Australian Government
Australian Transport Safety Bureau

Derailment of train 1MP5

Goddards, Western Australia | 28 December 2010

Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
RO-2010-015
Final

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SAFETY SUMMARY

What happened

At about 1603 (WST) on Tuesday 28 December 2010, freight train 1MP5 derailed on the Trans-Australian Railway Line at Goddards approximately 240 km east of Kalgoorlie in Western Australia. The derailment occurred within a recently constructed crossing loop on a section of track managed by the Australian Rail Track Corporation (ARTC).

Train 1MP5 consisted of two locomotives hauling two crew vans and 49 wagons. There were no injuries as a result of the derailment but 23 wagons derailed, many of which were significantly damaged (including all triple-deck car carrier wagons) and about 700 m of track required replacement.

What the ATSB found

The ATSB determined that the derailment was a result of flange climb initiated by a track misalignment which probably grew as train 1MP5 traversed it, becoming large enough to initiate the derailment of the 11th wagon, followed by the 13th wagon and then the subsequent catastrophic derailment of wagons 15 through to 35.

Factors which contributed to the misalignment were the high ambient temperature, inadequately de-stressed rail and insufficient ballast through the derailment site. The ATSB also found that the ARTC's quality assurance processes used during the contracted construction of the crossing loop could be improved.

What has been done as a result

The ARTC have taken action as a result of the derailment and investigation relating to track construction, audit and quality control processes

Safety message

Track managers should have robust audit and quality control processes in place to ensure that work undertaken on their railway by contractors meets the relevant contracted standard.

CONTENTS

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau 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 safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

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 appropriate, or to raise general awareness of important safety information in the industry. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (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 operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

1 FACTUAL INFORMATION

1.1 Overview

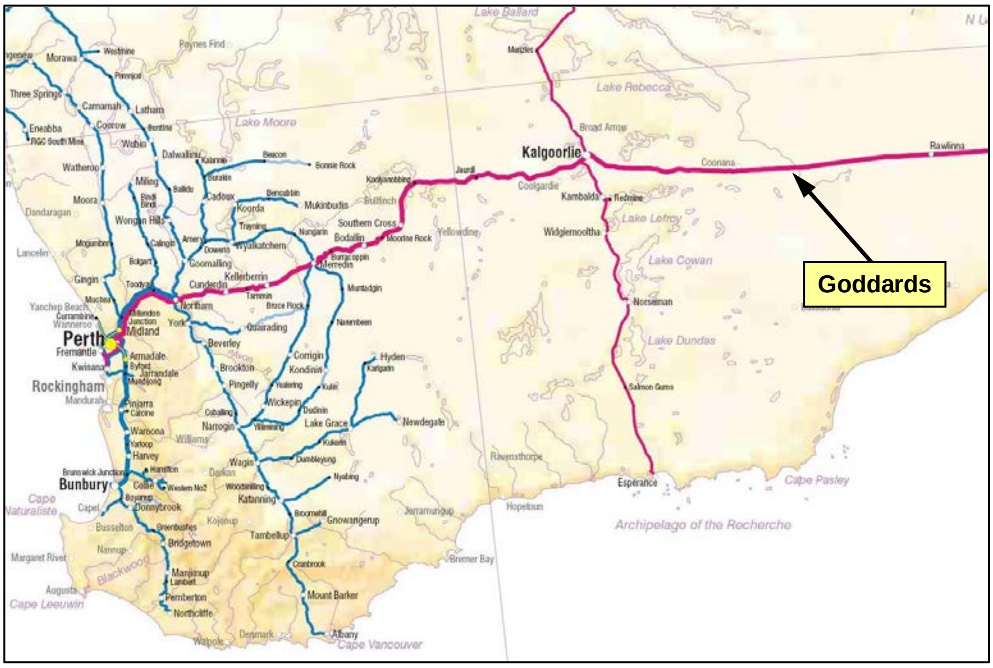
At about 1603[1] on Tuesday 28 December 2010, the driver of freight train 1MP5 reported that his train had derailed within Goddards yard, Western Australia. The train originated at the Melbourne Freight Terminal and was in transit to the Perth Freight Terminal. The train consisted of two locomotives hauling two crew vans and 49 wagons.

There were no injuries as a result of the derailment, but 23 wagons derailed, many of which were significantly damaged, and about 700 m of track required replacement.

1.2 Location

Goddards crossing loop is located on the Trans-Australian Railway[2] (TAR) at the 1545.049 km mark[3], about 240 track kilometres east of Kalgoorlie, Western Australia (Figure 1). It is owned and operated by the Australian Rail Track Corporation (ARTC) with maintenance contracted to Transfield Services.

Figure 1: Location of Goddards, Western Australia



Geoscience Australia. Crown Copyright ©.

1 The 24-hour clock is used in this report. Australian Western Standard Time (WST), UTC + 8 hours.

2 The Trans-Australian Railway (TAR) crosses the Nullarbor Plain of Australia from Port Augusta in South Australia to Kalgoorlie in Western Australia.

3 Distance in kilometres from a track reference point located at Coonamia in South Australia.

1.3 Track information

Track across the TAR consists of a bi-directional single line with crossing loops (short sections of double track) provided at regular intervals to allow trains to cross (travelling in opposing directions) or pass (travelling in the same direction) each other.

Goddards yard is one of many crossing loops located on the TAR; however, it was relatively new, being commissioned into service on 6 February 2010. The track structure through Goddards yard comprises Continuously Welded Rail[4] (CWR), with the mainline being 60 kg/m and the crossing loop 47 kg/m (located to the south of the mainline) on a ballast bed of 250 mm supporting concrete sleepers. Sleeper spacing is nominally set at 667 mm, with the rails fastened to the sleepers using Pandrol resilient clips. The turnouts located at each end of the yard are 60 kg/m mounted on concrete bearers.

The track through Goddards was relatively straight, almost level grade and situated about 1 m above the natural ground surface. At the time of the derailment, posted mainline track speed through Goddards was 110 km/h.

1.3.1 Goddards

As part of the Federal Government's economic stimulus plan to deliver productivity benefits to the Australian economy through investment in transport infrastructure, the ARTC identified a range of projects aimed at improving the performance of rail freight services across Australia. Amongst the various projects was the re-railing of line between Koolyanobbing and Kalgoorlie in Western Australia and the provision of four new crossing loops between Port Augusta in South Australia and West Kalgoorlie in Western Australia. Two new crossing loops were provided in Western Australia, one located at Chifley (1642.000 km) and the second at Goddards (1545.049 km), the derailment site.

Both of the new crossing loops were configured to operate in a manner similar to the existing crossing loops located across the TAR and accordingly, Goddards yard was provided with self-restoring point machines and mainline point indicators[5].

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4 Continuous welded rail (CWR) – Track where the rail is joined by welding (and other non-moveable joints such as glued insulated joints) in lengths greater than 300 m. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology.

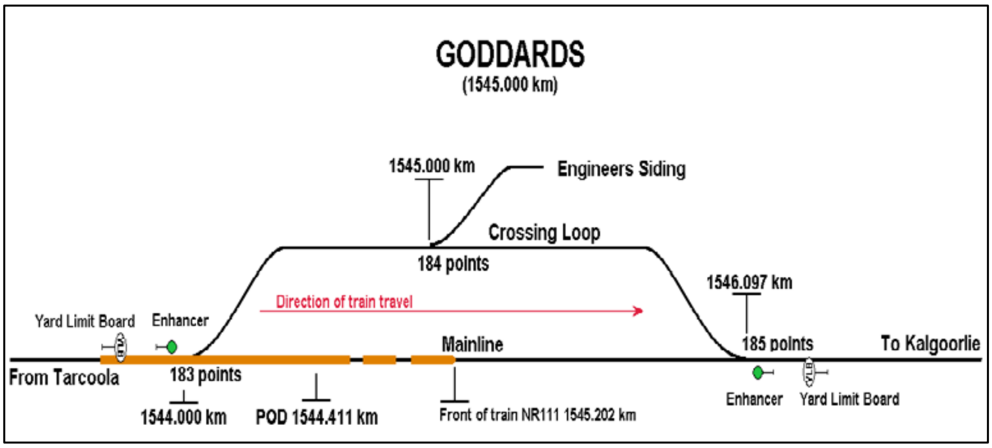
5 An indicator showing the position of points. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology.

An ‘Operational Scope’ for Chifley and Goddards (Figure 2) outlining the ‘Crossing Loop Works’ was developed by the ARTC and internally signed-off on 21 April 2009. Following the establishment of the Operational Scope, the ARTC entered into a formal agreement with Transfield Services on 3 June 2009 to undertake the work, with design input provided by KBR (Kellogg Brown & Root Pty Ltd). The contract between the ARTC and Transfield Services prescribed the provision of:

- a loop having a nominal standing room of 1850 m between clearance points
- new 60 kg/m standard carbon rail for the mainline with the adjacent loop constructed from 47 kg/m rail recovered from the original mainline
- new concrete sleepers with Pandrol resilient clips at a nominal sleeper spacing of 667 mm
- new 60 kg/m 1:12 points mounted on concrete bearers connecting the mainline and loop
- track ballast comprising 60 mm crushed rock
- a 120 m long engineers siding located off the loop line
- as built verification of key measurements through survey at completion of the works
- all quality documentation
- assistance to the ARTC in the preparation of configuration management documentation.

Except where specified otherwise, Transfield Services was required to supply all personnel, plant and equipment, sub-contractors and materials necessary for the delivery of the project, including the rail de-stressing and tamping of the track.

Figure 2: Schematic of Goddards, Western Australia



Construction of the crossing loop commenced late 2009 with final inspection occurring towards the end of January/early February 2010 before commissioning into service on 6 February 2010, vide Train Notice 225/2010.

1.4 Freight train 1MP5

Freight train 1MP5 was an intermodal freight service owned and operated by Pacific National. It consisted of two locomotives (NR111 leading and NR43 trailing), two crew accommodation carriages and 49 freight wagons (eight of which were multiple platform vehicles[6]). The train was loaded with a combination of single stacked containers on flat-bed wagons and triple-deck car carrier wagons loaded with new and second-hand cars. The train was 1615.0 m long with a trailing gross mass of 3667.8 t.

The train crew consisted of two sets of two drivers. The two crews worked rotating shifts with one crew driving while the other rested. The resting crew were accommodated in a fully equipped crew van marshalled immediately behind the locomotives. An examination of the drivers' records established that they were appropriately qualified, assessed as competent and medically fit as prescribed by the *National Standard for Health Assessment of Rail Safety Workers* and in date. The driver at the time of the derailment had about 8 years train driving experience.

1.5 Environmental conditions

The Bureau of Meteorology (BoM) has automatic weather observation stations at various locations across the Nullarbor. The closest weather station to the derailment site was Balgair, approximately 129 km east-south-east of the derailment site, with further sites located at Kalgoorlie (approximately 236 km west) and Forrest (approximately 408 km east).

On the day of the derailment, a temperature of 39.5°C was recorded for Balgair at 1500, approximately 1 hour before the derailment, with a maximum temperature of 40.3°C. The sky was relatively clear of cloud and no rain was recorded.

1.6 The occurrence

At 0645 on 28 December 2010, the morning of the derailment, the drivers of train 1MP5 signed on for duty at Cook Depot, South Australia. Train 1MP5 departed Cook at 0652.

The train arrived at Loongana, Western Australia at 1105, where a crew change was made with the two resting drivers from the crew van. The train departed Loongana at 1118 after crossing train 2PM5.

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6 Multiple platform vehicles on train 1MP5 included 5-pack, 5-unit and 2-pack freight wagons.

- 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 not always consist of five units; they could be 2-packs, 3-packs etc.
- 5-unit: A wagon consisting of five permanently coupled platforms, each platform independently supported on a pair of bogies. Note, 5-units are the most common but they do not need to consist of five units, i.e. there could be 2-units, 3-units in the same configuration.

Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology.

At Boonderoo, Western Australia, the train crossed with Melbourne bound train 2PM6, where the co-driver and driver of 1MP5 swapped train operating duties. Train 1MP5 departed Boonderoo at 1511 after a stop of 35 minutes, continuing towards Perth under the authorisation of ARTC's Network Control Officer (Train Authority - W17) to proceed from Boonderoo to Golden Ridge.

Train 1MP5 approached Goddards travelling at a speed of about 75 km/h. As the train neared Goddards yard, the driver cross-checked the status of 183 points enhancer (colour light indicator) with the co-driver; it was displaying a green aspect[7]. The train continued towards Kalgoorlie, traversing 183 points located at the eastern end of Goddards yard. After passing over 183 points, when approximately 100 m further on, the driver observed a track buckle a further 100 m ahead. The driver indicated in his statement that the track seemed to deviate to the left in the shape of a 'horse-shoe' which spanned about six sleepers. The driver reduced power intending to coast over the misalignment, thereby minimising as much as possible the lateral forces that the train would exert while traversing it.

The driver stated that just before the lead locomotive passed over the misalignment, he observed two sleepers directly ahead move in a southerly direction towards the crossing loop (left in the direction of travel). As the locomotive traversed the misalignment it lurched heavily and both drivers feared that it would derail. The driver allowed the train to slow down. He and the co-driver then looked back through the rear view mirrors and observed dust coming from the trailing portion of the train, indicating that a number of wagons had probably derailed. The lead locomotive NR 111 came to a stand about 791 m past the initial point of derailment.

Post occurrence

Following the derailment, the train driver contacted the ARTC network control centre to advise that train 1MP5 had derailed on the mainline within Goddards yard. The co-driver, assisted by a driver from the crew van, walked back along the train to assess the extent of the derailment and damage.

On Wednesday 29 December, the undamaged portion of train 1MP5 departed Goddards for Kalgoorlie. The remainder of the site was progressively recovered, with the crossing loop being reinstated with track components recovered from the mainline. The crossing loop was re-opened for rail traffic at 1224 on 1 January 2011. The crossing loop was used for an extended period at a reduced speed of 30 km/h until final reinstatement of the mainline some months later.

Dangerous goods

Train 1MP5 was hauling five wagons containing materials classified as dangerous goods. All five wagons were undamaged as a result of the derailment; however, the train was also transporting a large number of new and second-hand motor vehicles located in triple-deck car carrier wagons. The car carrier wagons all derailed, ejecting many of the vehicles causing extensive damage. On arrival at the derailment site there was a noticeable smell of fuel near the car carrier wagons, associated with spillage from some of the vehicles. It was only after receiving clearance from emergency services that access to this area of the derailment site was permitted for investigation and recovery processes.

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7 Indicates that the points at both ends of the crossing loop were set for the mainline.

Loss and damage

A total of 23 freight wagons were derailed, with 14 sustaining significant damage. Six double-deck and four triple-deck car carrier wagons, and four container flat wagons sustained the majority of damage (Figure 3). About 550 m of mainline and 200 m of the crossing loop track was damaged in the derailment.

Figure 3: View looking north, mid train wreckage

2 ANALYSIS

Early on 29 December 2010, an investigator from the Australian Transport Safety Bureau (ATSB) and representatives from both the ARTC and Pacific National flew to Zanthus, Western Australia. They then travelled by road vehicle to site, arriving at Goddards about 0730. Once on site, the position of rolling-stock, containers and track were plotted and photographed.

The information was supplemented with evidence gathered from various sources, including the ARTC and Pacific National. Evidence included train control graphs, train control voice and data logs, locomotive data logs, driver interviews, contract documentation, site drawings, track upgrading records, maintenance records, etc.

The preliminary examination of this evidence established that:

- there were no identified mechanical defects or deficiencies with the train that would have contributed to the derailment
- at the time of the derailment, the two drivers were appropriately qualified and certified as medically fit in accordance with the *National Standard for Health Assessment of Rail Safety Workers*
- the signalling system, including the 183 points located at the eastern end of Goddards yard, was operating correctly and would not have contributed to the derailment.

2.1 Sequence of events

An extract of the locomotive data log from NR111 (Figure 4) 'Boonderoo to Point of Derailment (POD)' shows that train 1MP5 was travelling consistently below posted track speeds and generally did not exceed 85 km/h from the time the train departed Boonderoo through to the POD at Goddards. This is consistent with the drivers' statements in that they indicated that they were travelling slower than normal as they had time available within the schedule and were also trying to conserve fuel.

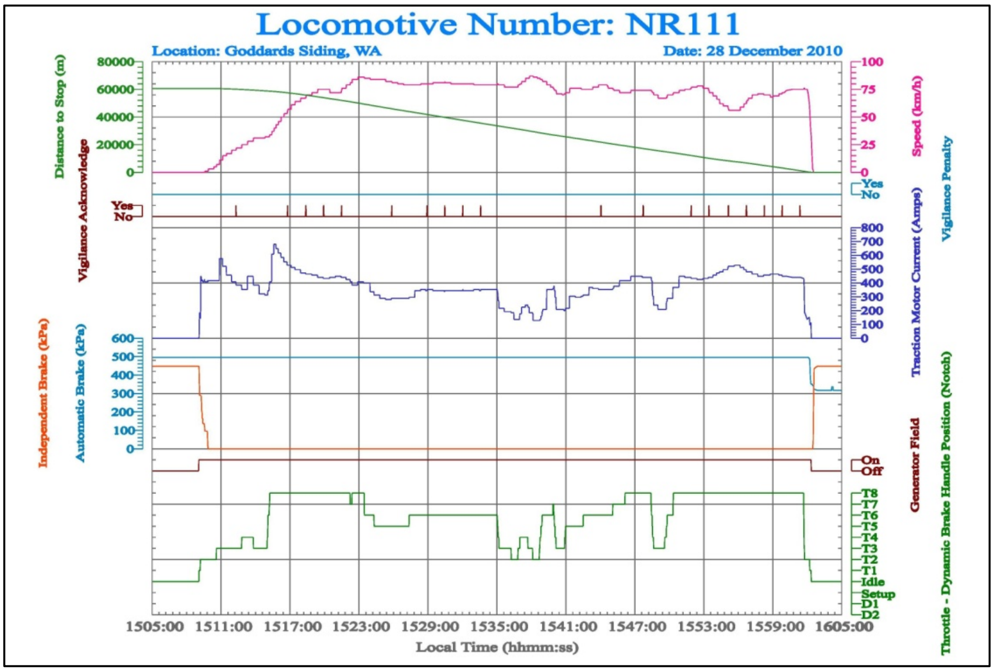
On approaching Goddards, train 1MP5 was at a speed close to 75 km/h and the driver maintained this speed while traversing 183 points. Shortly after passing over 183 points, about 100 m further on, the driver saw a track misalignment. The misalignment was to the left in the direction of train travel, about 100 m ahead. In his account of events, the driver stated that it was difficult to see the misalignment any earlier as it was obscured by heat haze.

The extract from the locomotive data log corroborates the driver's recollection of events. The data clearly shows that train 1MP5 was travelling at a speed of 75 km/h, 35 km/h below the posted track speed of 110 km/h, as it approached and traversed the POD. It then shows that the driver responded to the misalignment by throttling off and allowing the train to slow, before making a final brake application, bringing the train to a stand about 791 m past the POD.

The action by the train driver in slowing the train in a controlled manner once past the POD showed sound driving skills. Heavy braking would have induced an increased risk of bunching the train and would have exacerbated lateral forces through the misalignment, probably increasing the extent of the damage.

It was concluded that in-line train forces were not likely to have initiated the derailment, nor did the actions of the driver contribute to the derailment.

Figure 4: Extract from NR111 locomotive data log - Boonderoo to POD



An examination of the drivers' roster established that both drivers had ample rest opportunities prior to the derailment. Due to this and the lack of fatigue indicating factors, it is considered unlikely that fatigue was a factor that contributed to the derailment.

An inspection of the rolling-stock did not identify any issues that would have had any direct or indirect effect on the derailment.

Summary

It is unlikely that rolling-stock or the actions by the train driver, including train speed or braking, were factors that contributed to the derailment.

2.2 Site observations

On arrival at Goddards and following inspection, the POD was determined to be at the 1544.411 km mark on the mainline and was a result of flange climb on the southern rail. Figure 5 shows the initial point of flange climb followed by two diagonal wheel contact marks, about 5 m in length, on the rail head just before the wheels dropped off into the six foot[8]. Signs of sleeper damage were observed past that point (Figure 6).

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8 The area between the closest rails of adjacent tracks. (ARA Glossary for National Code of Practice and Dictionary of Railway Terminology)

Figure 5: Photograph taken under wagon RRAY7176-R, shows evidence of initial flange climb and scoring on rail head

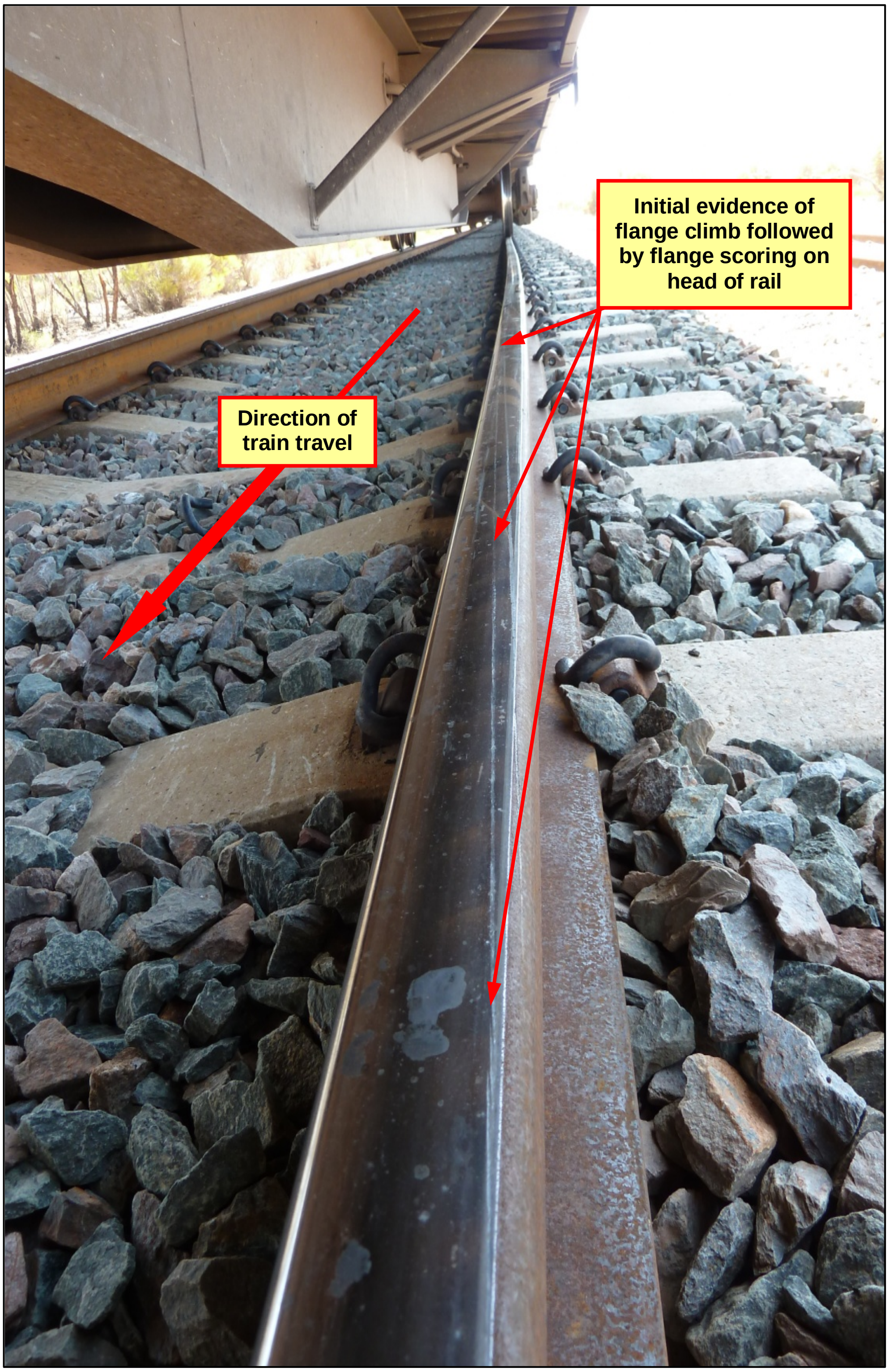
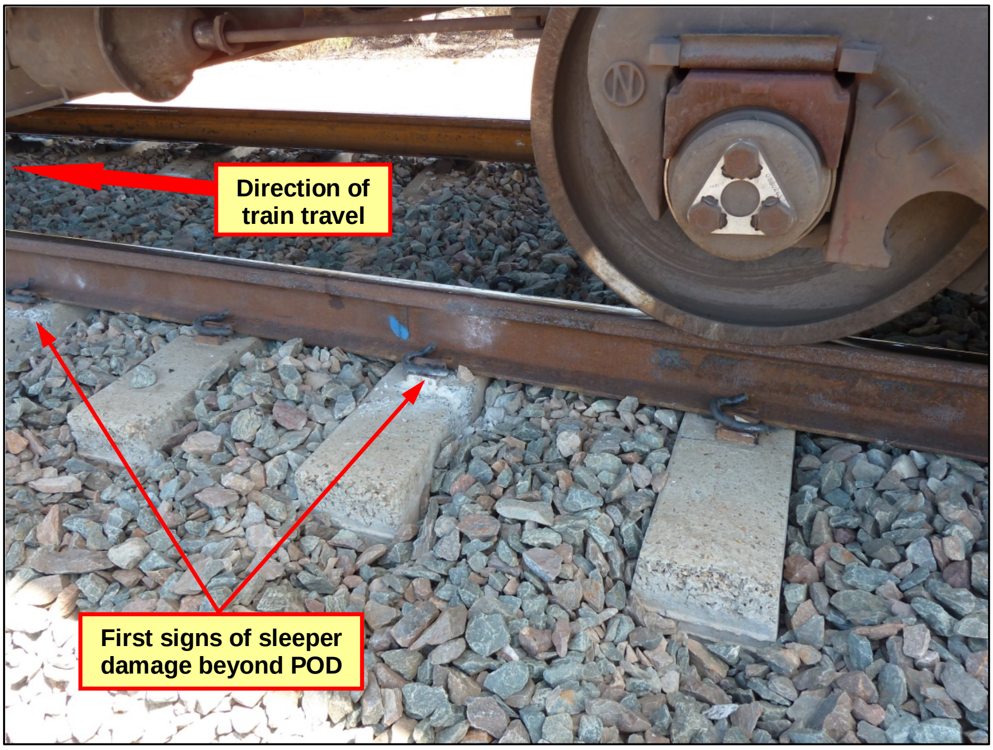


Figure 6: Photograph of track and wagon RRAY7176-R, shows evidence of initial sleeper damage



Beyond the POD, the wheels and bogies of derailed wagons advancing along the track progressively damaged the track structure, both within the four foot[9] and the six foot, with ballast being ploughed into and along the track. This resulted in the loss of track structural integrity, with subsequent destruction of the track and the final multi-vehicle pile-up as seen at Figure 7.

Figure 7: Photograph shows multi wagon pile-up

[9] The area between the rails of a standard gauge railway. (ARA Glossary for National Code of Practice and Dictionary of Railway Terminology)

The photograph at Figure 8, taken on the northern side of the mainline near the POD, showed evidence of horizontal sleeper displacement of about 100 mm to the right, within the ballast bed. This suggested an initial misalignment to the left in the direction of train travel, which was corroborated by the train drivers.

However, site observations on 29 December 2010, the day after the derailment, show the track diverging to the right forward of the POD. It was concluded that the final position of the track forward of the POD was probably as a result of the track being kicked to the right by lateral train forces as the train traversed the misalignment, followed by longitudinal forces reflected back along the track as derailed wagons finally came to an abrupt halt ahead of the POD.

Figure 8: Photograph on northern side of mainline near the POD, shows evidence of horizontal sleeper displacement

Track spread/gauge widening was examined as a possible cause for the derailment. A track spread/gauge widening derailment usually results in wheels falling in between rails. Site observations determined that the POD was initiated by flange climb and therefore there was no evidence to suggest gauge widening with wheels falling between the tracks.

A broken/fractured rail was also discounted as a possible cause for the derailment. There was no physical evidence of any broken or fractured rail immediately at or before the POD.

Examination of derailed wagons focused on RQSY34487-M, (Figure 9) the 11th wagon in the consist, a container flat, carrying two ISO containers[10], one with bulk liquid. This wagon was identified as the first to have derailed, namely the leading wheel-set of the lead bogie. The POD was about 537 m to the rear of this wagon. Wagon RQSY34487-M was examined for mechanical condition, dragging equipment, etc and found to be operationally fit for purpose.

[10] ISO containers are used for the intermodal transport of freight. They are manufactured according to specifications from the International Standards Organization (ISO) and are suitable for multiple transportation methods such as truck and rail, or rail and ship.

There was no indication of any mechanical deficiency with the train or the wagon so this was discounted as a possible cause for the derailment.

Figure 9: First of derailed wagons RQSY34487-M, note the lead wheel-set of the leading bogie

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Summary

Based on the observed track damage and the statements of the train drivers, it was concluded that the derailment of freight train 1MP5 at Goddards was the result of a horizontal track misalignment, at or near the 1544.411 km mark. The misalignment grew as the train traversed the POD, becoming large enough to initiate the derailment.

2.2.2 Track stability

Track integrity is of prime importance in the running of a safe railway and is reliant on the inter-relationship of many track components, including the sub-base, ballast bed, sleepers, rail and fastening systems, and embraces track stability.

Track design, construction, testing/commissioning and subsequent maintenance are all essential components in minimising the risk of track failure and possible train derailment. Track maintenance activities such as resurfacing can release the mechanical interlock between ballast stones and sleepers, resulting in a track structure that is in a temporarily loose or disturbed state. The track will bed-in under traffic or through the use of a mechanical stabiliser. Track disturbing work can leave the track vulnerable to track buckling under conditions such as when the rail neutral temperature is not managed or if the rails are exposed to very high ambient temperatures. Resurfacing can also result in realignment of the track, changing the length of the rails, thus changing the rail neutral temperature.

New or rebuilt track will bed-in under traffic and it is common practice to resurface track after a defined period of time, or after passage by a specified gross tonnage of traffic, to return the track to design alignment. The post-commissioning resurfacing should rectify any dips and misalignments in the track.

Replacement of worn/broken rail, stress adjustment and environmental influences, such as ambient temperature, all affect track stability.

Track misalignment

Continuous welded rail provides significant advantages over traditional rail jointing methods such as fish-plated rail. However, initial construction, maintenance practices, the subsequent effects of live load stresses, induced rail stresses and ambient temperature can result in track buckling during extreme heat and rail weld breaks during extreme cold.

The main factors that influence track buckling are:

- dynamic rail forces
- lateral track resistance
- longitudinal rail forces.

Dynamic rail forces

The long term effect of trains moving along a section of track can result in rail movement (creep) and an associated redistribution of longitudinal rail forces. Typically, a train slowing into a fixed point (for example a turnout) encourages bunching of the rail in the direction of train movement, thereby increasing the compressive forces within the track. This exposes the track to a greater tendency for track misalignment and the associated risk of train derailment.

The derailment within Goddards yard occurred about 400 m west of the eastern turnout (183 points). Trains travelling towards 183 points (easterly direction) and preparing to cross/pass would be slowing before coming to a stand in advance of 183 points. The slowing of the train would increase compressive track forces in the approach to 183 points, increasing the risk of a track buckle in this area.

The simplest known way to detect longitudinal rail movement is to install and monitor rail creep using creep monuments[11]. The lack of any observed creep monuments in the approach to the turnouts at Goddards made it impossible to determine whether there was any longitudinal track movement. Therefore, there was no immediate way for maintenance staff to determine whether there was any rail creep and an associated increased risk of track misalignment/buckling in this area prior to the derailment. This issue was identified and discussed with the ARTC who advised:

> ARTC has recently completed a risk assessment on the use of monuments and the Welded Track Stability Analysis process as a whole for use across ARTC's network. This assessment is still undergoing internal review but at this stage it indicates rather than undertake monumenting ARTC will undertake measuring the actual stress of the rail. It is proposed to investigate the implementation of a network wide stress testing regime which targets the higher risk locations first (i.e. similar to Goddards, those locations near fixed points) and then addresses the remaining lower risk locations).

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[11] Creep monument: A permanent monument on each side of the track to facilitate the accurate measurement of creep. The monuments are installed in the cess, at least 3.5 m clear of the track centreline. Rails are punch marked on the field side of the head on the up side of each monument. Source: ARA Glossary for the National Codes of Practice and Dictionary of Railway Terminology.

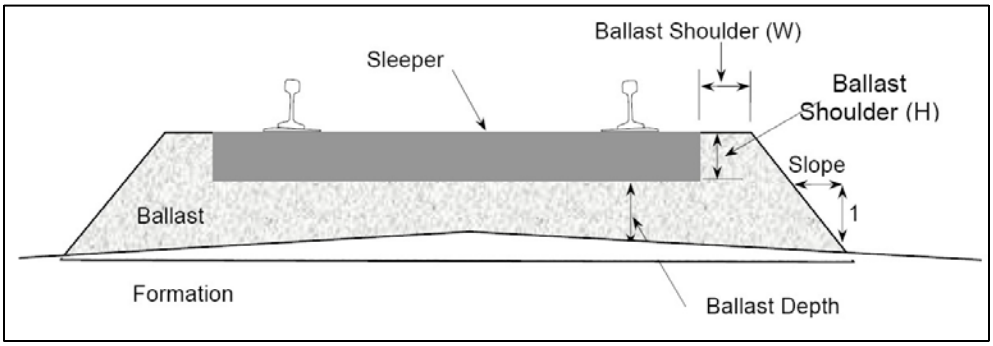
> It is proposed to roll this out network wide. Creep monitoring will only provide an indication of any relative movement at that particular point and not provide an indication if there is a particular issue with rail stress or what the rail stress may be at that location.

Based on discussions with the ARTC and their written response it is evident that they are focusing on measuring actual stress within CWR rail, rather than traditional track monumenting, as means for managing track stability.

Lateral track resistance

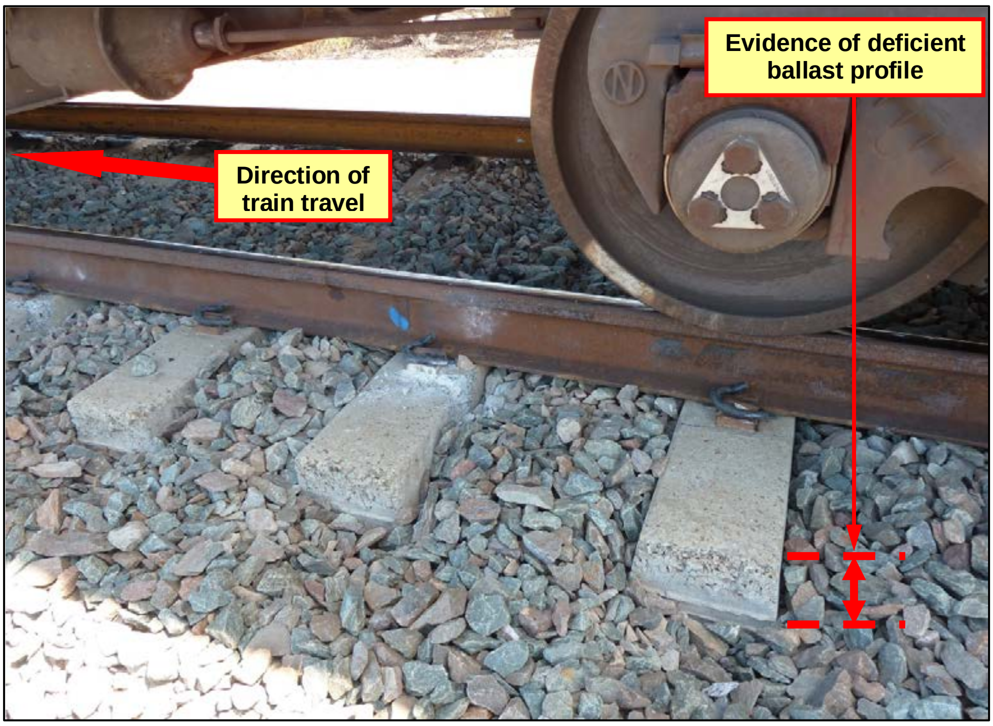
Track buckling is heavily influenced by the quality/quantity of ballast surrounding sleepers, particularly within the crib and surrounding the shoulder. Where ballast within the crib and/or shoulder is deficient or in poor condition, the track will be more susceptible to misalignment due to a lack of lateral track stability.

Figure 10: Drawing from ARTC Code of Practice, Section 4 Ballast



The *ATRC Track and Civil Code of Practice SA/WA and Victoria, Infrastructure Guidelines – Section 4 Ballast* specifies a minimum width (W) of 300 mm, height (H) of (150 mm) and a shoulder slope of 1 in 1.5 for concrete sleepers (Figure 10).

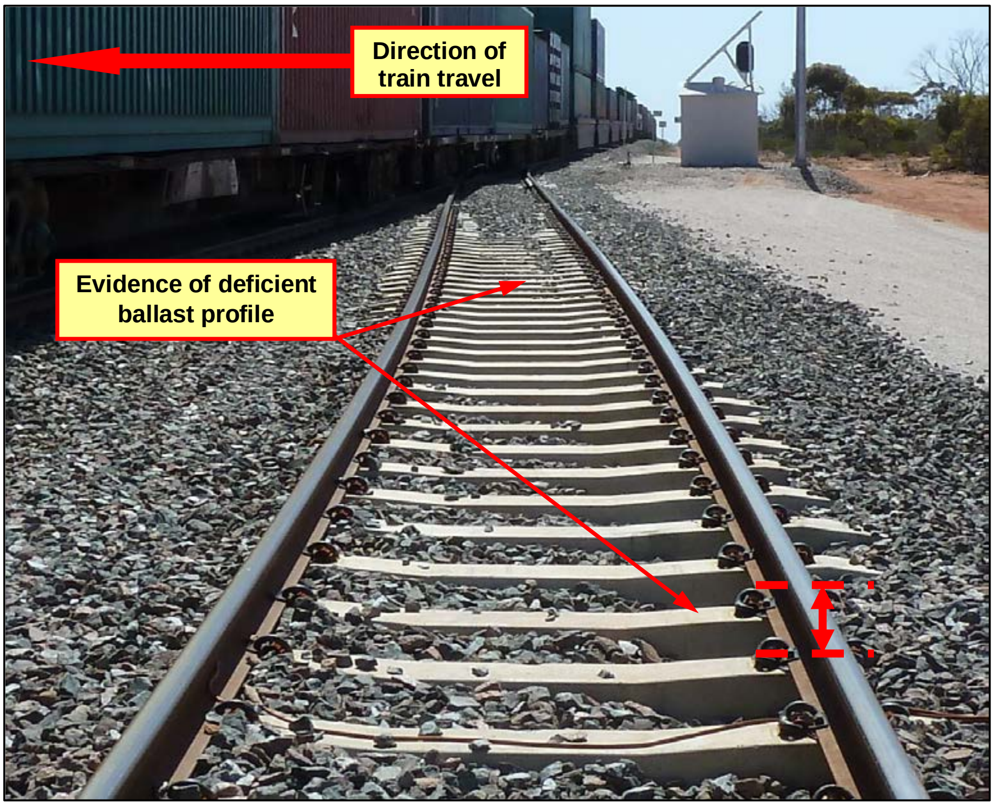
Figure 11: Photograph showing lack of shoulder ballast



During the site inspection it was noted that the ballast profile at the POD (Figure 11) and various locations throughout Goddards yard, as illustrated at Figure 12 (183 points), was ballast deficient and did not meet ARTC requirements.

It was concluded that the track structure at the POD probably had reduced resistance to lateral movement due to deficient shoulder ballast.

Figure 12: Photograph at 183 points showing lack of ballast within crib



Longitudinal rail forces

Longitudinal rail forces that act along the length of the track can be considerable and are particularly sensitive to rail temperature. The neutral temperature, or stress free temperature for rail, is a theoretical temperature at which the rail is neither in tension or compression. If the rail temperature is greater than the neutral temperature, the rail will be in compression, with an increased likelihood of the track buckling. Conversely, if the rail temperature is less than the neutral temperature, the rail will be in tension, with an increased likelihood of the rail breaking.

The *ARTC Track and Civil Code of Practice SA/WA & VIC - Infrastructure Guidelines - Section 6 Track Lateral Stability* prescribes a design neutral temperature of between 35°C and 40°C.

Longitudinal rail force is directly proportional to the difference between the rail neutral temperature and actual rail temperature. A reduction in the rail neutral temperature will result in increased compression forces in the rail. The rail neutral temperature can be affected by factors including:

- uncorrected rail creep
- uneven rail stresses, particularly near fixed points.

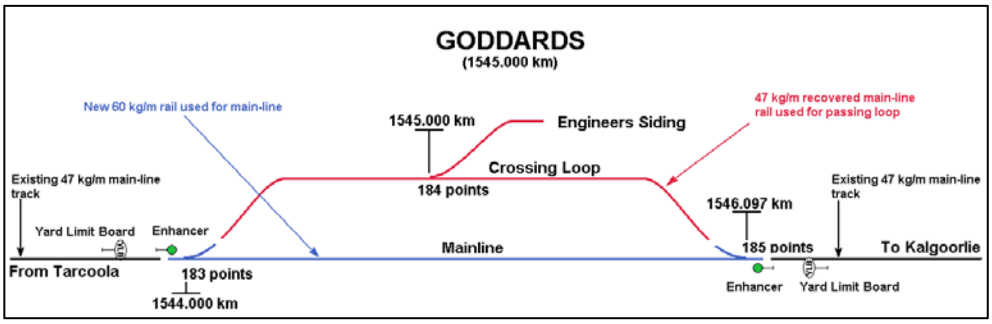
It is therefore vitally important, particularly during the track construction phase, to ensure that the rail is correctly ‘de-stressed’; that is the correct amount (length) of rail is inserted/removed from track at the specified (neutral) rail temperature. Put simply, too much rail in the track is equivalent to lowering the rail neutral temperature and therefore increases longitudinal compressive rail forces on hot days.

The Goddards crossing loop was installed in-between existing 47 kg/m tangent track, with two new 60 kg/m turnouts located at the extremities of the crossing loop and new 60 kg/m rail connecting the turnouts (Figure 13). The new turnouts and associated concrete bearers were substantially heavier than the tangent track and therefore acted as fixed points. It was therefore essential to correctly de-stress the 60 kg/m tangent rail, located between the two turnouts (fixed points), to limit the magnitude of any longitudinal rail forces and the associated risk of track buckling.

Project management and quality assurance

The design documentation for Goddards yard was provided by KBR with construction undertaken by Transfield, under an alliance arrangement[12] with the ARTC. The Goddards scope of work was formally signed off between the ARTC and Transfield on 3 June 2009.

Figure 13: Goddards crossing loop works



Although the ARTC held project meetings with Transfield, this was mainly to outline the scope of works; there was little if any direct site supervision provided by the ARTC. Under the alliance agreement, the ARTC considered that Transfield was responsible for the delivery of an operationally safe siding at Goddards, consistent with the KBR engineering design and the *ARTC Track and Civil Code of Practice SA/WA & VIC.*

At the conclusion of the work, Transfield was required to provide the ARTC with:

- as built verification of key measurements through survey at completion of the works
- all quality documentation
- assistance in the preparation of configuration management documentation.

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12 Alliance arrangement - A project delivery method whereby consortia of partners deliver a project. The original ‘Track Maintenance Alliance Agreement’ between the ARTC and Transfield Services, dated 24 July 2004, is for the provision of track maintenance services for the ARTC. The agreement was updated by progressive ‘Deeds of Variation’ and in force at the time of derailment. The agreement requires that Transfield Services comply with the *ARTC Track and Civil Code of Practice SA/WA & VIC.*

The documentation supplied to the ARTC by Transfield included the following information relevant to the occurrence:

- Inspecting and Test Plan (ITP)/Checklist
  Alumino thermic Welding
  Item 8 - 'Stress adjustment is carried out in accordance with Transfield instruction.' was signed off as completed - 12 February 2010.
- Inspecting and Test Plan/Checklist
  Main Line re-railing
  Item 18 – 'Ballasting process must be carried out in accordance with ARTC engineering standards and inspected throughout ITP Ballasting.' was signed off as completed - 12 February 2010.
- Inspecting and Test Plan/Checklist
  Track Construction
  Item 6 – 'Ballasting process must be carried out in accordance with ARTC engineering standards and inspected throughout ITP Ballasting' and Item 9 – 'Slewing of tracks carried out in accordance with ARTC engineering standards to avoid damage and rail stress.' Both items were signed off as completed - 12 February 2010.
- Inspecting and Test Plan/Checklist
  Turnout Construction
  Item 12 - 'Ballasting process is carried out in accordance with ARTC engineering standards and "For Construction" drawings and inspected throughout ITP Ballasting (includes boxing up).' was signed off as completed - 12 February 2010.
- Inspecting and Test Plan/Checklist
  Ballasting
  Item 20 – 'Ballast must be 50 mm below top of the rail to allow normal train operations.' was signed off as completed - 12 February 2010.
  Item 13 – 'Ballast profile must conform to "For Construction Drawings". was signed off as completed - 12 February 2010.
- Final Inspection
  Makes reference to 'Ballast Profile' – 'meets requirements' and 'Track Stability' which embraces de-stressing as conforming to specifications. Both items were signed off as completed – 1 February 2010.

Although the 'Inspecting and Test Plan/Checklist' and 'Final Inspection' indicated that ballasting was completed, the site examination following the occurrence showed that the ballast did not meet the prescribed requirements of the *ARTC Track and Civil Code of Practice SA/WA & VIC* in the vicinity of the derailment (Figure 11). This was also evident at other locations throughout Goddards yard and can be seen in Figure 12.

With respect to stress adjustment, although the project documentation was signed off to indicate that this work had been completed, Transfield could not provide the ARTC, or the ATSB directly, with any documentation detailing the stress adjustment work undertaken at Goddards loop, despite repeated requests. The strong implication is that Transfield did not conduct the required rail stress adjustment work at Goddards.

Discrepancies were also noted in Transfield's documentation. In particular, the 'Inspecting and Test Plan/Checklist' forms were signed off as complete on 12 February 2010, but the siding was commissioned into service on 6 February 2010. It was also noted that the 'Final Inspection' form was signed off as complete on 1 February 2010. This is counter to normal process, as the 'Inspecting and Test Plan/Checklist' should predate commissioning and the 'Final Inspection' form should postdate the 'Inspecting and Test Plan/Checklist'. The 'Inspecting and Test Plan/Checklist' contains all details that must be known before feeding into and completing the summary level 'Final Inspection' form.

It was also noted that the version date on the 'Final Inspection' form was 29 February 2010; however, the work was signed off as being complete on 1 February 2010. From this, it can only be deduced that the form was filled out after 29 February 2010. This therefore raises significant questions regarding the provision and accuracy of the quality assurance documentation supplied to the ARTC by Transfield and the effectiveness of ARTC's project management in controlling the process.

Rail temperature and track buckling

The closest weather station near Goddards is Balgair, located about 129 km east-south-east. On the day of the derailment, the maximum temperature recorded at Balgair was 40.3°C, with an overnight minimum of 15.5°C. A temperature of 39.5°C was recorded about 1 hour before the derailment.

The temperature range at Goddards was probably similar, with the temperature at the time of the derailment about 40°C..

Track buckling tends to be more pronounced during those times when there is a large differential between minimum and maximum ambient temperatures, for example early summer. As the rail heats and cools, it tries to expand and contract, but these actions never equalise (the rail movement is not equal) and residual stresses remain in the rail.

Experience has also shown that where rail is subject to full sunlight, the rail temperature may be 15 to 20 degrees Celsius higher than the corresponding ambient air temperature[13]. The rail temperature at the POD was therefore likely to have been between 55°C to 60°C.The rail temperature at the time of derailment was probably well above the design neutral temperature, causing high compressive rail forces. This, coupled with a large variation between the minimum (low/overnight) and maximum (high/daytime) ambient temperatures, which was the largest temperature variation in the area since Goddards was commissioned, probably resulted in a redistribution of stress concentration near the 1544.411 km mark, causing the track misalignment that initiated the derailment of train 1MP5.

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13 Investigation Report – 23Nov2002 by Darnick – Pacific National 6SP7 derailed, Section 5.7.4 Page 40.

Summary

Based on available evidence the ATSB determined that elements of the track work through Goddards yard did not comply with the *ARTC Track and Civil Code of Practice SA/WA & VIC* with respect to ballasting and rail de-stressing. It was further determined that the audit and quality assurance processes were insufficiently robust to protect against the risk of track construction inadequacies. This, coupled with a large variation between the minimum (low) and maximum (high) ambient temperatures on 28 December 2010 allowed a significant track misalignment to develop, at or near the 1544.411 km mark, resulting in the derailment of train 1MP5.

2.2.3 Track maintenance and inspection

As previously discussed, track maintenance, for example resurfacing, can substantially reduce the friction bond between ballast and sleeper, thereby lowering the track's ability to resist lateral movement until the track consolidates under traffic. A review of the maintenance records shows that the turnout at the 1544.000 km point, which is at the eastern end of Goddards yard, was resurfaced on 18 August 2010, but there was no evidence of resurfacing of the mainline through Goddards, nor any other track disturbing works near the buckle site. Track maintenance (disturbing the track) was therefore discounted as a possible cause for the derailment.

The inspection of track visually and by using mechanised track geometry vehicles are two of the main methods for assessing track geometry and identifying potential areas of rail misalignment risk.

In Western Australia, the ARTC, as an accredited rail infrastructure owner, was required to demonstrate safe rail operations through the implementation of a comprehensive Safety Management System (SMS). The SMS is required to satisfy the requirements of the Australian Standard *Railway Safety Management* AS 4292.1 – 2006. Section 6 of the standard requires that organisations:

> ... shall have in place procedures for inspection and testing of safety-related engineering and operational systems. The procedures shall define the location, method, level of detail and frequency of inspection and testing ...

The ARTC uses the *ARTC Track and Civil Code of Practice SA/WA & Vic* as the basis for mandating/assessing and recording the condition of its track and determining remedial maintenance actions.

The track through the derailment site was examined using a mechanised track geometry car on 10 October 2010, about 12 weeks before the derailment. A review of the records did not reveal any anomalies that required corrective action in accordance with ARTC track standards. However, while the records show consistent track quality from the turnout (183 points) along the main line to the 400 m mark, there was evidence of a slightly larger top and line measurement near the derailment site. The top and line measurements indicate the possibility of a small hole in the track coinciding with a minor line deviation. Neither the hole nor the line deviation measurements were of a magnitude that would have warranted corrective maintenance, but indicate the likelihood of a track weak point near the track buckle that occurred on 28 December 2010.

Records show that visual track inspections were regularly performed, with one being completed on 27 December 2010, one day before the derailment. There were no reported track faults through the area near the derailment site that required remedial action or the imposition of a speed restriction. However, the *ARTC Track and Civil Code of Practice SA/WA & Vic, Infrastructure Guidelines – Section 4 Ballast* at section *4.4.1 Inspection* mandates:

> (a) Patrol inspection
>
> The interval between patrol inspections of ballast should not exceed 7 days on mainlines and 28 days on crossing loops. Track patrol inspections should keep a lookout for ballast defects and conditions (i.e. indicators of a defect) that may affect the integrity of the track structure including the following:
>
> (i) Track sections with inadequate ballast profile

A review of inspection and maintenance records established that there were no issues identified as likely to have affected the stability of the track at or near the derailment site. However, the *ARTC Track and Civil Code of Practice SA/WA & Vic* prescribes that inspections should identify and report track sections with inadequate ballast profile. To enhance the robustness of future track inspections the ARTC has advised:

> As a further means of confirming the inspectors are suitably qualified to complete this task a new competency card system (Pegasus) is being rolled out across ARTC's network that will require all contractors to have a Pegasus card, which will outline the specific competencies that the individual has and hence the respective tasks that they can undertake.

3 FINDINGS

3.1 Context

At about 1603 on Tuesday 28 December 2010, freight train 1MP5 derailed on the Trans-Australian Railway Line approximately 240 km east of Kalgoorlie in Western Australia. There were no injuries as a result of the derailment but there was significant damage to rolling-stock and track.

Based on the available evidence, the following findings are made with respect to the derailment but should not be read as apportioning blame or liability to any particular individual or organisation.

3.2 Contributing safety factors

- The derailment of freight train 1MP5 at Goddards was probably initiated as a result of a large variation between the minimum (low) and maximum (high) ambient temperatures on the 28 December 2010 causing a track misalignment on the mainline, at or near the 1544.411 km mark.
- The ballast profile through the derailment site did not fully comply with the *ATRC Track and Civil Code of Practice SA/WA and Victoria, Infrastructure Guidelines – Section 4 Ballast,* in particular with respect to shoulder ballast requirements. This meant the track had reduced resistance to lateral track movement.
- It is likely that the rail through Goddards yard was not de-stressed and that high residual compressive forces caused longitudinal track movement, initiating a track misalignment at or near the 1544.411 km mark.
- The quality assurance processes used in the acceptance of the Goddards crossing loop project were not sufficiently robust to mitigate the risk of track construction inadequacies. *[Minor safety issue]*
- The *ARTC Track and Civil Code of Practice SA/WA & Vic* prescribe that patrol inspections should report instances of inadequate ballast profile. On this occasion the patrol inspection(s) were ineffective in identifying inadequate shoulder ballast at the derailment site.

3.3 Other safety factors

- The lack of creep monuments or any other system for monitoring the rail creep in the approach to 183 points made it difficult to determine whether there was any longitudinal track movement that may have caused an increased likelihood of track misalignment.

3.4 Other key findings

- It is unlikely that rolling-stock or the actions by the train driver, including train speed or braking, were factors that contributed to the derailment.
- Track maintenance (disturbing the track) activities were discounted as a possible cause for the derailment.
- Evidence of lateral sleeper displacement (about 100 mm) on the northern side of the mainline near the POD supports the train driver's observations of a misalignment to the left, in the direction of train travel.
- The deflection of the track, to the right, forward of the POD was probably caused by the track being kicked by lateral train forces, as the train traversed the misalignment, followed by longitudinal forces reflected back along the track as derailed wagons came to an abrupt halt directly ahead of the POD.
- Track spread/gauge widening was discounted as a possible cause for the derailment.
- A broken/fractured rail was discounted as a possible cause for the derailment.

4 SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the rail industry, the ATSB may issue safety recommendations or safety advisory notices as part of the final report.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

4.1 Australian Rail Track Corporation

Documentation and quality control

Safety issue

The quality assurance processes used in the acceptance of the Goddards crossing loop project were not sufficiently robust to mitigate the risk of track construction inadequacies.

Action taken by the Australian Rail Track Corporation

The Australian Rail Track Corporation has advised that it will reinforce its project management and audit processes, as outlined in its Project Management Procedure (PP 157), with its employees, in particular the requirement for:

> ... ongoing “spot” audits of the works by nominated Project Managers and Engineers.
>
> … ad hoc audits undertaken by an internal audit department …
>
> … formal close out process and handover to the respective maintenance representatives.
>
> … identification of any outstanding (punch list) items that may require follow up work …
>
> … review the documentation of the completed works.

APPENDIX B: SOURCES AND SUBMISSIONS

Sources of Information

Asciano Ltd (Pacific National)

Bureau of Meteorology

The Australian Rail Track Corporation

References

ARTC Track and Civil Code of Practice SA/WA & Vic

National Standard for Health Assessment of Rail Safety Workers.

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:

- Asciano Ltd (Pacific National Pty Ltd).
- Office of Rail Safety, Western Australia.
- The Australian Rail Track Corporation.
- Witnesses and individuals

Submissions were received from Office of Rail Safety, Western Australia and the Australian Rail Track Corporation. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

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Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
Derailment of train 1MP5, Goddards, Western Australia
28 December 2010

RO-2010-015
Final