	3	4 and 6	1 and 2
D	Left turn from Side Rd. B to Major Rd.	1	2	1 and 2
E	Cross intersection (from Side Rd. B to Side Rd. A)	1	2 and 8	1 and 2
F	Right turn from Side Rd. B to Major Rd.	1	2 and 8	1 and 2
G	Right turn from Major Rd. to Side Rd. A	7	8	2
H	Right turn form Major Rd. to Side Rd. B	5	6	1

Timing for each stage of RISZ operation shall be as noted in Table 3.

Table 3 – Standard timing for RISZ operation stages

RISZ operation stage	Condition	Duration (in seconds)
Activation period	Minor road advance detection – detection location ≤ 150 m	30
	Minor road advance detection – detection location >150 m	45
	Major road right turning advance detection	30
Extension period	N/A	30
Cancellation period	N/A	10

The delay between vehicle detection and sign activation should be as minimal as possible, ideally no greater than 1 s.

The information discussed in the preceding text is not an exhaustive guidance on configuring all elements of RISZ. It is aimed at providing clarity on the desired outcomes of the system and general guiding principles on design and operations of the system. The exact means of configuring and programming detectors, VSLS and RISZ controller to align with the operational structure stated in the preceding text should be determined by qualified ITS professionals at the design and implementation stages of projects. During the detailed configuration stage, the potential complications associated with the operations, particularly how concurrent activations are managed, should be taken into account. For example, if a vehicle is waiting on the major road to turn right at the same time another vehicle is waiting on the minor road, the vehicle on the major road departing the right turn lane stop line sensor should not deactivate the VSLS.

7.3 Advance detector and variable speed limit sign placement

7.3.1 Minor road advance detector and variable speed limit sign

Placement of VSLS and advance detection location are based on time to collision principles, which aims to achieve the following key outcomes:

- Minimising the possibility of side impact crashes above an impact speed of 50 km/h, that is, maximising the possibility for major road traffic to brake and slow down upon seeing a conflict, so if a crash was to occur, the impact speed is no higher than 50 km/h.
- Minimising the possibility of major road traffic that have not been subject to the reduced speed limit coming into conflict with the turning vehicle at the intersection. In other terms, any vehicle that has passed the VSLS by the time they are activated, should have ideally gone past the intersection by the time the turning vehicle that had activated the signs arrives at the intersection.

- Ensuring major road traffic subject to the reduced speed limit regularly observes the presence of a vehicle within the intersection area. If the minor road vehicle is too far from the intersection (still approaching the intersection) when major road traffic that have been subject to the reduced speed limit arrives at the intersection, drivers on the major road may not perceive any reason for the reduced speed. This could lead to loss of confidence in the system and consequently poor compliance with the reduced variable speed limit.

Based on the principles discussed above, the recommended positioning of VSLS on the major road and the advance detection location on the minor road are specified in Table 4 and Table 5, respectively.

Table 4 –Placement of VSLS on the major road approaches

Major road operating speed	RISZ variable speed limit	VSLS location on the major road (measured from the intersection)
110 km/h	80 km/h	270 m
100 km/h	70 km/h	230 m
80 km/h	60 km/h	175 m

Table 5 – Location for minor road advance detection

Minor road operating speed	Major road operating speed - 110 km/h	Major road operating speed - 100 km/h	Major road operating speed - 80 km/h
110 km/h	185 m	170 m	140 m
100 km/h	180 m	165 m	135 m
80 km/h	160 m	150 m	130 m
70 km/h	150 m	140 m	120 m
60 km/h	135 m	125 m	110 m
50 km/h	115 m	110 m	95 m

Advance detection locations specified in Table 5 is as measured from the intersection limit line.

The advance detection locations provided in Table 5 do not necessarily need to coincide with the physical placement of the advance detector sensors if overhead radar sensors are used. The radar sensor can be physically installed some distance away from the detection location (to manage physical roadside constraints, optimise radar detection capability and so on) and appropriately angled to detect the minor road vehicles at the recommended detection point.

Achieving the exact locations identified in Table 4 for VSLS may not always be feasible due to roadside constraints. In such cases, the VSLS may be repositioned by the minimum distance required to avoid the obstacle. Any adjustment to the VSLS location requires a corresponding change to the minor road advance detection location as well to ensure the system functions effectively and achieves the intended outcomes. Refer to Appendix B for the corresponding minor road advance detection locations based on adjusted VSLS locations.

Although adjusted VSLS and minor road advance detection locations will allow the system to operate within acceptable parameters, the locations specified in Table 4 and Table 5 provide the most optimal performance. As such, where possible relocating any conflicting infrastructure such as other directional signs should take precedence over considering alternate VSLS locations.

Note: The VSLS and minor road advance detection locations specified in Table 4, Table 5, and Appendix B assume flat terrain. If the major or minor road approaches have an upward or downward longitudinal grade, location adjustment factors shall be applied as outlined in Appendix C. No grade adjustment is required for longitudinal grades between -2% and +2%.

7.3.2 Secondary minor road advance detectors

In some cases, secondary side roads or driveways may exist between the minor road advance detection point (as specified in Table 5) and the intersection. To ensure vehicles from these locations can activate RISZ, secondary sensor(s) should be installed on the minor road, positioned as close as practicably possible to the driveway or the side road. This sensor will function similarly to the primary advance detector, activating VSLS by detecting vehicles turning from the sideroad or the driveway toward the intersection.

When RISZ activation is triggered by a secondary sensor (which is placed closer to the intersection than the primary advance detector), there is a higher risk of minor road vehicles coming to conflict with major road traffic that have not been subject to the RISZ reduced speed limit. However, this approach is significantly safer than allowing vehicles from driveways or side roads between the primary advance detector and the intersection to go undetected by the system.

The following are the key operating principles of the system when a secondary advance detector is used:

1. Detector 1 (primary advance detector, see Figure 4) detects a vehicle, and the controller activates VSLS 1 and 2 for a preset time (activation period). This period should be determined based on the slowest practical speed a vehicle could travel between Detector 1 and Detector 1A (see Figure 4), assumed to be 25 km/h unless a higher or lower value is justified. This activation period will differ from the standard activation period noted in Table 3, which only considers a single advance detector.
2. If a vehicle that has been detected by Detector 1 turns onto the secondary side road (that is not detected by detector 1A), the VSLS will turn off after the initial activation period set by Detector 1. From the perspective of major road motorists, this results in a ‘false’ system activation.
3. If a vehicle that has been detected by Detector 1 continues on towards the major road intersection, it will be detected again by Detector 1A which will keep the ESLS active for an

additional set time which shall be consistent with the activation periods noted in Table 3 (detection location referenced in Table 3 in this case refers to detection location of the secondary detector, that is Detector 1A, and not the primary detector, Detector 1).

4. A vehicle turning towards the major road intersection from the secondary side road is detected by detector 1A and activates ESLS for a preset activation period which shall be consistent with the activation periods noted in Table 3.

5. Operating principles at the stop line detector (Detector 2, see Figure 4) is same as those outlined in Section 7.2.

Figure 4 illustrates a typical intersection where a secondary advance detector is required.

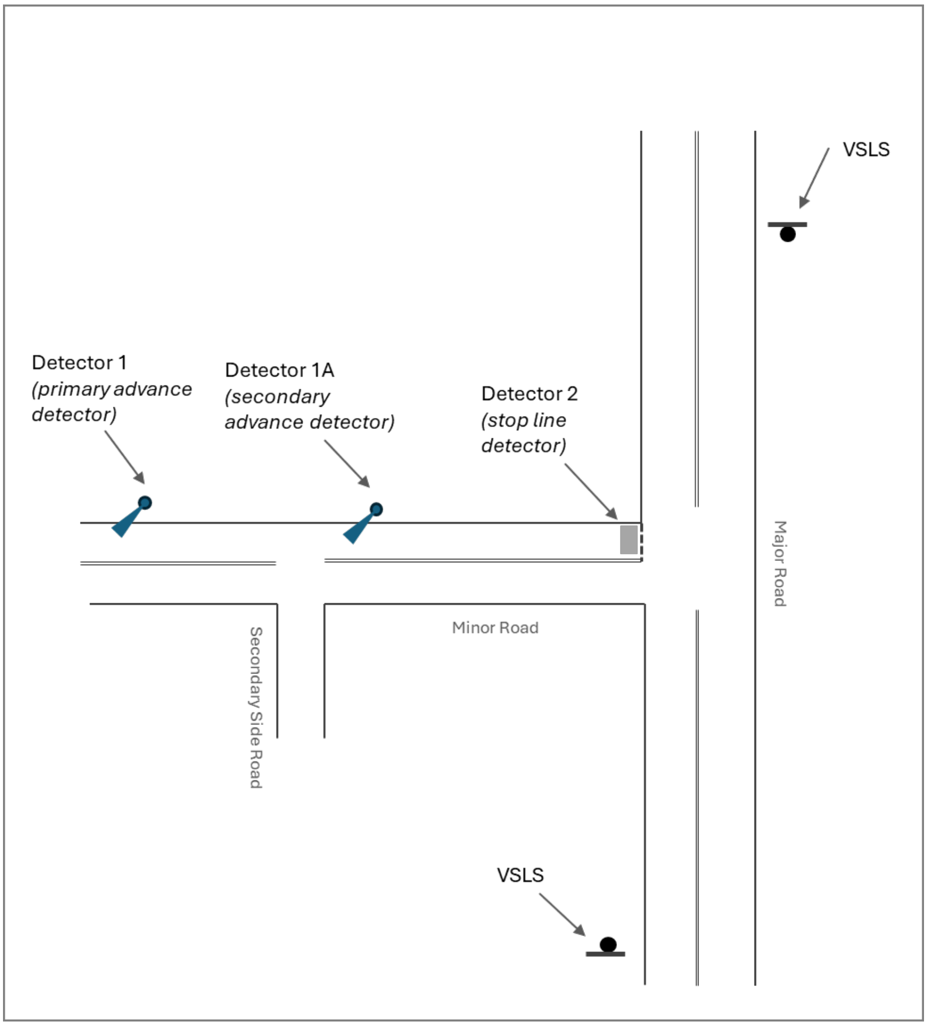

Figure 4: RISZ layout with minor road secondary advance detector

The same operational logic should be extended if multiple secondary detectors are required to capture multiple driveways or secondary side roads. However, designers should assess at the project level whether each access point warrants secondary detection. For low-usage access points, such as farm gates or secondary property entrances, omitting a secondary detector may be acceptable. The decision should consider the trade-off between the risk of occasional missed detections and the added costs, as well as the potential for increased system complexity and failure points.

If vehicles turning from all side roads or driveways between the minor road primary detection point (as specified in Table 5) and the intersection can be captured by relocating the primary advance detection point by 25 m or less, then the primary minor road detection point and the corresponding VSLS location on the major road may be adjusted as per Appendix B, in lieu of providing a secondary minor road advance detector.

If a higher percentage of traffic detected by the primary detector turns onto a secondary side road instead of continuing to the major road intersection, false activations increase. Despite the short activation period limiting major roads traffics' exposure to a false detection, frequent occurrences can still cause a loss of confidence in the system and consequently poor compliance. Therefore, if more than 25% of traffic detected by the primary advance detector turn at a side road without proceeding to the major road intersection, then the primary advance detector may be relocated by more than 25 m (along with corresponding adjustment of VSLS) if the need for a secondary advance detector can be eliminated. Any relocation of the primary advance detector location shall remain within the limits noted in Appendix B.

7.3.3 Major road advance detector (for right turning from major road)

For advance detection of right turning vehicles from the major road, the detector should be placed at the beginning of the right turn lane. If the right turning lane is particularly long and there is a higher possibility of late divergence, then the detector should be placed at or after where the vehicles are likely to practically diverge into the right turning lane. Due to the complex nature of an intersection with turning and through lanes in close proximity, advance detection of right turns from the major road would ordinarily necessitate the use of ground sensors such as inductive traffic loops rather than above ground detectors. Above ground options may be considered if there are radars that are sufficiently advanced to precisely detect vehicles only on the right turning lane without being influenced by traffic on the through lane.

In some cases, the placement of the advance detector will be too close to the intersection to eliminate potential conflict of right turning vehicles with opposing traffic that have already passed the VSLS by the time they are activated. This is an inevitable limitation of the system. If the sensor was to be placed further back on the taper of the right turn lane to minimise this concern, there is a risk that a high proportion of traffic will fail to activate the sensor.

7.4 Variations to standard layout and operations

7.4.1 Major road with undivided carriageway

Where the major road carriageway is undivided or the provided median is too narrow to allow for staged turns, the right turn lane stop line sensors should be placed within the right turn lane, parallel to the right turn lane limit line. Apart from this minor design change, the operations as well as the detector and VSLS locations shall be in accordance with Section 7.3.

7.4.2 Intersections without right turning lanes

The design for detecting right turning traffic from the major road as stated in Section 7.3 cannot be used if there is no channelised right turning treatment at the intersection. In this case, for advance detection, an above ground radar speed sensor should be used to detect vehicles slowing down on approach to the intersection. Table 6 states the recommended location for advance speed detection. RISZ shall be activated if the approaching vehicle speed is less than 80% of the ordinary vehicle operating speed on the road. It is acknowledged that this system carries the risk of RISZ being falsely activated by a slow-moving vehicle not intending to turn at the intersection. However, with the activation threshold set to a relatively low speed (80% of vehicle operating speed) and given that vehicle speeds tend to have low variability in high-speed rural rods with moderate traffic volumes, such 'false' activation of the system is expected to be infrequent.

Table 6 – RISZ activation criteria for right turning from the major road in absence of right turning lanes

Major road vehicle operating speed (major road)	Location for advance speed detection (See Note 1)
110 km/h	95 m
100 km/h	75 m
80 km/h	50 m

Note 1: Measured from the centreline of the minor road.

If the available radar technology permits vehicle speeds to be reliably measured at two distinct points, then speeds can be measured approximately 10 m to 15 m prior to the detection location specified in Table 6, and RISZ activated only if the vehicle is shown to be decelerating between the two points (as well as the speed below the threshold stated in the preceding text in this section). This will improve the reliability of the system as false activations from simply slow-moving vehicles not intending to turn at the intersection will be minimised.

The stop line detection sensor is generally an underground option such as an inductive loop and should be placed where a right turning vehicle will be waiting at the intersection until a suitable gap is found in the opposing traffic stream. When there is no dedicated right turning facility, this will generally be across the live through lane. Alternatively, a second radar sensor may also be used for stop line detection. However, if there is seal widening for through traffic to go past a vehicle waiting to turn right, radar detection can be affected by through traffic and the overall system reliability can be compromised.

While the technique discussed in the preceding text should be adequately reliable at T-intersections, it is acknowledged that at crossroad intersections, the advance detection may not distinguish between left and right turning traffic. This can result in the system being activated when there is no risk of a side impact collision, that is, when a vehicle is decelerating to turn left from the major road. As such, at crossroad intersections, there will be some instances of false activations. It should however be noted that the stop line detector will only pick up right turning vehicles (given that stop line detectors can differentiate between vehicle presence and passage). This means a false activation of the system by a left turning vehicle will not be extended beyond the initial activation period. The exposure of the major road traffic to a false activation can be minimised by reducing the duration of the initial activation. Accordingly, when there are no turning lanes and the activation is triggered by a speed radar, the initial activation period shall be limited to 15 s. All other timing parameters (extension and cancellation periods for all sensors and activation period for side road advance detectors) should remain as noted in Table 3 and Section 7.3.2 (where applicable).

Despite the reduced exposure to false activations through a short activation period, excessive occurrences are still undesirable as it can compromise the credibility of the system in road users' perspective. Therefore, if the volume of left turning traffic from a major road approach is higher than the right turning volume, then RISZ should not be set to be activated by traffic on that approach. This means the system activation can be set to minor road approaches and only one of the major road approaches.

The design of RISZ discussed in this section for the intersections with no turning lanes are summarised as follows:

- Side road vehicle detection (both advance and stop line detection) should be the same as the standard layout and operations defined in Sections 7.1 to 7.3.
- Advance detection of right turning vehicles from the major road approach should be via a speed detector radar. Location of advance detection is stated in Table 6 and the system should be activated if the recorded speed of a vehicle is lower than 80% of the ordinary vehicle operating speed on the road.
- For crossroad intersections, if the left turning traffic volume from any major road approach is higher than the right turning volume from the same approach, RISZ should not be designed for activation by right turning traffic from that approach.

At priority-controlled intersections, crashes involving vehicles turning right from the minor road (and crossing if at a crossroad intersection) are generally more prevalent than crashes involving vehicles turning right from the major road. Right turn out crashes also tend to be of higher severity on average as the 90-degree side impact collision will be on the driver's side door, as opposed to on the passenger's side door in the case of a right turn in crashes (given the higher prevalence of single occupant vehicles). This when combined with the fact that designing for detecting right turning vehicles from the major road, particularly at locations without canalised right turning treatments, can be complex, it is acceptable for RISZ to be designed only to be activated by the minor road traffic. However, this does not realise the full potential benefits of the system, and hence should only be reserved for instances where there are major barriers to implementing the standard designs discussed in this section.

7.5 Signage standards and layout

7.5.1 Variable speed limit signs

VSLS shall be an electronic display that is identical in layout to a Speed Limit (R4-1) sign, but has illuminated white numerals and an illuminated red annulus on a black background. All VSLSs used for RISZ shall be of Size C (in accordance with the TfNSW Traffic Signs Register) regardless of the RISZ variable speed limit that they display. A portion of the red annulus surrounding the speed numeral shall flash continuously to create a dynamic effect on the signs. The signs shall be displayed with the flashing operations for the entire duration that they remain active. The flashing operations of VSLS shall be in accordance with AS 5156. Electronic signs without the flashing operations shall not be used for RISZ. Use of flashing signs are intended to improve conspicuity of the signs. The speed limit change point in RISZ will not typically entail a change in the road environment (as is generally the case with most other speed limit changes, such as transitioning from a rural to a peri urban environment), and hence there is a high risk of the signs being unnoticed by the drivers. The flashing operation of the sign will minimise this risk by introducing a dynamic element to the signs.

On two-lane carriageways, VSLS are not required to be gated and can be placed only on the left-hand side of the drivers approaching the intersection. However, in instances where advance visibility to the signs is limited or there is an abundance of other visual stimuli to the drivers in the immediate surrounding (for example, built up peri urban environments, other regulatory, warning, advance directional or advertising signs in the immediate vicinity), the VSLS should be gated. If there is more than one through lane approaching the intersection, VSLS should be gated. If the opposing traffic streams are separated by a solid median, the right-hand sign should be placed on the median, provided that it is sufficiently wide for a sign to be placed safely.

7.5.2 Signage to indicate end of rural intersection speez zones

Standard static Speed Limit (R4-1) signs showing the regular posted speed limit of the major road should be installed past the intersection to derestrict the RISZ variable speed limit and inform motorists that they are allowed to get back up to the posted speed limit. During the times that RISZ is not active, these signs will simply function as repeater speed limit signs.

R4-1 signs shall be no closer to the intersection than the VSLS are from the intersection. For example, for a 100 km/h road, as the VSLS should be placed 230 m in advance of the intersection (as stated in Table 4), the R4-1 sign should be placed at least 230 m past the intersection. Placing the R4-1 signs closer to the intersection carries the risk of drivers being able to clearly see the signs prior to going past the intersection and starting to accelerate, thus compromising the objective of RISZ to achieve low speeds through the critical conflict points at an intersection. Where VSLS are gated, R4-1 signs may be mounted on the same pole as the VSLS facing the opposite direction provided that detailed requirements such as weight and wind loading and are satisfied.

An R4-1 sign indicating the speed limit of the minor road shall be installed on the minor road facing traffic leaving the intersection. This ensures that motorists who may have been subject to the RISZ variable speed limit on the major road before turning onto the minor road are clearly informed of the applicable posted speed limit to continue ahead with. If there is an already existing R4-1 sign on minor road within 500 m of the intersection, providing an additional sign closer to the intersection is not required.

7.5.3 Advance warning signs

Providing adequate advance warning prior to drivers being subject to the RISZ variable speed limit is important for safe and effective operations of the system. This will prepare drivers to slow down if RISZ is activated, which will reduce abrupt braking at the VSLS and thereby minimise the possibility of increased rear end crash risk. Accordingly, the advance warning sign G6-364n (see Figure 5 for the layout of the sign) shall be provided prior to the VSLS for all RISZ installations. The RISZ variable speed shall be displayed within the black annulus of the sign. The recommended positioning of the RISZ warning sign is specified in Table 7.

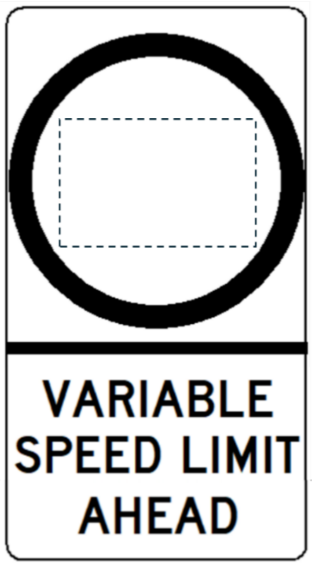

Figure 5 – RISZ advance warning sign (G6-364n)

Table 7 – Recommended placement of RISZ advance warning sign

Major road operating speed	Distance from VSLS
80 km/h	120 m to 140 m
100 km/h	170 m to 210 m
110 km/h	210 m to 260 m

As noted with the VSLS, the advance signs are not typically required to be gated. However, the signs can be gated in situations where advance visibility is limited and increased conspicuity is desirable due to the nature of the roadside environment. On multilane carriageways, similar to VSLS, the advance sign should also be gated. If the opposing traffic streams are separated by a solid median, the right-hand sign should be placed on the median provided that it is sufficiently wide for a sign to be placed safely.

In addition to the RISZ specific warning sign shown in Figure 5 , other intersection advance warning or guide signs shall be provided independent of RISZ installations as required by AS 1742.2 and AS 1742.15. In particular, if intersection warning signs are required on the major road approaches due to reduced advance visibility, as specified in AS 1742.2, they shall be provided regardless of whether a RISZ is present on site. While RISZ deploys a lower speed limit in the presence of conflicts at an intersection, it does not explicitly alert drivers to the presence of an intersection ahead. Also, the reliance on multiple technological components means the system inherently provides a lower level of reliability. As such, RISZ on its own should not be relied upon to warn major road motorists of the presence of an intersection ahead when advance warning is warranted (as specified in AS 1742.2).

7.6 Optional design enhancements – intersection run through prevention system

Along with gap misjudgement, one of the most common causes of intersection crashes, particularly at crossroad intersections, is drivers failing to notice the presence of an intersection ahead or being unaware that they are approaching from a minor road requiring to yield to other traffic. At RISZ sites, the intersection run through risk can be effectively mitigated by supplementing the standard RISZ design with an activated warning sign on the minor road. This supplementary system can utilise the same vehicle detection radar used by RISZ which will minimise the additional costs.

The warning sign shall be an electronically displayed Stop Sign Ahead (W3-1) or Give Way Sign Ahead (W3-2) along with a supplementary electronic display with the wording ‘Prepare to Stop’ or ‘Prepare to Give Way’ depending on the intersection control. A flashing component can be incorporated into the sign display to add a dynamic element and further increase its conspicuity. The warning sign shall only be activated if the speed of the vehicle on the minor road approach at the RISZ advance detection location (as stated in Table 5) exceeds 85^{th} percentile operating speed on the road.

The location of the warning sign should be in accordance with Table 8. If the sign cannot be physically placed at the recommended location due to roadside constraints, then it should be moved further away from the intersection and mounted as close as practicable to the recommended location.

Table 8 – Warning sign location for intersection run through prevention system

Minor road speed limit	Location of activated advance intersection control sign (Measured from the intersection limit line)
110 km/h	135 m
100 km/h	115 m
80 km/h	75 m
70 km/h	60 m
60 km/h	50 m
50 km/h	40 m

At the recommended speed detection points, vehicles typically would not have started decelerating towards the intersection and therefore the vehicle speeds are only a crude indicator of the intersection run through risk, that is, a vehicle could be travelling at a speed lower than the 85^{th} percentile speed, but still fail to recognise the presence of an intersection ahead. This is an inevitable limitation of the system. If vehicle speeds were to be detected when they have started decelerating towards the intersection (which would be a better indicator of the run through risk), by the time the warning sign is activated, it will be too late for a driver to react to it and brake to come to a complete stop prior to the intersection. Given this inherent limitation in system reliability, practitioners should take into account the benefits it will likely provide in the context of the individual sites relative to the additional costs it will incur (for example, electronic signs, roadside barriers to protect signs (if needed), additional power requirement which can lead to the need for higher capacity batteries and so on if the source of power is solar energy).

7.7 Detailed design considerations

This document outlines best practice guidance and key requirements for planning and concept design of RISZ. It does not include detailed technical specifications for system setup, installation, operations, or maintenance. These aspects should be defined at a project level by appropriately qualified professionals, in line with the operational structure and logic described within this standard. During detailed design and implementation, relevant TfNSW and Australian standards, along with general industry best practices, should be followed. Key considerations during detailed design include, but not limited to, the following:

- Hardware and software specifications of ITS components including RISZ controller, radar detectors, ground vehicle detection systems such as inductive loops and method of communication between different system components (detectors, RISZ controller and VSLS).

- System installation such as setup and alignment of radar detectors to precisely detect vehicles at the designed detection points.
- Determining detailed operating logic of the system specific to the site, taking complexities such as concurrent activations (for example, a minor road vehicle is waiting to turn at the same time a vehicle is waiting to turn right from the major road) into account and configuring all system components to satisfy the site-specific operational logic.
- Power supply and cabling, including determining if connecting to the electric grid or off-grid options such as solar power is more appropriate for the specific location. If solar power is used, factors such as wattage of the solar panels, capacity of the batteries, orientation of solar panels considering shading effects should be carefully assessed for reliable operation of the system.
- Housing system components to minimise risks such as weather damage and vandalism to ensure continual reliable operations of the system.
- Placement of street furniture to minimise the risk of creating additional roadside hazards for road users. For example, using frangible poles for signs (this needs to be considered in view of the additional weight from the electronic signs, potential solar panels and any other ITS components, such as communication devices that can be mounted on a single pole) or use of roadside barriers. Standard safety assurance processes such as road safety audits should be undertaken for RISZ implementations at the design stage and post construction.
- Testing prior to commissioning – On-site testing of the system as a whole once installed. All critical elements of the system such as advance detectors only detecting approaching vehicles about to perform a conflicting turn, stop line detectors holding the VSLS active precisely for the duration that a vehicle is waiting at the intersection, whether the RISZ controller appropriately manages concurrent activations, VSLS being active within an acceptable delay from the advance detection and so on should all be tested prior to full activation of the system.
- Ongoing operations – remote monitoring capabilities, fault detection and communication and need for data retention need to be considered and designed for.

RISZ is a new treatment with no prior installations in NSW. Mandating rigid technical requirements at this stage, based solely on theoretical principles, could hinder optimal design and implementation. As more experience is gained through deployments, this document will be supplemented with a supply and installation guide to facilitate more streamlined delivery.

8 Alternative forms of warning or advisory messaging

There are alternate forms of RISZ that use activated warning or advisory signs instead of a reduced variable speed limit on the major road. This may include an activated advisory speed, variable message signs with the wording 'Slow Down' or static intersection advance warning sign with activated conspicuity indicators (see Figure 6 and Figure 7 for examples of such applications). Systems of this nature are already in use in NSW as well as other Australasian jurisdictions. However, studies including both on-site trials (Refer Mackie et al., 2014, *New Zealand's Rural Intersection Active Warning System* for further details) and driving simulator studies (Refer Meuleners et al., 2018, *Rural Intersection Active Warning System (RIAWS): A Driving Simulator Study* and Stephens et al., 2021, *A Simulator Evaluation of Driver Responses to Dynamic Warning Signs at Rural Intersections* for further details) have provided robust evidence that such applications are significantly less effective than implementing a variable speed limit through the intersection.

An advisory speed accompanied by an intersection warning sign advises the driver to slow down to the advisory speed at the intersection, whereas the proposed design with a regulatory variable speed limit aims to achieve lower speeds well in advance of the intersection. The latter provides a significantly higher chance for a driver to break and lower the impact speed to as close as possible to 50 km/h, which is considered the critical impact speed for side impact collisions. Additionally, there is an increasing contribution from vehicle technology for speed limit compliance. Most modern vehicles detect speed limits from signs and display it on the dashboard with some alerting drivers of a non-complying speed. However, vehicles only detect regulatory speeds and not advisory speeds or other forms of speed related warnings.

On this basis, RISZ shall be implemented on NSW roads only with a regulatory variable speed limit (that is, a variable speed limit determined in accordance with Section 6.2) and not with any other forms of warning or advisory signs, including advisory speeds.

Figure 6 – Example 1 of alternative forms of RISZ that should not be used in NSW (Source: Mackie et al., 2014, *New Zealand's Rural Intersection Active Warning System)* and Bradshaw et al., 2013)

Figure 7 – Example 2 of alternative forms of RISZ that should not be used in NSW (Source Bradshaw et al., 2013, *Vehicle Activated Signs: An emerging treatment at high-risk rural intersections)*

9 Performance monitoring and evaluation

Monitoring is the systematic collection of data about the performance of road safety treatments after their implementation. Evaluation is the statistical analysis of that data to assess the extent to which the treatment (or a wider treatment program) has met the safety objectives. Given that RISZ are a relatively novel treatment, their performance should be monitored and evaluated for future direction on the use of the treatment. It is also vital for establishing reliable crash modification factors for the treatment (that is, a quantifiable indicator of the number of crashes that the treatment is expected to reduce), which is foundational for road safety planning and strategic level decision making.

The primary performance indicator to be monitored for RISZ in the short-term is vehicle speeds on the major road. Vehicle speeds while RISZ is active can then be compared to the vehicle speeds while the system is inactive to understand the overall effectiveness of the system. Several key factors to consider when planning to monitor and evaluate RISZ are as follows:

- Vehicle speeds should be recorded on the major road as close as practically possible to the intersection.
- Each vehicle speed record should be timestamped, so whether the RISZ was active and if the vehicle was subject to the RISZ variable speed limit can be determined.
- The direction of travel should be distinguishable.
- The following should be confirmed with the organisational unit responsible for ongoing technological operations and maintenance of RISZ prior to the start of the monitoring period:
  - Whether all logs of RISZ activations (that is, exact time of VSLS activation and deactivation) for the entire duration of the monitoring period can be retrieved from the RISZ controller.
  - Whether the specific sensor that activated RISZ can be identified for each system activation. This is important because if the activation is from a vehicle turning right from the major road, only the conflicting direction of major road traffic will be subject to the variable speed, unlike in the case of an activation from the minor road where major road vehicles in both directions will be subject to the RISZ variable speed limit.
- The device used for recording vehicle speeds (that is, traffic count tube setup or similar) and RISZ should have precise, synchronised timing to be able to accurately determine which vehicles were subject to the variable speed limit. Differences in timing, even as small as several seconds, can substantially affect the evaluation results. The timing synchronisation should be verified prior to commencing monitoring as well as regularly throughout the monitoring period.
- The monitoring period should commence sometime after the initial system implementation. The novelty of any treatment, particularly one that is still not commonplace on our road network can influence driver behaviour. This novel effect will wane with time and hence should not be allowed to influence monitoring and evaluation, which aims to assess sustained effects of the treatment. As such monitoring for formal evaluation purposes should not commence earlier than four weeks from implementation.
- Monitoring should be planned for a continuous period of at least four weeks. This allows any data irregularities such as days of wet weather (that can have a marked influence on vehicle speeds) to be excluded if needed and still retain a sufficiently large sample of data to be able to draw meaningful conclusions during evaluation.

- During evaluation, vehicles that are decelerating to turn from the major road and accelerating having just turned from the minor road should be excluded as these will skew the results. If the vehicle speeds are recorded close to the intersection, this can typically be done by setting a lower bound for the major road speeds.

10 Rural intersection speed zones approval

Given that RISZ involves a change of speed limit on a road, albeit the speed limit being variable, all RISZ implementations require approval from TfNSW in accordance with the approvals and authorisation requirements stated in TS 03631.

Note: The speed zone review process stated in TS 03631 does not directly apply for RISZ and the RISZ variable speed limit should be set in accordance with Section 6.2 of this document.

Appendix A Intersection risk metrices

A.1 Intersection collective risk

For the purpose of assessing the intersection risk, the collective risk is defined as the sum of FSI equivalents per intersection in a crash period (typically five years). FSI equivalents is a way of illustrating all crashes in terms of a corresponding number of FSIs. FSI equivalents are determined by multiplying each crash at an intersection by the average number of FSIs for that crash type, which is known as a severity index. Severity indices can also be interpreted as the probability that any given crash type, in a given road environment will result in a fatality or serious injury. Severity indices have been determined by assessing the severity outcome of different crash types in different road environments from a large sample of crashes and they differ by the crash type, form of intersection control and the speed environment. For example, drivers turning right out of a side road are particularly vulnerable to being hit in the driver's door from the right, which typically results in a high severity outcome and hence carries a high severity index. In contrast, rear-end collisions rarely result in death or serious injury and hence has a low severity index.

Overall, this approach provides a more robust way of assessing the crash risk by minimising the bias from a very small number of high severity crashes, which are intrinsically rare events. For example, the underlying safety risk at an intersection that has had several minor or moderate injury side impact crashes will not be overlooked under this approach, as it acknowledges the common crash type at the location typically carries a high risk of a serious injury or fatality. The fact that the past crashes have been of low severity is not necessarily a reflection of safe infrastructure (it could be due to a range of other factors such as lower operating speeds due to weather conditions, higher quality vehicles). Similarly, this approach would not allow a single high severity crash at a location to overinfluence the risk profile.

A.2 Intersection personal risk

Personal risk is the risk of death or serious injuries to the passenger(s) in each vehicle entering the intersection and is derived by dividing the collective risk by a measure of traffic volume exposure.

Appendix B Alternate variable speed limit sign locations and corresponding advance detector locations

Table 9, Table 10 and Table 11 (for major road speeds of 110 km/h, 100 km/h, and 80 km/h, respectively) provide adjusted minor road advance detection locations when the standard major road VSLS position (outlined in Table 4) needs to be modified due to roadside constraints. Likewise, if the advance detection location has to be adjusted to account for driveways or secondary side roads on the minor road approach (as discussed in Section 7.3.2), these tables should be used to determine the corresponding VSLS location on the major road.

Table 9 – Minor road advance detection location for adjusted VSLS location – Major road speed 110 km/h

VSLS location for major road speed	Minor road speed – 110 km/h	Minor road speed – 100 km/h	Minor road speed – 80 km/h	Minor road speed – 70 km/h	Minor road speed – 60 km/h	Minor road speed – 50 km/h
200	97	98	94	92	86	74
205	103	104	99	96	89	77
210	109	109	104	101	93	79
215	114	115	108	105	96	82
220	121	121	113	109	100	85
225	127	127	118	113	103	88
230	133	133	122	117	107	91
235	140	139	127	121	110	94
240	146	145	132	125	114	97
245	153	151	136	129	117	100
250	159	157	141	134	121	103
255	166	162	146	138	124	106
260	172	168	151	142	128	109
265	179	174	155	146	131	112
270	185	180	160	150	135	115
275	191	186	165	154	139	118
280	198	192	169	158	142	121
285	204	198	174	162	146	124
290	211	204	179	166	149	127
295	217	209	184	171	153	129
300	224	215	188	175	156	132
305	230	221	193	179	160	135

VSLS location for major road speed	Minor road speed – 110 km/h	Minor road speed – 100 km/h	Minor road speed – 80 km/h	Minor road speed – 70 km/h	Minor road speed – 60 km/h	Minor road speed – 50 km/h
310	237	227	198	183	163	138
315	243	233	202	187	167	141
320	250	239	207	191	170	144
325	256	245	212	195	174	147
330	263	251	216	199	177	150
335	269	257	221	204	181	153
340	276	262	226	208	184	156

Table 10 – Minor road advance detection location for adjusted VSLS location – Major road speed 100 km/h

VSLS location for major road speed	Minor road speed – 110 km/h	Minor road speed – 100 km/h	Minor road speed – 80 km/h	Minor road speed – 70 km/h	Minor road speed – 60 km/h	Minor road speed – 50 km/h
160	78	78	79	77	71	65
165	84	83	84	82	75	68
170	90	89	89	86	79	71
175	95	95	94	91	83	75
180	102	101	99	95	87	78
185	108	107	104	100	91	81
190	114	114	109	104	94	84
195	121	120	114	109	98	87
200	128	127	120	113	102	91
205	135	133	125	118	106	94
210	142	139	130	122	110	97
215	149	146	135	127	114	100
220	156	152	140	131	118	103
225	163	159	145	136	121	107
230	170	165	150	140	125	110
235	177	171	155	144	129	113
240	184	178	161	149	133	116
245	191	184	166	153	137	119
250	198	191	171	158	141	123
255	205	197	176	162	144	126
260	212	203	181	167	148	129
265	219	210	186	171	152	132

VSLS location for major road speed	Minor road speed – 110 km/h	Minor road speed – 100 km/h	Minor road speed – 80 km/h	Minor road speed – 70 km/h	Minor road speed – 60 km/h	Minor road speed – 50 km/h
270	226	216	191	176	156	136
275	234	223	197	180	160	139
280	241	229	202	185	164	142
285	248	236	207	189	168	145
290	255	242	212	194	171	148
295	262	248	217	198	175	152
300	269	255	222	203	179	155

Table 11 – Minor road advance detection location for adjusted VSLS location – Major road speed 80 km/h

VSLS location for major road speed	Minor road speed – 110 km/h	Minor road speed – 100 km/h	Minor road speed – 80 km/h	Minor road speed – 70 km/h	Minor road speed – 60 km/h	Minor road speed – 50 km/h
105	50	48	51	50	50	45
110	55	53	56	55	55	48
115	60	58	62	60	59	52
120	65	63	67	65	63	56
125	71	68	73	70	67	59
130	77	74	79	75	72	63
135	83	80	84	80	76	66
140	89	86	90	85	80	70
145	96	93	96	90	85	73
150	103	100	101	95	89	77
155	110	107	107	100	93	81
160	117	114	113	105	97	84
165	124	121	119	110	102	88
170	132	128	124	115	106	91
175	140	135	130	120	110	95
180	148	142	136	125	115	98
185	156	149	141	130	119	102
190	164	157	147	135	123	106
195	171	164	153	140	127	109
200	179	171	159	145	132	113
205	187	178	164	150	136	116
210	195	185	170	155	140	120

VSLS location for major road speed	Minor road speed – 110 km/h	Minor road speed – 100 km/h	Minor road speed – 80 km/h	Minor road speed – 70 km/h	Minor road speed – 60 km/h	Minor road speed – 50 km/h
215	203	192	176	160	145	123
220	211	199	181	165	149	127
225	219	207	187	170	153	131
230	226	214	193	175	157	134
235	234	221	199	180	162	138
240	242	228	204	185	166	141
245	250	235	210	190	170	145

Appendix C Variable speed limit sign and advance detector location adjustments for grade

C.1 Variable speed limit sign location adjustment for major road grade

VSLS location adjustments to account for major road grade are shown in Table 12 and Table 13.

Note:

- The appropriate grade adjustment factor should be determined based on the average longitudinal grade between the VSLS and the intersection in the direction of traffic approaching the intersection.
- Only the VSLS location should be adjusted to account for the major road grade. No corresponding adjustment is required for the minor road advance detection point unless the minor road approach is also on a gradient, in which case it should be independently adjusted as outlined in Appendix section C.2.
- The grades of the two major road approaches should be assessed separately. If the grades differ, the VSLS locations on each approach may also vary slightly.
- The VSLS location adjustments in Table 12 and Table 13 are independent of how far from the intersection, the VSLS are placed. That is, whether the standard VSLS location from Table 4 is used or repositioned based on Appendix B, the adjustment factors in Table 12 and Table 13 remain applicable.

Table 12 – VSLS location adjustment for major road grades – Major road speed 110 km/h or 100 km/h

Major road gradient – Major road speed 110 km/h or 100 km/h	VSLS location adjustment (m)
< -6%	+10
-6% to -3%	+5
-3% to +3%	No Adjustment
+3% to +8%	-5
> +8%	-10

Table 13 – VSLS location adjustment for major road grades – Major road speed 80 km/h

Major road gradient - Major road speed 80km/h	VSLS location adjustment (m)
< -5%	+5
-5% to +5%	No Adjustment
> +5%	-5

C.2 Minor Road advance detection location adjustment for minor road grade

Minor road advance detection point adjustments to account for minor road grades are shown in Table 14 to Table 19.

Note:

- The appropriate grade adjustment factor should be determined based on the average longitudinal grade on the minor road between the advance detection location and the intersection limit line in the direction of approaching traffic.
- Only the advance detection point should be adjusted to account for the minor road grade. No corresponding adjustment is required to the VSLS on the major road, unless the major road is also on a gradient, in which case the VSLS location should be independently adjusted as specified in Appendix section C.1.
- At a crossroad intersection, the grades of the two minor road approaches should be assessed separately. If the grades differ, the advance detection location on each approach may also vary.
- As noted in Table 14 to
- Table 19, the gradient adjustment also depends on how far the advance detection location is from the intersections.

Table 14 – Minor road advance detection location adjustment for minor road grades (m) – minor road speed 110 km/h

Advance detector location (See Note 1)	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
50 – 60 m	-11	-8	-6	-3	+3	+6	+9	+11
60 – 70	-13	-10	-7	-3	+3	+7	+10	+13
70 – 80	-15	-12	-8	-4	+4	+8	+12	+16
80 – 90	-18	-13	-9	-4	+5	+9	+14	+18
90 – 100	-20	-15	-10	-5	+5	+10	+15	+20
100 – 110	-22	-17	-11	-5	+6	+11	+17	+22

Advance detector location (See Note 1)	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
110 – 120	-24	-18	-12	-6	+6	+12	+18	+23
120 – 130	-26	-20	-14	-6	+7	+13	+19	+24
130 – 140	-29	-22	-15	-7	+7	+13	+19	+24
140 – 150	-31	-23	-16	-7	+7	+13	+19	+24
150 – 160	-33	-25	-16	-7	+7	+13	+19	+24
160 – 170	-34	-26	-17	-7	+7	+13	+19	+24
170 - 180	-35	-26	-17	-7	+7	+13	+19	+24
180 – 190	-36	-27	-17	-7	+7	+13	+19	+24
190 – 200	-37	-27	-17	-7	+7	+13	+19	+24
> 200	-37	-27	-17	-7	+7	+13	+19	+24

Note 1: Minor road advance detection location before adjusting for gradient, based on standard values provided in Table 4 or adjusted location based on values provided in Appendix B.

Table 15 – Minor road advance detection location adjustment for minor road grades (m) – minor road speed 100 km/h

Advance detector location (See Note 1)	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
50 – 60 m	-11	-8	-6	-3	+3	+6	+9	+11
60 – 70	-13	-10	-7	-3	+3	+7	+10	+13
70 – 80	-15	-12	-8	-4	+4	+8	+12	+16
80 – 90	-18	-13	-9	-4	+5	+9	+14	+18
90 – 100	-20	-15	-10	-5	+5	+10	+15	+19
100 – 110	-22	-17	-11	-5	+6	+11	+16	+20
110 – 120	-24	-18	-12	-6	+6	+11	+16	+20
120 – 130	-26	-20	-13	-6	+6	+11	+16	+20
130 – 140	-28	-21	-14	-6	+6	+11	+16	+20
140 – 150	-29	-22	-14	-6	+6	+11	+16	+20
150 – 160	-30	-22	-14	-6	+6	+11	+16	+20
> 160	-31	-22	-14	-6	+6	+11	+16	+20

Note 1: Minor road advance detection location before adjusting for gradient, based on standard values provided in Table 4 or adjusted location based on values provided in Appendix B.

Table 16 – Minor road advance detection location adjustment for minor road grades (m) – minor road speed 80 km/h

Advance detector location (See Note 1)	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
50 – 60 m	-11	-8	-6	-3	+3	+6	+9	+11
60 – 70	-13	-10	-7	-3	+3	+7	+10	+12
70 – 80	-15	-12	-8	-4	+4	+7	+10	+13
80 – 90	-17	-13	-9	-4	+4	+7	+10	+13
90 – 100	-19	-14	-9	-4	+4	+7	+10	+13
> 100	-20	-14	-9	-4	+4	+7	+10	+13

Note 1: Minor road advance detection location before adjusting for gradient, based on standard values provided in Table 4 or adjusted location based on values provided in Appendix B.

Table 17 – Minor road advance detection location adjustment for minor road grades (m) – minor road speed 70 km/h

Advance detector location (See Note 1)	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
50 – 60 m	-11	-8	-6	-3	+3	+6	+9	+11
60 – 70	-13	-10	-7	-3	+3	+7	+10	+12
70 – 80	-15	-12	-8	-4	+4	+7	+10	+13
> 80	-20	-14	-9	-4	+4	+7	+10	+13

Note 1: Minor road advance detection location before adjusting for gradient, based on standard values provided in Table 4 or adjusted location based on values provided in Appendix B.

Table 18 – Minor Road advance detection location adjustment for minor road grades (m) – minor road speed 60 km/h

Advance detector location	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
For any location within the bounds provided in Appendix B	-10	-8	-5	No adjustment required	No adjustment required	+4	+6	+7

Table 19 – Minor road advance detection location adjustment for minor road grades (m) – minor road speed 50 km/h

Advance detector location	-8%	-6%	-4%	-2%	+2%	+4%	+6%	+8%
For any location within the bounds provided in Appendix B	-8	-5	-3	No adjustment required	No adjustment required	+3	+4	+5