Contract Report

Evaluation of Active Advance Warning Signs (AAWS) using existing installations

by *David Green*

for VicRoads on behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC)

VC74957- March 2009

arrb research

ARRB Group Ltd
ACN 004 620 651
ABN 68 004 620 651

- ARRB Research
- ARRB Consulting
- ARRB Technology

www.arrb.com.au

Victoria
500 Burwood Highway
Vermont South VIC 3133
Australia
P: +61 3 9881 1555
F: +61 3 9887 8104
info@arrb.com.au

Western Australia
191 Carr Place
Leederville WA 6007
Australia
P: +61 8 9227 3000
F: +61 8 9227 3030
arrb.wa@arrb.com.au

New South Wales
2-14 Mountain Street
Ultimo NSW 2007
Australia
P: +61 2 9282 4444
F: +61 2 9282 4455
arrb.nsw@arrb.com.au

Queensland
123 Sandgate Road
Albion QLD 4010
Australia
P: +61 7 3260 3500
F: +61 7 3862 4699
arrb.qld@arrb.com.au

South Australia
1 Ulah Place
Semaphore Park SA 5019
Australia
P/F: +61 8 8242 1039
arrb.sa@arrb.com.au

Indonesia
Jalan Kemang Utara No 26
Jakarta Selatan 12730
Indonesia
P: +62 21 719 6815
F: +62 21 717 90172

Sept 05

arrb consulting

Evaluation of Active Advance Warning Signs (AAWS) using existing installations

for VicRoads on behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC)

	Reviewed
Project Leader	David Green
Quality Manager	Chris Jurewicz

VC74957- March 2009

arrb consulting

Summary

VicRoads, on behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC) has commissioned ARRB to undertake a comparison study of the effectiveness of the active advanced warning signs (AAWS) at level crossings in improving driver approach speeds and compliance with level crossing controls.

The comparison study was undertaken at two similar level crossings controlled by flashing lights and boom barriers. One of the level crossings had AAWS installed while the other level crossing did not.

The two level crossings used in the investigation were:

- LX1498 – Hamilton Hwy at Inverleigh / Murgheboluc (flashing lights plus boom barriers plus AAWS.
- LX1516 – Hamilton Hwy at Cressy (flashing lights plus boom barriers).

The study involved the use of pneumatic tube traffic data loggers at both level crossings to log traffic data and the status of the railway level crossing control (e.g. flashing light only phase, boom down phase etc).

The study was undertaken over a four week period although the eastbound approach of the Inverleigh / Murgheboluc level crossing lost one weeks worth of data due to vandalism of the logging equipment. For the four week survey the number of level crossing operations recorded at the Cressy site was 385, while for the full four week survey period the number recorded at the Inverleigh / Murgheboluc level crossing was 458.

No conclusive statements could be made with respect to the effectiveness of AAWS at improving driver approach speed behaviour and compliance due to the low number of vehicles recorded within key periods.

However the following observations were noted when comparing the data from the two sites:

- Vehicles that observed an active AAWS and inactive railway crossing lights reduced their speed compared to free flow conditions on approach (130m in advance) to the railway crossing.
- Vehicles that observed an active AAWS had a slightly larger reduction in speed from free flow conditions during the period when the flashing lights at the railway crossing are active, as compared to vehicles approaching the site without AAWS.
- At the site with an AAWS, vehicles travelling across the railway tracks in the three seconds prior to the railway crossing flashing lights being operational had speeds similar to free flow conditions. It should be noted that very low number of vehicles were measured during this time.
- At the site with an AAWS, vehicles travelling across the railway tracks from the time the crossing became active till the time the boom arm began to drop, showed lower travel speeds as compared to free flow speeds.
- At the site without an AAWS, vehicles travelling across the railway track from the time the flashing lights at the crossing became active till the time the boom arm begins to drop, showed slightly higher travel speeds as compared to free flow speeds.
- Violation rates between the non-AAWS site and the AAWS site were comparable.

- The installation of an AAWS does not appear to impact on the timing of level crossing violations.
  - The timing of violations at the start of the phase for both the control and treatment site were predominantly within the first four seconds.
  - The timing of violation at the end of the phase for both the control and treatment site were predominantly occurring 3 seconds after the boom begins to rise.
  - assenger vehicles violating the level crossing control during the middle of the phase were negligible for both the treatment and control site.
- Observation of heavy vehicle approach speed and compliance with the level crossing control is limited due to the low number of heavy vehicles observed during critical time windows relative to the level crossing control (e.g. just prior to booms barrier falling and just after boom barriers have been released to rise).

It is noted that a study undertaken at level crossings controlled by other level crossing controls (e.g. flashing lights only) may report different findings/observations to that outlined in this study.

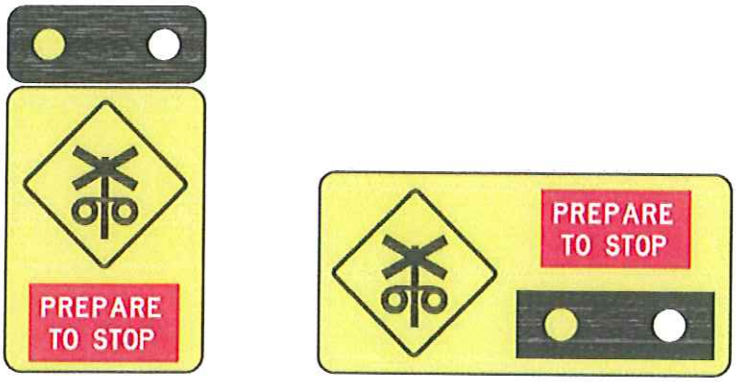
arrb consulting

Contents

1 Introduction

Level crossing crashes have become a major concern in Victoria with the occurrence of several vehicle to train crashes in recent times that resulted in multiple fatalities and significant property damage.

An outcome of a review of level crossing safety was a proposal to install active advance warning signs (AAWS) at level crossings. Typical AAWS signs are shown in Figure 1.1.



Source: Standards Australia (2007)

Figure 1.1: Examples of active advance warning signs in a horizontal or vertical format

The AAWS is activated a predetermined time prior to the level crossing control becoming active. This is dependent on typical vehicle approach speed and location upstream of the level crossing as outlined in Standards Australia (2007). For an 80 km/h road the AAWS may be activated 5 to 14 seconds prior to the activation of the level crossing control.

VicTrack is currently implementing an AAWS installation program over the next two to three years at 54 level crossings across Victoria. The current controls at the 54 sites are give way signage, flashing lights, or flashing lights and boom barriers. As part of the VicTrack program, the AAWS may also be installed along with an upgrade to the level crossing control (e.g. from flashing lights to boom barriers plus AAWS).

As major crashes at railway crossings are rare, it was not practicable to determine the effectiveness of the AAWS in preventing incidents. Therefore a study was developed to determine the influence of AAWS on improving driver approach speeds and compliance with level crossing controls to provide an indication of the AAWS safety effectiveness.

This report describes the study undertaken and its findings.

2 Method

This section of the report describes the study method undertaken as part of the evaluation study.

2.1 Study type

ARRB has undertaken a review of all sites where AAWS installation is proposed by VicTrack (Green 2008). Unfortunately there were no sites with sufficient vehicle and train volumes to enable a before and after study to be undertaken during the 2008 calendar year.

In order to commence a study within the 2008 calendar year, it was agreed to undertake a comparative study of a site where AAWS has been installed with a site where AAWS is proposed to be installed at a later date.

2.2 Site selection

After a review of the 54 sites (Green 2008), two sites were selected for the study. The sites selected are outlined in Table 2.1:

Table 2.1: Sites to undertake the study

	Control type	Level crossing no.	Road name	Location	VicRoads Reference	Speed limit	Photos and plans
Treatment site	Flashing lights plus boom barriers plus AAWS	LX1498	Hamilton Hwy	Inverleigh / Murgheboluc	93 C3	80 km/h	Appendix A
Control site	Flashing lights plus boom barriers	LX1516	Hamilton Hwy	Cressy	92 C2	80 km/h	Appendix B

These sites were selected for the following reasons:

- They had the same type of railway level crossing control.
- They were located on the same section of road and within the same part of the state.
- They were both located in the same speed zone (80 km/h).
- They required a similar survey duration of 4 weeks in order to get sufficient data for the study (i.e. surveys could be undertaken over the same period).
- They had similar traffic flows based on data originally supplied by VicRoads.
- There was a lack of alternative sites.

There were some differences between the two sites which might have influenced the driver's approach speeds. They were as follows:

- The Inverleigh crossing had a different topography than the Cressy crossing.
- The Inverleigh crossing is located away from any townships and located in the middle of a 100 km/h speed zone (80 km/h speed zone at the level crossing itself has recently been implemented). The approaches to the Cressy crossing were previously 90 km/h, but both approaches have now been reduced to 80 km/h.
- Ballarat-Colac Road (Route C146 which runs between Cressy and Colac) intersects the Hamilton Highway approximately 80 m in advance of the eastbound approach to the Cressy level crossing.

The method for data review as outlined in the following sections was developed to address these issues.

2.3 Data collection

Data for the study was collected using pneumatic tube traffic loggers. One of loggers was interfaced with the signal controller (enabling the logging of both vehicles and the signal crossing activation). The loggers used are outlined in Table 2.2 and shown in Figure 2.1.

Pneumatic tube loggers were used in this investigation for the following reasons:

- The duration of the survey needed to get a reasonable number of vehicle to train interactions required an automated process for collecting data.
- The equipment was successfully used in previous similar level crossing safety studies.
- Alternative speed logging equipment that could be interfaced with railway level crossing control hardware was prohibited by cost and availability.

All loggers were synchronised with the logger installed at the level crossing. The AAWS was activated at a constant time (for each level crossing) in advance of the level crossing controls, therefore no logger needed to be interfaced with the AAWS.

Table 2.2: Data collection methods

Standard pneumatic tube loggers	Pneumatic tube loggers interfaced with signal box.
A logger on each approach, 750 m in advance of the level crossing to detect general free speed of the vehicle on the approach to the level crossing. The tubes associated with these loggers will only span the lane corresponding with the approach.	A logger at the stop line on the same side of the railway line as the level crossing signal controller to detect vehicle speed at the level crossing, to log the phase of the level crossing control and to determine compliance with the level crossing.
A logger on each approach, 130 m in advance of the level crossing. The logger would record the speed of vehicles after the driver has observed the status of the AAWS and responded on their approach to the level crossing. This distance is in accordance with general truck stopping sight distance (ignoring grade correction adjustments to stopping sight distance). The tubes associated with these loggers will only span the lane corresponding with the approach.	This will include detection of any vehicle passing through the crossing at various stages of the signal control (i.e. lights flashing but prior to boom barrier being lowered) and detection of any vehicle that may have gone around the boom barrier. The tubes associated with this logger will span across the entire carriageway.
A logger at the stop line on the opposite side of the railway line to the signal controller to detect vehicle speed at the level crossing and to determine compliance with the level crossing. This will include detection of any vehicle passing through the crossing at various stages of the signal control (i.e. lights flashing but prior to boom barrier being lowered) and detection of any vehicle that may have gone around the boom barrier. The tubes associated with this logger will span across the entire carriageway.	

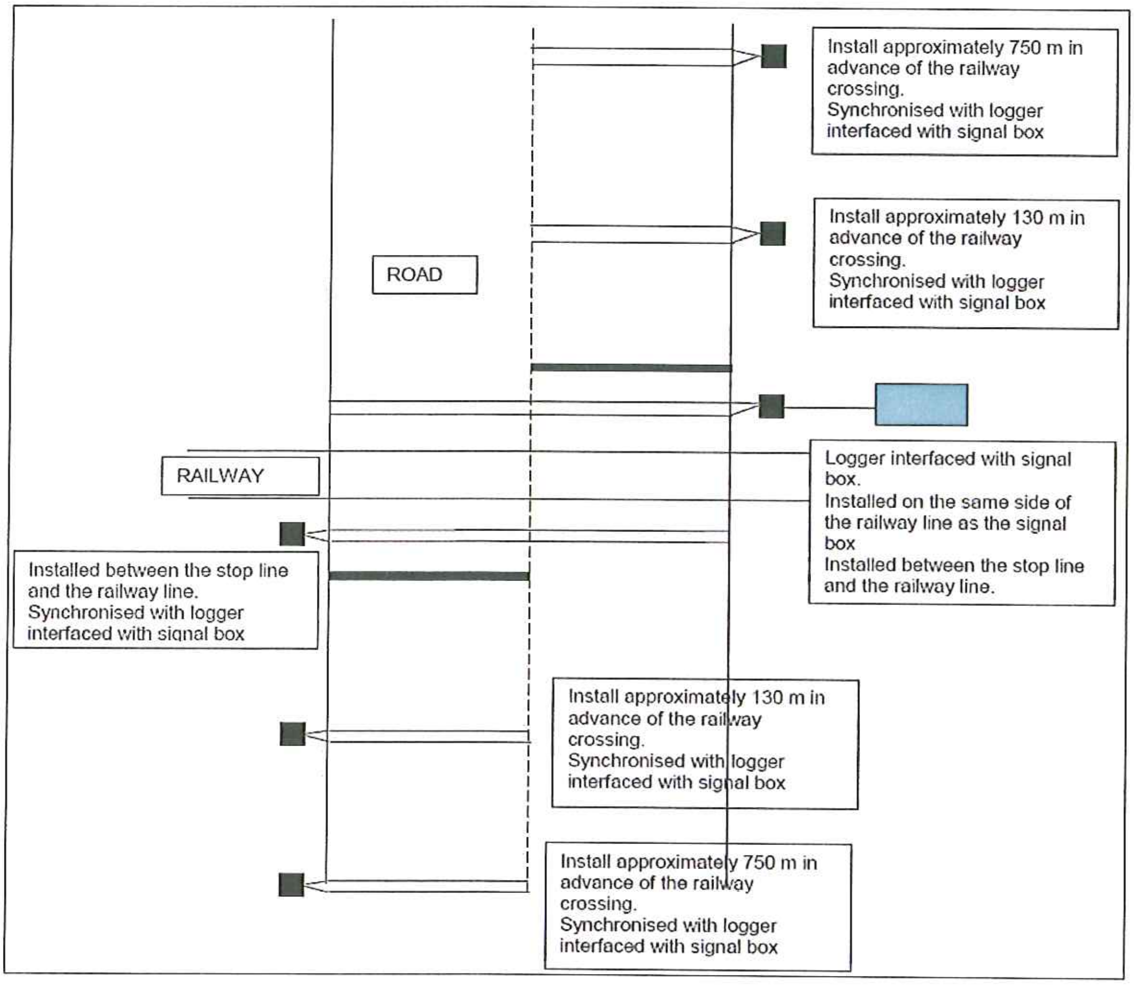


Figure 2.1: Schematic drawing of the lay out of the traffic loggers with respect to the railway level crossing

2.4 Data analysis

Review of the traffic data recorded by the loggers installed on the approach to the level crossing was undertaken with the aim of determining the following:

- The approach speed of the vehicle at both level crossings when a train was not present.
- The approach speed and compliance level at both level crossings when the AAWS and level crossing controls were active.
- Driver speed at both level crossings when the AAWS and level crossing controls were active compared to when the AAWS and level crossing control were inactive. This was undertaken in preference to a comparison between speeds between the two sites when a train was present, as the difference in topography could influence the approach speeds.
- If AAWS influenced driver approach speeds and compliance with the level crossing controls by comparing the difference in the change in driver approach speed and compliance level between the site with AAWS and the site without AAWS.

As outlined in Section 2.2, Colac-Ballarat Road intersects the Hamilton Highway on the eastbound approach to the Cressy railway level crossing. For stop line vehicle speed data only, those vehicles detected at the logger installed 130 m just prior (several seconds) to being detected at the stop line were used.

Vehicles turning right into Colac-Ballarat Road were in the right turning lane when passing the logger installed 130 m in advance of the level crossing. Vehicles travelling in the right hand turn lane were not recorded by the traffic logger and hence not included in this investigation. As a result right turning traffic into Colac-Ballarat Road was expected to have negligible impact on this investigation.

For the westbound approach the potential impact of the Colac-Ballarat Road intersection on the opposite side of the railway level crossing was also expected to have negligible impact on this investigation for the following reasons:

- The intersection is located sufficient distance away from the loggers installed at 130 m and 750 m to not have an impact on vehicle speeds recorded at these loggers.
- Due to the function of Colac-Ballarat Road, only small vehicle volumes in comparison to Hamilton Hwy were expected to turn left into Colac-Ballarat Road.

2.5 Study limitations

It is worth noting that the findings of this survey were likely to be limited due to the following reasons:

1. Being a comparative study, any conclusions are limited to a simple comparison between the two sites and may not accurately reflect the broader effect of mass installation of AAWS across a large number of sites.
2. Being a comparative study any observed difference in vehicle speeds and compliance level may be influenced by local factors which may potentially be different at different sites (e.g. grades, intersections etc).
3. The comparative study was undertaken at sites where flashing lights and boom barriers are used as the level crossing control. The impact of AAWS on driver approach speed and compliance may be different at sites with other types of level crossing controls (e.g. at level crossing controlled by flashing lights only).
4. The small amount of data (traffic and train data) able to be obtained within the study timeframes will limit the robustness of the observed relationships.

3 Findings

This section of the report presents the key findings from the data analysis.

3.1 Vehicle to train interactions

The total number of vehicle to train interactions captured in the four week survey for both approaches of the two sites is outlined in Table 3.1. Vehicle to train interactions are considered to be those vehicles which were detected at the logger placed 130 m in advance of the level crossing from the period six seconds prior to activation of the level crossing control and until the level crossing control is no longer active.

Table 3.1: Number of vehicle to train interactions per site and approach

Site	Approach	Number of vehicles in the sample	
		Passenger	Heavy
Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing	Eastbound approach	563	91
	Westbound approach	651	157
Control site (No AAWS installed) Cressy level crossing	Eastbound approach	341	53
	Westbound approach	409	62

Although the survey duration was sufficient to achieve 30 heavy vehicle to train interactions, the number of vehicles approaching and arriving at the level crossing in a specific window relative to the level crossing operation was very low. (e.g. the number of vehicles traversing the level crossing between the period when the lights of the level crossing became active and the boom gate dropped down).

3.2 Impact on approach speed based on median and 85th percentile vehicle point speeds

Table 3.2 and Table 3.3 show the median vehicle point speed (i.e. 50th percentile speed) and Table 3.4 and Table 3.5 show the 85th percentile point speed of passenger and heavy vehicles approaching each level crossing.

It is noted that the speed of vehicles which violated the level crossing control at the end of the phase (i.e. when the boom gate was released) was not considered relevant to this investigation.

Analysing the data presented in Table 3.2 through to Table 3.5 the following observations were noted:

3.2.1 When train was not present

- The median and 85th percentile free speed of vehicles away from the level crossing (750 m in advance of the level crossing) was within or marginally over the speed limit.

  It is noted that the eastbound approach to the Cressy level crossing was sign posted as 80 km/h, while the other approaches were designated as 100 km/h speed zones.

There was not a significant difference between the median speed of passenger and heavy vehicles at this location.

- There was a reduction in the median and 85th percentile speed of vehicles as they approached the level crossing (130 m in advance of the level crossing). This figure ranged from 9.5% to 21.8% for the median speed and 6.3% to 16.9% for the 85th percentile speed with the magnitude being different at each approach of the two sites. The median speed of vehicles in advance of the level crossing across the sites ranged from 75 km/h to 87 km/h while for the 85th percentile the speeds ranged from 83.3 km/h to 100.4 km/h, with the Cressy site having slower speeds for both approaches. This may be due to the presence of the Ballarat-Colac Road and also the existing 80 km/h speed zone to the west of the site.

  There was not a significant difference between the median and 85th percentile speed of passenger and heavy vehicles 130 m in advance of the level crossing at both sites, with the exception of the eastbound approach of the Cressy level crossing. The 85th percentile speed of passenger vehicles was approximately 7% less than that of the heavy vehicles detected 130 m in advance of the eastbound approach of the Cressy level crossing.

- With the exception of the eastbound approach of the Cressy level crossing there was an additional reduction (less than 10 km/h) in both the median and 85th percentile speed as vehicles traversed the level crossing itself when a train was not approaching or traversing the level crossing. As this occurred when there were no trains present, it is assumed that this is in response to the changed driver comfort level when traversing the level crossing.

  It was observed that the median and 85th percentile speed of vehicles at the eastbound approach of the Cressy level crossing was slightly higher (less than 2 km/h) than the median and 85th percentile speed recorded 130 m in advance of the level crossing

3.2.2 When train is present – 130 m in advance of the level crossing

- There was observed to be a reduction in the median and 85th percentile speed of vehicles detected 130 m in advance of the level crossing within six seconds of the level crossing control becoming active at both the treatment and control site.

  Due to the low sample size of vehicles arriving within this period relative to the operation of the level crossing, no conclusive statement could be made as to whether the reduction in vehicle speeds were better for the site with AAWS, compared to the site without AAWS. Based on the small amount of data collected there was:

  - a reduction in median speed of 7% and 20% for passenger vehicles at the treatment site (average reduction of 13.5%)
  - a increase in 85th percentile speed of 2.3% and a reduction of 16.3% for passenger vehicles at the treatment site (average reduction of 7%)
  - an increase in median speed of 3% and a reduction of 7% for passenger vehicles at control site (average reduction of 2%)
  - an increase in the 85th percentile speed of 7.8% and a reduction of 8.7% for passenger vehicles at the control site (average reduction of 0.45%)
  - due to the low numbers of heavy vehicle data recorded for this period any reduction in median and 85th percentile speed could be completely random.

- There was a large reduction in the median and 85th percentile vehicle speed 130 m in advance of the level crossing when the level crossing control was active at both the treatment and control sites.

Due to the low sample size of vehicles arriving within this period relative to the operation of the level crossing, no conclusive statement could be made as to whether the reduction in vehicle speeds were better for the site with AAWS, compared to the site without AAWS. Based on the small amount of data collected, there was:

- a reduction in median speed on both approaches of 41% for passenger vehicles at the treatment site
- a reduction in 85th percentile speed of 32.4% and 37.2% for passenger vehicles at the treatment site (average reduction of 34.8%)
- a reduction in median speed of 42% and 32% for passenger vehicles at the control site (average reduction of 37%)
- a reduction in 85th percentile speed of 25.6% and 34% for passenger vehicles at the control site (average reduction 29.8%)
- a reduction in median speed of 54% and 47% for heavy vehicles at the treatment site (average reduction of 51%)
- a reduction in 85th percentile speed of 36.6% and 44.6% for heavy vehicles at the treatment site (average reduction of 40.6%)
- a reduction in median speed of 51% and 46% for heavy vehicles at the control site (average reduction of 49%)
- a reduction in 85th percentile speed of 36.2% and 45.5% for heavy vehicles at the control site (average reduction of 40.9%).

3.2.3 When train is present – at the level crossing

- Very few heavy vehicles were detected travelling through the level crossing just prior (three seconds) to the level crossing becoming active and in the period between when the lights started flashing and boom gates came down. Due to the low numbers of heavy vehicles recorded crossing the level crossing within these time windows no comment can be made with respect to the speed of heavy vehicles travelling through the level crossing within this period. With respect to compliance with the level crossing control by heavy vehicles refer to Section 3.3.
- Compared with the control site, the site with AAWS had similar changes to the median and 85th percentile speed of passenger vehicles crossing the railway line within three seconds of the level crossing control becoming active at the site (this is relative to the median and 85th percentile speed recorded just upstream of the level crossing). It is noted that very low numbers of vehicles were recorded during this period.
- With the exception of the eastbound approach of the control site, the median speed of passenger vehicles travelling through the level crossing between, when the lights started flashing, and when the boom gate came down, was very similar to the median speed of vehicles crossing the railway crossing when the signals were not active (note only a low number of vehicles were observed during this period).

  The eastbound approach of the Cressy level crossing reported an increase in the median speed of 7.3%.

  A average reduction in the 85th percentile speed of 6.5% was observed at the treated site. Although the 85th percentile speed of one approach of the control site remained consistent with the upstream speed, the other approach was observed to have a significant increase (15.5%) in the 85th percentile speed from the reported upstream speed.

- No significant increase in median and 85th percentile speed was observed of vehicles travelling through the treated level crossing site either just prior (three seconds) to the level crossing becoming active or between the period when the lights at the level crossing start flashing and the boom barriers come down.

Table 3.2: Median speeds of passenger vehicles when crossing control was active / not active

Measure		Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing		Control site (No AAWS installed) Cressy level crossing	
		Eastbound approach	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	99.6 km/h	93.9 km/h	83.8 km/h	96.6 km/h
Median speed When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	86.9 km/h	85 km/h	75.4 km/h	75.5 km/h
	At the railway level crossing.	82.1 km/h	78.6 km/h	75.8 km/h	70.4 km/h
Median speed When trains are present or approaching	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	81.1 km/h 25 vehicles	68.4 km/h 31 vehicles	77.8 km/h 11 vehicles	70.35 km/h 20 vehicles
	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	51.6 km/h 538 vehicles	50.45 km/h 620 vehicles	44.1 km/h 330 vehicles	51.6 km/h 389 vehicles
	At the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	81.95 km/h 12 vehicles	81.45 km/h 14 vehicles	79.2 km/h 22 vehicles	67.05 km/h 14 vehicles
	At the railway level crossing Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	82.6 km/h 7 vehicles	74.4 km/h 19 vehicles	81.35 km/h 8 vehicles	69.6 km/h 8 vehicles

Notes:

1 Due to the presence of the Ballarat-Colac Road (Route C146) only those vehicles detected at the detector located 130 m in advance of the level crossing within 12 seconds of the being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

2 Six seconds is based on the time to travel 130 m at 80 km/h and allows for provision for a reaction time to the AAWS. It is noted that AAWS activates ten seconds prior to the level crossing control at the Inverleigh site and will activate nine seconds prior to the level crossing control at the Cressy site.

3 A three seconds time window was chosen to compare the median speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

Table 3.3: Median speed of heavy vehicles at level crossing for the entire survey period and when a train is passing through

Measure		Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing		Control site (No AAWS installed) Cressy level crossing	
		Eastbound approach	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	99.7 km/h	94.9 km/h	84.2 km/h	93.4 km/h
Median speed When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	87.3 km/h	86.2 km/h	78.1 km/h	75.3 km/h
	At the railway level crossing.	83.7 km/h	77.6 km/h	79.7 km/h	70.6 km/h
Median speed When trains are present or approaching	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	70.45 km/h 2 vehicles	77.8 km/h 5 vehicles	73.6 km/h 3 vehicles	57.3 km/h 3 vehicles
	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	39.9 km/h 89 vehicles	46.1 km/h 152 vehicles	38.25 km/h 50 vehicles	40.45 km/h 58 vehicles
	At the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	80.8 km/h 1 vehicle	77.4 km/h 3 vehicles	76.6 km/h 1 vehicle	71 km/h 1 vehicle
	At the railway level crossing Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	68.6 km/h 1 vehicle	68.6 km/h 1 vehicle	74.7 km/h 3 vehicles	46.2 km/h 3 vehicles

Notes:

1 Due to the presence of the Ballarat-Colac Road (Route C146) only those vehicles detected at the detector located 130 m in advance of the level crossing within 12 seconds of the being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

2 Six seconds is based on the time to travel 130 m at 80 km/h and allows for provision for a reaction time to the AAWS. It is noted that AAWS activates ten seconds prior to the level crossing control at the Inverleigh site and will activate nine seconds prior to the level crossing control at the Cressy site.

3 A three seconds time window was chosen to compare the median speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

Table 3.4: 85th percentile speeds of passenger vehicles when crossing control was active / not active

Measure		Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing		Control site (No AAWS installed) Cressy level crossing	
		Eastbound approach	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	105.8 km/h	99.8 km/h	94.6 km/h	102.7 km/h
85th percentile speed When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	100.4 km/h	98.1 km/h	83.3 km/h	85.3 km/h
	At the railway level crossing.	96.9 km/h	91.5 km/h	84.9 km/h	80.7 km/h
85th percentile speed When trains are present or approaching	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	102.7 km/h 25 vehicles	82.1 km/h 31 vehicles	89.8 km/h 11 vehicles	77.9 km/h 20 vehicles
	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	63.1 km/h 538 vehicles	66.3 km/h 620 vehicles	55 km/h 330 vehicles	63.5 km/h 389 vehicles
	At the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	100.8 km/h 12 vehicles	90.7 km/h 14 vehicles	84.7 km/h 22 vehicles	75.7 km/h 14 vehicles
	At the railway level crossing Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	89 km/h 7 vehicles	87.2 km/h 19 vehicles	98.1 km/h 8 vehicles	80.9 km/h 8 vehicles

Notes:

1 Due to the presence of the Ballarat-Colac Road (Route C146) only those vehicles detected at the detector located 130 m in advance of the level crossing within 12 seconds of the being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

2 Six seconds is based on the time to travel 130 m at 80 km/h and allows for provision for a reaction time to the AAWS. It is noted that AAWS activates ten seconds prior to the level crossing control at the Inverleigh site and will activate nine seconds prior to the level crossing control at the Cressy site.

3 A three seconds time window was chosen to compare the median speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

Table 3.5: 85th percentile speed of heavy vehicles at level crossing for the entire survey period and when a train is passing through

Measure		Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing		Control site (No AAWS installed) Cressy level crossing	
		Eastbound approach	Westbound approach	Eastbound approach[1]	Westbound approach
Free speed on the approach to the railway level crossing	Approximately 750 m in advance of the railway level crossing.	104.2 km/h	101.3 km/h	95.4 km/h	99.3 km/h
85th percentile speed When train not present (i.e. level crossing and AAWS not active)	Approximately 130 m in advance of the railway level crossing.	100.3 km/h	97.7 km/h	89.4 km/h	85.8 km/h
	At the railway level crossing.	97.6 km/h	88.7 km/h	91.6 km/h	82.1 km/h
85th percentile speed When trains are present or approaching	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 6 seconds prior to the level crossing control becoming active)[2].	76.6 km/h 2 vehicles	87.6 km/h 5 vehicles	77.9 km/h 3 vehicles	68.6 km/h 3 vehicles
	Approximately 130 m in advance of the railway level crossing Vehicles only detected at this logger when the level crossing control is active (i.e. level crossing control lights are flashing).	55.6 km/h 89 vehicles	61.9 km/h 152 vehicles	48.7 km/h 50 vehicles	54.7 km/h 58 vehicles
	At the railway level crossing Vehicles only detected at this logger when the AAWS is active in advance of the level crossing control (i.e. 3 seconds prior to the level crossing becoming active)[3].	80.8 km/h 1 vehicle	78.7 km/h 3 vehicles	76.6 km/h 1 vehicle	71 km/h 1 vehicle
	At the railway level crossing Vehicles only detected at this logger between when the lights start flashing and the boom gate comes down.	68.6 km/h 1 vehicle	68.6 km/h 1 vehicle	83.7 km/h 3 vehicles	68.5 km/h 3 vehicles

Notes:

1 Due to the presence of the Ballarat-Colac Road (Route C146) only those vehicles detected at the detector located 130 m in advance of the level crossing within 12 seconds of the being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

2 Six seconds is based on the time to travel 130 m at 80 km/h and allows for provision for a reaction time to the AAWS. It is noted that AAWS activates ten seconds prior to the level crossing control at the Inverleigh site and will activate nine seconds prior to the level crossing control at the Cressy site.

3 A three seconds time window was chosen to compare the median speed of vehicles passing through the site just prior to the level crossing becoming active in response to observing the status of the AAWS.

3.3 Difference in compliance level

Table 3.6 and Table 3.7 show the level of driver compliance with the level crossing control for the treatment and non-treatment site.

In the following discussion, the violation rate refers to the number of violations per 100 operations and per 100 vehicles detected 130 m in advance of the level crossing within six seconds of the level crossing becoming active but when AAWS was active.

- Given the low number of level crossing violations by passenger vehicles at the start of the phase (i.e. between flashing lights and boom down) the violation rates between the treatment and control sites were comparable although the site with AAWS was slightly improved.
- For heavy vehicles the average violation rate at the start of the phase (i.e. between flashing lights and boom down) at the site with AAWS was significantly lower than at the site without AAWS (0.2 and 1.4 respectively). It is noted that this is based on a low number of violations and heavy vehicle to train interactions.
- The violation rates for both passenger and heavy vehicles during the boom down phase were generally zero.
- For passenger vehicles the average violation rate at the end of the phase (i.e. at the boom up period but prior to the lights stop flashing) was comparable between the two sites although the site with AAWS was slightly improved.
- For heavy vehicles the average violation rate at the end of the phase (i.e. at the boom up period but prior to the lights stop flashing) was comparable between the two sites although the site with AAWS was slightly improved.

Table 3.6: Passenger vehicle compliance with controls at both crossings

Measure		Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing		Control site (No AAWS installed) Cressy level crossing	
		Eastbound approach	Westbound approach	Eastbound approach[1]	Westbound approach
The number of vehicles detected 130 m in advance on the level crossing within six seconds of the level crossing becoming active but when AAWS would be operating.		563	651	341	409
Number of level crossing control operations during the survey		356[2]	458	385	385
The total number of vehicles driving over the level crossing per violation type	Flashing lights only	7	18	8	8
	Boom down	0	0	0	2
	Boom up	167	92	100[3]	178
Rate of violation (number of violations per 100 operations per 100 vehicles detected 130 m in advance of the level crossing within six seconds of the level crossing control becoming active but when AAWS would be operating.	Flashing lights only	0.3	0.6	0.6	0.5
	Boom down	0	0	0	0.1
	Boom up	8.3	3.1	7.6[3]	11

Notes:

1 Due to the presence of the Ballarat-Colac Road (Route C146) only those vehicles detected at the detector located 130 m in advance of the level crossing within 12 seconds of the being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

2 Logging equipment missed one week worth of data due to vandalism of the logging equipment.

3 This included all passenger vehicles detected crossing during this phase.

Table 3.7: Heavy vehicle compliance with controls at both crossings

Measure		Treatment site (AAWS installed) Inverleigh / Murgheboluc level crossing		Control site (No AAWS installed) Cressy level crossing	
		Eastbound approach	Westbound approach	Eastbound approach[1]	Westbound approach
The number of vehicles detected 130 m in advance on the level crossing within six seconds of the level crossing becoming active but when AAWS would be operating.		91	157	53	62
Number of operations during the survey		356[2]	458	385	385
The total number of vehicles driving over the level crossing per violation type	Flashing lights only	1	1	3	3
	Boom down	0	0	0	0
	Boom up	12	0	7[3]	15
Rate of violation (number of violations per 100 operations per 100 vehicles detected 130 m in advance of the level crossing within six seconds of the level crossing control becoming active but when AAWS would be operating.	Flashing lights only	0.3	0.1	1.5	1.3
	Boom down	0	0	0	0
	Boom up	3.7	0	3.4[3]	6.3

Notes

1 Due to the presence of the Ballarat-Colac Road (Route C146) only those vehicles detected at the detector located 130 m in advance of the level crossing within 12 seconds of the being detected at the stop line were included. Other detected vehicles were assumed to have come from Ballarat-Colac Road.

2 Logging equipment missed one week worth of data due to vandalism of the logging equipment.

3 This included all heavy vehicles detected crossing during this phase.

The violation distribution (in terms of percentage of the total number of violators) of passenger vehicles proceeding through the level crossing at the AAWS site versus the non-AAWS site is shown in Figure 3.1. The timing of the majority of the violations between the site with AAWS and the site without AAWS was similar. The majority of the violations occurred within the first two seconds of the lights beginning to flash and six seconds after the boom gates have started to rise.

Due to the low number of heavy vehicle violations (in particular during the start of the phase) identified during the survey, no further review has been undertaken.

Raw data for the violation distribution for both passenger and heavy vehicles is outlined in Appendix C.

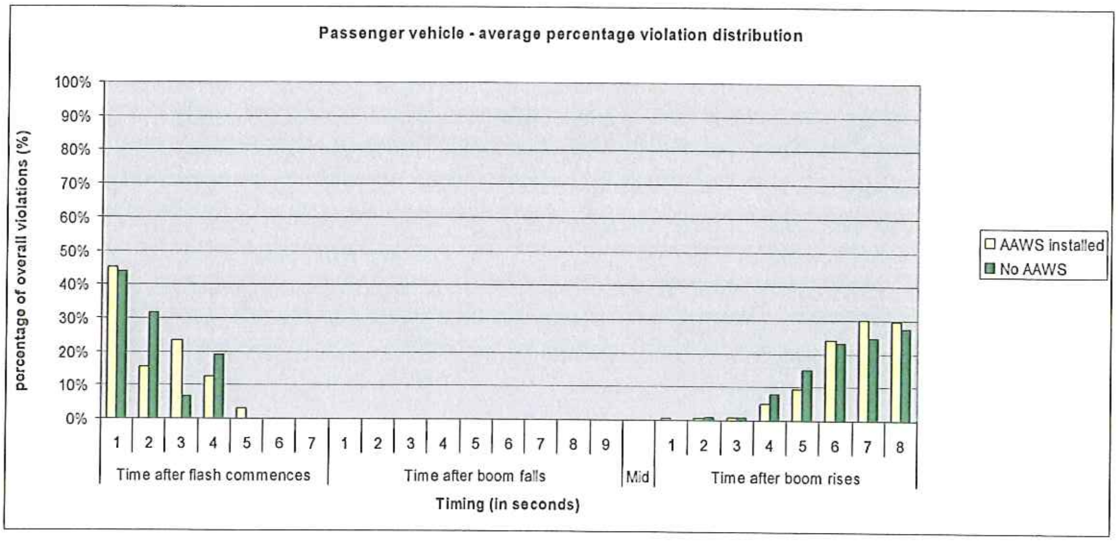


Figure 3.1: AAWS site versus non-AAWS site - average percentage violation distribution for passenger vehicles

4 Discussion

This section discusses some of the key findings of the comparative study undertaken between two level crossing sites controlled by boom barriers and flashing lights, but with one site given the additional support of AAWS.

Due to the low number of vehicles recorded within key periods (i.e. just prior to the flashing lights commencing and between flashing lights commencing and boom down) no conclusive statements could be made with respect to the effectiveness of AAWS at improving driver approach speed behaviour and compliance, however the following observations were noted when comparing the data from the two sites:

- The site with AAWS had a larger reduction in the median and 85th percentile speed of passenger vehicles 130 m in advance of the level crossing when arriving at this point within six seconds of the level crossing control becoming active.

  Due to the low number of heavy vehicles logged within this period during the investigation, no comment can be made with respect to the impact AAWS has on heavy vehicle speeds.

  It is noted that a reduction in median speed was observed at sites without AAWS installed. It is uncertain why this would occur.
- The site with AAWS had a slightly larger reduction of median and 85th percentile speed (for both passenger and heavy vehicles) in advance of the level crossing during the period when the level crossing was active.
- Compared with the control site, the site with AAWS had similar changes to the median and 85th percentile speed of passenger vehicles crossing the railway line within three seconds of the level crossing control becoming active at the site (this is relative to the median and 85th percentile speed recorded just upstream of the level crossing). It is noted that very low numbers of vehicles were recorded during this period.
- The site with AAWS showed a reduction in the 85th percentile speed of passenger vehicles passing through the level crossing at the commencement of the level crossing becoming active, while the site without AAWS reported an increase.
- The violation rate between the two sites were comparable, however the site with AAWS had a slightly improved compliance level with the level crossing control both at the start and end of the level crossing operation.
- AAWS does not appear to impact on the timing of the violations undertaken. The timing of the violations between the site with AAWS and the site without AAWS were observed to be similar (i.e. predominantly within the first four seconds of the flashing lights commencing and prior to the boom coming down, and predominantly after the first three seconds after the boom has began to rise).

5 Conclusion

No conclusive statements could be made on the effectiveness of AAWS in improving approach speed behaviour and compliance at level crossings controlled by boom barriers and flashing lights due to the low number of vehicle to train interactions recorded during critical periods of the level crossing operation (e.g. at the beginning of the level crossing operation).

The study showed that driver approach speeds at the site with AAWS were slightly improved and that the two sites had comparable violation rates (although the violation rate at the site with AAWS was slightly lower).

In addition the study did not indicate that AAWS resulted in the median speed of vehicles travelling through the level crossing to significantly exceed the speed limit in response to the advance warning of the imminent level crossing activation.

It is noted that a study undertaken at level crossings controlled by other controls (e.g. flashing lights only) or a study undertaken at different level crossing sites may report different conclusions to that outlined in this study.

References

Green, D 2008, 'Evaluation of Active Advance Warning Signs (AAWS) options report', contract report VC74563, ARRB Group, Vermont South, Vic.

Standards Australia 2007, *Manual of uniform traffic control devices, part 7, railway crossings*, AS 1742.7-2007, SA, North Sydney.

Appendix A – Photos and plans of the Inverleigh / Murgheboluc level crossing

Photos and plans of the Inverleigh / Murgheboluc level crossing are shown in Figure A.1 through to Figure A.7.

Figure A.1: Westbound - approx 800 m from the level crossing

Figure A.2: Westbound - approx 200 m from the level crossing

Figure A.3: Westbound - at the level crossing

Figure A.4: Eastbound - approx 800 m from the level crossing

Figure A.5: Eastbound - approx 200 m from the level crossing

Figure A.6: Eastbound - at the level crossing

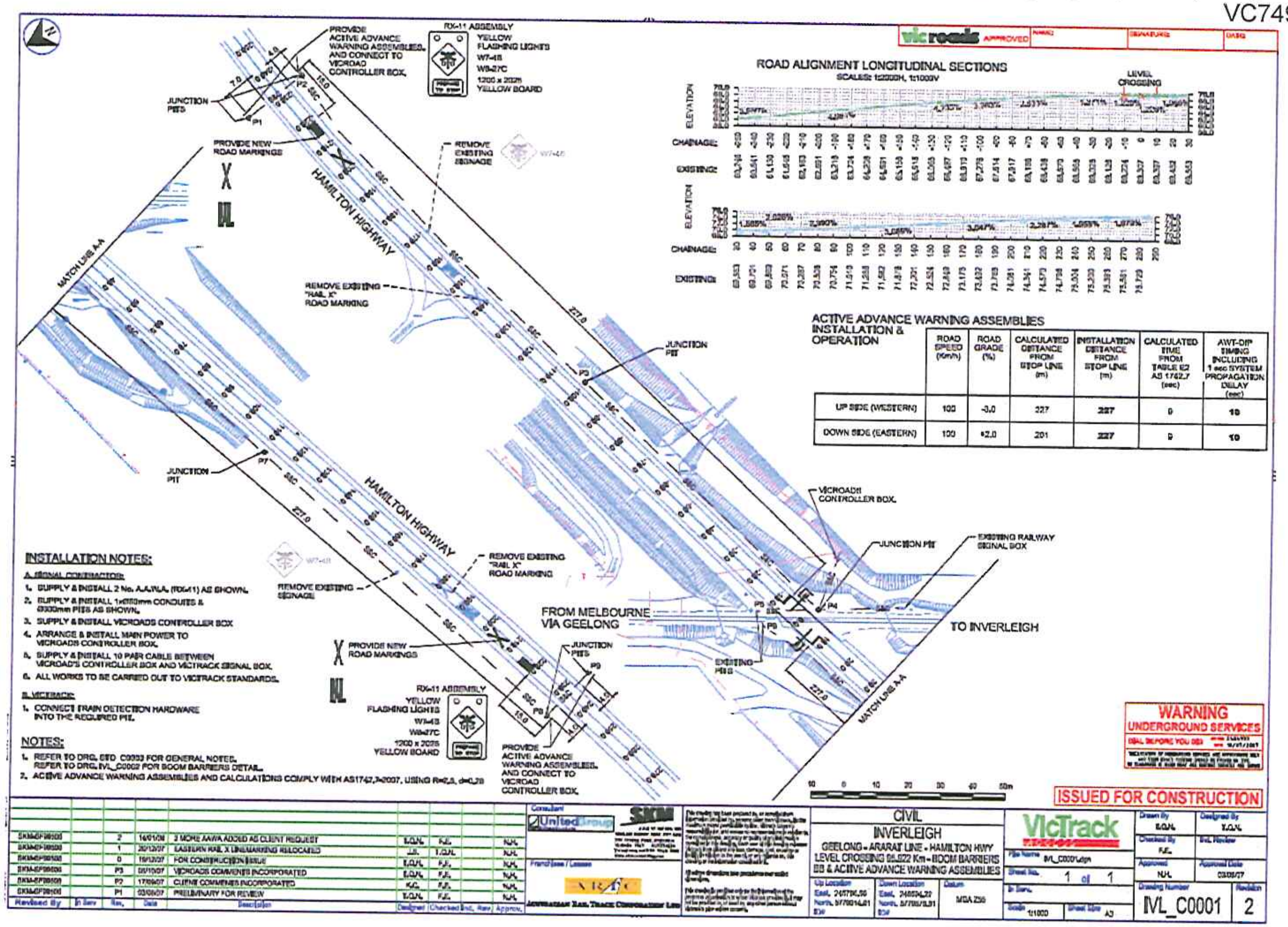


Figure A.7: As built drawings for AAWS at the Inverleigh level crossing

Appendix B – Photos and plans of Cressy level crossing

Photos and plans of the Cressy level crossing are shown in Figure B.1 through to Figure B.8.

*Figure B.1: **Eastbound - approx 700 m from the level crossing***

*Figure B.2: **Eastbound - approx 200 m from the level crossing***

Figure B.3: Eastbound - at the level crossing

Figure B.4: Westbound - approx 800 m from the level crossing

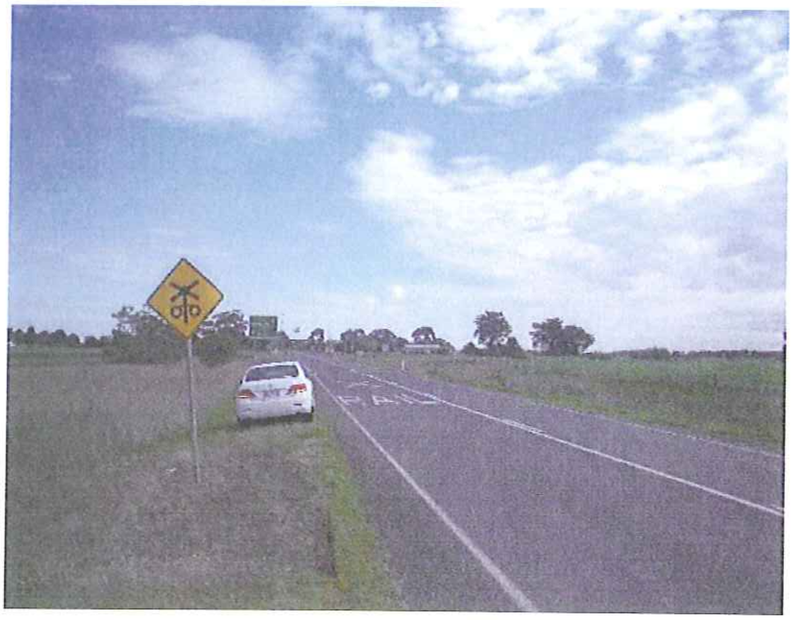


Figure B.5: Westbound - approx 200 m from level crossing

Figure B.6: Westbound - at the level crossing

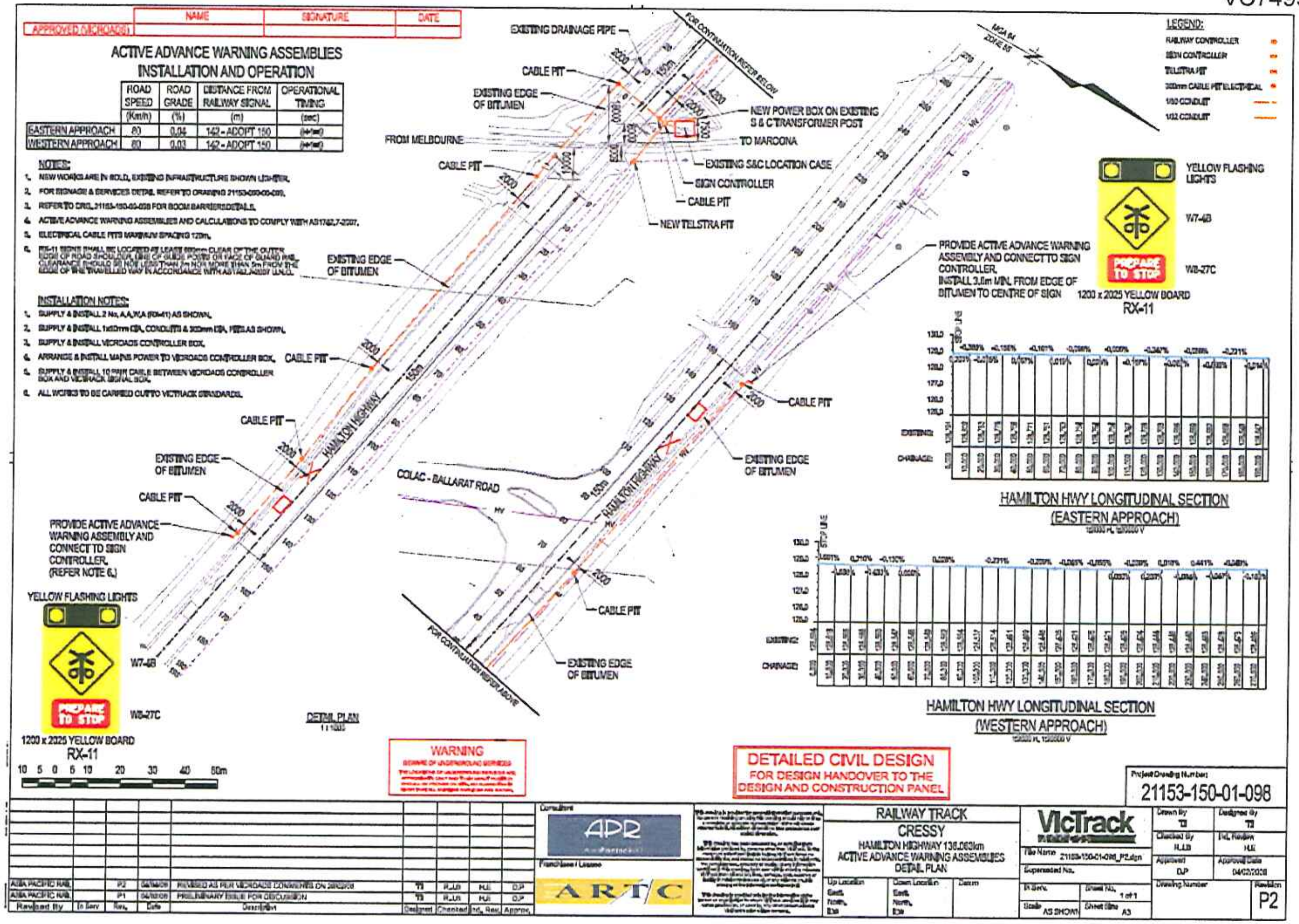


Figure B.7: To be constructed drawings for the AAWS installation at the Cressy level crossing – plan 1

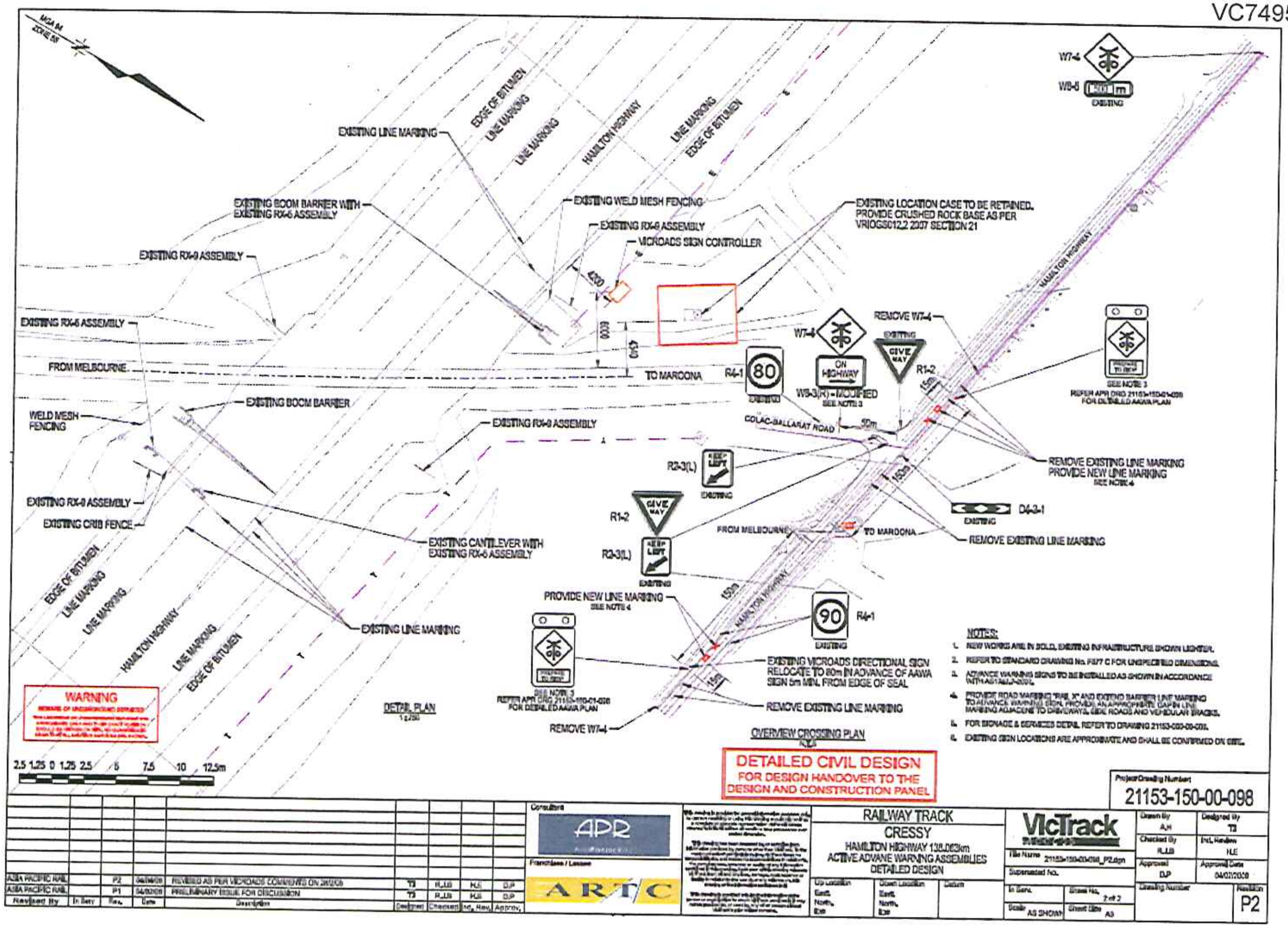


Figure B.8: *To be constructed drawings for the AAWS installation at the Cressy level crossing – plan 2*

Appendix C – Violation distribution

The violation distribution for the two sites for passenger vehicles is outlined in Table C.1 and Figure C.1.

Table C.1: Passenger vehicle violation distribution

	Seconds	Inverleigh - Eastbound	Inverleigh - Westbound	Cressy - Eastbound	Cressy - Westbound
Time after flash commences	1	4	6	3	4
	2	1	3	2	3
	3	1	6	1	0
	4	1	2	2	1
	5	0	1	0	0
	6	0	0	0	0
	7	0	0	0	0
Time after boom falls	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
	5	0	0	0	0
	6	0	0	0	0
	7	0	0	0	0
	8	0	0	0	0
	9	0	0	0	0
Mid	-	0	0	0	2
Time after boom rises	1	1	0	0	0
	2	2	0	0	3
	3	3	0	0	3
	4	17	0	3	24
	5	26	3	11	33
	6	33	27	22	42
	7	42	32	29	35
	8	43	31	35	38

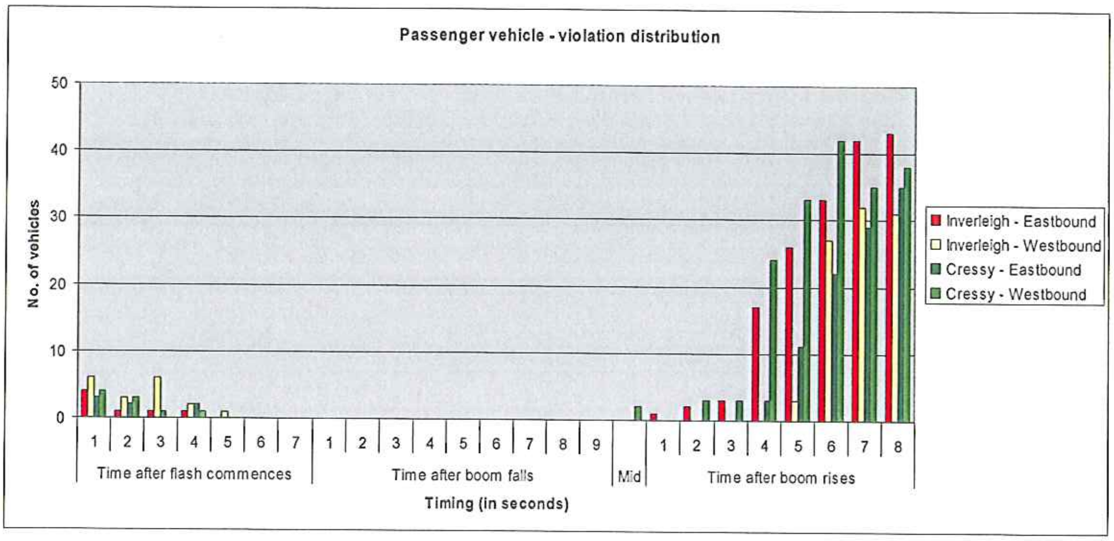


Figure C.1: Passenger vehicle violation distribution

The violation distribution for the two sites for passenger vehicles is outlined in Table C.2 and Figure C.2.

Table C.2: Heavy vehicle violation distribution

	seconds	Inverleigh - Eastbound	Inverleigh - Westbound	Cressy - Eastbound	Cressy - Westbound
Time after flash commences	1	0	1	0	0
	2	1	0	1	1
	3	0	0	0	1
	4	0	0	2	1
	5	0	0	0	0
	6	0	0	0	0
	7	0	0	0	0
Time after boom falls	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
	5	0	0	0	0
	6	0	0	0	0
	7	0	0	0	0
	8	0	0	0	0
	9	0	0	0	0
Mid	-	0	0	0	0
Time after boom rises	1	0	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	1
	5	0	1	0	2
	6	0	3	4	2
	7	0	2	1	3
	8	0	6	2	7

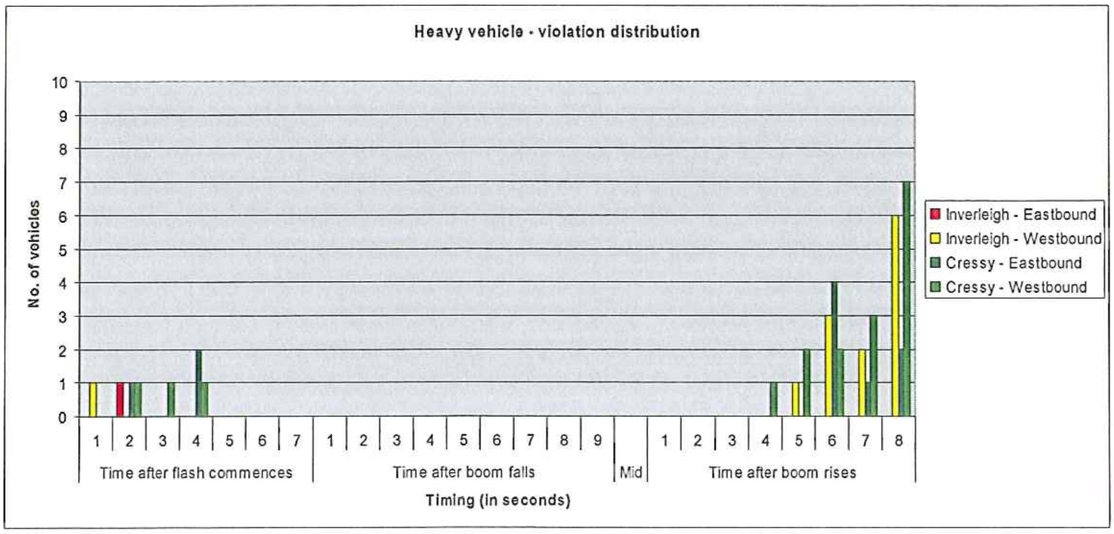


Figure C.2: Heavy vehicle violation distribution