

Traffic Control - Avoiding End of Queue Collisions on High Speed Roads

In recent years a number of incidents have occurred at roadwork sites with end of queue collisions. Many of these have resulted in fatalities and serious injuries due to them occurring on high speed rural highways. To avoid these types of incidents occurring, it is imperative that appropriate traffic management planning occurs.

Queueing and delay is an expected consequence when any roadworks require the use of traffic control. Before implementing any type of traffic control it is the responsibility of the traffic management designer to consider the following:

- The speed of traffic
- The road environment (e.g. horizontal and vertical curves, road surface, road grade¹)
- The sight distance road users will have to the traffic control position
- Driver reaction times (general case assumption = 2.5 sec)
- The traffic volume
- The traffic composition (e.g. large vehicles may require greater stopping sight distance)
- Work times and duration
- Expected time traffic will be stopped
- Worksite length (see table 4.9 of AS1742.3 for maximum length of single lane section)
- Personnel available

Once the traffic management designer has gained the above information the expected queue length can be predicted using the following steps:

1. Determine the hourly traffic volume in the direction of travel at the time of the works²;
2. Divide the hourly traffic volume by 60 to determine the vehicles expected every minute;
3. Determine the length of time to the nearest minute that vehicles will be required to stop (this includes stop time for work reasons and clearance times);
4. Multiply this number by the vehicles expected per minute (i.e. vehicles per minute X number of minutes);
5. Determine the types of vehicles that will be using the road and multiply its length by the number (include a 3 m space between each vehicle):

Vehicle Type	Approximate length
Car	5.5 m
Truck / Bus	19 m
Road Train / B Double	36.5 m

This will give you the expected queue length.

¹ Downgrades may require greater stopping sight distance.

² Traffic volumes can be provided by the relevant road authority. Where no traffic volumes are available the person preparing the plan should attend the site and count vehicles for a 5 minute period. Note that growth rates need to be considered when using data older than 12 months.

Example:

1. Hourly traffic volume 100 vehicles per hour with 10 % heavy vehicles north bound
2. Determine volume per minute: $100/60 = 1.7$ vehicles per minute
3. Vehicles to be stopped a maximum of 5 minutes. This includes 4 minutes for a closure to allow a machine to cross the road and 27 seconds for the other queue to travel 300m at 40km/h ($300 / 11.1\text{m/s} = 27$ seconds) and an additional 30 seconds to allow for additional queue and to take into account reaction and acceleration times.
4. 1.7 vehicles per minute x 5 minutes = 9 vehicles
5. 90 % cars and 10 % trucks

Vehicle Type	Vehicles per 5 minutes	Length
Car	90 % of 9 = ~ 8	$8 \times (5.5+3) = 68 \text{ m}$
Truck / Bus	10 % of 9 = ~1	$1 \times (19+3) = 22 \text{ m}$
Total	9 vehicles	90 m

The predicted queue length is 90 m north bound.

Note: the expected queue length in the opposing direction is often vastly different, particularly in am or pm peak.

Now you must determine how to adequately warn road users of the traffic control and end of queue.

End of Queue Protection – High Speed Roads

Roads with a traffic speed greater than 70 km/h are required to have the PREPARE TO STOP sign a minimum of the posted speed in meters from the end of the queue (see clause 4.7.8 of AS1742.3).

It is important to ensure adequate Stopping Sight Distance is provided to the PREPARE TO STOP sign and the end of queue. This is the distance required to allow a driver to react and stop their vehicle.

The diagrams below depict how these signs should be laid out to ensure adequate advanced warning to road users (note this exceeds distances given in AS1742.3).

Notes Regarding Diagrams:

- The diagrams do not depict speed reduction and advanced warning signage which must be included. Advance warning signs shall be at least D m in advance of the PREPARE TO STOP sign.
- The additional PREPARE TO STOP sign should be installed at least 2D from the end of the queue.
- It is recommended the PREPARE TO STOP sign T1-18B is used in advance of the end of queue.
- Provide PREPARE TO STOP and symbolic warning sign D m from the control point.
- Sight distance to the end of queue should be a minimum of 2D.
- Where the queue is expected to be more than 4D provide additional PREPARE TO STOP sign at the predicted end of queue (figure 2).

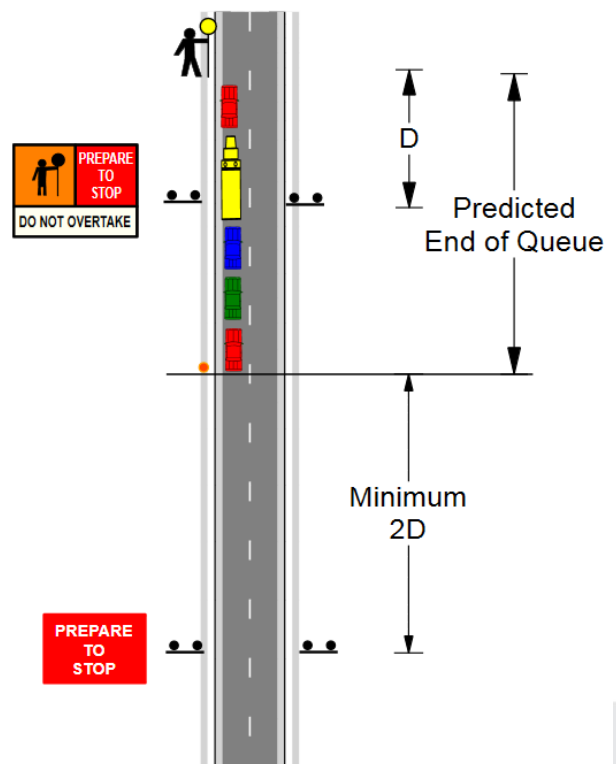


Figure 1: Predicted Queue Length <4D.

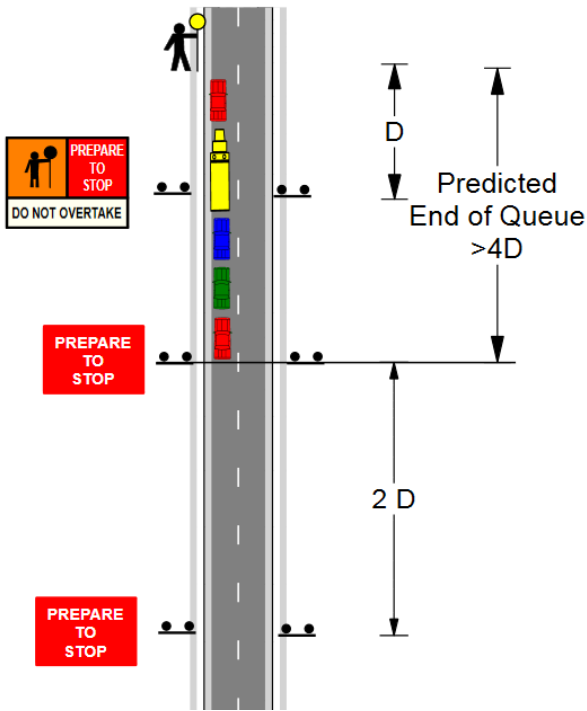


Figure 2: Predicted Queue Length >4D.

Speed of Traffic km/h	Dimension 'D' m
55 or less	15
56 to 65	45
Greater than 65	Equal to speed of traffic, in Km/h

Value of Dimension D

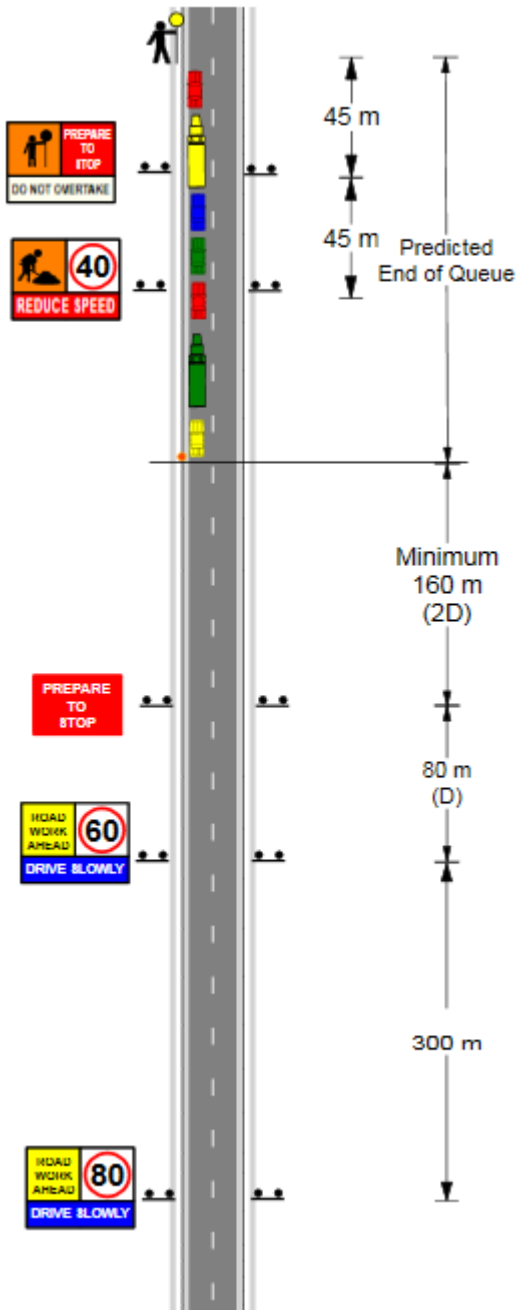
Measures to help reduce risk of end of queue collisions:

- (a) Avoid undertaking the works during peak periods and shut down the site when it gets too busy.
- (b) Ensure single lane operation complies with the requirements in table 4.9 of AS1742.3.
- (c) Ensure there is adequate sight distance to traffic controllers and the predicted end of queue, where there is a curve or crest with restricted sight distance have the traffic control position extend prior to that point to ensure adequate sight distance.
- (d) Where practicable use a second traffic controller to slow vehicles down prior to the primary traffic controller.
- (e) Monitor queue lengths and ensure additional warning signs are erected beyond the end of queue
- (f) Use advance warning variable message signs where practicable.
- (g) Drive through the site with traffic to ensure signs are adequately warning road users.
- (h) Use a UHF broadcast to warn heavy vehicles of queued traffic and wet slippery roads.
- (i) Install rumble strips to help alert motorists.
- (j) To ensure road users are compliant ensure signs are only erected when their need is warranted, remove all signs when they are no longer applicable.
- (k) Use of vehicle activated electronic warning signs.

Scenario 1:

Traffic Controller on 110 km/h 2 lane 2 way road reduced to 40 km/h – predicted end of queue less than 4D.

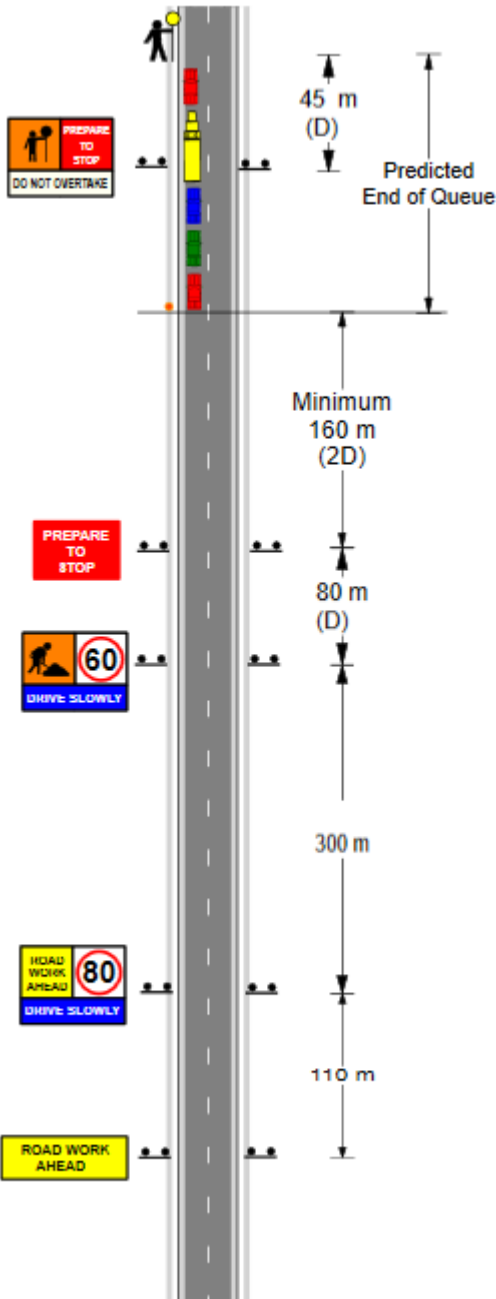
Notes:



1. The PREPARE TO STOP sign shall be placed a minimum of 2D from the predicted end of queue (recommend T1-18B is used).
2. Sight Distance to the end of queue shall be a minimum of 160 m (2D).
3. The Traffic Controller (symbolic) and PREPARE TO STOP signs shall be D meters from the traffic controller position.
4. The 60 km/h buffer zone should be a minimum of 200 m.
5. It is recommended a traffic cone is placed at the predicted end of queue as a marker to assist in monitoring the end of queue.
6. The active Traffic Controller may not be able to see the expected queue length and may prompt other team members to conduct a drive through inspection to ensure adequate site distance to the end of the queue.
7. The 40 km/h work site speed limit is only warranted when worker clearance to traffic is less than 1.2m.

Scenario 2

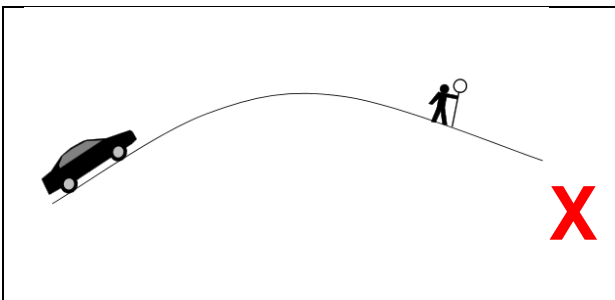
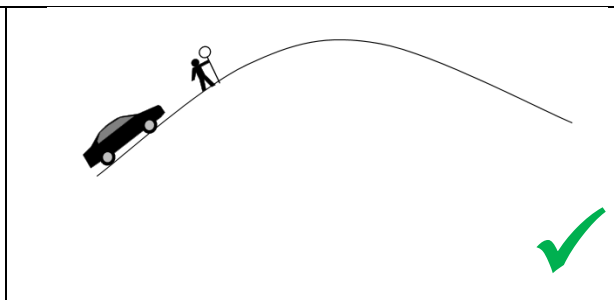
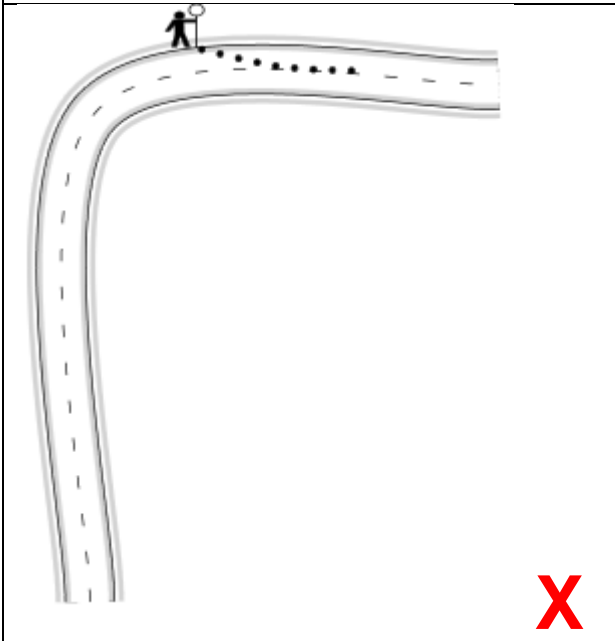
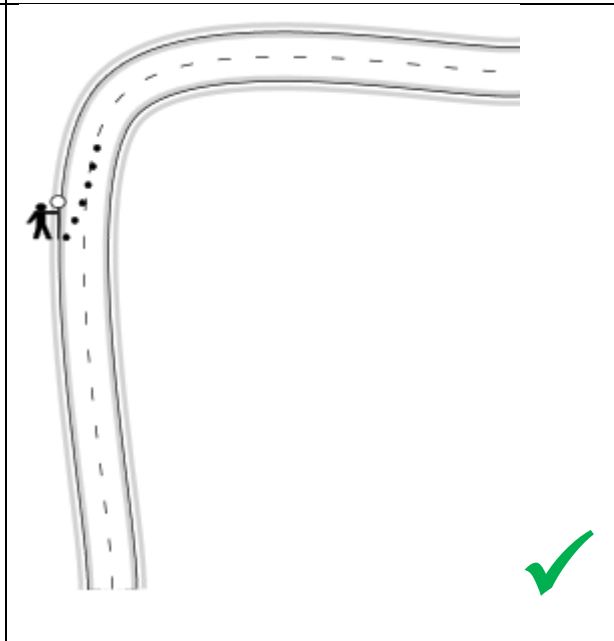
Traffic Controller on 110 km/h 2 lane 2 way road reduced to 60 km/h – predicted end of queue less than 4D



Notes:

1. The PREPARE TO STOP sign shall be placed a minimum of 2D from the predicted end of queue (recommend T1-18B is used).
2. Sight Distance to the end of queue shall be a minimum of 160 m (2D).
3. The Traffic Controller (symbolic) and PREPARE TO STOP signs shall be D meters from the traffic controller position.
4. The 60 km/h zone shall be a minimum of 200 m prior to the traffic controller.
5. It is recommended a traffic cone is placed at the predicted end of queue as a marker to assist in monitoring the end of queue.
6. The active Traffic Controller may not be able to see the expected queue length and may prompt other team members to conduct a drive through inspection to ensure adequate site distance to the end of the queue.

Traffic control near curves or crests

	
	
<ol style="list-style-type: none">1. Ensure appropriate stopping sight distance to the traffic control position and end of queue.2. If the curve or crest restricts the sight distance for road users, consider relocating the traffic control position before the curve or crest. This may also apply if sight distance is restricted to the predicted end of queue.3. Provide drivers with adequate sight distance to interpret signage leading up to the roadwork site.	