

Rail Safety Investigation Report

YASS JUNCTION

19 November 2002

Pacific National train G9821 derailed due to misalignment.



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1.0 EXECUTIVE SUMMARY

Preliminary Facts

1. The misalignment site at 305.650km has had a history of instability with misalignments at 305.625km on 23 January 1998 and at 305.650km on 26 January 1994. All three misalignments at this site, including the incident under investigation, occurred at 34°C.
2. The misalignment site track structure was known to contain some substandard track structure components including nattery ballast, substandard sleeper plates and associated fasteners.
3. The misalignment site was disturbed on 15 October 2002 between 304.700km and 305.660km (10m past the misalignment location) to address stability loss concerns in the adjoining 500m section. This disturbance consisted of automated track machinery carrying out track realignment and track resurfacing works over the misalignment location. At the time of misalignment the Welded Track Stability Analysis (WTSA) loss had reduced to an acceptable level (21%).

The Accident

4. On Tuesday 19 November 2002 at 15:10, Pacific National Service G9821 (G9821) travelling between Goulburn to Parkes derailed at 305.650km on the Down Main line in the Goulburn to Yass section. G9821 was travelling at approximately 74km/h at the time of derailment. Following the derailment, G9821 travelled approximately 6km before coming to a stand at 311.700km.
5. A total of five (5) grain wagons derailed within the train's consist. An inspection of the track following the derailment revealed a misalignment at 305.650km.
6. The misaligned curve consisted of mainly timber sleepers with approximately 1 in 9 steel ties supporting 53kg rail. The point of derailment was situated between a 322m radius left hand curve prior to the misalignment site and an 805m radius left hand curve after the misalignment site. The gradient of the track on the Down Main at this location is a descending 1 in 75 grade, where the track speed for freight is 75km/h approaching the site and increases to 80km/h at 306.040km.
7. No injuries resulted from the incident. Track damage however was sustained as a result of the derailment over a 6km distance. This damage included periodic sleeper damage, broken shoulders on steel sleepers and track out of alignment.
8. Manual lining of the track occurred following the derailment to allow for the reopening of the Up Main with a 10km/h speed restriction applied. The line was reopened to traffic at 22:45 on 19 November 2002.

Causal Factors

9. The investigation found that a severe track misalignment was the principal event, which led to G9821 derailing.
10. The investigation was not able to identify a major incident causal factor. Although a number of the track structure components such as ballast, fastener and sleeper condition were identified as substandard, the condition of these items were not considered to have directly contributed to the incident in either isolation or as a combination of factors. An extensive track adjustment review was also conducted by the investigation in order to determine if track adjustment stresses contributed to the misalignment. This review confirmed that the track was in correct adjustment prior to the misalignment, thereby discounting this as a potential causal factor.
11. No rolling stock defects were detected on G9821 that could have contributed to the misalignment. Train handling and vehicle loading requirements were also determined compliant to standard requirements.

Contributory Factors

12. The investigation identified the use of track resurfacing machinery, prior to the incident, as a potential contributing factor to the incident. This contributing factor concerned the potential for track resurfacing machinery to concentrate internal rail stresses at the point at which the machinery exists from the track structure. The investigation was not able to quantify the extent if any of its contribution.
13. Track resurfacing work had taken place on the misaligned curve 35 days prior to the misalignment date. This track resurfacing work would have effectively reduced the lateral track stability at the time of misalignment, albeit only to a minor extent.
14. The ambient temperature recorded at the misalignment site shortly after the incident was 35°C. This temperature was the hottest temperature recorded in the Yass area since the track resurfacing work was carried out on 15 October 2002.
15. A WOLO¹ notification (speed restriction imposed on trains during extreme ambient temperature conditions) compiled at 14:00 on 19 November 2002, covering the misalignment site at 305.650km was not received by G9821 prior to the misalignment at 15:10. Effectively, G9821 was travelling 8.5 km/h above the WOLO speed in force at the time of misalignment. G9821 could not be advised of this speed restriction due to the late application of this WOLO and the fact that G9821 could not be contacted by WB radio or CountryNet train radio prior to 15:10.

¹ The term **WOLO** was historically applied as a NSW Government Railway telegram code with the meaning **W**elded track restrictions on the speed and **O**perations of **L**ocomotives.

Post Incident Safety Actions Carried Out

16. During 2003 Rail Infrastructure Corporation (RIC) carried out the following safety actions and remedial works in order to avert the occurrence of a similar incident at 305.650km and other track locations of misalignment concern within the Yass maintenance area.
 - (1) Interim track configuration change from continuously welded rail to jointed welded rail;
 - (2) Reduction in the ambient temperature at which temporary speed restrictions are applied to locations of misalignment track stability concern;
 - (3) Rail painting with solar radiation inhibitor paint in order to reduce the rail temperature at times of high ambient temperatures;
 - (4) Installation of interdispersed low profile concrete sleepers on tight radius curves to improve the track structure stability; and
 - (5) Rail profile grinding of tight radius curves to reduce vertical impact forces from rolling stock which in turn reduces lateral track stability.

To date there has been no further track stability issues at 305.650km or misalignment incidents at those locations where the safety actions have been implemented.

Recommendations

17. As of 1 July RailCorp was vested with safety management responsibility for the safety management of Rail Infrastructure Corporation. The safety recommendations of this investigation have therefore been amended to reflect this change and are contained in Section 8.0 of this report. It is recommended that the following remedial safety actions be undertaken by the specified responsible entity:

- a. **RailCorp:**

- (1) Conduct a stability review of the ballast, fastener mechanism and sleeper condition at 305.650km and repair the track structure where the configuration falls below standard requirements;
- (2) The occurrence of this type of incident highlights the increased risk of misalignment on track configuration that is not configured to standard requirements. RailCorp therefore should ensure that adequate ongoing maintenance and inspection is applied to this type of track configuration in order to compensate against its reduction in track structure stability;
- (3) RailCorp conduct further research into the potential reduction of track structure stability associated with natterly ballast. This research should attempt to quantify if this potential contributing factor is likely to play any significant role in initiating a misalignment in comparison with more standard types of ballast composition. RailCorp should determine and implement corrective actions to address any concerns raised from this research;

- (4) Review and amend where necessary the WTSa algorithm considering the combination of ballast condition and non standard track;
- (5) In relation to the occurrence of misalignment incidents, define a standard that details the required incident site information and method of calculation required to check for rail adjustment as a potential misalignment contributing factor;
- (6) Specify a rail adjustment competency re-certification period;
- (7) Conduct further research into the potential transfer of internal rail stresses by track resurfacing machinery at the point at which the machinery exits the track structure. Determine and implement corrective actions to address any concerns raised from this research;
- (8) Carry out an appropriate level of operator train speed monitoring to gauge operator's compliance with approved track speeds;
- (9) Produce mandatory inspection criteria for vehicles involved in main line derailments;
- (10) Review the applicable Network Rules governing the application of WOLO notifications to ensure there is no ambiguity of the Network Control Officer's responsibility to communicate, where possible, WOLO conditions to trains that have entered the "affected portion of line";
- (11) Ensure WOLO notifications are compiled and applied, where possible, prior to the 12:00 application time;
- (12) Consult with rail operators on improving the locomotive train radio call alert system to provide train crews with the ability to identify that an incoming call has taken place and has not been answered;
- (13) Review the radio communication infrastructure currently available to Signal Boxes in order to determine if this infrastructure is adequate to facilitate the rail safety communication requirements of signallers;
- (14) Create WOLO notification Operator Specific Procedures for Train Controllers to assist in the training and execution of these notifications via train radio;

b. Pacific National:

- (15) Ensure all vehicles involved in main line misalignment derailments are inspected against applicable RailCorp minimum operating standards for rolling stock. This inspection, where possible, should determine if the rolling stock has played a contributing role in the misalignment; and
- (16) Ensure train crews are vigilant in their recognition and response to incoming train radio calls.

2.0 TERMS OF REFERENCE

<i>Date of incident:</i>	19 November 2002
<i>Location:</i>	Yass Junction
<i>Details of Incident:</i>	G9821 Pacific National freight train derailed as a result of a track misalignment.
<i>Type of Inquiry:</i>	Railway Investigation Section 67.
<i>Investigator:</i>	Transport Safety & Rail Safety Regulation, Ministry of Transport.
<i>Assisting:</i>	Rail Infrastructure Corporation Pacific National
<i>Owning Railway:</i>	Rail Infrastructure Corporation
<i>Operator:</i>	Pacific National
<i>Infrastructure Maintainer:</i>	Rail Infrastructure Corporation

The Executive Director of the Transport Safety & Rail Safety Regulation authorised the investigation and publication of this report pursuant to the provisions of Sections 67 and 70 of the Rail Safety Act 2002 NSW. The Office of Transport Safety Investigation (OTSI) has finalised this investigation pursuant to schedule 5 Section 17 of the Rail Safety Act 2002 NSW.

The investigation was commissioned to:

1. Identify all factors that contributed to the occurrence of the incident.
2. Identify whether the incident type should been anticipated and assess the effectiveness of the risk management strategies adopted.
3. Assess the adequacy of the emergency response to the incident as it affected the safety of all persons involved.
4. Advise on matters arising from the investigation, which would enhance the safety of rail operations.

3.0 INVESTIGATION METHODOLOGY

The investigation has been conducted in accordance with the principles of Australian Standard AS 5022:2001, Guidelines for railway safety investigation.

The objective of the investigation was to determine the circumstances surrounding the accident and provide information to prevent the recurrence of similar events.

The investigation is in no case intended to imply blame or liability. However sufficient factual information is included to support the analysis and conclusions. Some information may reflect on the performance of individuals and organisations, and how their actions have contributed to the outcomes of the matter under investigation.

System safety accident investigation (SSAI) techniques have been applied to structure the investigation and analyse the evidence.

The SSAI approach includes:

- Applying the Reason model to analyse accident causation in terms of latent conditions and active errors.
- Identifying and analysing human factors issues.
- Identifying and analysing the risk management strategies that should have prevented the accident.
- Using events and conditions charting to illustrate the incident.

Information and data has been gathered as evidence for the investigation. This includes:

- Locomotive data logger.
- Review of Rail Infrastructure Corporation and Pacific National safety management systems.
- Interviews with personnel involved in the incident.
- Curve and gradient diagram.
- Infrastructure maintenance standards and procedures.
- Infrastructure maintenance records.
- Wagon maintenance history.
- Wagon derailment certification.
- Misalignment track measurements.
- Track configuration information.
- Crew rosters.
- WOLO safeworking rules
- Meteorological data

4.0 FACTUAL INFORMATION

4.1 Overview

Five (5) vehicles on Pacific National Service G9821 (G9821) derailed their leading bogies on the Down Main South at Yass Junction in the afternoon of 19 November 2002. Shortly after the derailment the Driver noticed that the train was not handling in the normal manner and visually detected dust emanating from the train's rear. The Driver then applied a minimum brake reduction bringing the train to a stand some 6km after the initial derailment. No injuries resulted from the incident.

An inspection of the track revealed a misalignment at the derailment location. Misalignments have previously occurred at almost the same location in January 1994 and January 1998.

The air temperature recorded close to the time of derailment was 34°C. A WOLO speed restriction telegram was issued on the incident day covering the section of track that misaligned. This telegram however was not communicated to G9821 prior to the incident.

Refer to Figure 4.1 below depicting the misaligned track. A number of timber sleepers were broken along with damage to track anchors as a result of the derailment.



Figure 4.1 Misaligned track at 305.650km

4.2 The Occurrence

G9821 departed Goulburn for Parkes at 13:55 on Tuesday 19 November 2002. Prior to the train's departure, the Goulburn Signaller provided the train crew with a copy of the current WOLO Speed Restriction Telegram covering the line between Bowning to Wallendbeen. An additional WOLO telegram was compiled for the line between Breadalbane to Bowning and faxed by the Goulburn Technical Office to Goulburn Signal Box at 14:01 and Junee Train Control at 14:02. G9821 could therefore not be warned of WOLO conditions between Breadalbane and Bowning with a hard copy of the WOLO telegram, as the WOLO notification was received at Goulburn Signal Box after G9821 had departed. A number of attempts were made by the Signaller at Goulburn to contact G9821 on the Without Brakevan (WB) radio, however the train at that point in time had moved out of radio range. The Train Controller at Junee, via the CountryNet train radio (train radio), also attempted to warn G9821 of the additional WOLO conditions without success.

On approach to the incident site the train descended a 1:75 grade. The Driver used dynamic brake² in order to control the train down this grade reaching a maximum speed of 75km/h. G9821 was estimated travelling at 74km/h over the derailment site. Figures 4.2 & 4.3 below detail the approaching and departing views to the point of derailment and the applicable curve and gradient diagram describing the derailment location respectively.



Figure 4.2 Down Main facing Up direction (left), Down Main facing Down direction (right) following track restoration at 305.650km

The incident occurred at approximately 15:10 at 305.650km where the leading bogies of the 23rd, 25th, 26th, 30th and 39th positioned vehicles derailed. Shortly after the derailment (309.000km) the Driver became aware that the train was not handling in the normal manner. The Driver then checked the rear of his train and detected dust emanating from the rear. The Observer also confirmed the presence of an abnormal amount of dust at the train's rear. As a result of this observation the Driver then applied the automatic air brake³ with a minimum reduction, effectively bringing G9821 to a stand at 311.700km.

² "Dynamic brake" denotes a train brake system where the locomotive's traction motors are used to provide a braking force to the locomotives wheel's via the traction motor system.

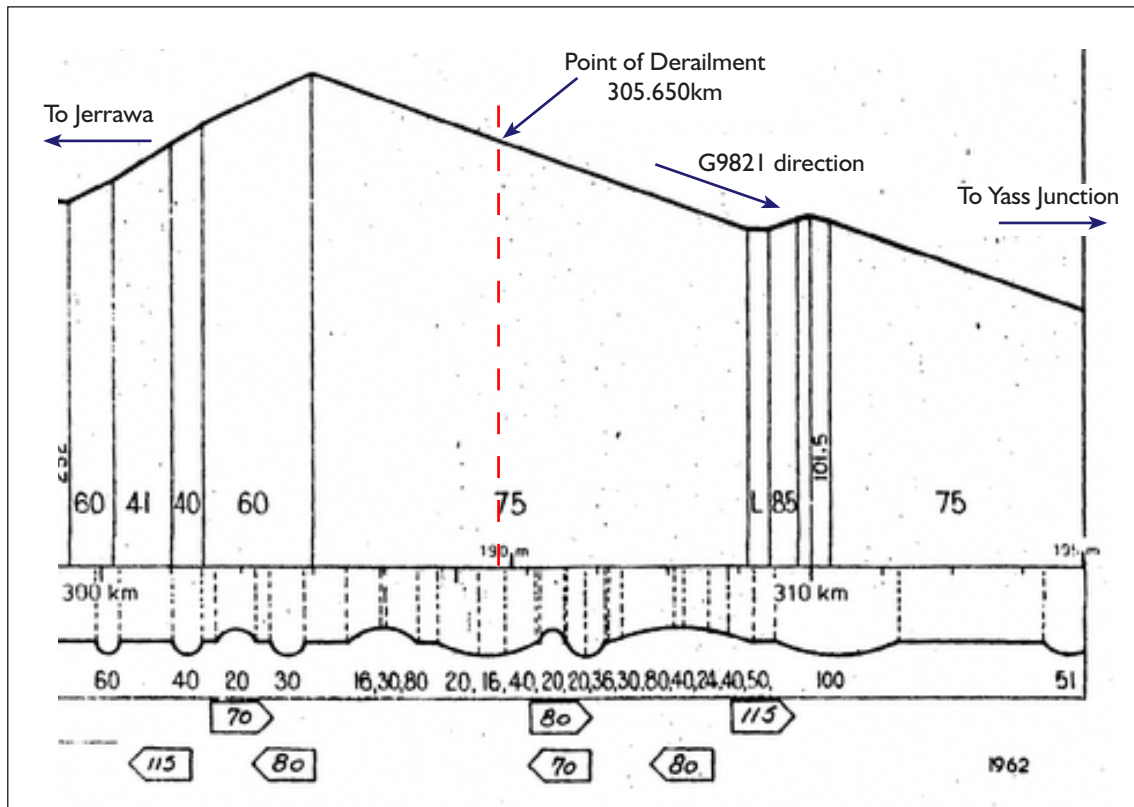


Figure 4.3 Curve and Gradient Diagram

Train Control was then contacted and was advised that G9821 was suspected to have derailed. After exiting the cab, the Driver and Observer placed detonator protection on the Down main line 500m to the front and rear of G9821 respectively. A track shorting clip was also applied to the Up Main line.

As the Observer walked to the rear of G9821, he confirmed that five (5) vehicles had derailed their leading bogies and that the derailed vehicles had not fouled the Up Main line. Just as the last detonator protection was laid out at the rear of G9821, a Hi-Rail arrived on the Down Main line. The Hi-Rail operator advised that he was carrying out a heat patrol and had identified a large track buckle at 305.650km.

Pacific National's First Response Group (FRG) arrived on site at 17:20. Jerrawa Signal Box was switched in at 17:50 and Yass Local Panel switched in at 19:38. Pilot staff working was introduced over the Up Main line between Jerrawa and Yass Junction at 19:45.

The train crew was subsequently breath tested by the Area Operations Manager returning a negative result.

³ A train's automatic air brake uses compressed air to apply the brakes to the train's wheels and to control the operation of the brake along the train. The compressed air is supplied by a motor driven compressor on the locomotive or train. The brake control is actuated from a "driver's brake valve". This valve is used to feed air to the brake pipe or to allow air to escape from the brake pipe.

All derailed vehicles were rerailed by 21:30. G9821 departed from the derailment site at 22:10 for Yass Junction under a 40km/h speed restriction. At Yass Junction, the five vehicles involved in the derailment were detached into the yard for further examination. G9821 then continued its journey to Parkes without incident.

The line was reopened to traffic at 22:45 under a 10km/h speed restriction.

4.3 Injuries

The train crew sustained no injuries.

4.4 Loss or Damage

Track:

Considerable track damage was sustained due to the derailment. This damage included sleeper damage, broken shoulders on steel sleepers, and track out of alignment. Refer to Figure 4.4 depicting typical sleeper damage sustained during the derailment.



Figure 4.4 Sleeper damage sustained during derailment

Rolling Stock:

The leading bogies of the 23rd, 25th, 26th, 30th and 39th positioned vehicles derailed. All bogies sustained gouging on their wheelsets from contact with ballast and sleeper plates. Refer to Figure 4.5 depicting an example of the wheel tread damage sustained by one of the derailed bogie's wheelsets. Other minor rolling stock bogie damage was sustained necessitating the replacement of safety loops, king pins, constraps and radial pads.



Figure 4.5 Derailed wheel on leading bogie and ballast gouging damage sustained on one of the derailed wheelsets

4.5 Workers Involved

Train Crew:

Relevant qualifications and medical records for the train crew were current at the time of derailment.

Maintenance Staff Track Patrol:

Relevant qualifications and medical records for the track maintenance staff involved in the track patrol were current at the time of derailment.

Relevant qualifications and medical records for those track maintenance staff involved in the rail adjustments carried out on 4 February 2000 and 28 September 1999 and the detailed walking inspection were current at the time of derailment.

4.6 Train Information

4.6.1 Train Consist

G9821 consisted of 2 x 81 Class locomotives and 40 grain wagons with a train load of 840 tonnes and 614.4m in length. All wagons within the train consist were unloaded.

Train Condition

Pacific National's first response group from Cootamundra attended the incident and re-railed all derailed bogies. A 40km/h speed restriction was placed on G9821 in order for the derailed vehicles to be transported to Yass Junction siding where they underwent wheelset changes and minor repairs.

The investigation could not determine if the entire train underwent a rolling stock condition assessment. The purpose of this condition assessment would have been to check for defective components that may have had the potential to contribute

to the incident. A wagon condition examination was however carried out on those wagons that derailed by the Cootamundra First Response Group as detailed in Appendix 9.6.

4.6.2 Train Maintenance Status

G9821 underwent a full train examination out of Goulburn on 19 November 2002. A copy of this train examination certificate was sighted by one of Pacific National's incident site representatives, however the certificate could not be provided to the investigation on request.

All vehicles within the train consist, with the exception of one, were clear of maintenance defects. This defect however was identified as body damage on the 19th wagon and was not considered to have had any impact on the mechanism of misalignment and subsequent derailment.

4.6.3 Train Data Logger Information

The following information has been summarised from Locomotive 8160's Hasler (train speed and brake application recorder) as it passed over the section of track between 297.670km to 311.700km at 14:57 to 15:12 on 19 November 2002.

ID	Time	Distance	Speed km/h	Brake Pipe kPa	Independent Brake ⁴	Event Description
1	14:57	297.670	50	500	0	Throttle is closed.
2	15:05	305.650	74	500	0	Dynamic brake applied as no automatic air brake used down the grade. Speed calculated at 23 rd position in train consist. Track speed 75km/h.
3	15:09	311.700	0	430	0	Minimum brake application made. Train brought to a stand within approximately 300m.

Table 4.1 – G9821 Brake Application Events

Figure 4.6 below identifies the Hasler print-out for G9821 with reference lines 1 to 3, where these reference lines correspond to the ID data 1 to 3 in the table above.

⁴ Independent Brake denotes the locomotive's air brake that can be independently applied to that of the automatic train brake.

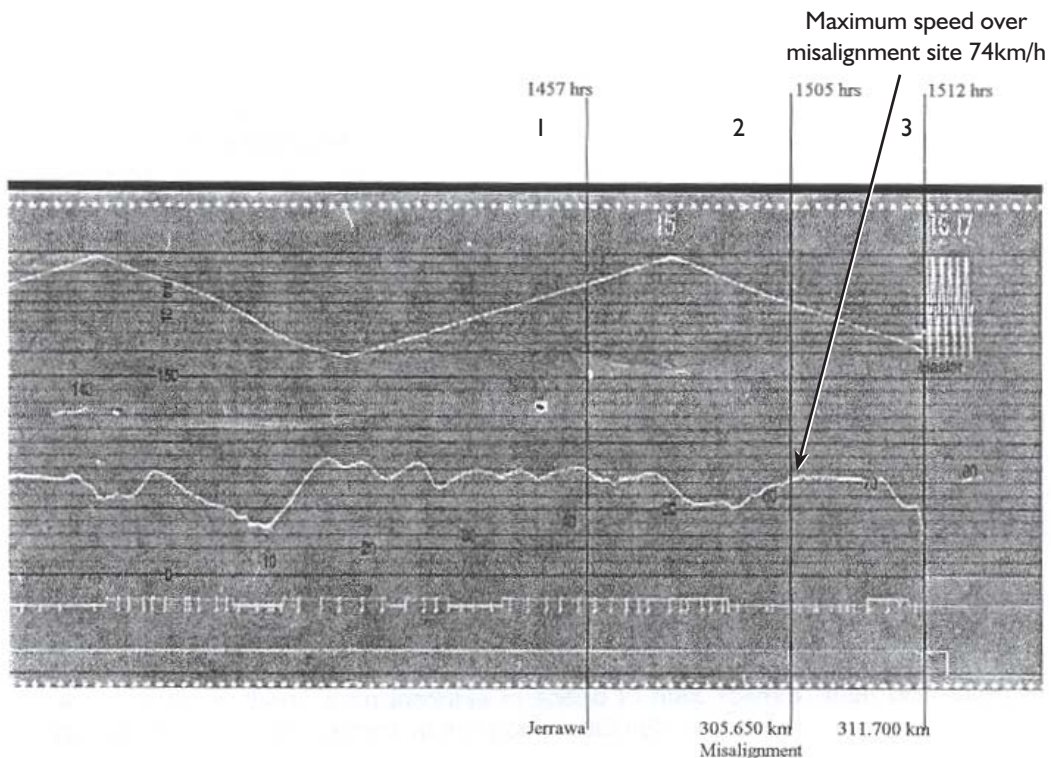


Figure 4.6 G9821 data logger print out 19 November 2002

Figure 4.6 above confirms that the rear section of G9821 was travelling at approximately 74km/h at the time of derailment.

4.6.4 Train Management Standard and Compliance

Pacific National's Train Management Manual dated September 1998 Page 4 provides guidance in the application of automatic air and dynamic braking. This manual stipulates:

"8.6.1 When the train is going over the apex (top) or crest of a grade, it is optional to use either the train air brake or dynamic brake first.

- With short light trains, it is general practice to apply the dynamic brake first. If necessary, the train air brake is added as a supplement to control train speed."*

As noted in Section 4.6.3, the dynamic brake was used to descend the 1:75 grade. As the train was unloaded and the train's speed was braked effectively (without sudden changes in the rate of speed) leading up to and following the misalignment site, the investigation considered the Driver's braking technique complied with Pacific National driver management standards.

Compliance with the track speed of 75km/h at 305.650km, for the entire length of G9821 (614.4m) was also achieved.

4.6.5 Toxicology Information

The Pacific National Driver and Observer were breath tested by the Area Operations Manager producing a negative result.

4.7 Track Details

4.7.1 Incident Location

The derailment occurred on the Down Main South line approximately 12km north of Yass Junction at 305.650km.

4.7.2 Misalignment Report

Following the misalignment the track maintainer submitted a misalignment report in accordance with CTN 02/15. Refer to Appendix 9.8 to review these misalignment reporting forms.

A check of rail adjustment was carried out in accordance with the “*Major Adjustment Disturbances*” requirement specified above. The check of rail adjustment at the design alignment revealed there was no additional steel within the 500m section. Refer to Appendix 9.9 detailing the adjustment check record at 305.650km.

4.7.3 Track Configuration

The misaligned curve consisted of mainly timber sleepers with approximately 1 in 9 steel ties supporting 53kg rail. The point of derailment was situated within a compound transition between a 322m radius left hand curve, prior to the misalignment site and an 805m radius left hand curve after the misalignment site. The gradient of the track on the Down Main at this location is a descending 1 in 75 grade, where the track speed for freight is 75km/h approaching the site and increases to 80km/h at 306.040km.

Steel Sleeper Pattern

At the standard sleeper spacing of 600mm and with a recommended steel sleeper pattern of 1:4, for curves less than 600m radius, there should be 1 steel sleeper spaced every 2.4m. A review of the number of steel sleepers in place on the misalignment curve can be referenced within Appendix 9.1.

This review highlights that there were 26 steel sleepers out of approximately 223 sleepers which equates to an installation pattern of approximately 1:9 steel sleepers laid between the ends of the cutting at 305.553km and 305.687km.

Rail Closures

A review of the location and number of rail closures⁵ installed in the misalignment curve can be referenced within Appendix 9.1. This review indicated that 6

⁵ “Rail closures” are short lengths of rail (usually no more than approximately 2m in length) that are welded into the rail to replace rail lengths identified with rail defects.

closures had been inserted within the misalignment curve between the start and end of the surrounding cutting at 305.553km and 305.687km. Five metre reference punch marks⁶ were not visible on the outside head of the rail at each of the closures. The Yass Civil Maintenance Team reported that they have only been using 5m punch marks over the last 2 ½ years to help control the process of Steel In = Steel Out.⁷

4.7.4 Track Maintenance Standards

Rail Infrastructure Corporation utilise a number of standards to manage the issue of track misalignment. These standards are contained within Rail Infrastructure Corporation's Civil Engineering Standards, Engineering Practices Manual and Civil Technical Notes.

References to two standards within the Engineering Practices Manual are worth noting for further review in the analysis section of this report.

RTS 3656 Version 2.0 February, 2002

Causes of Misalignment

This standard sets out the procedures necessary to affect temporary and permanent repairs to misalignments on welded track. The track related causes of misalignment are also detailed in this standard. Frequently the cause is a combination of several factors. These factors are summarised in Table 4.2.

No.	Factor
1	Track disturbed by resurfacing, ballasting, cleaning and partial resleepering (PRS), etc
2	Track is incorrectly adjusted
3	Track has insufficient ballast
4	Track has foul ballast or glazed ballast bed
5	Track has incorrect anchoring pattern and/or insufficient anchoring or effective anchors ineffective due to positioning or "sprung anchors"
6	Sleepers and fastenings are defective
7	Insufficient superelevation or sharp "kink" in curves.
8	Trains exceeding speed boards
9	Sleepers not firmly packed

Table 4.2 – Causes of Misalignments

⁶ Small indentations are punched on the cess side head of the rail using a steel punch. These two punch marks are applied to the rail at a standard spacing of 5 metres. The rail closure or thermit weld is located at the approximate midpoint of the two punch marks. Punch marks effectively record a defined length of the rail prior to the rail being cut for the removal and insertion of a rail closure or thermit weld. Rail maintenance staff then utilise these reference marks to ensure that no addition or reduction in the length of rail occurs between the two reference punch marks when either the rail closure or thermit welds are inserted within the rail.

⁷ Rail Infrastructure Corporation Standard Adjustment and Field Welding for Continuous Welded Track RTS.3650 – Version 2.0, February 2002, Appendix 5 Page 12.

Civil Technical Notes CTN 02/15 Dated 16 August 2002:

Lines with weak track structure and/or poor condition

On lines which feature sharp curves, where alignment is difficult to maintain, it is recommended that additional measures be taken to stabilise the tracks, including:-

- Use of dynamic stabiliser when tamping.
- Additional ballast especially on shoulders (but clear of train trips).
- Additional speed restrictions in hot weather.

4.7.5 Track Condition

The track condition at the misalignment site is described in the following track configuration categories:

Anchor Condition

The anchor condition as assessed in the pre-misalignment WTSA report was good, resulting in a 2% loss of stability as calculated in C2443 Table 5. A review of the anchor condition post derailment, and following track restoration confirmed this analysis.

Ballast Profile Condition

The ballast profile as identified following the derailment was considered “*full*”⁸ for both “*shoulder*”⁹ and “*crib*”¹⁰ throughout the misalignment site. Refer to Figure 4.7 depicting typical ballast profile throughout the misalignment site.



Figure 4.7 Typical Shoulder and Crib Ballast Profile throughout Misalignment Site.

Ballast Condition

Nattery¹¹ ballast was identified throughout the misalignment site. Over time this type of ballast breaks down into small pieces and eventually fine particles of silt, where the interlocking properties of the ballast against a wooden sleeper are lost. Ballast that has broken down in this manner may also be referred to as a glazed ballast bed. Once the ballast and timber sleeper interlocking properties break down so too does the lateral stability of a timber sleeper within the ballast. As shown in Figure 4.8 small pieces of Nattery ballast were evident following movement of those timber sleepers subject to the misalignment. Following the misalignment a number of sleepers were replaced in and around the misalignment site. The exposed sleeper pods¹² revealed smooth surfaces where the Nattery ballast had broken down to an extent where there was little evidence of ballast interlocking with the timber sleeper surface.



Figure 4.8 Nattery Ballast Broken Down at Base of Sleeper Pod Following Movement of Sleeper after Misalignment.

Foul Ballast

Foul ballast¹³ was identified to varying degrees throughout the misalignment curve. Refer to Figure 4.9 depicting the ballast condition just below the top surface of the ballast. Vegetation was also identified within the four foot throughout the

⁸ Term used to describe the correct ballast profile condition supporting the sleeper ends in Rail Infrastructure Corporation Track Examination System – WTSA Guidelines for Field Examination and Assessment Standard RC2442 Version 2.0 Dated Feb 2002. Page 2-3.

⁹ “Shoulder” denotes the ballast profile present at the ends of a sleeper.

¹⁰ “Crib” denotes the depth of ballast between two adjacent sleepers, relative to the top surface of each adjacent sleeper. A full crib of ballast is identified when the ballast’s surface is level with the top surface of each adjacent sleeper.

¹¹ Nattery ballast denotes ballast taken from a particular ballast quarry that has subsequently closed down.

¹² Sleeper pods denotes the cavity exposed within the ballast when a sleeper is removed from the ballast.

¹³ Foul ballast denotes ballast that has been contaminated with fine silt particles. This contamination inhibits the ballast formation from providing adequate water drainage around the track structure.

misalignment curve, as depicted in Figure 4.10, indicating the extent of foul ballast in this section of track. The vegetation was also noted to be more prevalent in the Down Main line compared to the Up Main line.



Figure 4.9 Foul ballast identified within the 500m WTSa section at 305.510km.

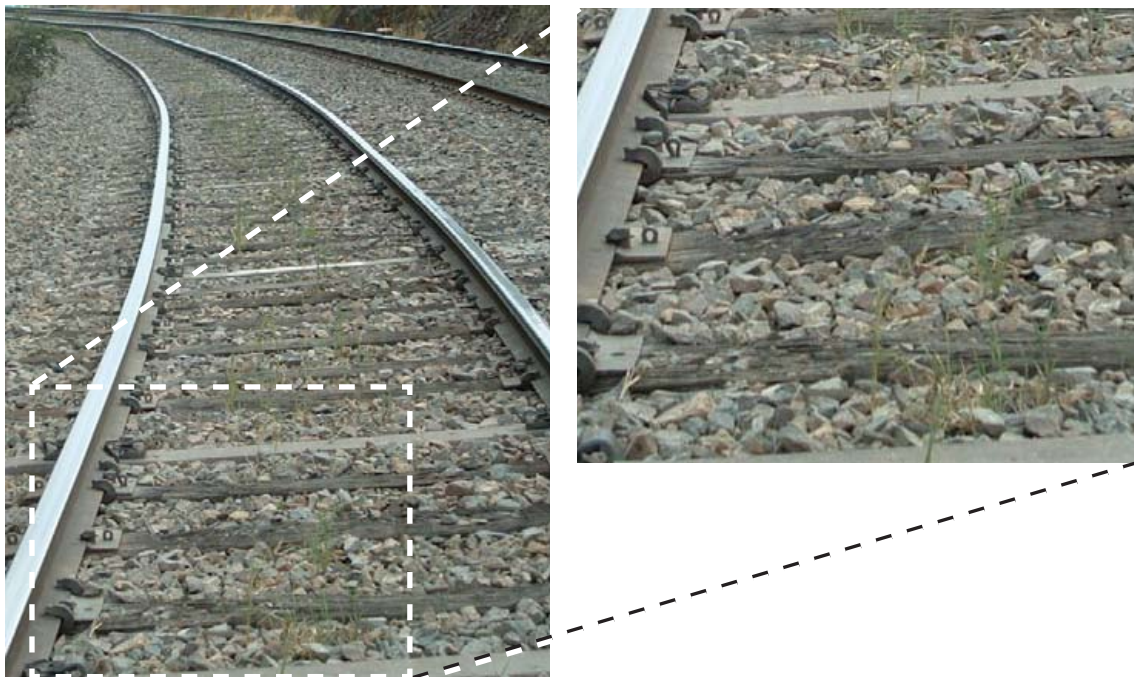


Figure 4.10 Foul ballast identified within the misalignment curve as evidence of vegetation in the four foot.

Rail Weld Alignment

All rail welds on the misalignment curve were determined to meet standard requirements.

Fastener Mechanism Condition

The fastener mechanism condition over the misalignment site varied from satisfactory to poor. A number of round holed sleeper plates without lock spikes were noted along with single sided sleeper plates as documented within the misalignment reports depicted within Appendix 9.8. Refer to Figure 4.11 below depicting a round holed sleeper plate without dog spike and Figure 4.12 depicting the location of sleepers with round holed sleeper plates without dog spikes relative to the misalignment. These sleeper plates are not standard requiring change on renewal of the applicable sleepers.

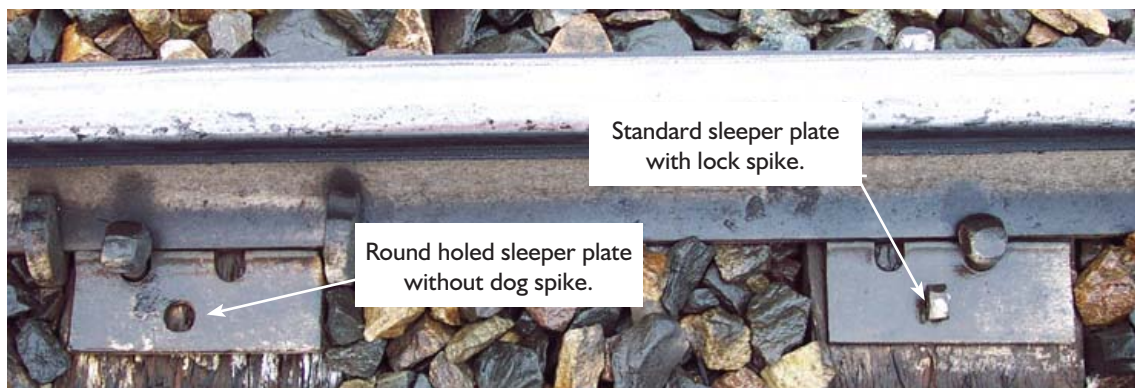


Figure 4.11 Round holed sleeper plate without dog spike at 305.650km.

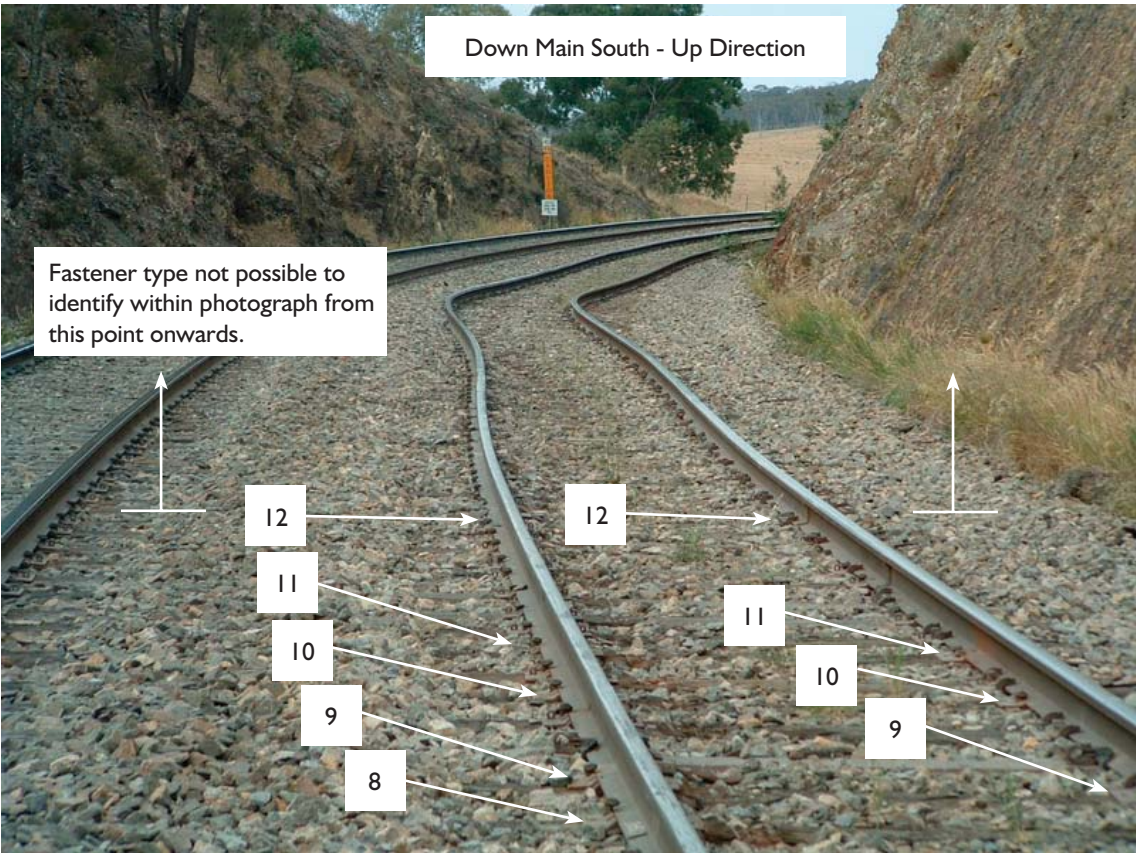
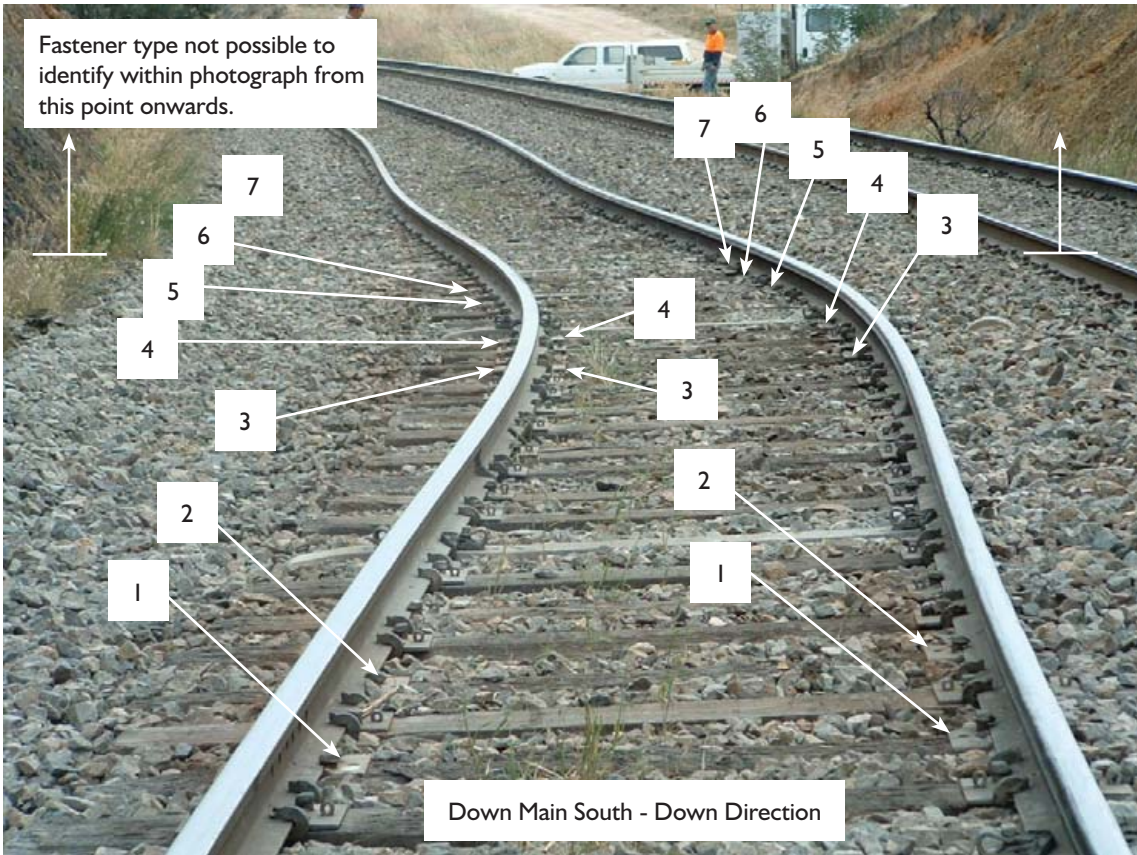


Figure 4.12 Sleepers Identified with Round Holed Sleeper Plates without Dog Spikes at the 305.650km misalignment site

Track Alignment

No defects were detected with the track alignment at 305.650km prior to the passage of G9821. No alignment problems had been detected on the last two track patrol runs over the misalignment site. Teams II maintenance records were also reviewed and indicated that no misalignment at 305.650km had been recorded prior to 19 November 2002.

Sleeper Condition

The sleeper condition within the misalignment curve was assessed as poor within the misalignment report as referenced in Appendix 9.8. At least 5 creosote sleepers were also identified within the misalignment curve. The ballast / sleeper interlocking properties are known to reduce significantly with this type of sleeper if the creosote starts to leach out of the sleeper thereby acting as a friction inhibitor. Refer to Figure 4.13 depicting a creosote sleeper and their typical impregnation markings.

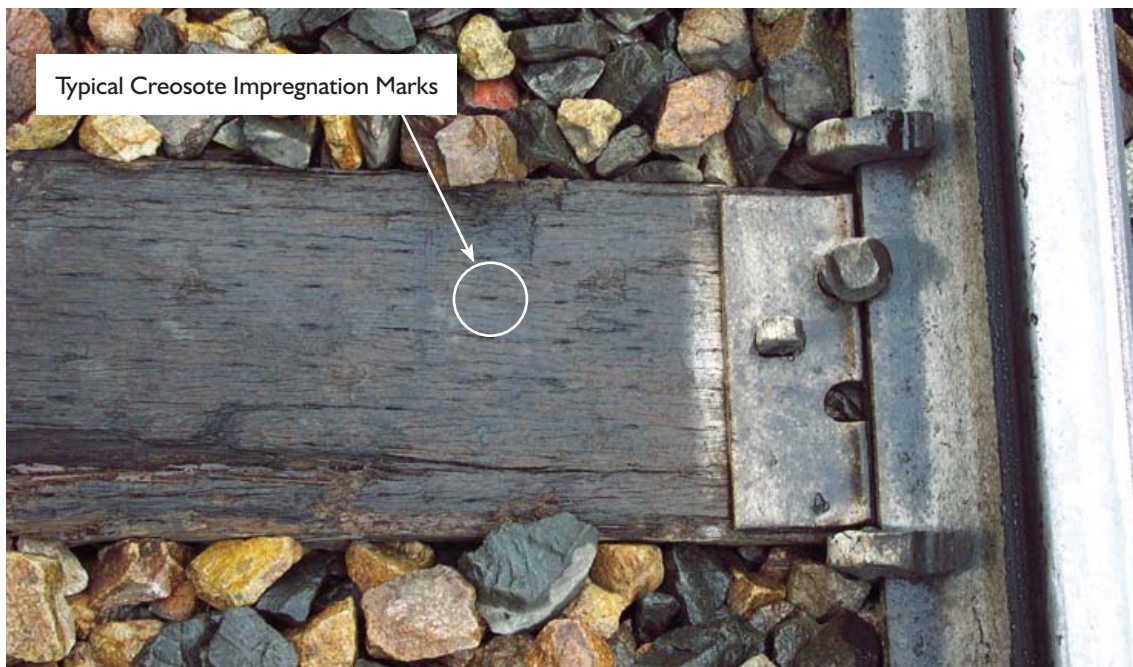


Figure 4.13 Creosote Sleeper In Misalignment Curve

Tangent Rail Creep

An inspection for the occurrence of sleeper skew was conducted at the incident site on 3 December and identified a number of skewed sleepers indicating that tangent rail creep¹⁴ had occurred in the vicinity of the misalignment site. Refer to Figure 4.14 to view sleeper skewing identified at the misalignment site.

¹⁴ Tangent Creep denotes the movement of rail in the longitudinal direction.

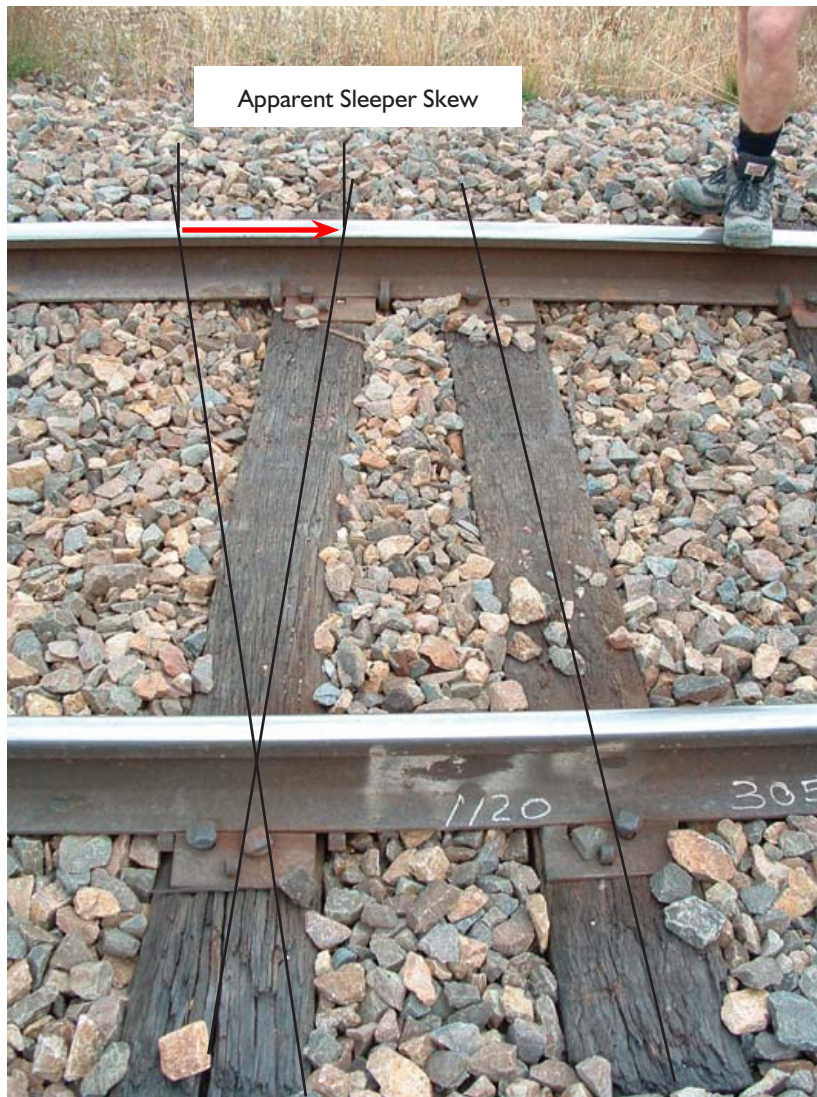


Figure 4.14 Sleeper skew noted at misalignment site

4.7.6 Track Maintenance

Welded Track Stability Analysis

The Welded Track Stability Analysis (WTSA) is part of Rail Infrastructure Corporation's Track Examination System. The WTSA process is concerned with the stability and adjustment of welded rail. The process is carried out in the late winter/early spring each year in an effort to identify all sections of welded rail where stability may have been reduced, and there exists a possibility the track may misalign in warm weather. Detailed procedures covering the measurement and analysis of welded track stability are covered in Rail Infrastructure Corporation standards C2442, C2443 & RC2442.

The following table represents the WTSA parameters identified at the Pre WTSA stage, immediately after WTSA rectification works, and Post WTSA rectification works at the time of derailment.

	1	2	3
WTSA Variables	WTSA Pre Summer	WTSA at Time of Derailment	WTSA after repairs
Stability Loss	17%	21%	47%
Ballast Crib/Shoulder	0 / 0	0 / 0	0 / 0
Disturbance Time Tonne	0	0 8	FOUL 23.9 24
TCI	1	1	1
Anchor	2	2	2
Rail Adjustment % Loss Up/Dn	0 / 11	0 / 6	0 / 11
Rail Temp Error Up/Dn Alignment	0 / 0 -8.2	0 / 0 0	0 / 0 0
Other	0	0	0
Line Factor	1.24	1.24	1.24
Major Factor			Time Disturbance

Table 4.3 WTSA Stability Loss Calculations at Track Resurfacing and Time of Misalignment

As per Table 4.3 above the WTSA value at the time of derailment, based on tonnage disturbance, would have resulted in a 21% stability loss. Had foul ballast been identified within this WTSA analysis, as identified in the WTSA analysis after repairs, the track stability loss would have equated to 24%.

Stability losses greater than 55% are considered Priority 1 locations and require rectification work prior to the next summer period. Locations with a loss between 40% and 55% are considered Priority 2 locations for stability rectification work. Stability losses of less than 40% are considered stable track and no further action is generally taken.

Pre-incident Track Realignment

The misalignment curve was realigned on 15 October 2002 between 304.700km and 305.660km to address stability loss concerns in the adjoining 500m section.

Re-alignment of the curve to within +/- 15mm of the design alignment was achieved.

Following track resurfacing work on 15 October 2002, the area experienced three nights of cold weather registering minimum temperatures of 2.7°C (18 Oct), 2.6°C (28 Oct) and 2.2°C (1 Nov). A number of surrounding curves that had previously undergone track resurfacing works were detected to have pulled in after these cold nights, however there was no evidence to suggest that the curve at 305.650km had pulled in prior to the misalignment.

As per CTN 02/15 dated 16 August 2002 the use of a dynamic stabiliser¹⁵ is recommended for curves “*where alignment is difficult to maintain*”. The Yass Team Manager has historically used the dynamic stabiliser in accordance with the technical note’s recommendation. The dynamic stabiliser however has not been made available in the Southern region since 1998, due to the cost of its operation and its limited availability.

The use of a dynamic stabiliser on a curve that has undergone track resurfacing improves the track stability loss by an immediate 21%. The effect of this immediate improvement in stability provides a number of benefits.

Had the dynamic stabiliser been used following the track resurfacing works at 305.650km the track stability loss would have reduced from 21% to 16% using the second calculation referenced in Table 4.3. If however foul ballast was considered in this calculation, as discussed in the Welded Track Stability Analysis Section above, no reduction in the WTSA stability loss would have been apparent with the 24% stability loss calculation not changing.

Rail Welds

Weld records were reviewed by the investigation to determine if recent rail welds had been inserted in the vicinity of 305.650km. No records of rail welding were identified in the 500m section (305.500km–306.00km) since 30 November 1998. Records of rail welding in the adjoining 500m section were identified as per the following table.

Km	Removed Date
305.050	04/04/2002
305.130	04/04/2002

Table 4.4 Most Recent Rail Welds Carried Out in Adjoining 500m Section to the Misalignment Curve

Rail weld returns for the welds carried out during April 2002 above were sighted identifying that punch marks had been used to assist in the control of steel in = steel out at these weld locations.

Rail Length Adjustment

Rail adjustment records were reviewed by the investigation to determine if the misaligned section¹⁶ of track had recently undergone an adjustment. A review of the maintenance records indicated that the misaligned section of track had undergone an adjustment on the following occasions:

¹⁵ A dynamic stabiliser is a large self propelled track machine that imparts high vertical dynamic oscillation forces to the rail in order to simulate those forces exerted on the rail from an extended period of high axle load rail traffic. The use of this machine effectively helps bed down and stabilise the track.

¹⁶ The misaligned section of track refers to the 500m section of track in which the misalignment site at 305.650km was located.

Km	Adjustment Date
305.600-305.600	08/12/2000
305.600-305.600	30/11/2000
305.500 – 305.600 Down Rail Only	30/11/1998

Table 4.5 Most Recent Rail Adjustments Carried Out in the Misalignment Section of Track

Weld Alignment Defects

Weld alignment records were reviewed by the investigation to determine if recent rail welds had been identified with alignment failures. No weld alignment defects were recorded prior to the derailment.

Rail Tie & Gauge Repair & Adjustment

Rail gauge repairs and adjustments had been undertaken in the vicinity of the misalignment site on the following occasions:

Type	Km	Removed Date
Repair Gauge (respike)	305.604 – 305.660	21/08/2002
Repair Ties (respike)	305.330 – 305.890	18/12/2001
Repair Gauge (respike)	305.623 – 305.623	25/08/2001
Repair (respike + ties)	305.624 – 305.677	21/02/2001
Adjustment	305.231 – 305.677	04/02/2000
Adjustment	305.619 – 305.658	28/09/1999

Table 4.6 Most Recent Gauge Repair and Adjustment Records Carried Out on the Misalignment Curve

The scope of works for this type of repair and adjustment included respiking and tie replacement where necessary.

Track Patrol Inspections

A routine track patrol was conducted on the morning of 18 November 2002. This inspection did not detect any noticeable track misalignments. An additional track patrol (Heat Patrol) was conducted in the afternoon of 19 November 2002 where the misalignment at 305.650km was subsequently detected after the passage of G9821.

Ballast Profile Inspection

As a part of the pre-summer welded track stability analysis, maintenance staff conducted a review of ballast deficiencies. The track maintainer carried out such an inspection where no ballast was required at the 305.650km site.

4.7.7 Asset Management Planning

The Yass Team Manager identified the requirement to improve the track structure at 305.650km in a submission to Rail Infrastructure Corporation in 2001. The

submission proposed for low profile concrete sleepers to be installed between 303.426km to 303.924km and 305.289km to 305.658km. This submission programmed for the work at 305.650km to be completed by 21 September 2001. The submission was not approved in the requested financial year and originally deferred for completion in the 2002/2003 financial year. This revised programmed date was further delayed with the project being finalised at the end of September 2003.

4.7.8 Track Measurements Following Misalignment

Misalignment curve track measurements were taken following the derailment and smooth lining on 20 November 2002. These measurements did not indicate any evidence of curve pull in prior to the misalignment. Significant alignment errors were only noted over the 40 metres associated with the misalignment, indicating the curve was most likely in alignment prior to the incident. Refer to Appendix 9.16 to review these measurements.

4.7.9 Post Misalignment Track Adjustment Check

A check of the 500m rail adjustment status was conducted by the local maintenance group on 24 November 2002. The rail adjustment was subsequently determined to be non – short of steel at this assessment. A further review of the rail adjustment status confirmed the original finding. This review compared gap measurements taken on 24 November 2002, as detailed in Appendix 9.9, with track joint gap measurements taken in December 2003. Refer to Appendix 9.17 to review the final track adjustment assessment.

Based on the final track adjustment check the rail neutral¹⁷ temperature for the Up and Down Rails would have been 36°C (+1°C offset) and 32 (-3°C offset) respectively. This variation would then translate to WTSA adjustment percentages losses of 0% Up Rail and 8% Down Rail. These revised values however would have made virtually no difference to the overall WTSA percentage values for the 500m section as calculated in Table 4.3 at the time of derailment.

4.7.10 Track Restoration

Restoration Works

Track restoration works were undertaken in the following manner.

- Initially the track was smooth lined (approximate alignment of the curve based on a visual estimation) with tractors on 19 November 2002 where a 10km/h speed was applied. The track was reinstated by the local maintainer and the line reopened at 22:45 on 19 November 2002.

¹⁷ The design neutral temperature of rail is nominated at 35°C, where the rail length (500m for CWR) at this temperature is required to be in correct adjustment when positioned on the design alignment. Correct rail adjustment is achieved when no temperature induced longitudinal compressive or tensile stresses are present within the rail at 35°C.

- On the morning of 20 November 2002 the damage was assessed and marked out with the speed increased to 20km/h.
- On 22 November 2002 joints were cut into the rail in order for the track machines to realign the track as illustrated in Figure 4.15. Conversion of the track from Continuously Welded Rail (CWR) to Jointed Welded Rail (JWR) in this manner also provides an interim misalignment control measure. JWR track has a greater tolerance to endure heat induced longitudinal rail stresses by virtue of the temperature expansion gaps created at each joint. These expansion gaps allow for a degree of rail expansion as the rail heats up. Longitudinal rail stresses are therefore experienced when the rail gap closes.
- On 23 November 2002 the track was realigned with the 20km/h speed still applied.
- On 10 December 2002 the track was tamped and a speed of 40/40¹⁸ was applied.
- On 25 December 2002 the track speed of 75/80 was reinstated.

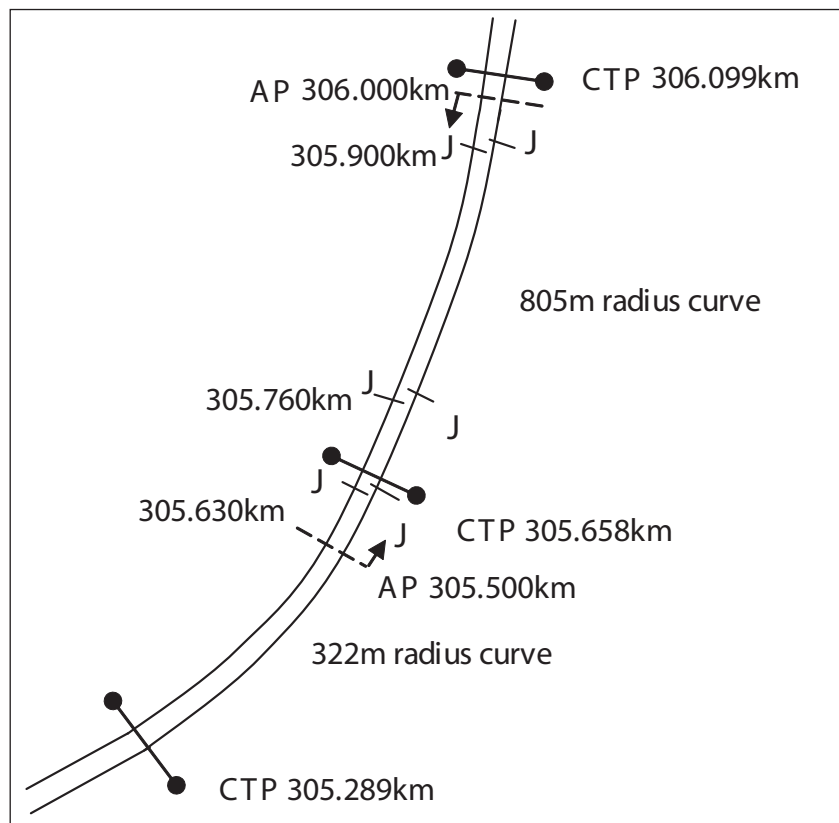


Figure 4.15 – Rail Joints Cut into Misalignment Curve During Restoration Works

As a part of the track restoration process the track was realigned, punch marked, cut and jointed. Following this procedure a check of rail adjustment was carried out where the conclusion was reached that there was no excess steel within the curve at 305.650km (refer to Appendix 9.9)

¹⁸ 40/40km/h represents two track speeds with the first speed indicating the track speed for freight and the second speed indicating the track speed for XPT, Xplorer and Endeavour trains.

The following joint gaps were measured at 38°C following installation of the rail joints within the misalignment curve on 22 November 2002.

Km	Down Rail (mm)	Up Rail (mm)
305.630	46	31
305.740	26	23
305.900	29	28

Table 4.7 Rail Joints and Gap Measured at 38°C Rail Temperature as Cut into the Misalignment Curve During Track Restoration

4.7.11 Post Incident Safety Actions Undertaken by Rail Infrastructure Corporation:

Since the derailment of G9821 on 19 November the Yass Maintenance Team implemented the following programs designed to assist in the prevention of future misalignments within the region.

Hot Spot Speed Restrictions

As described in Section 4.9.2 the Yass Team Manager modified the process for applying speed restrictions at locations with a history of track stability problems (Hot Spot locations). The process was effectively amended to require the following.

- On days forecasted at a maximum temperature of 30°C or above (previously 35°C) Hot Spot speed restrictions would be applied at all Hot Spot locations.
- On days where the temperature is monitored by the Yass Team Manager and predicted to reach 30°C (previously 35°C) or above, a WOLO telegram is to be issued to cover the Yass maintenance area.

Rail Painting

In an attempt to reduce the rail temperature at Hot Spot locations within the Yass Maintenance Area, the rail web, foot and sleeper plates at these locations were painted white as depicted in Figure 4.16. This work was completed by the end of January 2003. Minimum rail temperature reductions of 5°C, at ambient temperatures of 30°C, were recorded in the Yass maintenance area compared with sections of rail without paint. Rail temperature reductions of up to 10°C have also been reported on rails painted within the North Coast Maintenance area. Refer to Appendix 9.14 detailing rail painting product information.



Figure 4.16 Rail Painting at Misalignment site 305.650km

Low Profile Concrete Sleepers

In an attempt to improve the lateral track stability of Yass Hot Spot locations, low profile concrete sleepers have been installed in a 1 in 4 pattern at these locations. Low profile concrete sleepers installed in the Up Main South at 305.650km are depicted in Figure 4.17 below.

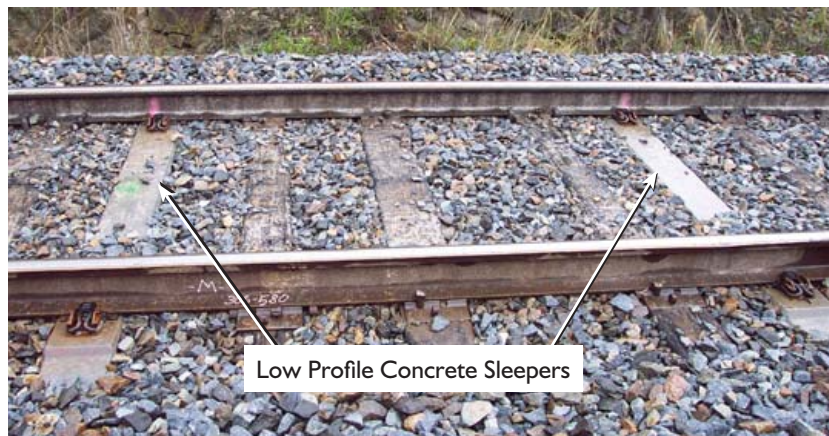


Figure 4.17 Low Profile Concrete Sleepers at 305.650km Up Main South.

Shoulder Ballast Stabilisation

In an effort to improve the lateral track stability at 267.500km the Yass Maintenance Team constructed a retaining wall to retain the curve's shoulder ballast as depicted in Figure 4.18. Low profile concrete sleepers in a 1 in 4 pattern have also been installed at this previous Hot Spot location (April 2002) together with the rails being painted. Since the installation of these track stabilisation measures the curve at 267.500km has not displayed any signs of instability.



Figure 4.18 Shoulder Ballast Stabilisation, Low Profile Concrete Sleepers and Rail Painting at 267.500km Down Main South.

Rail Grinding

A program of rail grinding within the Yass maintenance area was conducted between July 03 and September 03 in conjunction with the concrete resleepering program. This program will improve the rail profile and reduce rail vertical displacements generated from the passage of trains, which in turn assists in maintaining lateral track stability. A total of 105km on the Up and Down Main South Lines within the Yass Maintenance Area has undergone rail grinding work. Refer to Figure 4.19 depicting rail grinding works at 252.500km Up Main South.



Figure 4.19 Rail Grinding and Low Profile Concrete Resleepering (sleepers placed ready for installation) at 252.500km Up Main South.