

The use of Wire Rope Safety Barrier (WRSB)

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Road Design Note RDN 06-02 September 2016

1. Purpose

This note covers the design requirements for wire rope safety barrier (WRSB) for all arterial roads in the state of Victoria.

This Road Design Note (RDN) should be read in conjunction with Sections 4.2 and 6.0 of the Austroads Guide to Road Design (AGRD) Part 6 and VicRoads Supplement (VRS) Part 6. Where conflicts or discrepancies occur between this note and the Austroads Guide to Road Design or VicRoads Supplements, this note shall take precedence.

This RDN should be read in conjunction with Road Design Note 06-04 Accepted Safety Barrier Products and Standard Section 711 – Wire Rope Safety Barriers.

2. Performance standards

WRSB shall meet the following requirements:

- Conformance with the requirements of Australian Standard AS/NZS 3845 Road Safety Barrier Systems.
- Satisfactory crash testing in accordance with the Recommended Procedures for the Safety Performance Evaluation of Highway Features as developed by the United States National Cooperative Highway Research Program (NCHRP Report 350) to at least Test Level 4 including the 4-11 test designation, or other accepted equivalent procedures.
- Conformance with the requirements of VicRoads Standard Specifications for Roadworks Section 711 – Wire Rope Safety Barrier.
- Details of the particular WRSB system including evidence of compliance with all of the above points that have been assessed by VicRoads and accepted for use.

WRSB systems accepted by VicRoads as complying with these requirements are listed in RDN 06-04. Licensed suppliers of any WRSB systems deemed complying with these requirements after issue of the latest version of RDN 06-04 will be issued with letters of acceptance. WRSB installations on the VicRoads network shall be designed and certified by a designer prequalified in the VicRoads road design category. While advice, guidance and approval may be sought from the licensed supplier during the design stage, at the time of writing this RDN no supplier has been accepted as a VicRoads prequalified designer.

Alterations made to a WRSB design following certification, shall be endorsed by the original designer and approved by the Superintendent.

WRSB systems must be constructed and maintained in accordance with specified design requirements and the supplier's specifications & maintenance instructions, by a contractor/installer with experience and knowledge in the area of WRSB installation.

3. Application of WRSB

WRSB may be used along the median of divided roadways and along the outer verge of roads where the warrants for the use of such safety barriers are met.

General guidelines for the use, selection and application of safety barriers are set out in Section 6.0 of the VRS Part 6.

As set out in Section 6.2.3 of VRS Part 6, flexible systems are generally considered the barrier of choice where site conditions are compatible with their use and the level of containment required is within their performance capability. Controlled crash testing and actual field performance has shown that flexible systems have lower occupant injury risk than semi-rigid barriers, which have lower occupant injury risk than rigid systems.

WRSB should be avoided on popular motorcycle routes due to the current motorcycle community perception that WRSB is especially hazardous for riders. While no direct evidence of increased injury from the ropes has been found, safety barrier posts present the greatest risk for motorcyclist injury and in these situations, guard fence with crash tested under-run is advised over WRSB with post cushions.

RDN 06-02 DPage 1 of 18FinalSeptember 2016
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4. Design requirements

This section provides details of design criteria to be met as part of the assessment of the suitability of WRSB for use at a particular site. As WRSB systems are proprietary products, the suitability of a WRSB for a specific site should meet both VicRoads and supplier requirements.

WRSB designers must provide an installation that will perform as designed and crash tested by the system owner. While each proprietary system has a different crash tested configuration and result, this RDN provides a uniform design practice that includes all WRSBs.

4.1. Horizontal & vertical alignment

As WRSB systems consist of tensioned ropes, there are limitations on their use with regard to their horizontal and vertical alignments as detailed below:

4.1 (a) Horizontal alignment

The minimum allowable curve radius for WRSB installations is 200m, or the supplier's minimum recommended radius, whichever is the greater.

The effect of barrier curve on barrier deflection should also be considered when determining a barrier radius. See Section 4.2.3 and Appendix A for the effects of curve on deflection.

100m radius curves may only be used in accordance with Appendix E - Stopping Refuge Bay Layout.

4.1 (b) Vertical alignment

The minimum allowable sag curve K value is 30. There is no K value limit for crest curves.

In some instances, the use of intermediate anchors at the base of sag curves may be considered to reduce ropes from rising. See section 4.3.7 for Intermediate anchor details.

Refer to AGRD – Part 3: Geometric Design and VRS Part 3, for the definition of K value.

4.2. Barrier offset criteria

This section describes the offsets required between the barrier and:

- Adjacent traffic lanes (4.2.2)
- Unyielding hazards (4.2.3)
- Fill batters and table drains (4.2.4)
- Vertical drops (4.2.5)
- Kerb and channel (4.2.6)
- Depressed grated pits (4.2.7)

4.2.1. General layout

Consistent with the type of barrier being used, it is desirable to locate safety barriers as far from the edge of the traffic lane as site conditions permit, as this will maximise the chance of the driver being able to regain control of the vehicle before impacting the barrier. Nuisance impacts on WRSB systems can be costly for Road Authorities as the flexible nature allows for greater damage during minor impacts and can require frequent repair.

There is no restriction on the maximum offset of WRSB from the edge of pavement, subject to the other requirements of this RDN being met.

4.2.2. Offsets to traffic lanes

The offset from the nearest traffic lane should be as generous as can be realistically provided. The ability of a vehicle to stop clear of the traffic lane is an important factor in the provision of a wide clearance from traffic lane to barrier.

4.2.2(a) Outer verges

Requirements for WRSB offset from the edge of the nearest traffic lane are as follows:

Desirable minimum offset – 4.0m

The desirable minimum offset of 4.0m provides a comfortable width for a vehicle to stop clear of the traffic lane and barrier. This offset also provides a recovery area between the traffic lane and barrier for errant vehicles. This offset should be adopted as a minimum wherever possible.

Minimum offset – 3.0m

The minimum offset of 3.0m provides an adequate width for a vehicle to stop clear of the traffic lane and barrier.

Absolute minimum offsets - < 3.0m

Absolute minimum offsets are defined as any offset between 1.0m and 3.0m. Absolute minimum offsets shall only be adopted after any required VicRoads approvals for offsets in this range have been obtained.

In accordance with Section 6.3 and Appendix VA of VRS Part 6, the approval of a VicRoads Regional Director is required for any WRSB installation at absolute minimum offsets.

Minimum and desirable offsets ensure that vehicles can safely pull over in an emergency and reduce the occurrence of nuisance vehicle impacts, therefore reducing maintenance efforts and cost for Regions.

Absolute minimum offsets should be considered as a last resort option, in which case a review of barrier type may be required to determine whether semi-rigid or rigid barriers will provide a greater long term cost effective barrier solution.

4.2.2(b) Medians

Offset requirements for WRSB in medians are the same as those on outer verges as described in Section 4.2.2(a). When seeking approval for absolute minimum offsets in medians, details of the width available for vehicles to stop on the adjacent outer verge should be provided to assist in the assessment process.

In addition to these requirements, where WRSB is installed close to one carriageway, the potential for that carriageway to

RDN 06-02 DPage 2 of 18FinalSeptember 2016	September 2016
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be affected by deflection of the barrier due to impacts from the opposing carriageway needs to be considered.

Where the offset proposed is less than the offset required to unyielding hazards described in Section 4.2.3, there is potential for the barrier to deflect into a traffic lane. Offsets in this range should only be adopted after an assessment that considers:

- Whether an alternative barrier type is more appropriate, and
- Whether the benefits of using WRSB justify the risk posed to traffic in the lane closest to the barrier.

Further guidance on narrow median options can be found in Section 5.4.3 of VRS to AGRD - Part 6 and Section 4.7 of VRS Part 3.

4.2.2(c) Other considerations

Effects of shoulders on offset requirements

Shoulder widths appropriate to the road classification and traffic lane configuration should be maintained.

Maintenance of areas adjacent to and surrounding WRSB

The on-going maintenance of the areas on both sides of the barrier should be taken into account when considering the installation of WRSB. The cost, practicality and Occupational Health & Safety implications of the maintenance of these areas need to be considered in accordance with Section 28 of the OH&S Act 2004.

Where WRSB is proposed adjacent to unsealed shoulders, the shoulders should be sealed in conjunction with the WRSB installation unless the WRSB is offset from the shoulder "sufficiently" to enable maintenance between WRSB and shoulder, in accordance with current maintenance practices and safe operating procedures.

Refer Section V6.7.12 of VRS to AGRD - Part 6 for additional guidance of when to seal.

Concrete maintenance strips shall be provided in accordance with VicRoads Standard Specification Section 711 and SD 3503.

Sight lines

The effect of WRSB on sight distances, particularly at intersections and driveways, should be considered when selecting barrier offsets. WRSB systems do not provide a see-through effect for drivers and when viewed at low angles, such as intersections or driveways, can interfere with sight lines up to the height of post (1025mm for tallest accepted system).

Where visibility is poor, consideration may be given to flaring the barrier terminal, shortening the barrier length or eliminating the protected hazards to achieve the required sight distances. Refer SD 3573 for flared WRSB terminal details.

Sight distances shall be in accordance with AGRD and relevant VRS.

Provision for stopping

The safety of vehicles stopping adjacent to a WRSB must be considered. Provision of stopping opportunities should be consistent with those available on adjacent sections of the road where barriers are not required.

Where long sections of barrier are being considered, provision for stopping should be made as follows:

- Offsets to Traffic Lane ≥ 4.0m: No special provision is required.
- Offsets to Traffic Lane < 4.0m:

When the entire barrier length is offset <4.0m from the traffic lane, the desirable maximum barrier length is 500m. Where barrier lengths longer than 500m are required, consideration should be given to providing refuge bays as shown in Appendix E at a maximum spacing of 500m. Where more than one barrier installation is proposed greater than 500m, a minimum separation between terminals of 50m that allows vehicles to stop clear of traffic lanes should be provided, subject to the clear zone and required point of redirection being met.

Provision for refuges or breaks between lengths of barrier at spacing less than 500m should be considered where the road alignment restricts the visibility of stationary vehicles.

4.2.3. Offsets to roadside hazards

When used to shield errant vehicles from roadside hazards (e.g. trees, poles, batters, etc), sufficient clearance must be allowed between the WRSB and the hazard to allow for either the dynamic deflection or working width of the barrier when impacted.

Dynamic deflection is the amount the WRSB deflects from its initial position during a full-scale impact test, while working width is the width required to prevent an impacting vehicle from colliding with a hazard above and behind the barrier. Working width includes both the dynamic deflection of the WRSB and the extra width to allow for the roll of an impacting vehicle. See figure 1. Since current WRSB systems are accepted at Test Level 4, the vehicle roll allowance is measured during an 8,000 kg single-unit truck impacting the barrier at 80km/h and 15°.

RDN 06-02 D	Page 3 of 18	Final	September 2016



Figure 1: Working Width (Source: AGRD - Part 6)

The desirable selection of either "working width" or "dynamic deflection" as sufficient clearance shall be based on the type of hazard requiring protection.

Case 1

Where the hazard can be impacted by the vehicle roll allowance (e.g. pole or tree), "working width" shall be used.

Case 2

Where the hazard is low enough that it does not interfere with the vehicle roll allowance beyond the barrier (e.g. batter), "dynamic deflection" is considered sufficient.

See Appendix A for standard barrier design deflections and details for the selection of "working width" or "dynamic deflection".

Further, for a certain vehicle impact, the extent of either the "dynamic deflection" or "working width" will be dependent on a number of factors including the:

- post spacing,
- length of barrier between anchors,
- curvature of barrier,
- wire rope tension,
- ambient temperature, and
- maximum rope height and range.

WRSBs are tested in a single configuration where the above factors are set. For design versatility, these factors may be designed in accordance with this RDN and the 'dynamic deflection and 'working width' shall be adjusted to suit. The minimum offset required between the barrier and the hazard is the maximum barrier deflection (Dmax), which can be calculated using the following formula:

Dmax	=	Dstd x FI x Fc, where:
Dmax	=	Calculated maximum barrier deflection (m)
Dstd	=	Standard barrier design deflection at the nominated post spacing (m) (working width or dynamic deflection)
FI	=	Barrier (rope) length correction factor
Fc	=	Barrier curvature correction factor

Accepted values of are detailed in Appendix A.

This formula is intended to determine Dmax on continuous lengths of barrier, between leading and trailing POR. Where a transition to another safety barrier system is required, the design is to meet the offset requirements of Section 4.3.8.

Wire rope tension is only applied during installation however, it is essential for designers to understand its affect on the system. Wire rope tension is specified by each system supplier and is calculated from the Annual Average Daily Temperature at site. While this ensures 'on average' the wire rope is correctly tensioned, it also means that during excessively hot or cold days the system will deflect more or less, respectively, than designed. It is therefore recommended that AADT is specified for simplicity at each site.

4.2.4. Offsets to fill batters & table drains

The offset required between WRSB and the hinge point of fill batters or table drain front slopes shall be the greater of:

- The minimum width of verge required to support the barrier, see Section 4.2.4(a), and
- The minimum width of verge required to accommodate deflection of the barrier, see Section 4.2.4(b).

4.2.4(a) Verge widths for support of WRSB

The verge width required between WRSB and the batter hinge point to support the barrier and anchor blocks at any particular site shall be determined in conjunction with the WRSB supplier.

The minimum offset from the batter hinge point, using the nominated default post footing is the greater of 1.0m or as per the supplier's specification. Where the verge width is reduced below 1.0m or the supplier's requirements, the post footing dimensions are to be increased in accordance with geotechnical testing and the WRSB supplier's guidance.

Refer VicRoads Standard Section 711 for information on Post Foundations and Anchor Blocks.

RDN 06-02 D	Page 4 of 18	Final	September 2016
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4.2.4(b) Verge widths for deflection of WRSB

The desirable verge width required between WRSB and batter hinge point is the full width of Dmax (deflection) described in Section 4.2.3. WRSB is designed and tested to work optimally when a flat traversable surface is provided behind the barrier (10:1 or flatter).

Where this is not possible or the cost is prohibitive, a batter overhang (BOmax) may be considered within the deflection area in accordance with the design precedence and formula below.

The intent of this formula is to ensure that during a capacity impact at least one set of wheels of the vehicle will remain on the verge. This is considered to occur when the maximum deflection does not overhang more than 1.3m past the batter hinge point.

Vmin	=	Dmax –	BOmax, where:	

- Dmax = Maximum barrier deflection, see Section 4.2.3;
- BOmax = Maximum batter overhang (1.3m);
- Vmin = Minimum verge width between the batter hinge point and WRSB, see also Section 4.2.4(a).

While 1.3m is the absolute maximum batter overhang allowable, smaller values are preferred where possible to ensure redirection can occur entirely on the verge. Designers will need to assess competing objectives such as the barrier offset to traffic lane vs. offset to the hinge point.



Figure 2: Verge widths for deflection

Note that this formula only applies to fill batters and table drains as the vehicle is able to pass over the hazard without impacting an unyielding hazard. Batter slopes beyond the batter hinge point should be desirably 4:1 or flatter.

The "working width" standard is not required for fill batters, table drains, culverts or retaining walls where the area behind the barrier intruded by an 8,000kg vehicle roll will not interfere with the hazard.

Where a WRSB system has been successfully crash tested with the barrier located on or beyond the batter, an installation similar to that tested may be adopted. The following conditions must be met before adopting this barrier configuration:

- Batter slope no steeper than crash tested slope.
- Barrier offset to batter hinge point no greater than crash tested offset.
- Pavement/verge crossfall similar to that crash tested.

- Barrier height equivalent to crash tested configuration.
- Adequate support available for post foundations, demonstrated by side load testing.

At the time of writing this RDN, no WRSB systems have been accepted at locations on or beyond the batter hinge point. Terminals for WRSB should not be located beyond the batter hinge point unless crash testing has shown the proposed terminal configuration to be acceptable.

Design Precedence: Offset to fill batters

Where site constraints do not permit a 10:1 traversable surface behind the barrier equal to Dmax, the recommended order of precedence for reducing verge widths to fill batters is as follows. All design decisions must be documented.

- 1. Provide a 10:1 traversable surface behind the barrier equal to Dmax;
- 2. Provide a 6:1 traversable surface behind the barrier equal to Dmax;
- Consider a reduced post spacing to lower Dmax, (NB: increase in barrier severity);
- 4. <u>Consider an alternate barrier type to suit available offset</u>, (*NB: consider change in barrier severity & performance*);
- Provide Vmin = 1.0m and BOmax = 1.3m, where batter slope is no steeper than 4:1, (*NB: greater verge widths are preferred*);
- Consider an increased concrete post footing size to provide Vmin ≤ 1.0m and BOmax ≤ 1.3m, where the batter slope is no steeper than 4:1;
- Undertake a context sensitive design with careful consideration of risk. Absolute minimum BOmax ≤1.3m where batter slope is no steeper than 2:1. (*NB: risk must be carefully managed and an alternate barrier type is strongly recommended)*;
- 8. Alternate barrier type required.

4.2.5. Offsets to vertical drops less than 1.0m

Offsets to vertical drops greater than 1.0m shall be designed in accordance with Section 4.2.3 - Offsets to Roadside Hazards.

If WRSB is being used on new roads to protect culverts or retaining walls, the minimum offset required between the barrier and the vertical drop shall be the Dmax as described in Section 4.2.3.

If WRSB is being retrofitted to an existing road and hazards requiring protection include culvert endwalls at offsets to the barrier less than the Dmax from Section 4.2.3, WRSB may be used to protect the endwall by reducing the post spacing to 1.0m at the culvert where the following conditions apply:

- Extension of the culvert to meet the offset requirements for culverts on new roads is impractical or the cost is prohibitive.
- The WRSB installation is at least 100m long and the culvert is not the only hazard warranting protection.

RDN 06-02 DPage 5 of 18FinalSeptember 2016	RDN 06-02 D	Page 5 of 18	Final	September 2016
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- Reduced post spacing of 2.0m is used on the remainder of the WRSB installation – See Appendix A.
- The 1.0m post spacing is applied as per Section 4.3.3.
- A minimum offset of 1.0m is available between the barrier and the endwall.

Where the culvert is the only hazard warranting protection, the offset requirements for new roads shall apply or an alternative barrier system such as guard fence should be adopted.

WRSB shall only be used for the protection of vertical drops after a risk assessment has established that the containment level provided by the proposed barrier system is appropriate for the site.

These restrictions only apply to vertical drops less than 1.0m as the vehicle is able to pass over the hazard without impacting an unyielding hazard. "Working width" standard is not required.

4.2.6. Offsets to kerb and channel

WRSB has, like other safety barriers, been designed and tested to contain and redirect an impacting vehicle when struck by the vehicle with its centre of gravity at or near its normal position. It is therefore desirable that kerb and channel should not be located in front of WRSB because when a vehicle crosses kerb, vehicle roll and pitch are developed. This is especially so where vehicle speeds exceed 70 km/h.

Where kerb and channel is essential, Table 1 below details the accepted range of offsets relative to the back of kerb

- The desirable offset locates the barrier far enough behind the kerb to allow an errant vehicle to stabilise after crossing the kerb before striking the barrier.
- The minimum and absolute minimum offset locates the barrier at a point where the vehicle bumper is likely to be close to its normal height above the ground when the barrier is hit. The absolute minimum offset range should only be used as a last resort given the bumper trajectory can vary outside this range.

WRSB should not be located outside the desirable, minimum or absolute minimum offset ranges.

Further, for speeds greater than 90 km/h, "barrier kerb" type is prohibited as the vehicle trajectory at high speeds is greatly affected by the impact angle, making it very variable and difficult to specify an acceptable offset.



Figure 3: Bumper trajectory behind kerb

Table 1: Offset of WRSB from back of kerb and channel

Operating speed (km/h)	Desirable ¹ (m)	Minimum ¹ (m)	Absolute Minimum ^{1,4} (m)
> 90 ³	≥ 4.5	0	1.2 to 1.8
70 to 90	≥ 4.0	0	1.2 to 1.8
<70	≥ 2.5	0	1.0 to 2.0

Source: Table V6.4 of VRS to AGRD - Part 6

Notes:

- 1. WRSB offsets from traffic lane described in Section 4.2 must also be met when considering offsets of WRSB from back of kerb.
- 2. Offset restrictions stated in Table 1 only apply to "barrier kerb" and "semi-mountable kerb" types. "Mountable kerbs" have no WRSB offset restrictions in accordance with Table V6.4 of VRS to AGRD Part 6.
- 3. "Barrier kerb" type prohibited.
- 4. "Absolute Minimum" indicates an offset range that is only acceptable if it is not possible to obtain the desirable offset, and Om offset is considered unfeasible due to nuisance hits. This range indicates where bumper trajectory (and centre of gravity) is expected to be low enough to allow the barrier to function as tested. This is indicated by the location of the second post in Figure 3.

4.2.7. Offsets to depressed grated pits

Where WRSB is proposed behind depressed grated pits as shown in standard drawings SD1411 and SD1421, offsets shall be as per kerb and channel with offsets measured to the edge of the pit apron.

4.2.8. Offsets to cut batters

Cut batters that are steeper than 4:1 or are hazardous due to a combination of height, slope and surface (Refer AGRD Part 6), shall be treated as a hazard and have a clearance between WRSB and hazard equal to or greater than Dmax.

The considerations and requirements outlined in Section 4.2.4 (b) shall not apply to cut batters, given a vehicle cannot pass over the hazard as they can with fill batters.

Where a WRSB system has been successfully crash tested with the barrier located on or beyond the cut batter, an installation similar to that tested may be adopted. See conditions specified in Section 4.2.4(b).

It should also be noted that cut batter slopes may reduce the clear zone required where the batter can contribute to redirecting the errant vehicle. Refer Section V4.2.2.3 of VRS to AGRD - Part 6.

4.3. Other requirements

This section provides some details of other WRSB design requirements, however full details of individual WRSB design requirements are provided in the supplier's specification and VicRoads Product Detail Sheets. The supplier's advice may be sought during the design stage for other system requirements.

RDN 06-02 D	Page 6 of 18	Final	September 2016
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4.3.1. Allowable slopes for installation of WRSB on batters

It is desirable to locate WRSB where the approach slope from the pavement is essentially flat. However, installation of WRSB on batters is acceptable where the slopes shown in Table 2 below are provided between the pavement and the barrier.

Table 2: Allowable batter slopes for WRSB

Project type	Allowable slope between WRSB & pavement
New construction	10:1 or flatter
Retrofitting barriers to Existing Road	6:1 or flatter

AASHTO 2012 advises a barrier free area from hinge point to 3.6m beyond the hinge point on a 6:1 slope. Slope rounding is also recommended.

WRSB may be installed on slopes steeper than those shown in Table 2 when the system has been crash tested on steeper slopes. See Section 4.2.4(b) for details.

4.3.2. Barrier length

Length of redirection (LOR)

The LOR is the length of WRSB required to redirect an errant vehicle and shield the driver from a roadside hazard. It is a requirement that WRSB be positioned so that the extremities of the length of redirection (point of redirection) are appropriately aligned with the hazard required to be protected.

Consideration needs to be given to the length of redirection for both adjacent and opposing traffic if the identified hazard can be impacted by the opposing traffic. Refer Appendix B.

The 'Run-Out Length Method' shall be used to determine the points of redirection in Victoria. This method has been used to determine minimum lengths of redirection shown on VicRoads Standard Drawing 3521.

Terminals

WRSB terminals are considered to be Gating. They are crashed tested to assess vehicle performance when impacted, however are not required to redirect or contain a vehicle.

The location of the leading and trailing POR on the barrier varies for each product. When the position of the POR is not critical or the system to be used is unknown, a terminal length, prior to the POR (gating section), of 12m may be assumed for design purposes. Designers may also refer to the supplier's drawings and specifications for further details.

Flaring

A barrier is considered to be flared when it is not parallel to the edge of traffic lane. A flared installation maximises the offset between the traffic lane and the barrier, increases the

likelihood of the driver being able to regain control and minimises nuisance hits.

WRSB is designed to work best with a glancing impact; therefore the flare alignment applied should not enable impacts with the WRSB to occur at an angle greater than 25 degrees.

Refer VicRoads Standard drawing SD 3573 for WRSB flare alignment and maximum flare offsets. This drawing is to be used in conjunction with SD 3521.

Minimum and maximum barrier length

The minimum length of WRSB required between leading and trailing POR is 60m where the WRSB system adopted is not specified in the design. When a system type is specified, the approved minimum length may be sought from the product supplier.

There is no fixed maximum length for an installation of WRSB. However, if the barrier is hit, particularly at the end anchor, the ability of the barrier to resist subsequent impacts before the barrier is repaired is uncertain. To reduce the risk of long lengths of barrier being disabled by single vehicle impacts, a maximum length of 1 km should generally be adopted. The effect of barrier length on barrier deflection should also be considered when determining an appropriate barrier length. See Section 4.2.3 and Section 4.3.7 for use of intermediate anchors.

Access for asset owners

Provision for the maintenance of assets, in particular those requiring large vehicles (i.e. power poles), should be considered when designing a WRSB installation. The longitudinal nature of WRSB has the potential to greatly restrict, or entirely block access to these assets.

Consideration must be given to the surrounding infrastructure and types of vehicles employed by service providers to best design WRSB appropriate to their access requirements.

The WRSB design and installation should provide reasonable access for asset owners including accessible overlapped breaks in the barrier, and a driveable path behind the barrier.

Access for emergency services

Provision of access for emergency services should be considered when designing a WRSB installation. When designing long lengths of centre median WRSB, consideration should be given to the crossing and turning movements of emergency service vehicles, noting that travel to the next cross road may not always be possible. Crossing points for emergency services can also act as maintenance accesses for wide medians.

The Country Fire Authority (CFA) Wire Rope Safety Barrier Position Paper should be considered in the design of WRSB and the CFA should be consulted at a regional level before the installation of a WRSB.

RDN 06-02 D Page 7 of 18 Fin	Final	September 2016
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4.3.3. Minimum length of reduced post spacing

Where the post spacing is reduced along the length of a WRSB installation to meet the offset requirements of Section 4.2.3, the following requirements shall be met. See Appendix D for worked example.

• Where the hazard is at least 10m long, the reduced post spacing shall apply for the full length of the hazard plus a minimum of 10m either side of the hazard.

	///////////////////////////////////////	HAZARD
WRSB		
10 m	≥10 m	10 m
	REDUCED POST SPACING	

Figure 4: Reduced post spacing for hazards longer than10m

• For hazards less than 10m long, the minimum length of reduced post spacing required is 30m, with 10m past the hazard.



Figure 5: Reduced post spacing for hazards shorter than 10m

4.3.4. Barrier height

The individual rope heights for a WRSB product are specified by the owner of the respective barrier system.

Where the WRSB is erected within 0 to 1m behind the back of kerb, the rope height shall be measured from the lip of kerb. Where the WRSB is erected within 1.5m from edge of carriageway without kerb, the rope height shall also be measured from that edge of carriageway (typically the edge line). For distances beyond 1.5m, the rope height shall be measured from the nominal ground surface at the WRSB location. Refer SD 3502.

4.3.5. Post foundations

Adequate ground support must be provided to the posts and anchors to enable the barrier system to perform as designed.

WRSB posts shall be located in concrete ground sockets in accordance with the supplier's specification. While it is always recommended that a geotechnical investigation is completed, the default post footing sizes shall be in accordance with RDN 06-04 unless a geotechnical investigation has been undertaken and an alternative size has been approved by the supplier.

Where the run-off road risk associated with heavy vehicles is particularly high, consideration may be given to larger post foundations than specified. Although larger foundations are not required for performance, it has been observed that impacts from heavy vehicles can cause the concrete foundations to pull out of the ground. This decision could be considered on a benefit/cost ratio for the project.

4.3.6. End treatments & run out areas

Appropriate terminations of the WRSB shall be provided beyond the length of redirection by installing end anchor blocks and cable connections in accordance with the supplier's specification.

Terminals successfully crash tested to NCHRP 350 Test Level 3 shall be used for all WRSB terminations.

WRSB anchor foundations shall be in accordance with the supplier's specification and default anchor foundation sizes shall be in accordance with RDN 06-04, unless a geotechnical investigation has been undertaken and an alternative size has been approved by the supplier.

Where site conditions permit, straight crash tested terminals should be used in conjunction with a flared barrier alignment to increase the offset of the terminal from traffic and minimise the likelihood of end on impacts. Details of the required layout of crash tested terminals and associated runout areas are shown on standard drawing SD 3573.

Runout Areas

End terminals on WRSBs are considered to be gating. This means that the terminal is designed to allow an impacting vehicle to pass through the terminal (AS/NZS 3845).

The provision of a run out area, whilst desirable, must not be considered a substitute for providing an adequate length of redirection.

Appropriate run out areas should be provided at all approach terminal locations. A run out area beginning from the start of terminal, extending 18m past the point of redirection and 6.0m behind the barrier shall be provided as per SD 3573.

Desirably the slope of the run out area should be 10:1 or flatter in order to achieve optimal terminal performance. Where this is deemed impractical, refer SD 3573 for minimum grading details.

Where the minimum run out area specified is not achievable, refer to SD 3573 for the appropriate order of precedence.

4.3.7. Intermediate anchors

Where the barrier length proposed for a given site exceeds 250m, but the Dmax calculated under Section 4.2.3 exceeds the available clearance behind the barrier, intermediate anchors may be used to reduce the barrier length (FI) used in the calculation of Dmax.

Depending on the specific barrier system, intermediate anchors may consist of an in-line anchor or separate barrier installations with overlapping points of redirection. Refer to supplier's specification for details.

Refer to Section 5 – Design Philosophy for guidance on when barrier lengths should be shortened.

RDN 06-02 DPage 8 of 18FinalSeptember 2016
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4.3.8. Transition to other safety barrier systems

WRSB shall not be directly connected to other safety barrier systems, including other proprietary WRSB systems or bridge end posts, unless details of the proposed connection have been submitted for assessment and accepted for use by VicRoads Technical Services.

However a WRSB may be interfaced with other safety barrier systems by overlapping barriers with sufficient clearance between them to ensure neither barrier adversely affects the performance of the other and overlapping is sufficient to allow a continuous 'length of redirection'. In this instance the required runout area shall not apply for the protected approach terminal.

Transition from a WRSB to a rigid barrier or bridge barrier, shall be undertaken in accordance with VicRoads Standard Drawings. In addition, it is strongly recommended that the use of an intermediate semi-rigid barrier be considered as protection to ensure that if a WRSB is decommissioned after impact, a rigid barrier end is not exposed. Releasing systems shall not be used in instances where an intermediate semirigid barrier cannot be provided.

Refer to VicRoads Standard Drawings for Roadworks.

5. Design philosophy

This section describes the approach that should be taken when designing WRSB installations. The aim of the design should be to maximise the offset of the barrier from the traffic lane, while providing adequate clearance behind the barrier to allow it to deflect on impact.

Ideally a WRSB installation will provide the desirable offsets to traffic lanes and hazards described in Section 4.2, while maximising the post spacing and length between anchors. Where site constraints do not permit an ideal installation, the order of preference for reducing offsets and barrier design parameters is as follows:

- 1. Reduce offset from traffic lane to barrier to a minimum of 3.0m.
- **2.** Adopt a reduced post spacing of 2.0m for the length of the barrier. See Appendix A.
- **3.** For installations longer than 250m, reduce barrier length between anchors to 250m minimum using intermediate anchors. See Section 4.3.7.
- **4.** Assess the risk of adopting a non-conforming or system specific design in accordance with the Superintendent and Appendix A.
- Consider stiffer barrier system such as guard fence, before reducing the offset to the traffic lane below 3.0m. See Section 4.2.2 and Appendix A.
- 6. It should be noted that while steps 1-3 above minimise the limits of a conforming design, steps 4 and 5 require additional consideration to the satisfaction of the Superintendent and Designer.

Appendix C provides details of how to apply this design philosophy.

Appendix D provides a worked example of WRSB design for a constrained site.

References

Supersedes: RDN 06 – 02C/Amdt 1 November 2015 VRS to AGRD Part 6 – Sections 4.2 to 6.0. VR Standard Drawings – SD 3500, 3503, 3521, 3573.

Approved by

Nava

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Road Design Notes are subject to periodic review and may be superseded.

Appendices

APPENDIX A:	Wire Rope Safety Barrier deflection calculation factors
APPENDIX B:	Procedure to determine the length of redirection of a WRSB
APPENDIX C:	Application of design philosophy
APPENDIX D:	Worked example
APPENDIX E:	Stopping refuge bay layout

Road Design Note 06-02 – Revision Summary

Issue	Approved	Date	Amendment
06-02	PRDE	July2012	First edition
А	PRDE	April2012	Major change
В	PRDE	Sept2013	Major change
С	M-RS&T	May2014	Major change
C / Amdt 1	M-RS&T	Nov2015	Minor change
D	M-RS&T	Sept2016	See below
Improved: Offset to fill batters, Offset from back of kerb;			
Added:	Added: Access for asset owners, Access for emergency services;		
Removed:	Reference to releasing terminals.		

RDN 06-02 D	Page 9 of 18	Final	September 2016
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Appendix A

A.1 Wire Rope Safety Barrier deflection calculation factors

The tables below contain the standard barrier design deflections (Dstd) and correction factors (FI, Fc) required to calculate the maximum barrier deflection (Dmax) as described in Section 4.2.3. (Dmax = Dstd x FI x Fc)

A.2 Dstd –Standard barrier design deflections at accepted post spacings

"Working width" or "dynamic deflection" shall be adopted, from Table 3 below, as the required standard barrier design deflection.

Table 3: D _{std} – Standard	barrier design	deflections ^{1,2}
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Post spacing class	Reduced	Standard
Post spacing	2.0 m	3.0 m
Working Width standard (4-12 Test)	1.9 m	2.3 m
Dynamic Deflection standard (4-11 Test)	1.5 m	1.8 m

Notes:

- 1. Values based on straight barriers, up to 250m long between anchors.
- 2. Values based on barriers with concrete post footings.
- Design deflections are based on NCHRP Report 350 Test Designations 4-11 and 4-12. See selection of 'dynamic deflection' or 'working width' for Dstd below.

A.3 Selection of "Dynamic deflection" or "working width" for Dstd

As stated in section 4.2.3, the selection of either "working width" or "dynamic deflection" as standard barrier design deflection Dstd, is dependent on the type of hazard being shielded. This can be simplified into two cases;

Case 1 – Where the hazard can be impacted by the vehicle roll allowance (e.g. pole or tree), "working width" shall be used. This is the preferred case for all situations.



Figure 6: Case 1 hazard

Case 2 - Where the hazard is low enough that it does not interfere with the vehicle roll allowance beyond the barrier (e.g. batter), "dynamic deflection" is considered sufficient.



Figure 7: Case 2 hazard

For these two cases, the "working width" and "dynamic deflection" values, quoted in Table 3 above, have been based on the results measured during NCHRP 350 crash test designation 4-12 and 4-11, respectively, which are considered a severe case for each hazard type.

As discussed in Section 2, each accepted WRSB system must demonstrate satisfactory crash testing in accordance with NCHRP report 350 to at least Test Level 4. This includes passing the following NCHRP 350 test designations:

- 4-10: 820 kg car at 100km/h and 20 degrees
- 4-11: 2,000 kg pickup at 100km/h and 25 degrees
- 4-12: 8,000 kg truck at 80km/h and 15 degrees

As a simplistic overview; the 820 kg vehicle impact ensures a low riding vehicle is captured by the barrier and the occupant ride down is acceptable. The 2,000 kg vehicle impact represents a worst case, high energy impact, generally resulting in the greatest dynamic deflection. And the 8,000 kg vehicle impact demonstrates containment for a higher centre of gravity vehicle, generally resulting in a larger working width than dynamic deflection due to the vehicle roll allowance beyond the barrier. See section 4.2.3.

As such, the WRSB "dynamic deflection" values are based on the 4-11 crash test where no vehicle roll and the greatest overall dynamic deflection was demonstrated, while the WRSB "working width" values are based on the 4-12 crash test, which resulted in a lesser dynamic deflection (than 4-11) but a greater overall working width beyond the barrier. Refer product crash test results for performance details.

FI – Barrier length correction factors

The FI to be adopted should be selected from Table 4 below.

RDN 06-02 D	Page 10 of 18	Final	September 2016

Table 4: Length correction factors (FI)

Rope length (m) ¹	Correction factor FI
0 - 250	1.0
251 - 350	1.1
$351 - 500^2$	1.15
> 500 ²	1.2

Notes:

- 1. Rope length is the total length of wire rope between anchor connections. (i.e. including terminals).
- 2. Deflection will continually increase as the wire rope length increases. Maximum barrier length shall be 1km in accordance with Section 4.3.2.

Fc – Barrier curvature correction factors

The Fc to be adopted should be selected from Table 5 below for all installations except those where impacts are only possible on the concave side of the curved alignment. For installations where impacts are only possible on the concave side, an Fc of 1.0 shall be adopted irrespective of curve radius.

Table 5: Curvature correction factors (F_c)

Barrier radius (m)	Correction Factor Fc
200 - 400	1.5
401 - 500	1.4
501 - 600	1.3
601 - 800	1.2
801 - 1500	1.1
> 1500	1.0

Notes:

1. Where the barrier alignment is straight, adopt Fc = 1.0

Concave side



Convex side



A.4 Non-conforming or system specific designs

If the requirements of this RDN cannot be met, a nonconforming or system specific design may be considered in accordance with the Superintendent, only after the use of a stiffer system of similar containment has been considered. The use of a non-conforming or system specific design can be advantageous over a lower containment barrier, such as guard fence, as the extra containment of a TL-4 system means protection for a larger range of vehicle types, especially if the impact energy is expected to be less than tested.

Non-conforming design

Where site conditions prevent the use of "working width" with case 1 hazard types, "dynamic deflection" may be considered for above ground hazards where a documented non-conforming design report has been completed, endorsed by Manager - Road Standards and Traffic and approved by the Superintendent.

This non-conforming design report shall demonstrate that the expected vehicle impact conditions on-site are reduced from the crash tested conditions. Including but not limited to a:

- small future vehicle fleet mix,
- reduced operating speed,
- lesser likely impact angle, and
- low probability of an impact.

By demonstrating that the 4-12 impact condition (8,000 kg truck at 80km/h and 15 degrees) is not expected on site; the deflection recorded during crash testing may not be expected and the "dynamic deflection" standard may be used as an absolute minimum case; 'case 3' below.



Figure 8: Case 3 hazard

The documented non-conforming design report for case 3 shall be endorsed by the Manager - Road Standards and Traffic, approved by the Superintendent and submitted to the final barrier supplier for review.

RDN 06-02 D	Page 11 of 18	Final	September 2016
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System specific design

Alternatively, where a specific product is known (e.g. an existing installation), the system supplier may be sought for advice and guidance of a specific systems performance. The system specific design may use data from the specific product crash testing as provided and approved by the product owner. System specific designs shall be:

- supported with evidence from the supplier,
- documented with correspondence from the owner,
- specified on the safety barrier design drawings,
- certified by a VicRoads prequalified designer, and
- approved by the Superintendent.

Any alterations made to the system specific design shall be endorsed by the original designer and supplier, and approved by the Superintendent. Approved suppliers of each WRSB system can be found in RDN 06-04.

All system specific designs shall use an accepted post spacing, specified in Table 3 (2.0m and 3.0m), with the exception of retro fit or context sensitive design exceptions. The use of alternate post spacing that have been crash tested shall be endorsed by the Manager of Safe System Design, and approved by the Superintendant.

RDN 06-02 D	Page 12 of 18	Final	September 2016

Appendix B

Procedure to determine the length of redirection of a WRSB

This procedure describes how to determine the minimum WRSB length of redirection (LOR) required to shield a hazard. A hazard in this context is defined as an obstacle or feature located on the roadside that may result in a higher severity accident when impacted by a vehicle than would be expected from a vehicle impacting the barrier. Refer to VRS Part 6 - Section 6.0 for discussion of hazards.

As a simplistic approach, the two main principles include:

- Using an accepted method to determine the required point of need for a hazard. The required point of need is the first point at which a road safety barrier is required to prevent an errant vehicle from striking the hazard. Barriers closer to the hazard are shorter in length. VicRoads preferred method is the "Run-Out Length method" specified in AGRD Part 6 Section 6.3.19. Refer also SD 3521 and 3573.
- Selecting a barrier product that can provide the redirective capabilities required between points of need; the minimum barrier length of redirection. Aligning the barriers POR with the required point of need will provide this minimum length of adequate protection.



Figure 9: Required point of redirection

The barrier POR location and configuration of the terminal is different for each WRSB product and should be confirmed with the supplier when the POR is critical. Where the POR is not critical, 12m from the beginning of the barrier may be assumed.

Reference should be made to Standard Drawing SD 3521 and 3573 in using this procedure.

1. One-way traffic

- 1.1 Locate the WRSB as close to the hazard as possible according to the instructions in Sections 4 and 5 of this RDN.
- 1.2 Determine the operating speed of the road alignment and the one-way AADT (approach volume). Refer to AGRD Part 3 - Section 3.0
- 1.3 Determine the width of the clear zone by referring to VRS Part 6 - Section 4.2 using the speed and volume from Step 1.2. The width of the clear zone is measured from the edge of the traffic lane nearest to the hazard.
- 1.4 Referring to Standard Drawing SD 3521 determine the distance "A" from the edge of the traffic lane to the WRSB and the protected width "B" from the traffic lane to the outermost point on the hazard.
- 1.5 Determine the minimum point of need (i.e. "Z" length) from Table B of Standard Drawing SD 3521. (multiply the "Z" value by the future AADT correction factor also in Table B of SD 3521)
- Locate the barrier POR at the calculated point of need. Length of redirection (LOR) = Z (approach) + length of hazard.

2. Two-way traffic

- 2.1 For the near-side traffic, determine point of need (i.e. "Z" length) on the approach end of the near-side traffic by repeating Steps 1.1 to 1.5 above.
- 2.2 For the far-side traffic, determine the point of need (i.e. "Z" length) on the approach end of the far-side traffic by repeating Steps 1.2 to 1.5 above, noting that the width of the clear zone and the distances "A" and "B" are measured from the centreline of the carriageway as shown in SD 3521.
- 2.3 Locate the barrier POR at the calculated points of need, providing a barrier LOR for the required length.
 Length of redirection = Z for the near-side traffic + length of hazard + Z for the far-side traffic.

RDN 06-02 D	Page 13 of 18	Final	September 2016
NDN 00-02 D	rage 13 01 10	i iliai	September 2010

Appendix C

Application of design philosophy

Figures C1 and C2 show the barrier design parameters that should be adopted when providing protection to unyielding hazards and embankment slopes respectively. The figures show how offsets and barrier design details should be modified as the clearance between the traffic lane and the hazard reduces.

Where a site has both embankments and unyielding hazards warranting protection, a barrier design that satisfies both Figure C1 and Figure C2 is required.

The approach shown in the figures can be summarised as follows:

Where site conditions restrict the clearance available between traffic lanes and a hazard warranting protection, the barrier design should be modified to limit its deflection before the offset of the barrier from the traffic lane is reduced below 3.0m. Where the hazard warranting protection is an unyielding hazard and a WRSB located 3.0m from the traffic lane would not have adequate clearance to the hazard after minimising post spacing and barrier length; consideration should be given to a non-conforming design before adopting a lesser containment barrier system such as guard fence or reducing the offset to the traffic lane below 3.0m. I.e. if the expected impact conditions on site are less than the crash tested conditions, then a TL-4 safety barrier system with reduced deflection may be more preferable than reducing the containment level. See to Section 4.2.2(a) for approval requirements applicable at the time of writing this RDN.

Where the hazard warranting protection is an embankment, the design parameters of WRSB are such that guard fence would generally not offer any advantages in terms of maximising the offset of the barrier from the traffic lane. The exception may be where the alignment is curved and the barrier length correction factor is significant, in which case guard fence should be considered if it allows a greater offset to traffic lane to be adopted.



Notes: 1. Use of minimum D_{etd} and reduced post spacing is not acceptable where the hazard is a vertical drop >1.0m. Refer Section 4.2.5

RDN 06-02 D	Page 14 of 18	Final	September 2016
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 For installations where the barrier curvature correction factor increases the design deflection significantly, guard fence should be considered to maximise the offset available from the barrier to the traffic lane.

4. Refer Section 4.2.4(b) for Design Philosophy - Offset to Fill Batters

RDN 06-02 D	Page 15 of 18	Final	September 2016
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Appendix D

Worked example



Barrier on curved alignment with hazards at varying offsets

Design input			
Alignment	700m radius curve		
Traffic volume	7,000 vehicles/day (2 ways)		
Speed limit	100km/h		
Cross section	2 lane 2 way highway in fill, 3.5m lanes, 2.5m shoulders, 1.5m verge, 4:1 batters, 4m wide (i.e. 1m high)		
Hazard	Trees at 1.6m, 2.0m and 3.0m offset from back of verge on inside of curve (refer diagram)		

Step 1: Identify hazards warranting protection

Determine clear zone width (VRS Part 6 - Section 4.0)

Speed limit = 100 km/h

Operating Speed = 110 km/h (AGRD Part 3 - Section 3.0)

One way traffic volume = 3,500 vehicles/day Basic clear zone width = 8m (VRS Part 6 – Figure V4.1)

4:1 fill batter slopes are considered partially recoverable where errant vehicles may travel further than on a flatter slope; Effective clear zone (ECZ) width (VRS Part 6 - Section 4.2.2.3)

For northbound traffic, 8m basic clear zone width extends over full width of batter. From VRS Part 6 - Figure V4.2, only half of the batter width can be included in the effective clear zone, so ECZ = 8 + 2 = 10m.



Figure 10: Effective clear zone

For southbound traffic, 1m of basic clear zone width extends over 4:1 batter. From VRS Part 6 - Figure V4.2, this clear zone width over the 4:1 batter is doubled, so ECZ = 7 + 2x1 = 9m.

- For northbound traffic, trees 1, 2 and 3 are within the ECZ, so protection is required.
- For southbound traffic, only trees 2 and 3 are within the ECZ and require protection.

Step 2: Determine barrier length of redirection

For northbound traffic, tree 1 will control the length of barrier required. For southbound traffic, tree 3 will control the length of barrier required.

Refer to Standard Drawing SD 3521 – Safety Barrier (Line B) Alignment Details

Northbound traffic

Tree 1 is offset 6.5m from the edge of traffic lane. Assuming a trunk width of 0.5m, adopt protected width B = 7m.

WRSB offset from traffic lane (A):

- Desirable offset = 4m (see Section 4.2.2)
- Minimum offset = 3m

At 4m offset from traffic lane, WRSB would be located on the 4:1 batter hinge point. This position is not acceptable, unless the system proposed has been successfully crash tested in this configuration (refer Section 4.2.4(b)). If the desirable offset is not possible, then WRSB should be located as far as possible from the traffic lane. As some verge width is likely to be required behind the barrier to meet design deflection requirements, try WRSB at 3m offset from traffic lane.

From Table B of SD 3521, at 110 km/h with A = 3.0m and B = 7m, Z = 65m.

 $AADT = 3,500 \text{ v/d}, \text{ therefore } Z = 55 \text{m} (65 \times 0.81)$

Southbound traffic

Tree 3 is offset 9m from the centreline of the road, which is the edge of the closest southbound traffic lane.

From Table B of SD 3521, at 110km/h with A = 6.5m and B = 9m, Z = 35m

AADT = 3,500 v/d, therefore Z = 30m (35 x 0.81)

Total length

Total Length of Redirection:

- Z for Tree 1 + Distance between Trees 1 & 3 + Z for Tree 3.
- = 55 + 120 + 30

= 205m

Barrier length:

- = 205 + terminals (12m where not specified)
- = 229m

RDN 06-02 DPage 16 of 18FinalSeptember 2016	September 2016
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Step 3: Determine barrier location and configuration

Having determined a length of redirection for the barrier at an offset of 3m from the traffic lane, the next step is to confirm that this offset is appropriate, and then determine the required post and anchor spacing. The aim of the design should be to maximise the offset of the barrier from the traffic lane and maximise the post and anchor spacing.

For the 3m offset from the traffic lane to be appropriate, the offsets required to hazards as described in Sections 4.2.3 and 4.2.4 respectively must be met.

Offsets to hazard (see Section 4.2.4)

The required offset between WRSB and hazard will be either "working width" for case 1 hazards or "dynamic deflection" for case 2 hazards. In this instance Tree 2 will act as a case 1 hazard and the batter will act as a case 2 hazard.

Tree 2 – Case 1 hazard

Given WRSB offset is 2.6m from Tree 2, working backwards to find allowable Dstd;

Dmax	=	DStd X FI X FC
Dmax	=	2.6m,
Fl	=	1.0, from Appendix A, Table 4, for barrier length

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= 229m
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Fc = 1.2, from Appendix A, Table 5, for 700m radius curve where convex side impacts may occur.
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2.6 = Dstd x 1.0 x 1.2,

Dstd = 2.17m

From Appendix A, Table 3, a "working width" standard for design deflection with a reduced post spacing is required to achieve Dstd = 2.17m (1.9m).

Fill Batter – Case 2 hazard

Given WRSB offset is 1 m from top of batter, the desirable verge width should be Dmax. working backwards to find allowable Dstd;

Dmax = Dstd x Fl x Fc

1.0	=	Dstd x	1.0 x	1.2

Dstd = 0.84m

From Appendix A, Table 3, a design deflection with either post spacing will not achieve Dstd = 0.84m.

If widening of the verge is not practicable, then the minimum verge width required can be Vmin.

Vmin = Dmax - 1.3m (see 4.2.4(b))

1.0m	=	Dmax – 1.3;
Dmax	=	2.3m
Dmax	=	Dstd x Fl x Fc
2.3m	=	Dstd x 1.0 x 1.2,
Dstd	=	1.91m

From Appendix A, Table 3, a "dynamic deflection" standard for design deflection with a standard post spacing is required to achieve Dstd = 1.91m (1.8m).



RDN 06-02 D Page	je 17 of 18	Final	September 2016
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Minimum constraint for the site is Tree 2, which requires reduced post spacing. Since the adoption of the larger post spacing would be preferable, and can be achieved for the case 2 batter hazard, it is possible to use a standard post spacing with a minimum length of reduced post spacing.

From Section 4.3.3, the minimum length of reduced post spacing is 30m. As the hazard can be approached from only one direction, the reduced post spacing should extend for 20m on the approach side of the tree, and 20m on the departure.

Having determined that WRSB can be located at 3m offset from the traffic lane and meets the clearance requirements to hazards and batters, confirmation is required from the barrier supplier that adequate support is available for the posts and anchors at this particular site.

Step 4 End treatments and runout areas

Both ends of the WRSB require crash tested terminals regardless if they are approach or departure. See Section 4.3.6.

Alternative treatments for the termination of WRSB are shown on standard drawing SD 3573. The highest standard treatment that can be accommodated at the site should be adopted. This may require earthworks to widen the verge in the vicinity of the terminal.

Treatments for the southern and northern terminals at this site are shown in Figures D1 and D2. The basis for these layouts is as follows:

Northern terminal – Figure D1

The desirable treatment would include a widening of the verge to provide a flat runout area behind the WRSB terminal and a flaring of the WRSB on a 200m radius curve prior to the terminal to offset the point of redirection a further 2m from the traffic lane and direct the terminal away from approaching traffic. However, in this case, as the length of redirection is relatively short at 30m, the adoption of this treatment, together with the 20m shortening of the length of redirection would result in Tree No.3 being located within 10m of the start of the terminal flaring (refer SD 3573), which is unacceptable.

This problem could be avoided by forgoing the shortening of the length of redirection available from offsetting the point of redirection by 2m, but an acceptable alternative would be to adopt a smaller flare, in this case a 1m offset, which still provides some shortening of the length of redirection without compromising the hazard free zone required beyond the terminal. This is the treatment shown in Figure D1 below.

Southern terminal – Figure D2

At this site there are no constraints preventing the adoption of the desirable flared terminal treatment shown on SD 3573. This treatment should be adopted where possible.

Straight terminal option - verge widening requirements

If the assessment of site constraints concluded that flared terminal treatments were not practicable then a straight terminal treatment as per SD 3573 could be adopted. Note that even the minimum straight terminal treatment shown in SD 3573 would require some verge widening in this case. This verge widening is important given the potential for WRSB terminals to destabilise vehicles in end on impacts.

Appendix E

Stopping refuge bay layout

Figure E1 below shows the preferred layout for stopping refuge bays within WRSB installations more than 500m long at offsets to traffic lanes of less than 4.0m. Refer Section 4.2.2(c).



Notes: 1.

100m radius curves are acceptable in this instance only to limit the size of the refuge bay. Class A post spacings will be required in these areas. Unyielding hazards should not be located within 5m of 100m radius curve sections where impacts on the convex side of the curve are possible.

RDN 06-02 D	Page 18 of 18	Final	September 2016