Office of the Chief Investigator
Transport and Marine Safety Investigations

Rail Safety Investigation
Report No 2008/06

Level Crossing Short Warning Time

Freight Train 9251

Queen Street Colac

9 July 2008

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THE CHIEF INVESTIGATOR

The Chief Investigator, Transport and Marine Safety Investigations is a statutory position established on 1 August 2006 under Part V of the *Transport Act 1983*.

The objective of the position is to improve public transport and marine safety by independently investigating public transport and marine safety matters.

The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration. In conducting investigations, the Chief Investigator will apply the principles of 'just culture' and use a methodology based on systemic investigation models.

The Chief Investigator is required to report the results of investigations to the Minister for Public Transport and/or the Minister for Roads and Ports. However, before submitting the results of an investigation to the Minister, the Chief Investigator must consult in accordance with section 85A of the *Transport Act 1983*.

The Chief Investigator is not subject to the direction or control of the Minister(s) in performing or exercising his or her functions or powers, but the Minister may direct the Chief Investigator to investigate a public transport safety matter or a marine safety matter.

Executive Summary

On 9 July 2008 a Warrnambool-bound freight train entered the Queen Street level crossing at Colac with the flashing lights and warning bells operating but before the boom barriers had commenced to lower. This type of incident is referred to as a 'short ring incident'. The operation of the level crossing equipment was witnessed by a member of the public and reported as a near miss. There were no reported injuries or damage to rail infrastructure or other property.

As part of a state-wide program, Queen Street together with several other level crossings in Colac had recently been upgraded with HXP-3 level crossing equipment. This type of equipment is manufactured in the USA and distributed under licence in Australia. Neither the manufacturer nor local distributor could recall a response similar to that which occurred at Queen Street.

The investigation found that the short ring incident was the result of vandals placing a road traffic sign-post across the track late the previous evening. This act set up responses within the level crossing protection system which caused it to assume a condition that effectively masked the approach of the freight train until it was almost at the Queen Street crossing.

In response to the incident, the positive start timer setting of the level crossing equipment has been modified at the Queen Street and adjacent Hart Street level crossings. This change of equipment setting will result in the crossing protection ringing continuously if a similar event was to occur.

The investigation has recommended safety actions in the areas of network risk management, monitoring of level crossing operation and documentation control.

1. CIRCUMSTANCES

On 9 July 2008 at about 0547 a Warrnambool bound freight train entered the Queen Street, Colac level crossing prior to the boom barriers being lowered. This late level crossing equipment operation was reported by a member of the public to the V/Line Train Control Centre (Centrol[1]) in Melbourne. The report indicated that the boom barriers had not commenced lowering until after the passage of the fifth wagon of the train.

When contacted, the driver of the train reported to Centrol that on the approach to the level crossing, a road sign placed across the track had been struck and pushed clear of the track and that the warning lights were operating when the train entered the crossing.

A road traffic sign-post was later found lying beside the track about 30 metres from the crossing. There were no reported injuries as a consequence of striking the traffic sign-post or by the short ringing of the warning devices.

A review of the crossing event logs validated the reported late activation of the warning devices and the position of the boom barriers.

Post incident testing of the level crossing equipment by V/Line did not identify any fault with the operation of the crossing equipment and at 0843 normal rail operations over the level crossing were authorised to re-commence.

[1] Centrol – Provides non-suburban train control and emergency contact.

2. FACTUAL INFORMATION

2.1 The train and crew

The train involved was the 0230 Melbourne to Warrnambool freight train, number 9251 which was crewed by a qualified locomotive driver and a trainee driver. It was operated by El Zorro Transport Pty Ltd and consisted of two locomotives and 17 wagons with a total mass of 448 tonnes. Data from the locomotive speed recorder indicated that the train passed through the level crossing at approximately 60 km/h; 10 km/h below the designated line speed for freight trains.

There is no evidence to suggest that the condition or operation of the train contributed to the incident.

2.2 Location

Colac is an intermediate location on the Melbourne to Warrnambool line with a single platform and a siding. The Queen Street level crossing is situated approximately 400 metres on the Melbourne side of the Colac Railway Station, 152.8 rail kilometres from Melbourne and is one of four level crossings within a distance of about 2.3 kilometres.

Figure 1: Rail approach to the Queen Street level crossing looking towards Warrnambool.

The crossing is an integral part of a significant intersection within the Colac Township incorporating route C154 which is the connecting highway to Forrest and Apollo Bay.

2.3 Environment

The following conditions were observed at Mt Gellibrand; the nearest weather recording location.

On the evening of 8 July 2008 at 2100 the temperature was 6.6 degrees Celsius with a relative humidity of 85 per cent and a south-west wind of about 20 km/h.

At 0600 on 9 July 2008 the temperature was about three degrees Celsius with a relative humidity of 93 per cent and patchy fog.

2.4 Infrastructure

2.4.1 Infrastructure management

The rail line and associated infrastructure including the level crossing warning system is owned by VicTrack (Victorian Rail Track Corporation) and managed by V/Line Passenger Pty Ltd.

2.4.2 Level Crossing Upgrade Program

An upgrade of the Queen Street level crossing was part of the State-funded LCUP (Level Crossing Upgrade Program). The crossing protection was upgraded from incandescent flashing lights to LED (Light Emitting Diode) flashing lights with boom barriers.

2.4.3 Level crossing design and construction

The scope of the works and the governing standards of design and installation were developed by VicTrack. RSS (Rail Signalling Services) was subsequently appointed by VicTrack to undertake all elements of the Queen Street level crossing design, construction, commissioning and handover, under a 'turnkey' contract.

The preliminary design phase included a risk workshop with road and rail stakeholders. In summary, no high or extreme risks were identified for the Queen Street crossing. The design was recognised as being based on current rail practice in Victoria, and was consistent with industry standards. The controls proposed were identified as having been used successfully at other locations. There were a number of follow-up actions identified during the risk workshop. Of note, in the context of this investigation, was that consideration should be given to enabling the positive start feature[2] to cater for stopping trains at Colac station.

The detailed design involved ongoing stakeholder consultation and the preparation of documentation to support the installation and commissioning of the upgraded crossing. It was subjected to an internal review in accordance with the contractor's quality assurance procedures and a final review by an external, independent reviewer engaged by the contractor.

RSS was responsible for planning, installing, testing and commissioning the crossing in liaison with VicTrack and V/Line. Acceptance of the upgraded crossing into service required the sign-off of RSS, VicTrack and V/Line and the crossing was subsequently commissioned on 30 May 2008. At this time the management of the upgraded

[2] Positive start feature responds as a motion detector for inbound train movements - refer to section 2.6.2 for a full description.

crossing became the responsibility of V/Line under their safety management system. The steps in the upgrade process are shown at Figure 2.

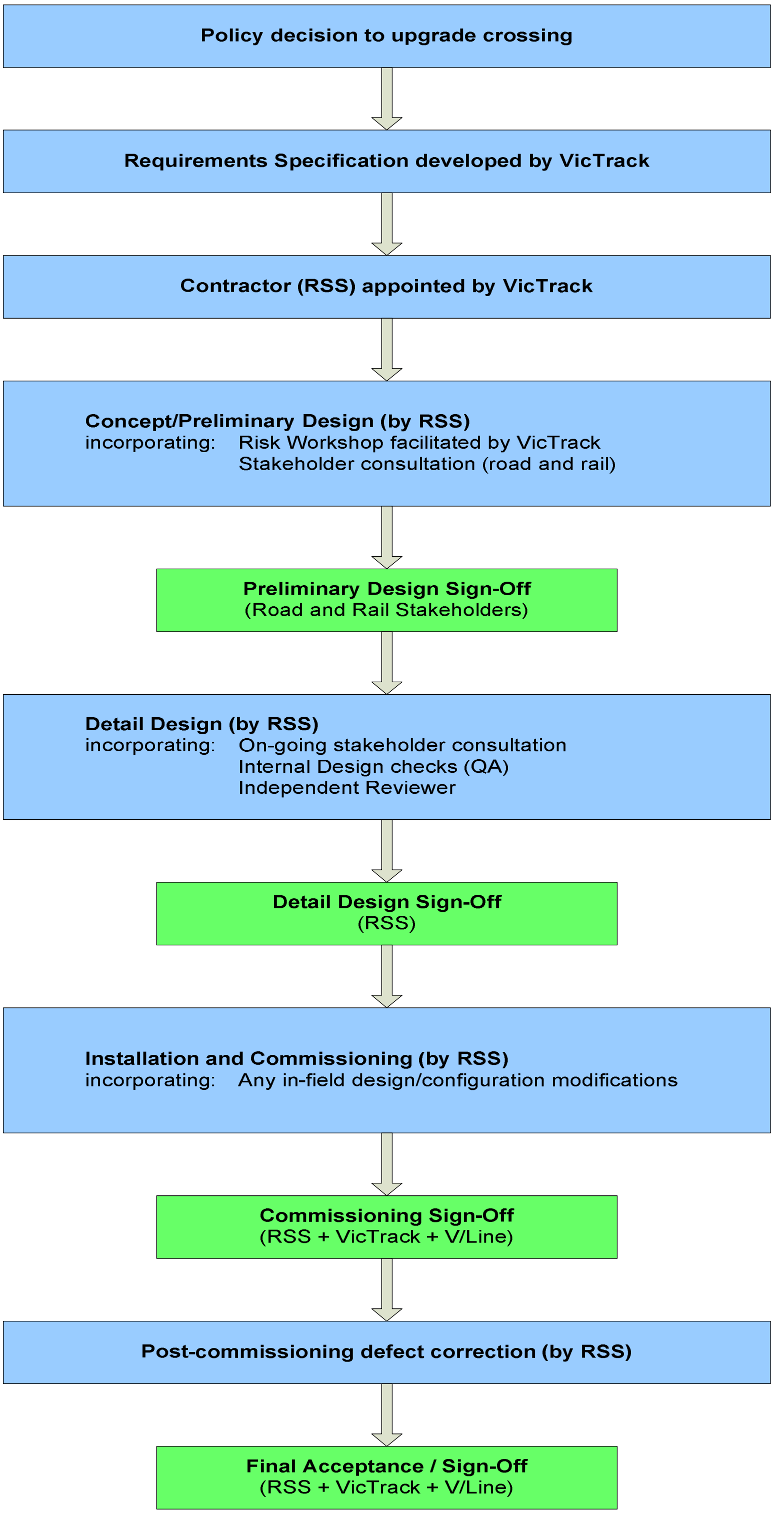

Figure 2: Queen Street level crossing upgrade process.

2.4.4 Track circuitry

The track circuits for the Queen Street level crossing overlap three other level crossing circuits; that for Church Street towards Melbourne and those for Hart Street and Armstrong Street towards Warrnambool. Separate operation of the circuits is facilitated through the use of a different frequency band for the circuit of each crossing. The Queen Street level crossing circuits extend about 1,000 metres either side of the crossing and operate on 430 Hz.

2.4.5 Track environs

On the approach from Melbourne, the Queen Street level crossing is situated on a rising gradient of two per cent (1:50). The track is rated as Class 2 with timber sleepers and CWR (Continuous Welded Rail) of 47 kg/m. On the approach to Queen Street the ballast was fouled with mud and had a thin, low shoulder (see Figure 3).

Figure 3: View of the Down approach to Queen Street, looking towards Warrnambool.

2.4.6 Post incident crossing equipment testing

Functional testing of the crossing did not identify any fault with the crossing system or equipment.

2.4.7 Site re-enactment

Tests were conducted by V/Line in an attempt to replicate the events leading up to the incident. Separate tests were conducted using a hard-wire shunt and a galvanized pipe similar to road traffic signage. The test using wire resulted in a good sudden shunt which was readily detected by the system as a false shunt and the system responded as designed. By contrast, testing with a length of galvanized pipe produced erratic and varied shunts depending on the amount of downward pressure applied to the pipe.

Additional testing with the galvanized pipe was conducted using water at the pipe to rail interface in an attempt to simulate any moisture that may have been present on the night of the incident. This latter testing was inconclusive and a system response similar to that which occurred on the night of the incident could not be replicated.

2.5 HXP-3 level crossing predictor

2.5.1 Predictor philosophy

As part of the Queen Street upgrade, the method of crossing activation was modified to incorporate predictor technology. Prior to upgrade, the crossing protection was activated using a fixed circuit system.

Crossing protection using fixed circuits results in level crossing activation whenever a train comes within a fixed distance of the crossing. The crossing circuitry in such systems is designed to accommodate a train approaching at the track speed limit. However, this makes for longer warning times for trains approaching the crossing at lower speeds. In some cases this may result in minutes, rather than the preferred 25-30 seconds of warning time, thus delaying road traffic or inducing motorists to drive around or through the crossing protection, potentially with a train approaching.

By contrast, a predictor system is designed to provide consistency in level crossing warning times. The system estimates the speed of the train, its arrival time at the crossing and activates the crossing protection to achieve a pre-determined warning time. This activation method is the preferred option in Victoria when upgrading level crossing sites outside the electrified network.

The upgraded Queen Street level crossing was fitted with an HXP-3 predictor system manufactured by GE Transportation of the USA and distributed in Victoria by RSS.

2.5.2 HXP-3 operational overview

To achieve constant warning times for level crossings, the HXP-3 predictor monitors the position and speed of an incoming train by transmitting and monitoring a low voltage AC signal along the track. After entering the track circuit area, the lead axle(s) shorts the circuit across the rails, typically referred to as a shunt. As the train closes on the crossing, the movement of the axle is monitored by the system.

Measurements of transmitted track current, transmitted check voltage and receiver voltage are analysed to calculate RX. The RX is a measure of circuit impedance and is used to determine the train's distance from the crossing and its expected time of arrival at the crossing.

The functionality of the HXP-3 unit is illustrated by Figure 4 which depicts the HXP-3 in normal operation with the numbers 1 to 5 indicating train positions as follows:

1. The train is beyond range of the HXP-3 and not yet detected (RX = 100).

2. The train is detected and RX begins to fall. The rate at which the RX changes is used to calculate the speed of the train. This speed is used to calculate the time the train will reach the crossing.

3. At this point the calculated train approach time equals the programmed crossing warning time, causing the crossing warning system to activate. RX continues to fall.

4. As the train arrives at the crossing, the RX = 0.

5. RX commences to increase following the train leaving the crossing, the RX increases to 100 once the train leaves the range of the HXP-3.

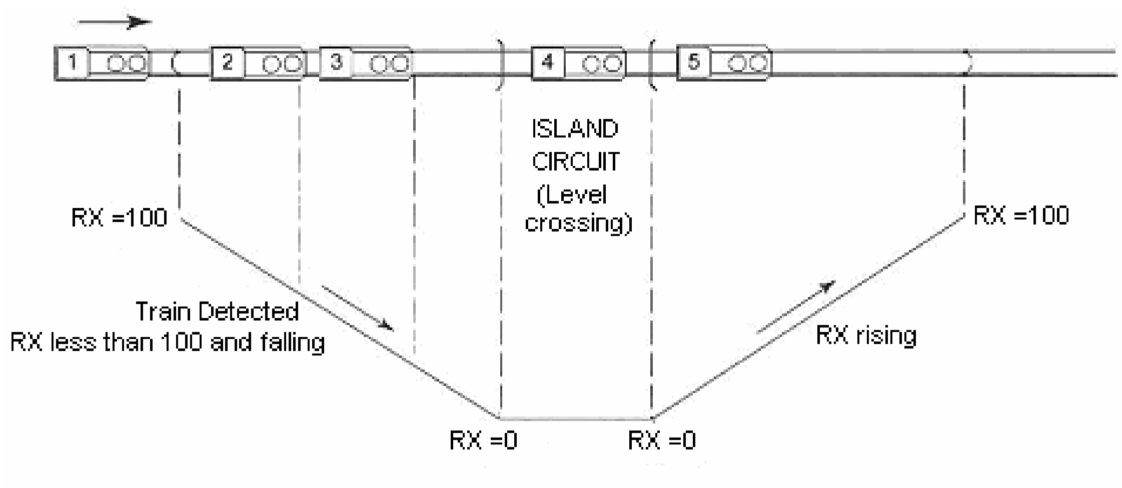

Figure 4: HXP-3 philosophy of operation

2.5.3 Key HXP-3 protective features

High signal detection feature

The high signal detection feature is designed to detect a broken rail or open bonding circuit condition within the crossing approaches and prevent a loss of warning time. The RX is normally adjusted to a setting of 100 with the approach track clear. With this pre-set condition, an RX reading of 110 or more will result in the HXP-3 entering a high signal condition which will cause the crossing to activate.

Low phase detection

The phase angle is influenced by ballast resistance, frequency settings and natural variations (environmental conditions) at the specific location. The phase angle is used to monitor the condition of the track ballast and the HXP-3 will detect a low phase condition before a significant loss of warning time occurs. A low phase condition will cause the crossing to activate.

High signal and Low phase monitoring

High signal and Low phase conditions are not normally alarm triggers for SMS text and e-mail notifications however they are monitored for follow-up action by the fault centre technician.

2.5.4 HXP-3 data logging

The HXP-3 has an optional Recorder Memory Module (RMM) featuring four distinct logging functions, namely:

(a) A train record log, which provides system diagnostic information regarding train movements.

(b) A system event log, which records any changes of status concerning all relay drives.

(c) A train data log, which records the RX and Phase response for up to four train movements.

(d) An external event log, capable of monitoring 14 digital and four analogue inputs.

HXP-3s can be equipped with an internal modem for providing remote access to recorder data. The HXP-3 at Queen Street was connected to a SEAR II logger with an external modem.

2.6 Queen Street level crossing protection

2.6.1 HXP-3 design parameters

The design of the upgraded Queen Street level crossing protection was typical of that for single track locations found throughout Victoria. Conditions peculiar to the site were the close proximity of a number of other level crossings, leading to overlapping of crossing circuits.

The principal operational parameters used in the design were:

(a) A maximum line speed of 115 km/h.

(b) A predictor warning time setting of 30 seconds.

2.6.2 HXP-3 options selected

The HXP-3 predictor system has considerable flexibility and several option settings are available to cater for site-specific conditions and operating requirements such as those present at Colac.

In relation to this incident, the key options and the selected settings at completion of design and subsequently at the time of commissioning are shown at Figure 5. A more detailed description of these setting options follows.

Option	Description of Setting	As Designed	Commissioned
7	LOS (Loss of Shunt)	16 seconds	16 seconds
18	MD-TMR (Motion Detector Timer)	10 minutes	10 minutes
20	FS-DET (False Shunt Detection)	RX = 80 10 minutes	RX = 80 10 minutes
21	POS-ST (Positive Start)	RX = 0 0 minutes	RX = 34 0 minutes

Figure 5: Key design options and settings.

Of note is the change to the Positive Start setting made at commissioning. The Positive Start was not enabled in the design which did not take into account any specific influence of Melbourne bound trains stopping at Colac Railway Station. The Positive Start feature was enabled during the commissioning process after it was identified at site that the 30 second warning time could not be guaranteed for Melbourne bound trains that stopped at the Colac Railway Station.

The decision to enable the Positive Start was made in agreement between the site representatives of RSS, VicTrack and V/Line. There was no external design review process applied for this on-site change.

POS-ST (Positive Start)

Positive Start provides a feature that responds to inbound train movement as a motion detector within the RX value of 74 to zero. (It should be noted that when enabled the feature acts on approaches from both directions to the level crossing.) POS-ST requires inbound train movement from an RX value higher than the positive start RX setting before starting. POS-ST is not initiated by a sudden shunt and POS-ST can be cleared by the following conditions:

- (a) when the crossing island clears following the passage of a train;
- (b) when the POS-ST timer plus the LOS timer times out; or
- (c) when the RX value increases to above the positive start RX setting such as when a train backs away from the crossing.

The POS-ST contains the following two variables:

- (a) Positive start RX which defines the RX value at which point the Positive Start region will commence. A train detected at a lesser RX value than this will activate the crossing protection. In this instance, the setting at commissioning of 34 equates to a distance of around 340 meters on either side of the crossing.
- (b) Positive start timer which defines the amount of time (minutes) that a train will be detected as stationary before the crossing protection will be lifted. Values can range from zero to 99 with the setting of 99 resulting in continuous ringing. In this instance, a timer setting of zero permits the

HXP-3 to recover and the protection to lift after the LOS time (16 seconds) when a train has come to a stand in the Positive Start region.

LOS (Loss of shunt) Time

This option is used to establish the time that the crossing will continue to ring after motion has stopped on the track selected. The LOS time is adjustable between four and 99 seconds. When an approaching train stops after the crossing activates but before reaching the island circuit (the track circuit in the immediate vicinity of the level crossing which, when occupied, operates the level crossing warning devices), the level crossing will not cease operating before the LOS time expires. The default value is 16 seconds.

MD (Motion Detection) and MD-TMR (Motion Detector Timer)

The HXP has a number of features to cause it to shift from its fundamental operating mode of CW (Constant Warning), to a secondary (safe) mode of MD (Motion Detect). In the MD mode, the prediction functions are disabled and the crossing is activated by a train in motion on the circuit (falling RX).

The device can be set manually to MD mode or automatically when track circuit conditions are such as to compromise the CW function.

The HXP-3 will also revert to the MD mode of operation should a train be stopped some distance within the approach. When these conditions arise, should the train be stationary for a period in excess of 10 minutes the level crossing protection will be activated immediately when the train moves again towards the crossing.

The version of HXP-3 installed at Queen St incorporates the "Motion Detect Timer" (MD-TMR) - Option 18 - that enables the period that the train must remain stationary prior to the device reverting to the MD mode to be extended from 10 minutes to a maximum of 99 minutes.

FS-DET (False Shunt Detection)

This option is used for the detection of a sudden shunt causing the RX to rapidly drop at a rate not achievable by an approaching train. Such sudden shunts could be caused by incidental contact across the rails by maintenance activities, or through vandalism. The setting option contains the following two variables:

(a) False Shunt RX which sets the maximum RX value whereby a false shunt can be detected.

(b) False Shunt Timer which sets the amount of time required to elapse before the crossing rings after a false shunt. Values can range from zero to 99.

2.6.3 Ballast compensation

The HXP-3 is fitted with BC (Ballast Compensation) which is used to counteract variations in the RX due to changing ballast conditions. To provide consistent warning times and accurate train speed data, the RX should be as close as possible to the nominal figure of 100 in all ballast conditions.

To compensate for the ballast conditions at the Colac site, the BC had been adjusted to a figure of 180 which compares to the factory (default) setting of 160.

2.6.4 Differences between actual and documented configurations

The actual (installed) configuration of the crossing equipment was found to be different to the design and AIS (as-in-service) drawings. Specifically, the HXP-3 electronics box was located on the diagonally opposite side of the crossing and the transmitter output and receiver input wires transposed.

The investigation was advised by the equipment supplier that the difference between design and installed configurations would have had no measureable effect on functionality.

2.7 Recorded data

2.7.1 RX data

The HXP-3 data logger records the variation in the circuit impedance (RX) over time. Data logger information supplied by the equipment distributer, RSS, has been reproduced in this report and was used as the basis of further examination by the investigation.

In each of the plots:

(a) the RX signal is shown in red;

(b) the state of the protection MDR (Motion Detector Relay) is shown in purple; and

(c) the occupation of the island circuit by a train is shown in yellow.

Signalling specialists were engaged by the investigation to assist in the interpretation of the data and the identification of scenarios which may have caused the behaviour. Each stage of behaviour is marked by a letter on the plot as a reference for the subsequent descriptions.

2.7.2 Evening of 8 July 2008

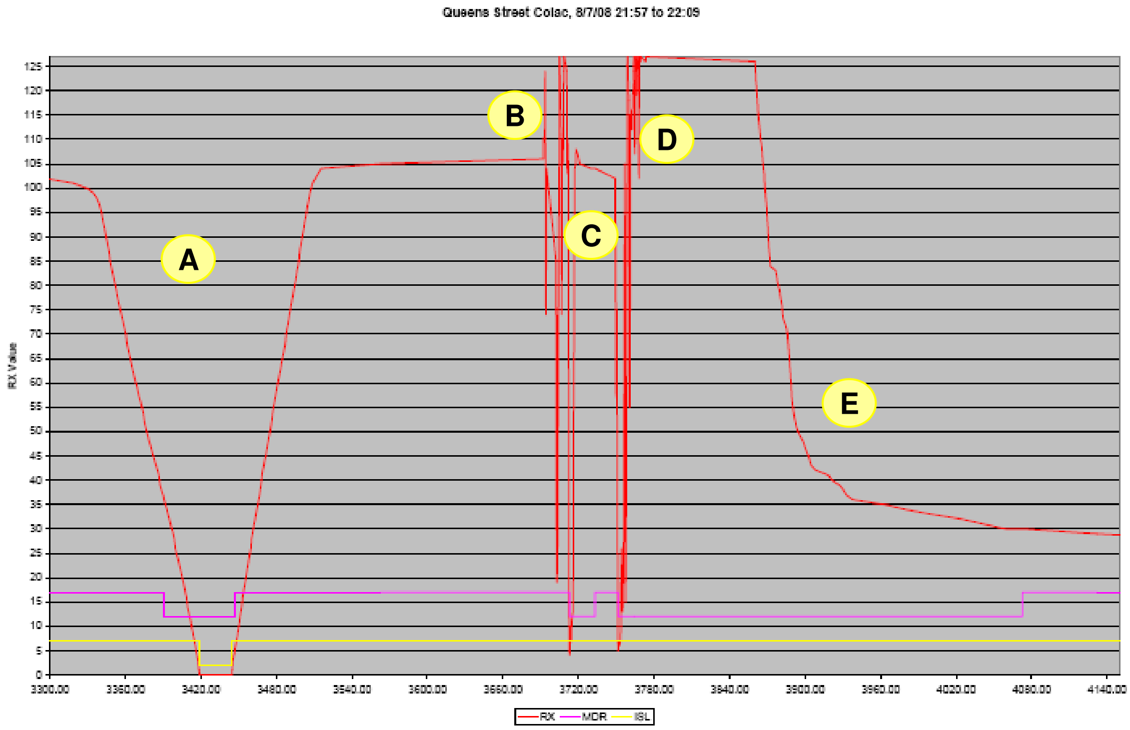

Figure 6: Variation in RX between approximately 2157 and 2209 on Tuesday 8 July 2008.

Stage A

This stage represents the typical passage of a train over the crossing and operation of the crossing protection. The steadily reducing RX value indicates an approaching train at around 2157. The RX falls to zero as the train enters the crossing island then steadily climbs after the train has cleared the island circuit and moves away from the crossing.

The MDR trace confirms operation of the protective devices, with warning signals activated about 25 seconds prior to the train entering the crossing and clearing following the passage of the train.

The train passing through the crossing at this time has been confirmed as service number 8243, the 8 July 1828 from Southern Cross to Warrnambool.

Stage B

There are sudden fluctuations in the RX signal at around 2202. The RX indications fluctuate wildly between about four and the maximum value that can be represented by an 8-bit digital representation, 127.

The equipment manufacturer advised that a high resistance shunt, of an order similar to the ballast resistance, can cause the phase to drop, resulting in a rise in RX and potentially accounting for the high signal condition.

There was general consensus between the investigation, the track manager and the equipment supplier that the erratic RX behaviour is consistent with the application of an imperfect shunt and supports the belief that a traffic sign-post had been laid across the rails and possibly manipulated on the rails.

The crossing protection was activated by the system about 18 seconds after the commencement of fluctuations in the RX signal. The RX data dipped to its lowest level (approximately four) just prior to crossing activation.

Stage C

The RX then stabilised just over the nominal “circuit clear” level of 100 indicating a loss of any shunt across the rails. The crossing protection lifted about 17 seconds after it had commenced.

Stage D

The RX drops suddenly and is again erratic suggesting the presence of a second, imperfect false shunt. Following further fluctuations, the RX signal indicates the system going into a high signal condition, staying at its maximum value of 127 for around one minute 25 seconds. Similar to the first imperfect shunt, the equipment manufacturer advised that a high resistance shunt may cause the RX to rise, potentially accounting for the high signal condition.

The protection activated about two seconds after the RX initially began to drop and immediately after it reached its lowest value of about five. The system first re-entered a high signal condition more than six seconds after the crossing activation.

Stage E

After remaining at its maximum RX for an extended period, the indicated RX value then began to decay. This decay was approximately reconstructed with an assumed time constant of 60 seconds. The signal reduced to an RX of 30 over approximately three minutes.

Having been active for about four minutes and 38 seconds, the protection lifted at about 2208 once the RX had stabilised at 30 for around 15 seconds. This is consistent with the LOS timing out.

The cause of the decay in the RX signal is not evident from the signal itself. The equipment manufacturer opined that temperature changes may have caused the rails to move slightly, thereby affecting the shunt over time. The shunt may have likewise been impacted by other physical or environmental factors which might have varied the interface between the rail and sign-post over this short period of time.

In addition to potential physical scenarios, there is the possibility that the RX signal had been internally generated and represented the recovery of the system from its extended period at a high signal condition. When proposed as a possibility, the equipment manufacturer said that an internal self test or reset condition will not cause the RX drift and advised that numerous self tests are built into the hardware and software, but none affect RX.

2.7.3 2208 on 8 July to 0547 on 9 July 2008

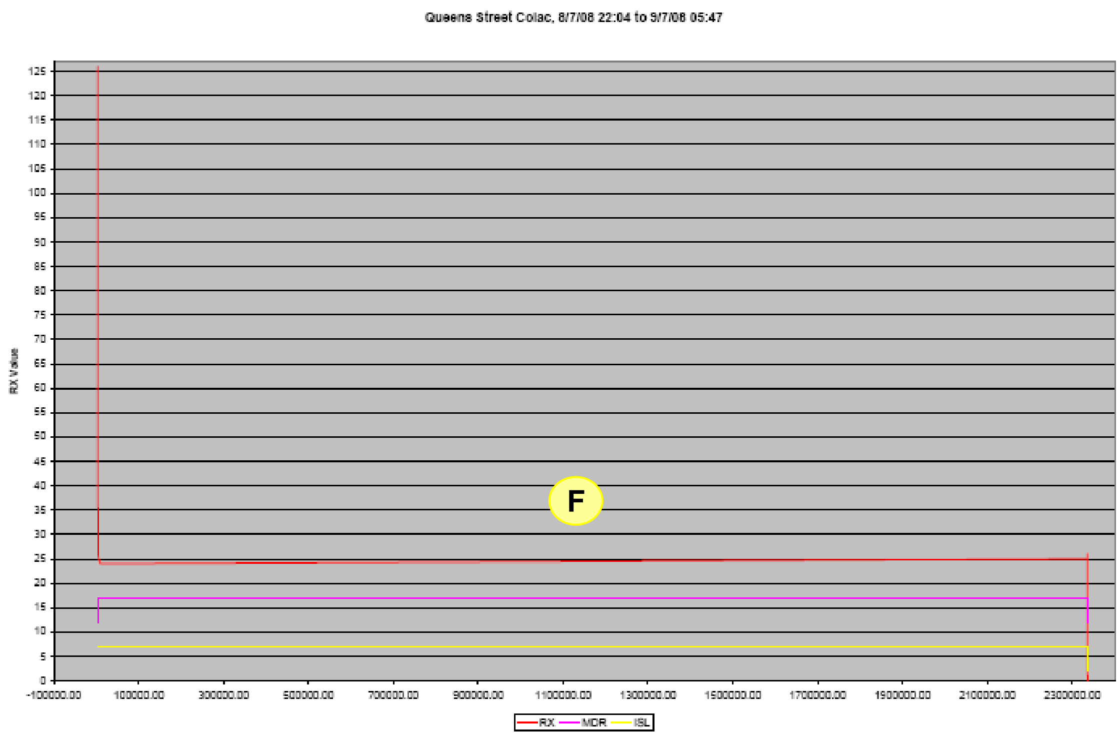

Figure 7: Variation in RX after stabilising and prior to passage of freight train.

Stage F

The initial spike is either a compressed or spurious record which should be ignored.

After recovering from its high signal condition and stabilising for a short period at an RX of 30, the RX reduced further to about 24 before remaining reasonably stable for more than seven hours overnight and until the early hours of the morning. The level crossing protection remained inactive throughout the night.

2.7.4 Short-ring incident at 0547 on 9 July 2008

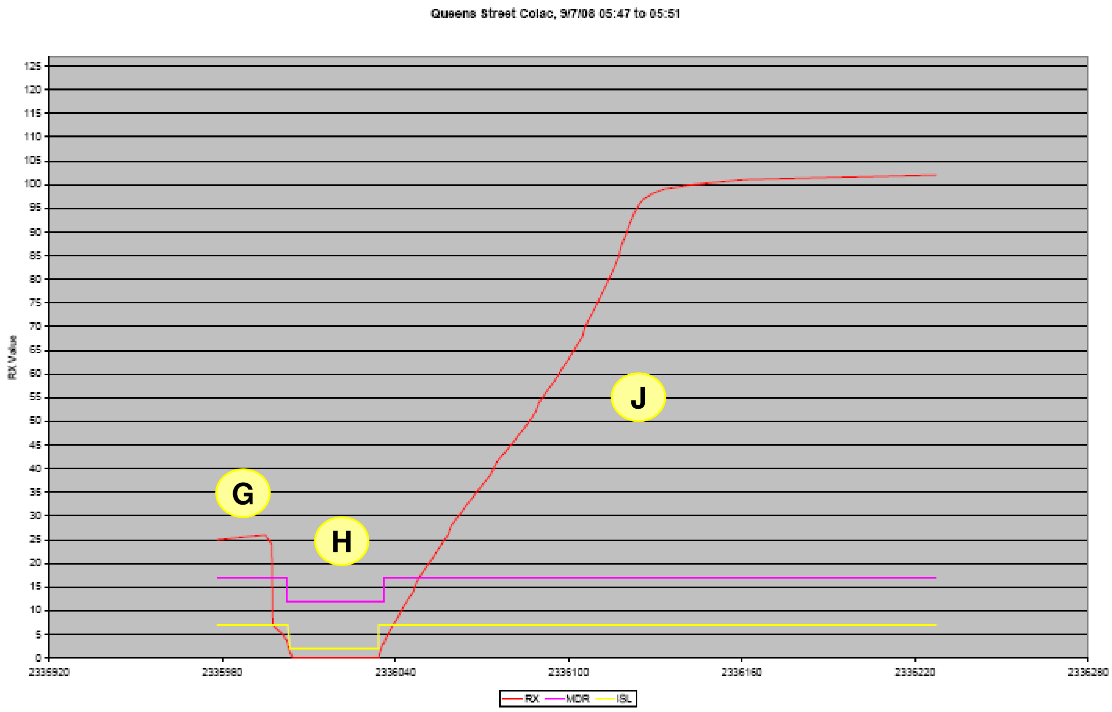

Figure 8: Variation in RX between 0547 and 0551 on Wednesday 9 July 2008.

Stage G

At around 0547, the RX rose slightly before dropping suddenly to about seven. This is consistent with the sudden removal of a shunt by the passage of a train and supports the view that the sign-post was pushed from the track by freight train 9251. The RX then commenced to drop at a rate consistent with the transit of a train before reaching an RX of zero at the crossing island circuit.

Stage H

The crossing protection activated about one second prior to the train entering the island circuit. The booms subsequently commenced lowering about eight seconds after the train entered the crossing and it was a further five seconds before the booms were fully lowered. The boom barrier timings conformed to the standard once the track circuit was activated.

Stage J

The RX and MDR signals indicate normal operation with the protection lifting after the passage of the train. The crossing protection cleared as the RX value rose, tracking the rear of the departing train.

2.7.5 Equipment manufacturer's analysis of data

The equipment manufacturer undertook bench testing and an examination of the data records for Queen Street in its attempts to analyse the events of the incident.

Performance of HXP-3

Bench testing indicated that the HXP-3 at Queen Street had responded as expected given the as-installed configuration settings and assuming the recorded RX signal as an applied input. The manufacturer said that both crossing activations at around 2203 on 8 July were due to the system going into a high signal condition.

Undefined phase condition

The manufacturer identified a system phase angle of 32 degrees for several hours after the system's extended period in a high signal condition. Such a phase angle would normally be expected to register as a low phase condition and cause the crossing protection to be active.

The manufacturer subsequently confirmed that the system had entered an "undefined phase" condition due to the very low amplitude of the received voltage signal. Such a condition is defined within the processor software to avoid inconsistent or erroneous measurement of phase between low amplitude signals and in turn avoid the unnecessary activation of the crossing protection. When in an undefined phase condition, the low phase protection is cancelled.

The manufacturer further commented that the undefined phase region would vary at each location depending on such things as the ballast condition, system frequency and track drive settings. Colac is known to have poor track ballast conditions.

2.7.6 Investigation bench simulations

Utilising a range of shunts, a number of attempts were made to induce a system response similar to that seen at the Queen Street level crossing. While varying behaviour was achieved, an RX signal similar to that experienced at Queen Street could not be replicated as an output to imperfect shunt activity. It was also not possible to fully examine the underlying internal processing of the HXP-3.

Simulations were then conducted using, as an input, a generated RX signal based on the event data. In these trials, the test system behaved in a similar manner to that experienced at Queen Street. Consistent with the actual event, the protection lifted after stabilising at an RX of 30 following the extended period in a high signal condition.

In conclusion, the tests demonstrated that the system would respond in a consistent and defined manner when the recorded RX signal was applied as an input. However, the testing did not enlighten the investigation on the cause(s) of the RX behaviour.

2.7.7 System alarms

In addition to the standard HXP-3 data logging facility, the Queen Street installation was also fitted with a SEAR II event monitor configured to respond to pre-programmed criteria to send alarm messages to the central computer system WAMS (Wayside Alarm Monitoring System) for analysis. When this information is of a safety critical nature, WAMS engages other methods to report the condition to a number of designated key operational people, either via e-mail or SMS messaging. On the day of the incident the e-mail and SMS alarm reporting systems were nullified due to technical issues with V/Line's communications carrier.

At 0547:49 on the day of the incident, two alarms were received at the central computer system; one indicating a short warning time (four seconds), the other indicating that the island track was occupied without the boom barriers being horizontal. These alarms were consistent with the witness report that a train had entered the crossing without sufficient warning and with the barriers not yet horizontal.

Centrol, which operates on a continuous basis, is not included in the alarm system notification protocols. Had the short ringing incident not been witnessed and reported by a member of the public, V/Line would not have had any knowledge of the Queen Street occurrence until the daily WAMS reports were interrogated.

After the second imperfect shunt, the crossing protection was active for less than five minutes. The SEAR II alarm system as programmed would not send out an alarm message unless the level crossing had been operating for at least 10 minutes, therefore in this instance, no alarms were generated or recorded in the period leading up to the short-ring incident.

2.8 Response to incident

Both RSS and the equipment manufacturer reported not having previously experienced HXP-3 behavior similar to that recorded at Queen Street.

On 28 July 2008, RSS issued the following recommendation to prevent a similar incident at the Queen Street and adjacent Hart Street crossings:

"*To reduce the risk of the level crossing at Colac Queen Street and Hart Street failing to operate as expected if a similar false shunt were to be placed across the track sometime in the future, Rail Signalling Services make the following recommendation :-*
That the Positive Start Timer be set at a value of 99, to ensure whenever Queen Street and Hart Street level crossings are activated by the Positive Start feature, that they will continue to operate indefinitely until the approach sections are clear."

In addition to immediately implementing the recommended change, V/Line suspended further commissioning of HXP-3 level crossing upgrades and conducted a system-wide risk assessment with respect to similar installations and proposed upgrades.

2.9 HXP-3 software upgrade

On 8 August 2008 the equipment manufacturer, GE Transportation Global Signalling, issued Engineering Safety Bulletin ESB 08-003 notifying of an upgrade of HXP-3 software to versions 4.20 and 42.0. At the time of the incident, the HXP-3 at Queen Street was fitted with software version 41.0. In part the engineering bulletin identified an issue with the existing HXP-3 software, stating *"Inconsistent operation of the False Shunt feature (option 20). If two consecutive shunts were placed on the approach, the second shunt had the potential of clearing the False Shunt timer. The new software retains the False Shunt feature when consecutive shunts are applied to the approach"*.

The equipment manufacturer has confirmed that the software upgrade was not in response to the Colac incident and that there was no change in version 42.0 which would have addressed the HXP-3 behaviour exhibited at Colac.

3. ANALYSIS

3.1 The incident

All available information indicates that at around 2200 on 8 July 2008 a road sign-post was positioned across the rail track 50 to 100 metres on the Melbourne side of the Queen Street level crossing. This resulted in an imperfect shunt across the rails and caused the activation of the level crossing protection system. The crossing protection then lifted in response to a return to a clear track condition, most probably due to the sign-post either being lifted off the track or losing effective contact with the rails.

A short time later an imperfect shunt again resulted in the crossing protection system being activated. The system subsequently went into a high signal condition, possibly in response to the shunt becoming relatively high resistance in nature, which the equipment manufacturer has advised can cause the phase to drop and the RX to rise. In this condition, the crossing protection remained active.

About one and a half minutes later, the system commenced recovering from its high signal condition, with the RX initially dropping steeply and then more slowly before initially stabilizing at a value of around 30. The reducing RX signal was not caused by the passage of a train as there was no rail vehicle present. The residual low impedance was almost certainly due to the sign-post being left on the track, possibly weighted in some way to achieve better contact between rail and post.

After about 15 seconds, at an RX of 30, the system timed out and the crossing protection lifted. This reflects a loss of shunt (LOS) condition and the operation is consistent with a positive start timer set at zero and an LOS set at 16 seconds.

The system remained in a low RX state of between 30 and 25 for about seven hours and 45 minutes. In this condition the shunt caused by the sign-post would have masked an approaching train and prevented the timely activation of the level crossing warning flashing lights and boom barriers.

At about 0547 the next morning, train 9251 struck the sign-post removing it from the track and triggering the activation of the level crossing protection. However, due to the already close proximity of the train to the level crossing, there was insufficient time to provide adequate warning and the lights commenced flashing only one to two seconds before the train entered the Queen Street crossing; significantly less than the design figure of 30 seconds.

There was also insufficient time for the level crossing boom barriers to lower prior to the train entering the level crossing. The boom barriers began to lower about eight seconds after the train entered the crossing and it was a further five seconds before the booms were fully down.

After the train cleared the crossing, the boom barriers lifted and the flashing lights ceased operating as designed.

3.2 Mechanisms leading to system response

Both physical testing and simulation have been undertaken in an attempt to ascertain the mechanism leading to the crossing protection response including the characteristics of the recorded RX signal. However, in no case was it possible to accurately reproduce a similar RX signal or system response by manipulation of a single or multiple imperfect shunts, such as a sign-post placed across the rails may have presented. Despite this, testing and review of data has provided some insight into possible mechanisms.

The initial erratic RX behaviour at around 2203 on 8 July is considered consistent with the manipulation of an imperfect shunt across the rails. While the precise mechanism of rail/shunt interaction cannot be replicated, the investigation has concluded that a sign-post placed or manipulated on the track led to the RX behavior and subsequent system response.

The mechanism leading to the decay in the RX signal after the extended period in high signal condition is less clear. A number of hypotheses have been put forward as to possible physical phenomena which could cause such a recorded RX signal. While such physical events are possible, in no case has there been strong supporting evidence for a particular physical scenario.

The alternative hypothesis is that the decay was in some way generated or contributed to by the HXP-3 system itself. However, given the complexity of the HXP-3 processor and the proprietary nature of the equipment and its software, it has not been possible for the investigation to examine this scenario with any depth nor draw any specific conclusion. The investigation does note that the equipment supplier has advised that an internal self test or reset condition will not cause the RX drift.

Even though the source of the decaying RX signal is unclear, the subsequent repercussions of the signal can be evaluated by simulation. Such simulations confirm that given the recorded RX signal, the system responded as one might expect given its configuration and settings. An interpretation of the reducing RX signal is of an approaching train that has slowed and come to a stand prior to entering the crossing.

3.3 Level crossing equipment performance

3.3.1 Queen Street level crossing response to false shunts

As commented above, it is probable that a sign-post was repeatedly used to create a shunt across the track on the Melbourne side of the Queen Street level crossing.

Due to the imperfect nature of the electrical connection between the sign-post and railhead, the system has not detected either shunt as a false shunt.

While the precise mechanism of the system response has not been confirmed, it is clear that the system failed to adequately detect the presence of the false shunt caused by the sign-post. This condition resulted in the masking of the approach of a subsequent train.

3.3.2 Positive start settings

Given the nature of the reducing RX signal after the extended period in a high signal condition to below the positive start RX setting of 34, a positive start timer setting of zero meant that once the RX had stabilized, the system would quickly time-out and the level crossing protection would lift. Had the positive start timer been set on 99, the crossing protection would have continued to operate indefinitely.

While a positive start timer setting of 99 would have prevented this short-ring incident, it is not unreasonable for a setting of zero initially to have been used at Queens Street, based on the rail traffic and operational expectations for the line.

3.3.3 Ballast compensation

While ballast conditions were not ideal and the ballast on the approach was fouled, the HXP-3 makes provision for system correction and the BC setting had been adjusted on-site. There is no evidence to indicate that the ballast conditions or the BC adjustment contributed to the incident.

3.4 Queen Street level crossing design and installation processes

3.4.1 Design

The design process was completed in accordance with accepted industry standards and guidelines. The design and construct methodology applied to the Queen Street upgrade was not considered contributory to the incident.

3.4.2 Site modifications

During commissioning tests it was identified that there was a possibility that the system may not be able to provide the standard warning time for Melbourne bound trains stopping at the Colac platform. As a result, the stakeholder representatives conducted an on-site risk assessment to modify the design by enabling the positive start feature. When enabled, the positive start timer was set at zero.

While this change was not subject to independent design review processes, the setting decisions made at site are not considered unreasonable. However, given the experience of the Queen Street incident, there appears to be a case for incorporating site modifications into a formal design review process.

3.4.3 Documentation configuration control

As-in-service drawings were found to be inconsistent with the actual site configuration. Likewise, site working documents for field maintenance staff did not fully reflect the actual system configuration.

While not consequential to the incident, this inconsistency reflects poor documentation control procedures.

3.5 System monitoring

The manner in which this safety critical incident came to V/Line's notice raises questions as to the effectiveness of the system monitoring processes in place at the time.

It is acknowledged that the network manager has the technical knowledge to establish system parameters for monitoring, alarms and response for their infrastructure that is best suited to their system. However, with this incident not all system monitoring notifications were active and available. This situation highlights an area where improved real-time monitoring of level crossing operation could be achieved by the inclusion of Centrol as a recipient to such alarms that were generated and transmitted by the SEAR II logger in this incident.

4. CONCLUSIONS

4.1 Findings

1. A road sign-post left on the track prevented the level crossing equipment from detecting the approach of train 9251.

2. Train 9251 was operated through Colac in accordance with V/Line's network requirements.

3. The level crossing design and design processes were consistent with the industry practices at that time.

4. No fault was identified in the installation of the crossing equipment.

5. The as-in-service configuration of the level crossing system was inadequately documented.

4.2 Contributing factors

1. An act of vandalism within the approach circuit for the Queen Street level crossing.

2. The level crossing protection system did not detect the presence of the sign-post as a false shunt.

5. SAFETY ACTIONS TAKEN SINCE THE EVENT

As reported at section 2.8, the positive start timer setting was changed to 99 at the Queen Street and the adjacent Hart Street level crossings.

The equipment manufacturer, GE Transportation, has undertaken testing to simulate the response of the HXP-3 in this incident. While the Chief Investigator's investigation has not been a party to the manufacturer's investigations, GE has advised that an internal self test or reset condition will not cause the RX drift experienced in this incident, and that numerous self tests are built into the hardware and software, but none affect RX.

GE has also advised that changes have been made to the HXP-3 equipment in the August following the incident were not made in response to the Colac incident and that they plan no further amendments to the equipment as a result of this incident.

5.1 Recommended Safety Actions

Issue 1

Other level crossing installations fitted with predictor technology may be vulnerable to a similar type of vandalism event.

RSA 2008069

That V/Line and ARTC (Australian Rail Track Corporation) review the risks associated with a similar event at other locations on the Victorian and Interstate networks and consider appropriate mitigating action.

Issue 2

Monitoring for abnormal level crossing activity by the WAMS alarm notification system does not include direct notification to the V/Line operations control centre, Centrol.

RSA 2008070

That V/Line reviews the WAMS reporting protocols to include Centrol for safety critical notification of level crossing system irregularities.

Issue 3

The as-in-service documentation for the level crossing was inconsistent with the actual layout of the site.

RSA 2008071

That RSS reviews its processes for assuring that as-in-service drawings fully reflect the final configuration of a level crossing, as commissioned.

RSA 2008072

That VicTrack takes action to ensure that accurate as-in-service documentation is provided at the final acceptance of a level crossing installation or upgrade.

RSA 2008073

That V/Line reviews its documentation configuration control policies and procedures.