Australian Government

Australian Transport Safety Bureau

# Derailment of train 7SP5

between Caragabal and Wirrinya NSW | 23 October 2011


Investigation

**ATSB Transport Safety Report**

Rail Occurrence Investigation

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**Addendum**

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# Safety summary

## What happened

At approximately 0530 on 23 October 2011 Pacific National freight train 7SP5 derailed near Wirrinya, New South Wales. Train 7SP5 was travelling from Stockinbingal towards Parkes and was 14 hours into its journey from Sydney to Perth.

The lead bogie of the 42nd wagon of the train derailed three kilometres north of Caragabal. The wheels of the bogie ran derailed for about 15 km until reaching the turnout at the southern end of Wirrinya where wagons separated from the train and overturned.

**Wirrinya derailment site**

Source: ATSB

The train crew were not injured. The last six wagons (all of which were multiple platform type) derailed. The derailment caused significant damage to the track and the turnout at Wirrinya.

## What the ATSB found

The ATSB found that a dip in the track with adverse twist close to Caragabal caused the bogie to derail. The dip was caused by the formation subsiding due to localised formation weakness, resulting in an inability for the formation to support the track structure above.

There was no evidence of formation damage due to re-sleepering or any pumping of formation material up though the ballast and the track geometry appeared to be relatively stable for some kilometres either side of the derailment site. Track inspections had been conducted in accordance with the NSW Base Operating Condition Standards, but it is unlikely that the inspections would have identified any warning signs of formation weakness before the derailment. This was supported by the drivers of train 7SP5 not noticing anything unusual as they traversed this location. Based on available evidence, it is likely that the track dip developed under train 7SP5 and was caused by an undetected weakness in the track formation.

There was a history of track geometry defects around this location, but they were generally not significant when compared to defects identified and rectified in other locations. Notwithstanding this, analysis of track defect history is important for planning maintenance activities. There may be an opportunity for greater examination of maintenance history and defect data to help strengthen a predictive maintenance system.

## What's been done since

The ARTC has implemented their Engineering Code of Practice (CoP) for its rail network in NSW as part of an ongoing program of procedure standardisation across the ARTC rail network. The CoP is slightly more stringent than the previous standards in its assessment of identified track defects. There was no evidence of pre-derailment track defects in this case, but where the formation may begin to collapse without resulting in a derailment, it is possible that the CoP may resulted in earlier maintenance action and potentially prevent a future derailment.

## Safety message

The opportunity may exist for managers and maintainers of track infrastructure to strengthen their predictive track maintenance systems by considering greater examination of historical maintenance and defect data.

# Contents

# The occurrence

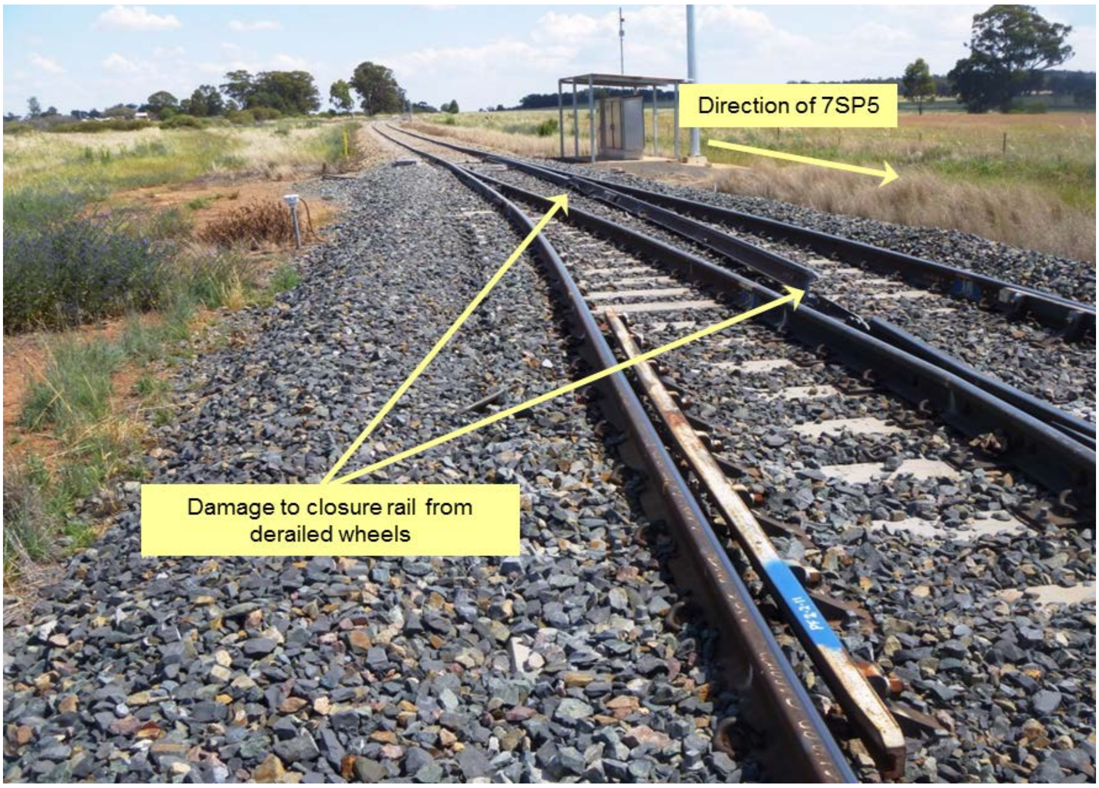
At about 0215 on 23 October 2011, the driver and co-driver of freight train 7SP5 commenced their shift at Cootamundra. They were rostered to work train 7SP5 from Cootamundra to Goobang Junction on the western outskirts of Parkes. Due to the late running of the train, the driver and co-driver travelled by road to meet it at Wallendbeen, where they took control from the previous crew at about 0255.

Train 7SP5 departed Wallendbeen at about 0305, travelling through Cootamundra, Stockinbingal and then towards Parkes. The journey toward Caragabal was uneventful. Although the maximum track speed was 115 km/h, the driver maintained a train speed of about 100 km/h to improve the ride quality over various rough sections of track.

Just prior to Caragabal (between the 530 km and 532 km marks), the drivers felt the locomotive pass over a noticeably rough section of track. The train was travelling at about 105 km/h and the drivers commented on their surprise that the train did not part and lose air pressure from the braking system. They looked back along the train to check its condition and observed nothing abnormal.

Shortly after passing through Caragabal, the leading bogie of the 42nd wagon (RRAY07178) derailed at the 538.598 km location. Train 7SP5 was running at 103 km/h (12 km/h below the posted track speed). Setting this speed was the last change to throttle/brake controls prior to the derailment and was done 2 minutes before the bogie derailed by stepping the throttle up from notch 6 to notch 8. The drivers did not notice the derailed bogie, which ran in the derailed state for approximately 15 km until it reached the turnout[1] at the southern end of the Wirrinya crossing loop (553.443 km) (Figure 1).

**Figure 1: Damage to turnout at southern end of Wirrinya**




Source: ATSB

[1] A combination of a set of points, V crossing and guard rails which permits traffic to turn out from one track to another.

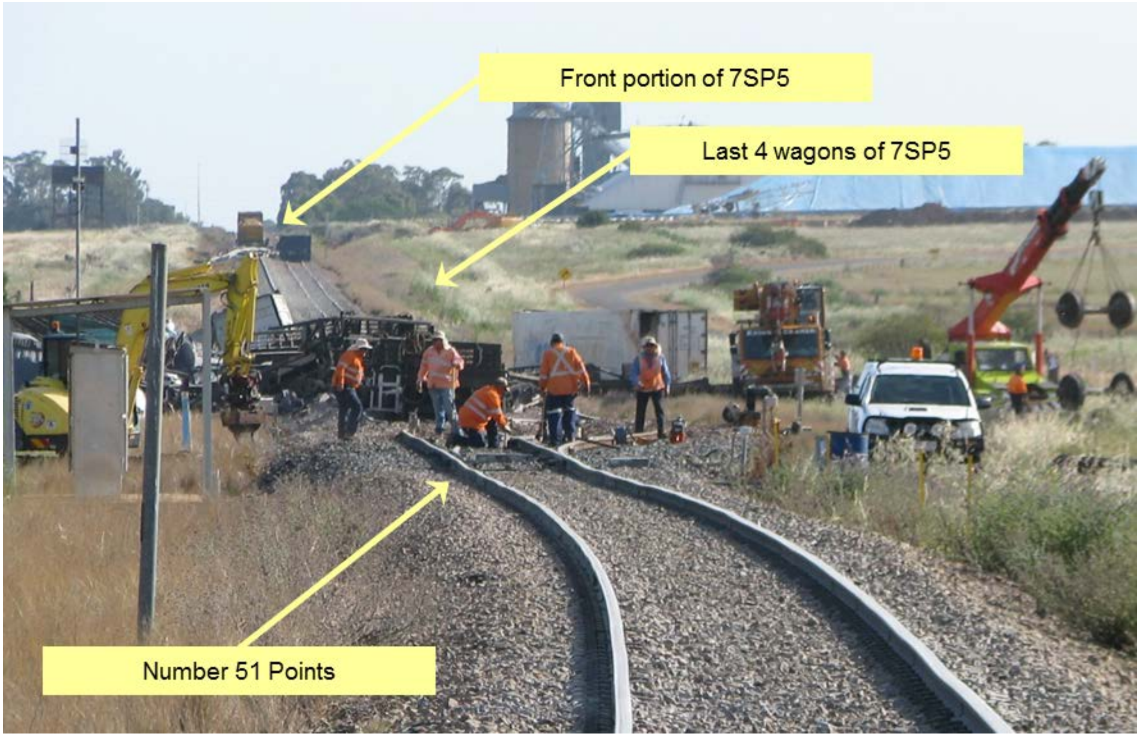
At approximately 0530 the wheels of the derailed bogie on wagon RRAY07178 struck the left-hand closure rail[2] of the turnout, breaking the rail in two places and pulling the right-hand stock rail out of alignment. The derailed bogie was pulled from under its wagon and the wheel-sets were dislodged from the bogie.

Lateral movement of derailed wagon RRAY07178 caused the trailing bogie of the wagon in front (RRAY07256) to also derail, but the bogie remained connected under the wagon. As the train continued, the dislodged bogie and wheel-sets (wagon RRAY07178) stripped the remaining five bogies from under RRAY07178 and caused its load to be dislodged. The four wagons trailing RRAY07178 were all RKKY wagons which detached from the train, derailed and piled up on top of each other at the southern end of Wirrinya (Figure 2).

During this time, the drivers felt the locomotive being jolted from behind before the train began to lose brake pipe pressure. The loss of pressure indicated that brake pipe air was venting to atmosphere and the train brakes would begin to automatically apply. The driver then reduced power, allowing the train brakes to slow the train.

Train 7SP5 continued to slow as it travelled along the main line through Wirrinya, dragging the bogie-less wagon RRAY07178. As the train came to a stand at the northern end of Wirrinya (about the 555.940 km location), the container on the last platform of RRAY07256 fell from the wagon onto the adjacent loop track (Figure 3). In total, the last six wagons of train 7SP5 derailed and a number of containers were thrown from their respective wagons.

**Figure 2: Derailment at Wirrinya showing front and rear sections of train 7SP5**




Source: ATSB

The derailment damaged the concrete sleepers along the 15 km section of track between the derailment point at the 538.598 km and the southern end of Wirrinya. The turnout and approximately 400 m of track on the loop and main line were damaged.

[2] Closure rails are rails located between switch and crossing components, cut to a length to fit the requirements of the turnout.

**Figure 3: Derailed wagons at northern end of Wirrinya**


Source: ATSB

## Post occurrence

The train crew were not injured during the derailment. Once the train had stopped the co-driver alighted from the locomotive and walked back along the length of the train to inspect the damage. The co-driver observed two derailed wagons that were still coupled to the train. The last four derailed wagons of the train and dislodged containers were located about 1 km away at the southern end of Wirrinya.

The driver reported the derailment to the network control officer at the Junee Control Centre at approximately 0610. The train had stopped across the Back Marsden Road level crossing and the driver requested permission to split the train and move the front portion to clear the level crossing. Later that day the train was split opening the level crossing to road traffic.

Staff from Pacific National, the Australian Rail Track Corporation (ARTC), Transfield Services, the Office of Transport Safety Investigations (NSW), and the ATSB attended the site to investigate. The damaged turnout was removed and repairs undertaken on the damaged loop track. The mainline was slewed across to the loop to allow re-opening of the track on the evening of 25 October 2011, two days after the derailment.

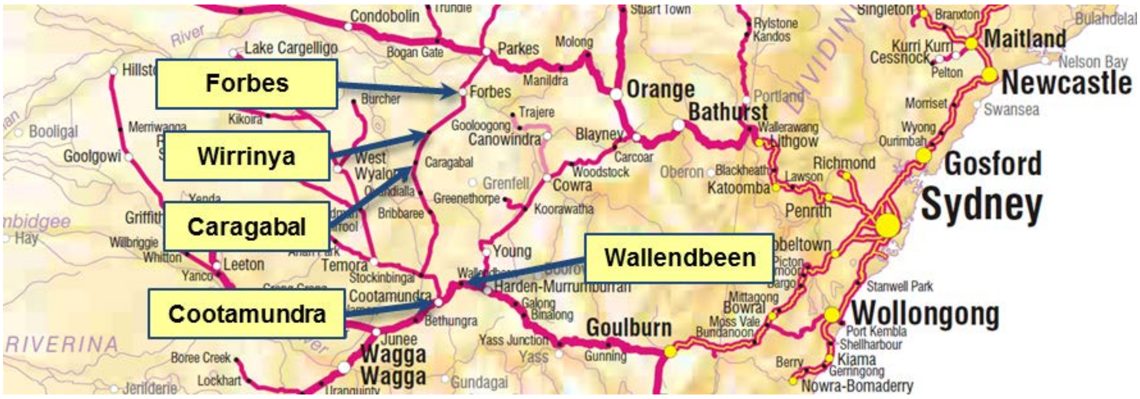
# Context

## The location

The derailment occurred between Caragabal and Wirrinya, situated in the central west of New South Wales (Figure 4). Wirrinya is located approximately 44 km southwest of Forbes and 124 km north of Cootamundra by rail.

The geography of the area is mostly flat with the railway sitting on a low embankment, approximately 1 m high. In the direction 7SP5 was travelling, the track follows a fairly straight alignment with minimal grades. The 35 km leading to Caragabal has a gentle descending gradient with four large radius curves. From Caragabal, the track continues with a descending gradient for 9 km, levels out, then climbs up to the crossing loop at Wirrinya. There are three, large radius curves between Caragabal and Wirrinya.

**Figure 4: Location of Caragabal and Wirrinya, New South Wales**

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## Site observations

ATSB investigators examined the derailment site and found the front portion of the train at the northern end of Wirrinya with the last two wagons of this section of train derailed (RRAY07256 and RRAY07178). The last four wagons of the train (RKKY wagons) had detached and were derailed approximately 200 m north of the turnout at the southern end of Wirrinya. The derailed wagons had suffered varying degrees of damage (Figure 5) with their components scattered across the rail corridor. The containers from wagon RRAY07178 were found lying adjacent to the RKKY wagons.

Amongst the wreckage at the southern end of the station were two wheel-sets[3] with evidence on the wheel tread and flange of having run derailed for some distance. Both wheel-sets were free of their bogies and a wheel on one of the wheel-sets had been dislodged from its seat on the axle (Figure 6). It was established that both wheel-sets had come from the lead bogie of wagon RRAY07178, which was still attached to the front portion of the train at the northern end of Wirrinya. These two wheel-sets were later determined to have been the first to derail.

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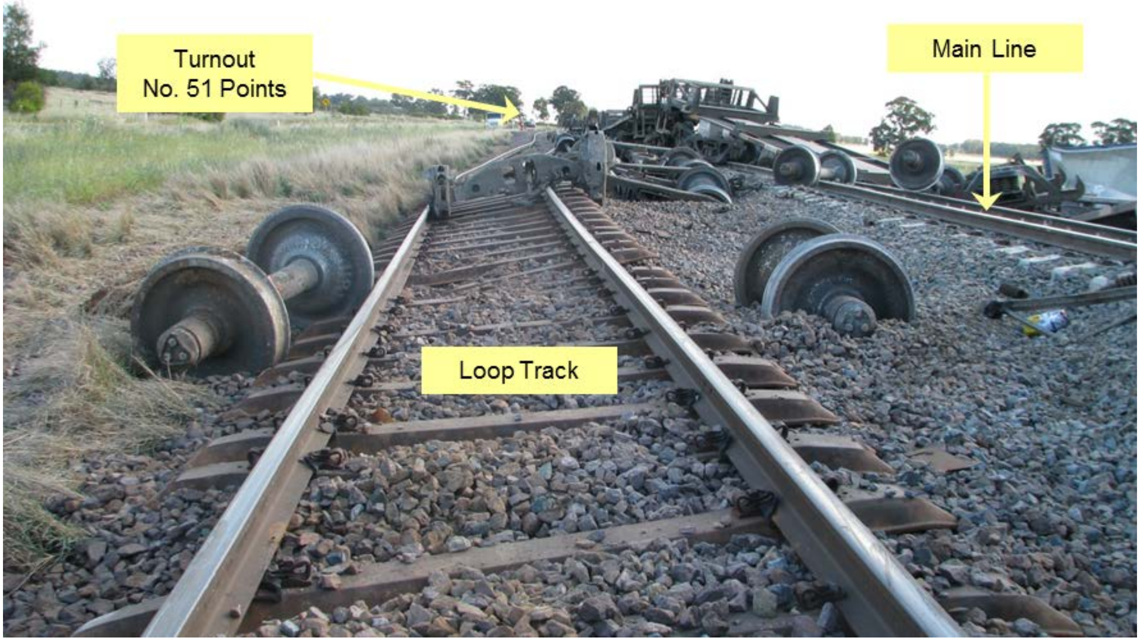
[3] A wheel-set is a pair of steel rail wheels pressed onto an axle. A wheel-set may or may not have bearings on the ends of the axle.

**Figure 5: Track at the 553.500 km mark**




Source: ATSB

**Figure 6: Wheels from southern end of Wirrinya with damage indicative of having run derailed for some distance**

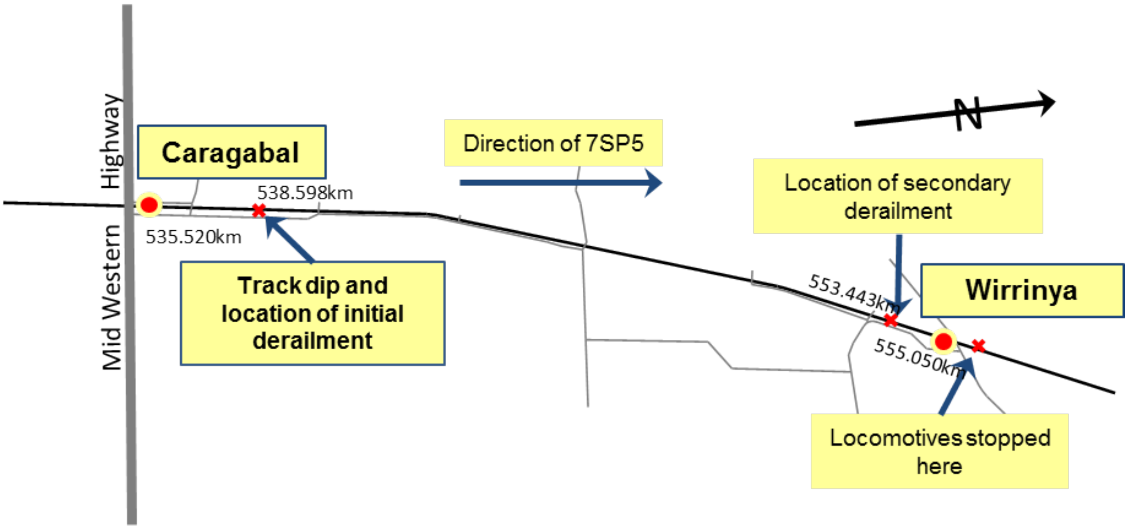
Source: ATSB

Both tracks (the main line and the crossing loop) at the southern end of Wirrinya were significantly damaged with the damage leading back to the mainline turnout (number 51 points). Witness marks and the damage to number 51 points indicated that, when entering the turnout, two wheel-sets were already derailed.

Evidence of derailed wheels travelling on the sleepers extended back for approximately 15 km, over six level crossings, to the 538.598 km mark where a dip[4] in the track was evident and fresh flange marks were found over the rail head (Figure 7). No evidence of the derailment was found on the track behind this location (that is, prior to the 538.598 km mark), which established this location as the initial point of derailment.

4 A vertical misalignment in the track.

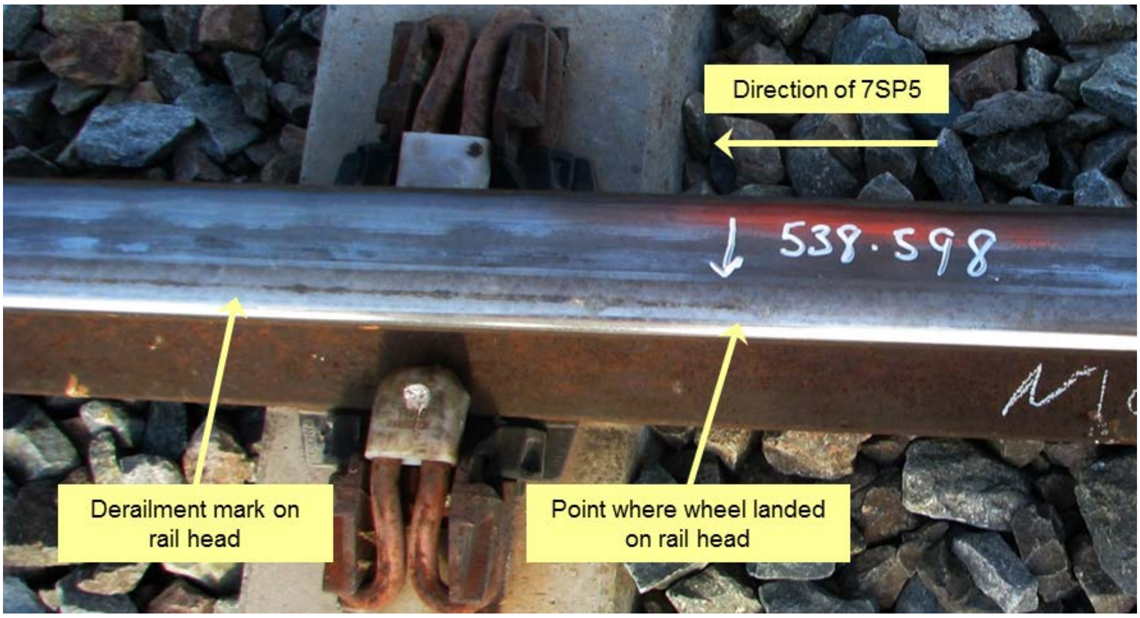
**Figure 7: Map of track where train 7SP5 derailed and came to a stand**




Source: ATSB

The first derailment witness mark (caused by a wheel flange) was found on the head of the right hand rail approximately 4 m past the track dip. The witness mark started about 12 mm in from the gauge face and extended for about 6.5 m along the rail before ending on the field side[5] of the rail (Figure 8), followed by rail wheel witness marks on the sleepers and in the ballast. The marking indicated that a wheel had unloaded, lifted off the rail, and landed with its flange on the head of the right-hand rail. This wheel then ran along the head the rail, dropping off on the field side of the rail and onto the right-hand sleeper ends, causing the left hand wheel to drop into the four-foot.[6]

**Figure 8: Derailment marks on right-hand rail at 538.598 km**




Source: ATSB

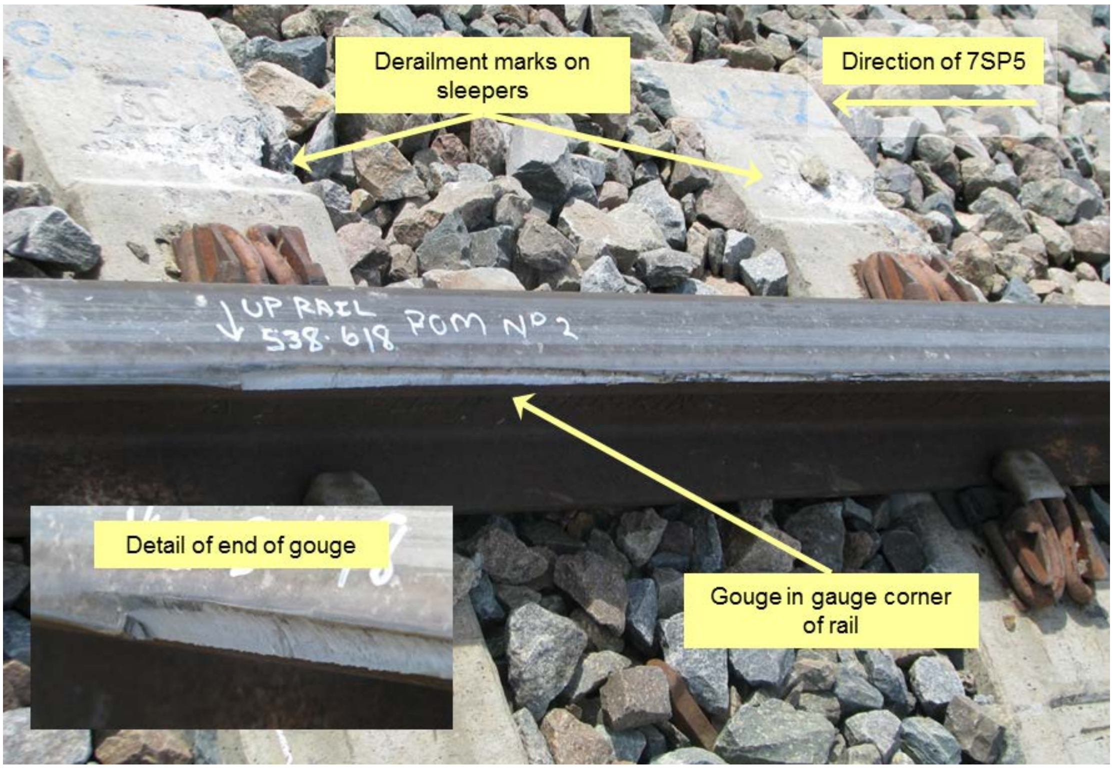
Approximately 15 m after the first witness mark a gouge mark was evident on the gauge corner of the right hand rail (Figure 9). The gouge ran for about 5 m, progressively increasing in depth, along the gauge corner, leading to a mark over the rail head that ran to the field side of the rail. The markings lead to second pair of marks on the sleepers and ballast. It was evident that, with

5 The side of the rail opposite the gauge face

6 Four-foot: rail industry term used to describe the space between the rails on standard gauge track.

the first wheel-set running with one wheel on the right-hand sleeper ends and one in the four-foot, the bogie had yawed, steering the trailing wheel-set (on the same bogie) so that the front of the flange on the right-hand wheel was running against the gauge face of the right-hand rail. This wheel-set had remained railed for a short distance and continued to attack the gauge face of the right-hand rail. It then climbed over the rail, following the first wheel-set onto the sleepers approximately 26 m after the dip in the track.

**Figure 9: Gouge in right-hand rail**




Source: ATSB

## Track information

The Stockinbingal to Parkes Railway was opened to through traffic in 1918 as a cross country branch line linking the Lake Cargelligo Line at Stockinbingal and the Broken Hill Line at Parkes. After 75 years of service as a branch line, it was re-designated as a main line when it became part of the main East-West rail Corridor in 1993, carrying heavier and longer trains. The route via the Main South Line bypassed the steep grades of the Main Western Line through Katoomba.

The track infrastructure was owned by the Country Rail Infrastructure Authority of NSW and leased by the ARTC. The ARTC maintains the track and associated infrastructure and provides the train control function from their network control centre in Junee. The train order system of safe working is used to authorise train movements.

The railway is a standard gauge single track with crossing loops and some sidings for loading grain. The terrain near the derailment site is predominantly river flat/flood plain.

The main line track structure is AS 90 lb/yd rail fastened to concrete sleepers with resilient clips. The track in the crossing loop at Wirrinya is laid on steel sleepers. Timber sleepers on the main line were replaced with concrete sleepers approximately 3 years prior to the derailment. The concrete sleepers were installed in 2009 using a side insertion method and additional ballast was added after the concrete sleepers were installed.

The track has a mainline speed limit of 115 km/h and this speed limit was implemented in March 2011 as one benefit of the re-sleepering project. The previous speed limit was 100 km/h.

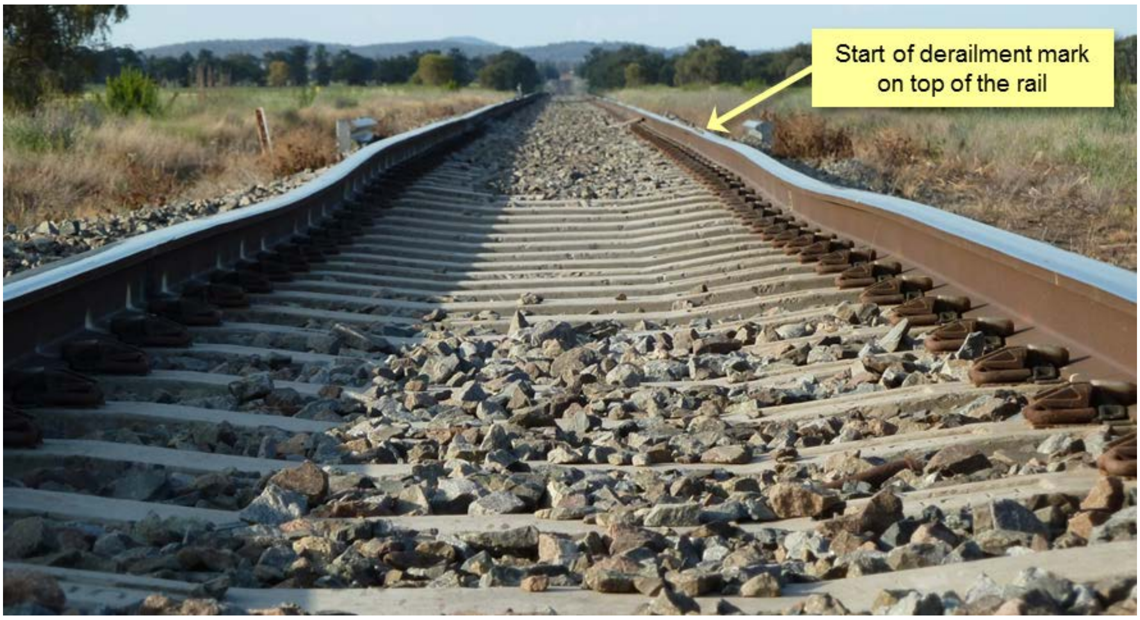
In the vicinity of the derailment near Caragabal (538.598 km) the rail was branded as being rolled (manufactured) in 1932. The rail has some table wear[7] with measurements showing that it was not at its wear limits. The contact patch on the top of the rail was across the full width of the head and there was some rail flow and fatigue damage. The wear, rail flow, and fatigue damage were not of a magnitude or severity that could have contributed to this derailment.

## Track formation

Track formation is the foundation of the track structure and it should provide stable support to the ballast, sleepers and rail components laid above it.

The ATSB examined the point of derailment and the dip in the track which extended over a distance of approximately 10 m. Through the dip, the ballast profile (both shoulder and crib) was noticeably reduced compared to the track on either side (Figure 10). On the southern side of the formation there was evidence of heaving or movement to the side of the formation fill material (Figure 11).

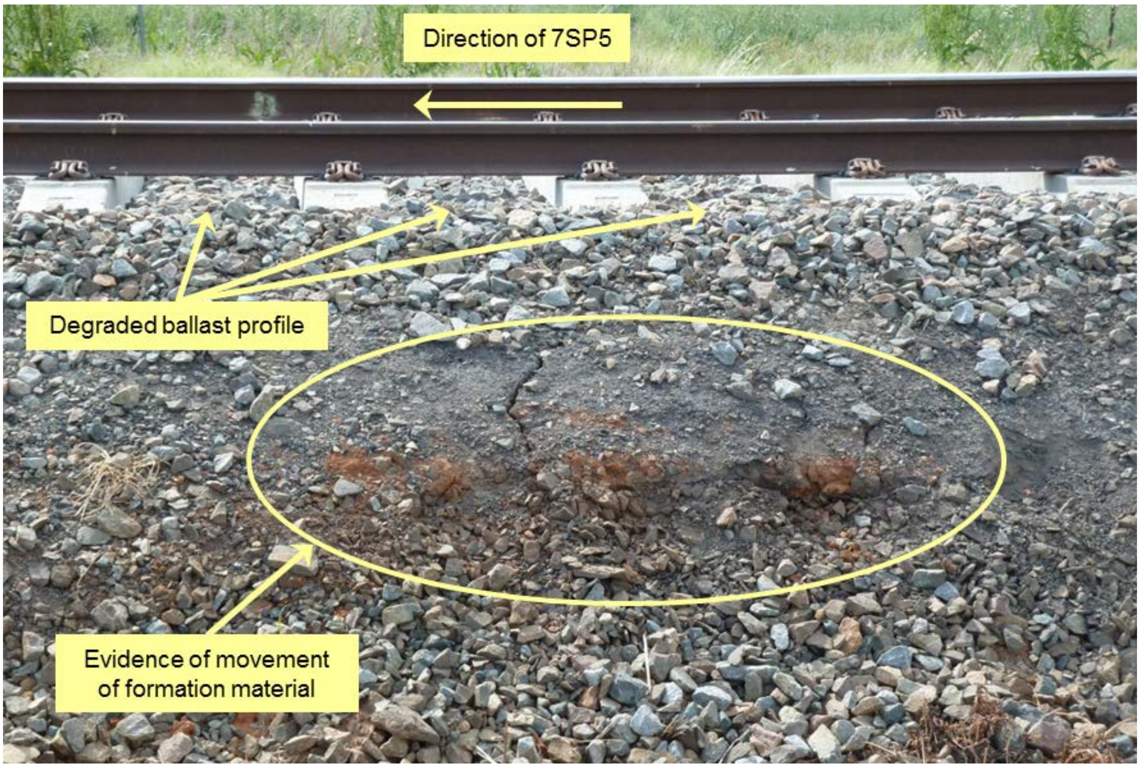
**Figure 10: Track dip at the 538.588 km mark looking in the direction of travel**




Source: ATSB

[7] Table wear is the loss of rail steel from the top of the rail.

**Figure 11: Evidence of heaving or formation movement on the down side of the track at the 538.588 km mark**




Source: ATSB

The formation is composed of compacted fill material that is typically locally sourced and is a structural component for the track taking the distributed loads of the rail traffic. The formation is the most deformable and most variable component of the track structure and, like all track components, is subject to fatigue due to the cyclic loading of rail traffic.

Over time ballast breaks down and the voids in the lower levels of the ballast fill with material creating a fouled layer that reduces the free draining nature of the track structure, changing the load distributions within the ballast and formation. Maintenance activities can include the removal and replacement of the fouled ballast. Fouled ballast can also be retained as a sub-ballast layer with clean ballast between the sub ballast and the sleepers. However there are maintenance activities that will agitate the sub-ballast layer and disturb the surface of the formation, particularly if there is insufficient clean ballast, creating areas where moisture can accumulate potentially weakening the formation and adding to the changes in the load distributions.

Stiffer track structures are desirable as they permit increased axle loads, increased train speeds, and reductions in some maintenance activities. Stiff track structures and the additional loads that may result from operational changes can accelerate the fatigue of the track formation, increasing the likelihood of formation failure.

The Stockinbingal to Parkes Railway served as a cross county branch line for 75 years. It was then re-designated and operated as a mainline for 15 years before the track structure was stiffened with the installation of concrete sleepers on the existing formation. The line speed was then increased by 15 per cent[8] to the current 115 km/h.

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8 Track impact loads are directly proportional to train speed.

## Track inspection and maintenance

The track was maintained by Transfield Services for the ARTC. Maintenance inspections for this section of track were carried out weekly by road/rail vehicle and locomotive cab ride inspections were conducted every six months. Track geometry measurements were conducted three times a year. Other inspections were programmed to check for specific defects such as ultrasonic testing of the rail for defects.

Road/rail vehicle and locomotive cab ride inspections were undertaken by track maintenance staff. These inspections are visual with the locomotive cab ride providing a ride quality indication. Train drivers, who often know the track intimately, assist in the defect detection process. Identified defects are noted and entered into an asset management database for action. Track geometry measuring vehicles such as the AK Cars measure the geometry of the track mechanically, or using accelerometers or lasers.

Guidelines for the inspection and assessment of track geometry were documented in the ARTC's NSW Base Operating Condition Standards, C2009, C2010, and C2011. Assessment of any track geometry defects is based on a table of defect limits and categories, and compared to a table of response priorities which are also dependent on rated track speed. The response priorities describe the appropriate action required to manage any risk to railway operational safety (Table 1).

Measurement and assessment of track geometry can be undertaken manually, using a track recording trolley or using a track recording vehicle. Manual measurements are taken when the track is unloaded, that is, with no train on the track. These measurements are referred to as static or unloaded geometry. Track recorder vehicles, such as the ARTC AK Cars, measure the track as they travel along it. The measurements are taken while the track is carrying the weight of the vehicle, including the locomotives hauling the AK cars. These measurements are called dynamic or loaded geometry. Depending upon how the ballast and formation are supporting the track, loaded and unloaded track geometry may vary. The NSW standards do not differentiate between static and dynamic measurements.

**Table 1: Response priority**

| Priority | Assessment | Repair |
|---|---|---|
| **Emergency** | Maximum 2 hours | 24 hours |
| **Priority 1** | Within 24 hours | Within 7 days, |
| **Priority 2** | Within 7 days | Within 28 days, |
| **All Others** | Planned Maintenance | Planned Maintenance |

Note [1] -If the requirements of the standard cannot be satisfied, trains may only pass the site under the written authority of the Civil Engineering Representative.

### *Pre-derailment track inspections*

The ARTC's maintenance records show that, in the 3 years since the track was re-sleepered, the AK cars had once a year (every third run) found a geometry defect around the 538.600 km location that required rectification. Weekly track patrols on three occasions in December 2008, January 2011, and May 2011 found track misalignments that required rectification. In March 2011 a train driver reported rough riding at the 538.750 km and in June 2011 a train driver reported a 'kick'[9] in the track at the 538.500 km mark. After each driver report temporary speed restrictions were put in place until maintenance staff could inspect the locations; in both instances no defects

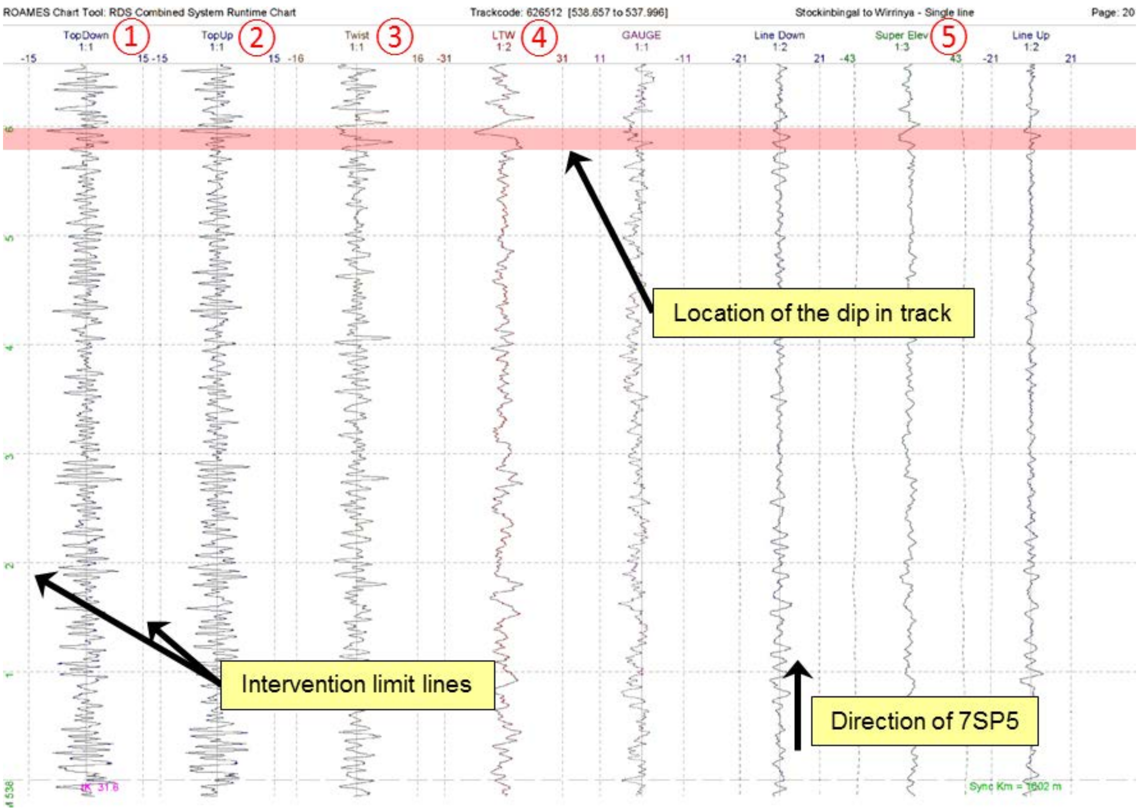
9 Train drivers will often refer to a misalignment that caused rough riding or concern as a kick in the track.

were found. Within a month of both drivers' reports ARTC's track geometry inspection train (the AK Cars) travelled the section. Both times small track geometry defects were measured but all were below the NSW Base Operating Condition Standards limits for repair.

At the end of June 2011 a tamping consist[10] lifted and packed the track from the 538.500 km to the 539.000 km to rectify a misalignment reported by the track maintenance staff in May 2011. The last AK Car run prior to the derailment of train 7SP5 was conducted in July 2011. Track geometry measuring vehicles, such as the AK Cars, generate charts of the parameters measured (illustrated in Figure 12). Exception reports of defects are also generated that may require immediate inspection and/or action. Exception reports list locations of the defects, defect types and their severity. The charts are continuous plots for each parameter measured and are plotted to scale permitting direct measurements to be made. Exception limits are plotted on the charts as dotted lines on both sides of each parameter's plot.

Track maintenance inspection records show that no further defects were found before the transit of 7SP5 on 23 October 2011. The drivers of train 7SP5 stated that they did not feel anything unusual near the 538/539 km location, but they had experienced a rough patch about 9 km earlier.

**Figure 12: AK Car graph (chart) from 538.000 km to 538.650 km – July 2011**




**Source: ARTC**

**Notes:** ① Top measurements for the down rail.

② Top measurements for the up rail.

③ Short Twist measurements.

④ Long Twist measurements.

⑤ Superelevation measurements.

10 A tamping consist is typically tamping machine and ballast regulator. The tamper lifts and lines the track, packing the ballast to maintain the reinstated track alignment. The ballast regulator shapes the ballast to ensure an adequate ballast profile.

The red band on Figure 12 shows the location of the dip in the track that was found at the 538.598 km mark. The top (vertical alignment), gauge, line (horizontal alignment) and super elevation graphs near the track dip are generally consistent with the graphs on the rest of the page. There are no points on the graph that would have resulted in them being listed on the AK Car exception report for follow-up inspection or action. There are minor spikes in the twist and long twist plots but neither has reached a level that would warrant immediate action.

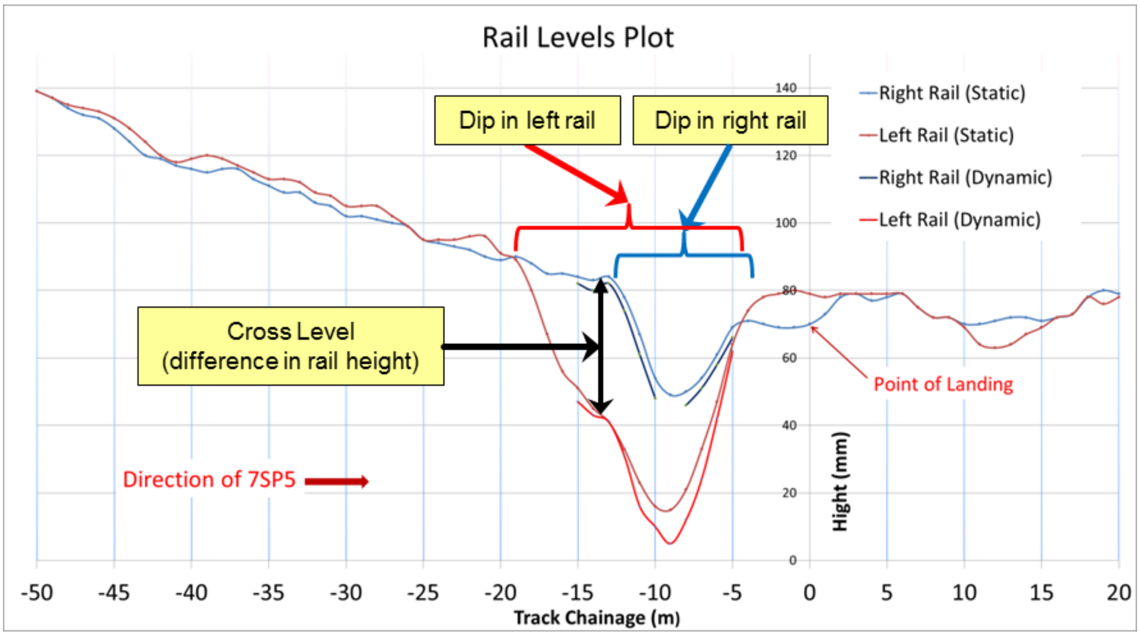
## Post-derailment track measurement

Both static and dynamic measurements were taken after the derailment of train 7SP5. Static geometry was measured using survey equipment while dynamic geometry was determined by measuring track deflection under the loading of a light engine movement (in this case, three locomotives travelling slowly). While locomotives provide significant loading for taking dynamic measurements, it is likely that a train travelling at track speed would generate higher loads causing potentially greater track deflection. The measurements revealed that there was a significant dip and twist in the track.

Figure 13 illustrates the (vertical) track geometry measured after the derailment. The scales are local and are referenced to the point of landing. Since the horizontal axis is in metres and the vertical axis is in millimetres, some vertical exaggeration is illustrated in the plot. The plot shows the vertical alignment of each rail (static) overlayed with the loaded deflections (dynamic).

An asymmetrical shape is evident for the dip with the left hand rail dropping before, and deeper, than the right hand rail. What is also apparent is how steep the ramp is on the left hand rail climbing out of the dip and where the wheel landed relative to the dip (illustrated in Figure 13).

**Figure 13: Plot of rail levels taken by investigation team after derailment**




Source: ATSB

### *Vertical alignment (Top)*

Vertical alignment (also known as top) is measured as the difference in rail level over a defined distance. Manual measurement and analysis of vertical alignment is achieved using two criteria. A mid-ordinate offset measurement of a 10 m chord and a mid-ordinate offset measurement of a 6 m chord. The post-derailment vertical alignment measurements[11] and the response priorities (based on a rated track speed of 115 km/h) for the track dip in this case are illustrated in Table 2.

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[11] Measured at 1 m intervals along the track using a dumpy level and staff.

**Table 2: Vertical alignment measurement and required response**

| | Static (mm) | Dynamic (mm) See note [1] | Response priority (C2009 & C2011) |
|---|---|---|---|
| **10 m chord** | 45 | 45 | Priority 1 |
| **6 m chord** | 25 | 19 | Priority 1 |

**Note [1] - Very small sample due to number of void measurements made.**

### *Cross level variation*

Cross level, also referred to as track cant or superelevation, is a measurement of the difference in level of the two rails at a single point along the track. Cross level variation is the difference between this measurement and the design cross level (zero design cant for tangent track). The post-derailment cross level variation[12] and the response priorities (based on a rated track speed of 115 km/h) for the track dip in this case is illustrated in Table 3.

**Table 3: Cross level variation and required response**

| | Static (mm) | Dynamic (mm) | Response priority (C2009 & C2011) |
|---|---|---|---|
| **Cross level variation** | -45 | -45 | Priority 1 |

### *Twist*

Twist is the variation in track cross level over a defined distance. Two twist lengths are defined in the NSW standards, long twist at 14 m and short twist at 2 m. Twist is important as excessive twist can prevent the bogies and wagons applying equal load on all wheels. The post-derailment twist (calculated using the cross level measurements) and the response priorities (based on a rated track speed of 115 km/h) for the track dip in this case is illustrated in Table 4.

**Table 4: Twist and required response**

| | Static (mm) | Dynamic (mm) | Response priority (C2009 & C2011) |
|---|---|---|---|
| **Long twist** | -48 | See note [1] | Priority 1 |
| **Short twist** | -21 | -23 | Emergency |

**Note [1] - Not available due to void measurement of only 10m of track**

### *Horizontal alignment (line)*

Horizontal alignment, often called line, is a measurement of the lateral (or horizontal) rail alignment and is typically measured by taking versine (mid-ordinate offset) measurements using a chord of defined length. In this case, versine measurements were taken each metre on the right hand rail using a 10 m chord with the left hand rail alignment calculated using the right hand rail measurements and the gauge measurements. While the track had moved about 7 mm to the left at the point where the right-hand wheel of the first bogie to derail landed on the head of the rail, the horizontal alignment measurements were within specified track maintenance limits.

12 Calculated from measurements obtained using a track gauge, a specialist tool for measuring track gauge and cant, sometimes referred to as Giesmar Gauge or Sola Gauge (a reference to the manufacturer).

#### *Gauge*

Gauge is the distance between the inside faces (gauge face) of each rail. The gauge was measured on site using a track measurement gauge.[13] The gauge measurements were within specified track maintenance limits.

### *Updated inspection and maintenance procedures*

In November 2011 (the month after the derailment) the ARTC implemented different inspection and maintenance procedures in NSW as part of an ongoing program of procedure standardisation across the ARTC rail network. The ARTC Engineering Code of Practice (CoP) is slightly more stringent in its assessment of track defects. For example, in this case, assessment of the post derailment track measurements would have returned an 'emergency' category for vertical alignment (assessed as priority 1 under the NSW standard) and twist. Under the CoP, this would require a response and/or repair before the next train compared to within 2 hours under the NSW standard.

When considering the pre-derailment inspection and maintenance records, there was no evidence of track defects near the 538.598 km location that would have warranted maintenance action under assessment of either the NSW standards or the ARTC CoP. However, had the formation begun to collapse without resulting in a derailment, it is possible that the ARTC CoP may have resulted in maintenance action before assessment under the NSW standards.

### *Summary of inspection and maintenance*

The investigation found that the track condition after the derailment would have warranted immediate repair when assessed against the documented requirements of the NSW standards. However, there is no evidence to suggest that the track was in that state when train 7SP5 began to pass over the track dip at the 538.598 km location. Similarly, there was no evidence to suggest that any track deficiency would have been identifiable during track inspections, nor any requirement for maintenance action. These findings are supported by the drivers of train 7SP5 not noticing anything unusual when locomotive NR45 (leading) passed this location. Based on available evidence, it is likely that the track dip developed under the train as it passed the 538.598 km location.

## Train and crew information

Train 7SP5 was a freight service operated by Pacific National Pty Ltd (PN) from Sydney to Perth. It consisted of three locomotives (NR 45 leading NR 65 and NR 49) hauling 46 freight wagons of which 13 were multiple platform type. The train was 1,610 m in length and had a trailing mass of about 3,407 t. The last four wagons (RKKYs) were empty and had been attached to the train for transfer to a maintenance facility. The train was travelling at a speed of about 103 km/h as it approached the derailment site.

The crew consisted of a driver and co-driver. The crew were based in Parkes but started their shift in Cootamundra where they had rested the night before. The driver and co-driver signed on duty at 0215 and then travelled by car to Wallendbeen to relieve the Sydney crew of train 7SP5 at 0255. Both the driver and co-driver held appropriate competencies for the tasks being performed and had been assessed as fit for duty in accordance with the requirements of the *National Standard for Health Assessment of Rail Safety Workers*. Both crew members were drug and alcohol tested at 0953 and retuned negative results.

An examination of the locomotive data showed that train handling through this section of track was as would be expected with no unusual changes to throttle settings or brake applications that would

[13] Purpose made measuring equipment used to measure track gauge and cant. These are gauge specific and are often referred to by track-men and fettlers as "a Gauge".

cause undesirable in-train forces. Train handling was not considered to be a contributing factor in this derailment.

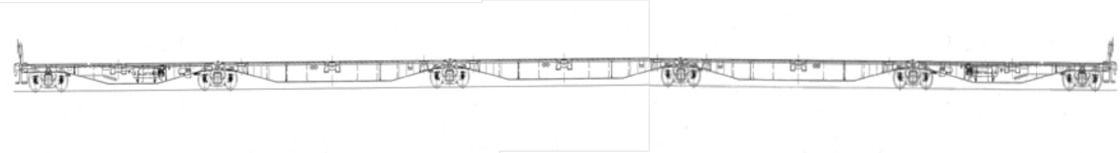
## Rolling stock

The last six wagons of train 7SP5 derailed in this incident. All six wagons were multi-platform wagons, these wagons were;

- RRAY07256X and RRAY07178M
- RKKY07367C, RKKY07334U, RKKY07356X, and KKY07323D

RRAY wagons were five-pack articulated wagons built for container traffic. These wagons consist of five platforms supported by six bogies (Figure 14). RRAY wagons have a total length of 73.1 m (over the couplers) and a capacity of 10 TEU[14] giving a maximum permissible gross mass of 228 t. The two end bogies sit under the end platforms in a similar position to those under a single platform wagon. The four intermediate bogies are shared, the adjacent ends of individual platforms are supported on these bogies using a device which permanently connects the platforms and permits free rotation in all planes.

**Figure 14: Diagram of RRAY wagon**



Source: Pacific National

RKKY wagons were three-unit wagons built to carry steel feedstock (plates and slabs). These wagons consist of three permanently coupled platforms, each platform independently supported on a pair of bogies. RKKY wagons have a total length of 44 m (over the couplers) and a maximum permissible gross mass of 276 t.

The evidence indicates that only the leading bogie on wagon RRAY 07178 derailed at the 538.598 km point suggesting the possibility that there may have been an issue with this bogie.

Wagon bogies that do not run true can be more prone to derailing on track geometry defects than bogies with normal running characteristics. There are many reasons for bogies not running true causing wheels to be biased towards one rail. These include a seized or stiff centre-bowl affecting bogie steering and mismatched side frames that cause the axles to be skewed. When a bogie attacks one rail, that is the bogie runs at an angle along the track such that one leading wheel favours one rail, it will, if deflected from that rail, always try to return to its natural state, favouring one rail. Evidence of bogies behaving this way includes sharp flanges and damage to the centre bowl lining.

The components of the lead bogie of wagon RRAY07178 were examined. The damage suffered from running derailed and being dislodged from under the wagon at Wirrinya made identifying any evidence of a bogie steering issue very difficult. Measurements of the wagons at a maintenance depot after the derailment indicated that the wagon components were within normal maintenance limits.

### *Vehicle loading*

There was no anomaly identified in the train speed, handling, rolling stock condition, or operational performance of train 7SP5 preceding the derailment. Train 7SP5 was loaded with general freight

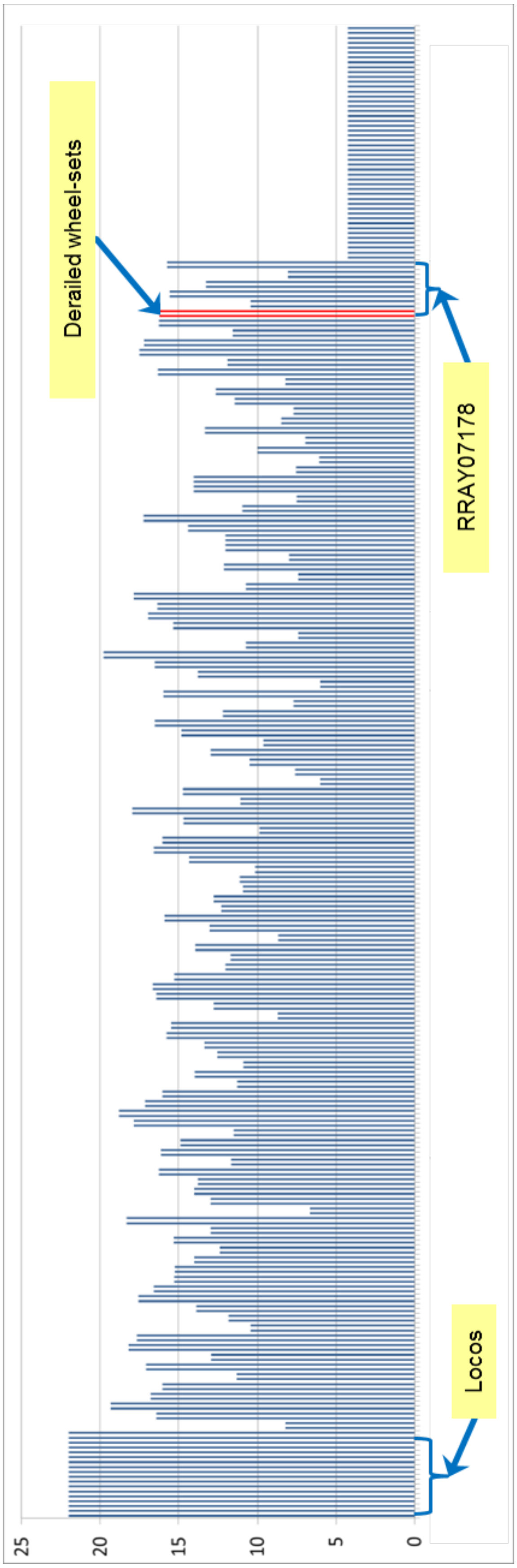
14 The unit of measure used to refer to the freight carrying space on a wagon required to carry a standard 6.1 metre (20 foot) container. Wagon sizes and train capacities are typically referred to in “TEUs” (twenty-foot equivalent units).

in shipping containers, five of which contained dangerous goods. One container on wagon RRAY07256 contained dangerous goods, the platform on which this container was being carried did not derail and the container remained securely attached to the platform. None of the containers that were dislodged from the train contained dangerous goods.

Figure 15 is a plot of the calculated axle loads of train 7SP5 based on the wagon weight and manifest information supplied by PN. The plot shows the locomotives, which have a 22 t axle load and the trailing wagons with axle loads ranging between 6 t and 20 t. Each line represents one axle (or wheel-set); the red lines indicate the two axles that derailed first. The four unloaded RKKY wagons are on the right of the plot, all with 4.25 t axle loads.

PN's procedure, 'FLM01-10_06 *Freight Loading Manual* and the ARTC CoP both state that the maximum weight variation between adjacent bogies must not exceed 20 t. The load differential between bogies either side of the first bogie to derail (the lead bogie of wagon RRAY07178) was calculated to be 5.8 t. The loading of the wagons around the axles that derailed was in accordance with PN's 'Loading Manual' and procedures in the ARTC CoP.

**Figure 15: Plot of axle loads of 7SP5**




Source: Pacific National and ATSB

# Safety analysis

At 0533 on 23 October 2011, train 7SP5 was travelling down a gentle grade when the leading wheel-set on wagon RRAY 07178 traversed a dip in the track resulting in the right wheel unloading, momentarily lifting off the rail and landing with its flange on the head of the rail. The wheel landed 4 m beyond the dip in the track therefore it is likely that it unloaded as it ran up the ramp out of the dip rather than as it dropped into the dip.

The derailed wheel then ran along the head of the rail before it, and its accompanying wheel-set on the same bogie completely derailed to the right of the track (in the direction of travel). The derailed bogie travelled unnoticed by the train crew for about 15 km until it reached the turnout at the southern end of the Wirrinya crossing loop and struck the left hand closure rail, causing further wagons to derail.

While the post-derailment geometry of the dip in the track exceeded the immediate response criteria of the NSW standards, there was no evidence to suggest the geometry defect existed before train 7SP5 began to traverse this section of track. It is likely that the track dip developed under the train as it passed the 538.598 km location.

Post-derailment observations found that the ballast profile through the dip (both shoulder and crib) was noticeably reduced compared to the track on either side of the dip. There was also evidence of heaving or movement within the formation fill material on the southern side of the formation, an indicator that the formation had subsided under the track. These are indicators of localised formation weakness resulting in an inability for the formation to support the track structure above.

The track was re-sleepered about 3 years prior to the derailment, using the side-insertion method[15] of sleeper replacement. A key consideration when replacing sleepers using the side-insertion method is to ensure sufficient ballast depth under the sleepers so as to prevent damage to the formation while scarifying the ballast in preparation for the new sleeper and inserting the sleeper. It is also important that there is sufficient ballast depth to ensure the sleeper/ballast forces are distributed over enough of the formation to prevent overloading of the capping layer and formation.

Formation damage due to scouring (possible when re-sleepering using side insertion) can cause water to pool, seep into and slowly weaken the formation. Mud-holes, pumping of formation material up through the ballast and unstable track geometry are indicators of this type of damage. In this case, the ballast below the sleepers was found to contain degraded ballast and dirt, but there was a layer of sound clean ballast forming the top of the ballast profile. There was no evidence of formation damage due to re-sleepering or any pumping of formation material up though the ballast and the track geometry appeared to be relatively stable for some kilometres either side of the derailment site. The ballast fouling may have been the result of track structure age and the progressive breakdown of ballast due to invasive maintenance (tamping) and re-sleepering activities.

Methods for calculating impact loads on track structures have a direct relationship between the magnitude of the impact load and the train speed. The increase in the maximum train speed on the Stockinbingal to Parkes railway will have resulted in an increase in the impact loads on the track structure, thus on the formation. A benefit of re-sleepering with concrete sleepers is an improvement in service capability including an increase in the maximum train speed capability of the track. In this case, the track structure (following upgrade with concrete sleepers) was consistent with ARTC interstate lines suitable for freight trains travelling at 115 km/h (depending on axle loading). There was no evidence that the track structure was not appropriate for the type

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15 The side insertion method involves removing existing sleepers and inserting new sleepers from the side of the track without the need to remove the rail. This method of sleeper replacement was examined in the ATSB report titled *Safety of rail operations on the interstate rail line between Melbourne and Sydney*, RI-2011-015.

of operation. However, if there were any localised and undetected weaknesses in the formation, it is possible that increased operational conditions may have contributed to accelerated failure.

While there was a history of track geometry defects around this location, they were generally not of a magnitude that required rectification when assessed against the NSW standards, nor would they have drawn more attention than other defects on this track. The records of the track inspections taken by track maintenance staff between the AK car run in July 2011 and the passage of train 7SP5 did not show any geometry defects that required rectification. The crew of 7SP5 also stated that they did not remember any poor ride through the area. Inspection of the track after the derailment found there was no rounding of the ballast or evidence of track pumping which is indicative of the cyclic impact loading of wheels passing over a track geometry defect. The dip in the track was therefore likely to be the result of a failure of the formation under the passage of train 7SP5.

Analysis of track defect history is important for a predictive maintenance system rather than relying on reactive maintenance. The ARTC adopts a predictive process to programming maintenance activities based on analysis of trends in key performance indicators over defined rail corridors (such as travel time lost due to speed restrictions and statistical track quality analysis). Greater examination of maintenance history and defect data over shorter track lengths may help strengthen a predictive maintenance system. While in this case the track defect history did not give sound indication of the imminent development of the defect that caused the derailment at the 538.598 km mark, the opportunity may still exist for the ARTC to consider improvements to their predictive maintenance systems.

# Findings

From the evidence available, the following findings are made with respect to the derailment of freight train 7SP5 near Wirrinya NSW on 23 October 2011. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

**Safety issues, or system problems, are highlighted in bold to emphasise their importance.** A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

## Contributing factors

- A significant track geometry defect caused one wagon wheel-set to become unloaded which then derailed.
- It is likely that the track geometry defect developed under train 7SP5 and was caused by an undetected weakness in the track formation.

## Other findings

- Track inspections were conducted in accordance with the ARTC's NSW Base Operating Condition Standards.
- It is unlikely that existing processes for track inspection would have identified any warning signs of formation weakness, nor the possibility for failure of the formation before the derailment.
- There was no evidence to suggest that train handling, freight loading or rolling stock condition contributed to the derailment of 7SP5.
- Examination of maintenance history and defect data strengthens a predictive maintenance system.

# General details

## Occurrence details

| | | |
|---|---|---|
| Date and time: | 23 October 2011 – 0545 EDST | |
| Occurrence category: | Accident | |
| Primary occurrence type: | Derailment | |
| Location: | Track Chainage 538.598 – 44 km south of Forbes in NSW | |
| | Latitude: 33° 41.237' S | Longitude: 147° 47.766' E |

## Train details

| | | |
|---|---|---|
| Train operator: | Pacific National | |
| Registration: | 7SP5 | |
| Type of operation: | Freight | |
| Persons on board: | Crew – 2 | Passengers – Nil |
| Injuries: | Crew – Nil | Passengers – Nil |
| Damage: | Substantial | |

## Track details

| | | |
|---|---|---|
| Track | Stockinbingal to Parkes Railway | |
| Track owner: | ARTC | |
| Track Maintainer: | Transfield Services | |
| Type of operation: | Freight | |
| Track Type | Mainline<br>Single Track | Loop line and turnouts at Wirrinya Station |
| Damage: | Substantial | |

# Sources and submissions

## Sources of information

Investigators from the Australian Transport Safety Bureau (ATSB) arrived at the derailment site at about 1100 on 23 October 2011. The positions and damage to rolling stock and track formation was recorded and the track geometry was measured at the point of derailment.

On 25th October 2011, investigators interviewed the crew who were operating *7SP5* at the time of the derailment.

The sources of information during the investigation included the:

- Pacific National Pty Ltd.
- RISSB Glossary of Railway Terminology - Guideline.
- The Australian Rail Track Corporation Ltd.
- The train crew of 7SP5.
- voestalpine VAE Railway Systems Pty Ltd.
- A Review of Track Design Procedures, Volume 2, Sleepers and Ballast, Railways of Australia.

## References

ARTC Engineering (Track and Civil) Code of Practice, Section 5 Track Geometry, Version 2.4 dated 08 November 2011

Pacific National Freight Loading Manual – General FLM 03-10

Rail Infrastructure Corporation standard; C 2009 Base Operating Condition Standards of Track Geometry, Version 3, Dated May 2004

Rail Infrastructure Corporation standard; C 2011 Base Operating Condition Standards of Track Geometry – Standing Orders, Version 2.1, Dated April 2003.

Rail Safety and Standards Board – Glossary of Railway Terminology - Guideline

## Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Australian Rail Track Corporation Ltd, the Office of the National Rail Safety Regulator, Pacific National Pty Ltd and the train crew.

Submissions were received from the Australian Rail Track Corporation Ltd, the Office of the National Rail Safety Regulator, Pacific National Pty Ltd and the train crew. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

# Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

## Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

## Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

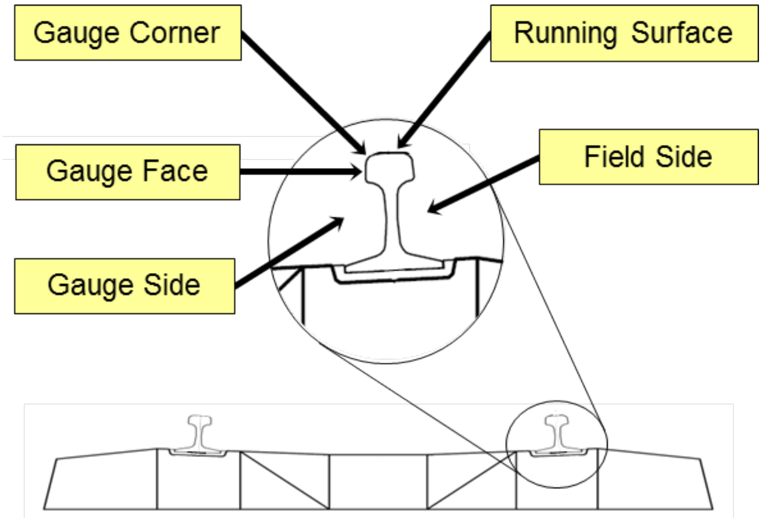
When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

# Glossary

| | |
|---|---|
| 5-pack | An articulated wagon comprising five platforms, the adjacent ends of individual units being supported on a common bogie and permanently connected by a device which permits free rotation in all planes. Example: 5-pack articulated wagon. Note, these do always consist of five units; they could be 2-packs, 3-packs etc. (RISSB Glossary of Railway Terminology) |
| 3-unit | A wagon consisting of three permanently coupled platforms, each platform independently supported on a pair of bogies. Note, 5-units are more common and also found as 2-units. (RISSB Glossary of Railway Terminology) |
| AK Car | The AK Car is used for condition monitoring of the track on the ARTC and CRN networks as well as for a number of third party networks. The car is a former NSW passenger wagon and is typically loco hauled and operated with two other support cars, resulting in the often used plural reference "AK Cars". |
| Articulated Wagon | A wagon comprising two or more units with the adjacent ends of individual units supported on a common bogie and permanently connected by a device that permits free rotation in all planes. (RISSB Glossary of Railway Terminology) |
| AS 90 lb/yd Rail | Rail of a profile that weighs 90 lb for every yard when new. The AS prefix indicates it is rolled to a profile (shape) defined in the Australian Standard (current at the time of rolling). |
| Bogie | A structure incorporating suspension elements and fitted with wheels and axles, used to support rail vehicles at or near the ends and capable of rotation in the horizontal plane. It may have one, two or more axle sets, and may be the common support of adjacent units of an articulated vehicle. (The bogie is commonly referred to as a 'truck' in AAR terminology.) (RISSB Glossary of Railway Terminology) |
| Crib (or Cribs) | Ballast filled spaces between sleepers. Sometimes also used to describe the space between the rails. |
| Flange | Wheel flange: The larger, inner part of the train's wheel. It is used as a means of the guidance of the train and keeping it on the track. (RISSB Glossary of Railway Terminology) |
| Four Foot | Term used to identify the area between the rails of a standard gauge railway. (RISSB Glossary of Railway Terminology) |

Gauge Corner | Transition surface separating the rail running surface from the rail side. (RISSB Glossary of Railway Terminology)




Lift and Pack | To raise and pack the track to the required design level. (RISSB Glossary of Railway Terminology)

Resurfacing | Lifting and packing track to re-establish a smooth surface or top to the track. Typically referring to mechanised lifting and packing.

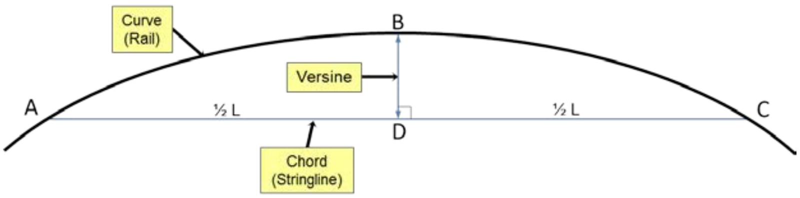
Shoulder | Ballast profile at the end of the sleepers. Also known as the Ballast Shoulder.

Tamping | The process by which ballast is packed around the sleepers of a track to ensure the correct alignment for the location, speed and curvature of the line. (RISSB Glossary of Railway Terminology).

Tamping Consist | Small fleet of track maintenance machines used to resurface (lift and pack) a track. Usually a tamper and a regulator, sometimes includes a dynamic stabilizer. Also referred to as a Resurfacing Consist.

Train Order | An instruction, on the prescribed form, issued by the train controller, in train order territory to direct the movement of rail traffic. (RISSB Glossary of Railway Terminology)

Versine (Hallade Method) | A method used in track geometry for surveying and setting out curves in rail way track. It involves measuring the mid-ordinate of a chord of a known length (typically 10 m in Australia). A stringline is used for the chord. A measurement is made between the middle of the stringline and the rail, this measurement can be used to calculate the radius of the curve.




Wheel Set (Wheelset) | An assembly consisting of axle, wheels, bearings, and where applicable associated components such as brake discs, traction gears, traction motor support bearings, gearbox, etc. (RISSB Glossary of Railway Terminology)

| | |
|---|---|
| Witness Marks | Marks on the rail, fastenings, sleepers, and ballast that have been made by a derailed wheel or rolling stock components post derailment. |

**Australian Transport Safety Bureau**

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Investigation

**ATSB Transport Safety Report**
Rail Occurrence Investigation

Derailment of train 7SP5 between Caragabal and Wirrinya NSW
23 October 2011

RO-2011-017
Final – 14 March 2014