Office of Transport Safety Investigations

RAIL SAFETY INVESTIGATION REPORT

DERAILMENT OF EL ZORRO GRAIN SERVICE 5CM7

RENNIE

3 JANUARY 2013

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THE OFFICE OF TRANSPORT SAFETY INVESTIGATIONS

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GLOSSARY OF TERMS

Ballast	Coarse aggregate packed under and around sleepers to hold track in position, spread weight and provide drainage.
Buckle (Misalignment)	A lateral displacement of the track occurring when the compression generated in the rails exceeds the ability of the track structure to hold itself in place.
Bogie	Assembly 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 two or more axle sets, and may be the common support of adjacent units of an articulated vehicle.
Data Logger	An electronic or tape recording data or event recording device fitted within rolling stock that is capable of recording certain information relating to the operation and movement of the rolling stock.
Down and Up Directions	Travel by rail away from Melbourne is referred to as being in the Down direction. Conversely, travel towards Melbourne is referred to as being in the Up direction.
Gauge	The distance between the inside running (or gauge) faces of the two rails, measured between points 16 mm below the top of the rail heads.
Kilometrage	The track distance measured from the buffer stop at No. 1 Platform in Melbourne Terminal (Southern Cross Station).
Network Control	The function responsible for managing train paths and issuing occupancy authorities.
Network Controller	A qualified worker who authorises, and may issue, occupancies and proceed authorities, and who manages train paths to ensure safe and efficient transit of rail traffic in the ARTC network.

EXECUTIVE SUMMARY

On 3 January 2013, El Zorro loaded grain service 5CM7 derailed 10 of its 40 wagons just south of the township of Rennie while en route from Oaklands in southern New South Wales to Melbourne via Benalla in Victoria. All 10 derailed wagons were extensively damaged and approximately 260 metres of track infrastructure was destroyed. No injuries were reported as a result of the derailment and none of the contents from the derailed wagons were spilt.

The investigation found that the train derailed when it traversed a buckle in the track. The buckle was due to the build-up of excessive compressive stress resulting from rail creep which was exacerbated by high temperatures on the day of the incident and the week leading up to it.

There was evidence that rail creep had persisted over a number of years, that track geometry was progressively deteriorating, and that sleepers and fasteners were becoming life-expired. Despite a number of indicators that the track was deteriorating, preventative maintenance had not been initiated. Additionally, there was no extant document providing guidance as to how to respond to a situation where a combination of track parameters on this line had reached a limit that must not be exceeded.

The report recommends that the Australian Rail Track Corporation (ARTC) conveys the findings of the investigation to the Alliance Board which administers the Benalla-Oaklands Infrastructure Agreement advising it of the need and means to implement measures to contain creep and other track characteristics that influence the likelihood of track buckling. It is also recommended that ARTC develop a standard or guideline to assist track managers in responding appropriately to unfavourable measurements in track condition.

A common strategy for mitigating risk associated with hot weather is the imposition of a 10 kph speed restriction on rail traffic when the temperature in an area is forecast to be 38ºC or higher. Research into the effects of temperature on rail had been undertaken by the Cooperative Research Centre for Rail Innovation but not completed due to other industry priorities. A recommendation is made that the Rail Industry Safety and Standards Board (RISSB) strongly encourage the rail industry to

reinvigorate the work and assign its completion as a high priority to the Australasian Centre for Rail Innovation when established in mid-2014.

As has been the case in previous investigations, difficulties were encountered in obtaining downloads from locomotive data loggers. A recommendation is made that the Office of the National Rail Safety Regulator (ONRSR) issues a notice to industry reinforcing the requirement for reliable data loggers to be installed in all locomotives.

PART 1 FACTUAL INFORMATION

Introduction

1.1 At 1503[1] on Thursday 3 January 2013, El Zorro loaded grain service 5CM7 derailed 10 of its 40 wagons just south of the township of Rennie (see *Figures 1 and 2*). The train was en route from Oaklands in southern New South Wales to Melbourne via Benalla in Victoria. The derailed wagons were the 29th to the 38th in the train's wagon consist. The last two wagons remained on the track. All 10n derailed wagons were extensively damaged and approximately 260 metres of track infrastructure was destroyed. No injuries were reported as a result of the derailment and none of the contents from the derailed wagons was spilt.

Source: Google Maps

Figure 1: Incident location

Location

1.2 The derailment occurred on the outskirts of Rennie, a small township in the lower south west region of NSW on the single line section between Oaklands and Benalla. The train was in the process of exiting an 805 metre radius right-hand curve when the derailment occurred (see *Figure 2*).

1 All times referred to in this report are in Eastern Daylight-saving Time (UTC+11 hours).

Source: Google Maps

Figure 2: Derailment site

Train Information

1.3 El Zorro grain train 5CM7 consisted of two locomotives, EL60 and G535, hauling 40 loaded WGBY grain wagons in 2-pack configurations (sets of two permanently coupled wagons). Each wagon had an estimated gross mass of approximately 76 tonnes. The train measured 693.34 metres in length and had a documented weight of 3282 tonnes.

1.4 The EL Class locomotive was leased from Chicago Freight Car Leasing Australia (CFCLA) and the G Class locomotive from Downer EDI Rail. The wagons were owned by Cargill Australia.

1.5 The derailed wagons were the 29th to the 38th wagons inclusive. The last two wagons, the 39th and 40th, remained on the track.

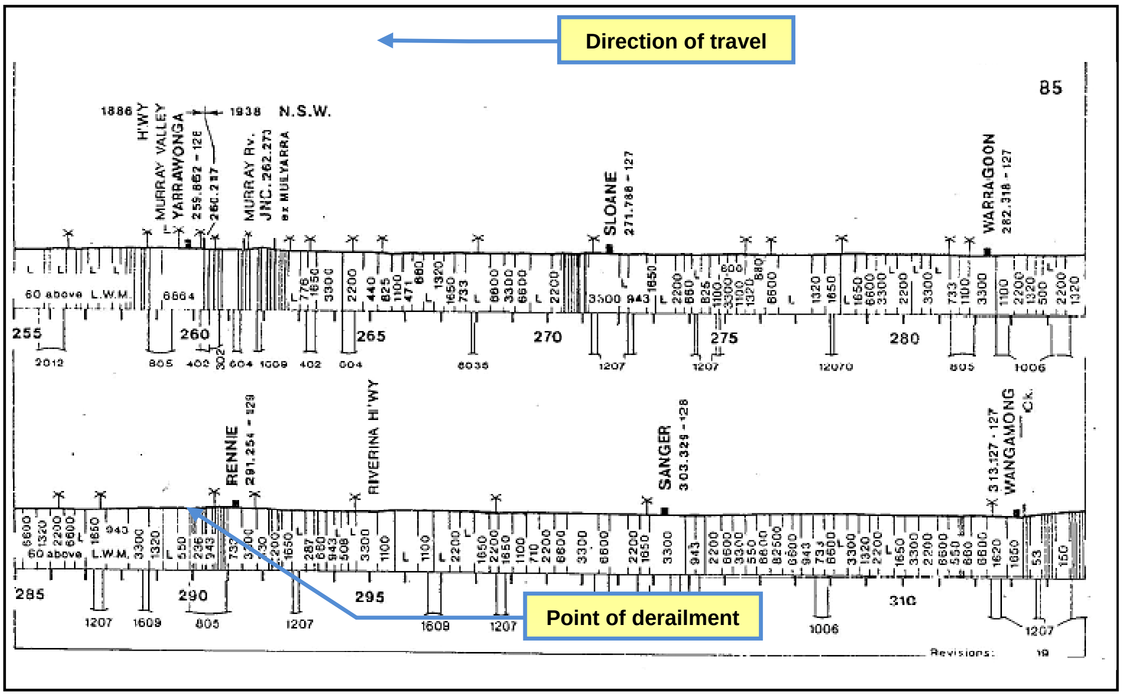
Track Information

1.6 The line between Oaklands and Benalla is owned by VicTrack, a Victorian State Owned Enterprise. The section is managed on their behalf under an Alliance Agreement between the Australian Rail Track Corporation (ARTC) and the Victorian Department of Transport. Works on the section of track are covered by the Benalla – Oaklands Infrastructure Agreement administered by the Alliance Board. At the time of the derailment, all works defined in the Alliance Agreement had been completed by ARTC who, prior to 1 January 2013, had engaged Downer EDI to undertake the track maintenance.

1.7 The line was originally constructed as a broad gauge track (1600 mm) but had been decommissioned some years ago. In late 2009, the line was converted to standard gauge track (1435 mm) and recommissioned. This gauge conversion was achieved by detaching one rail and moving it inwards the necessary distance, then re-fastening it to the existing sleepers.

1.8 During the gauge conversion several thousand new timber sleepers were inserted at predetermined locations. However, the area in which the derailment occurred was not re-sleepered as part of the gauge conversion.

1.9 The section of track was managed as a Class 4 track (as defined in the Victorian Civil Engineering Circulars (CECs) up until January 2012. From this point the track was classified under the National Code of Practice (NCoP) as a Light Weight Line. The line consisted of staggered, jointed and bolted 40 to 43 kg/m rail with some 47 kg/m rail. The rail was fastened to timber sleepers using dog spikes and base plates, and anchored at intervals using 'fair' type anchors. The track is comparatively flat with a gradient of 1:550 in the vicinity of the derailment (see *Figure 3)*. Train working for the section is managed by 'staff only' working.[2] The posted track speed at the point of derailment was 50 km/h.



Source: ARTC

Figure 3: Curve and gradient diagram

2 The possession of a token (the staff) gives the train sole permission to enter a block section.

1.10 The line is used on a seasonal basis to service the grain harvest throughout the south-west region of NSW. When required, El Zorro and another operator, Pacific National, ran a single empty train on alternate days to Oaklands and then loaded on the return trip to Appleton Dock in Melbourne.

Train Crew Information

1.11 The train was crewed by two El Zorro employees; a qualified driver, who was on a trial trip for route qualification, accompanied by a Special Class Instructor Driver (SCID). The SCID was observing the driver as part of the driver's route qualification trial. Both crew members were within their respective medical and competency assessment periods and the SCID was familiar with and endorsed for the route.

Environmental Conditions

1.12 At 1500 on 3 January 2013, the temperature recorded at Yarrawonga, approximately 21 kilometres south of the derailment site, was 34°C. The maximum on the day was 35.9°C. At Oaklands, approximately 23 kilometres to the north of the site, the temperature was recorded as 28.2°C. The weather was described by the crew as hot, dry and windy.

Before the Derailment

1.13 The crew members signed on at Yarrawonga at 0600 and travelled by road motor vehicle to Oaklands where they took charge of 5CM7.

1.14 After loading operations were completed, the train departed Oaklands at 1345 en route to Yarrawonga where the crew were to be relieved. They stated that the trip was uneventful until just beyond the township of Rennie. As the train negotiated a right-hand 805 metre radius curve and entered a tangent (straight) section of track, the SCID observed a "ripple" (buckle/misalignment) within the track but judged it to be no more significant than ones they had already driven over.

The Derailment

1.15 Moments after traversing the section of track where the SCID had observed the "ripple", the crew experienced a rapid loss of brake pipe air pressure and an automatic emergency application of the train's brake, resulting in it coming to a stand at approximately kilometrage 289. At the same time the driver observed in his side mirror a large cloud of dust towards the rear of the train. Immediately prior to the automatic brake application, the SCID had observed his speedometer reading 44 km/h, 6 km/h below the posted track speed.

1.16 The crew was initially unsure as to whether the train had derailed or an air hose had parted between wagons, so the SCID instructed the driver to walk along the train and determine the cause of the loss of air. Approaching the 29th wagon, the driver observed that the wagon's trailing bogie had derailed and that the track beyond was significantly damaged. There was also a small grass fire, the smoke from which was masking the wagons beyond. He reported his observations to the SCID.

After the Derailment

1.17 The driver continued on, moving around the fire, and found the next nine wagons derailed. They were extensively damaged as was the track. He informed the SCID who immediately contacted the ARTC Network Control Centre South at Junee (NSW) and apprised the network controller of the situation, including the grass fire.

1.18 After the initial contact with the crew of 5CM7, the network controller protected the train appropriately by placing blocks to prevent unauthorised rail traffic entering the section. The SCID was directed to safeguard the Staff until the local ARTC track manager arrived to take charge. The SCID then assisted the driver in securing and stabling the train.

1.19 In response to the advice that there was a fire, the network controller contacted the NSW Rural Fire Service who arrived at 1549. They extinguished the fire and departed at 1710.

1.20 Because of the remoteness of the area, El Zorro management requested the NSW Police breath test the crew. The Police from Mulwala completed this at the derailment site and reported back to El Zorro at 1621 that both members of the crew had returned a negative result for the presence of alcohol.

1.21 On 4 January 2013, severe heat conditions prevailed throughout NSW and Victoria. Because of this the NSW Rural Fire Service Group Captain directed El Zorro and ARTC not to conduct any recovery operations until conditions cooled down.

1.22 As a result of this directive and the prolonged fire restrictions that were in force at the time, the re-railing process was delayed until Saturday and Sunday 12/13 January 2013. The remaining wagons were then hauled by rail to Appleton Dock for weighing and unloading.

Injuries and Damage

1.23 There were no injuries to personnel as a result of the derailment but approximately 260 metres of track was destroyed. There was no damage to the locomotives and the 30 wagons which remained on the track. The ten derailed wagons sustained extensive damage mostly to the underside running equipment of the wagons. However, it was possible to carry out temporary repairs on site, including replacing bogies, so as to allow the wagons to be re-railed and recovered to Appleton Dock. They were then transferred to a wagon maintenance facility for further assessment and repairs.

PART 2 ANALYSIS

Summary

2.1 Initial investigation found defects in track infrastructure including poor quality sleepers with loose fastenings, deteriorated track geometry, increasing rail creep and inconsistent ballast profile. Hot climatic conditions resulted in high compressive forces building up within the rail. The condition of the track was such that it could not resist these forces and so buckling occurred under the train. Unable to negotiate the tight curvature of a buckle, one of the trailing wagons mounted the rail and ultimately derailed.

2.2 Further investigation revealed:

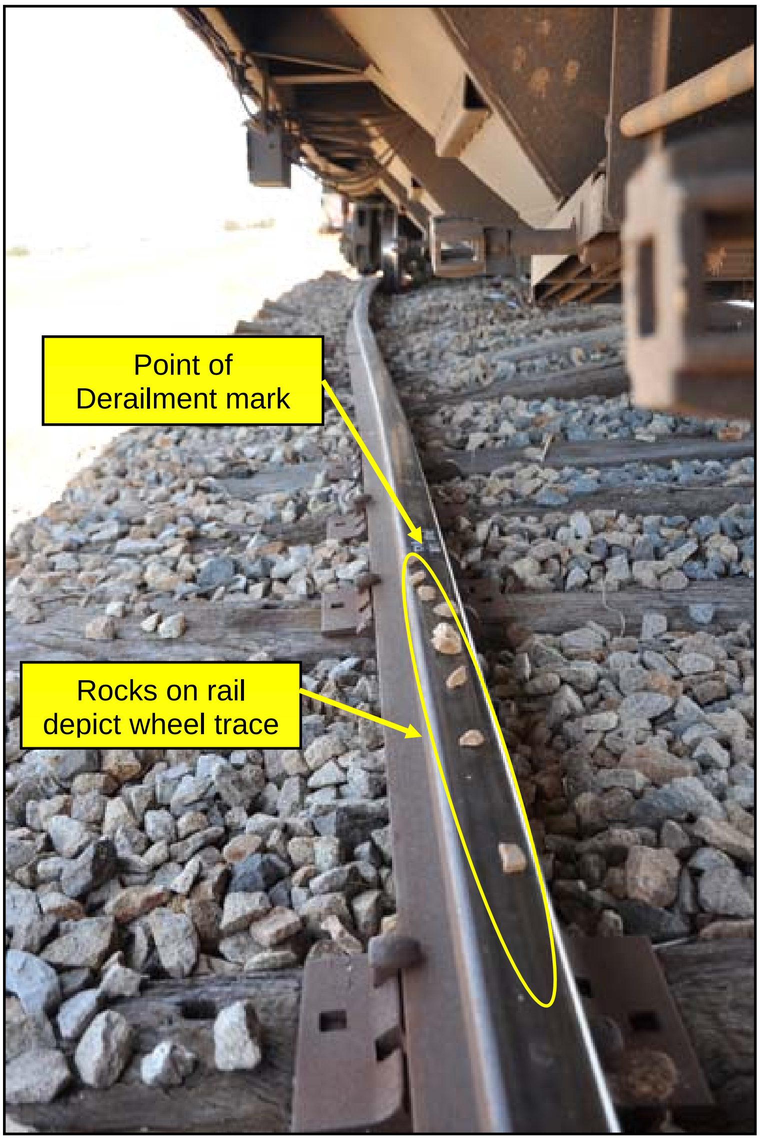
- The management of rail creep within the area of derailment had gone unchecked for three years.
- ARTC had standards for measuring and assessing individual components of a Track Condition Index (TCI), but did not have a standard applicable to this line that required consideration of TCI as a component of overall track stability.
- Due to the classification of the line, the local track manager was not required to examine the line in detail with regard to track stability.

2.3 The local track manager was not required to identify and assess crucial track characteristics that, in combination, could contribute to the occurrence of a track buckle. Hence, rail creep caused increased compressive stress and weakness in the track structure went uncorrected.

Derailment

2.4 Examination of marks on the Up rail[3] identified the point of mount (POM) at km 289.850 and point of derailment (POD) at km 289.852 (see *Photograph 1*). Such a relatively short distance between the POM and the POD is consistent with a derailment due to buckled track. Corresponding marks were also identified on the Down rail where the wheels dropped off the rail.

3 The Up rail is the left hand rail when facing in the direction of travel to Melbourne. The Down rail is the corresponding right hand rail.



Photograph 1: Point of derailment marks on the Up rail

2.5 Post-derailment, investigators observed a buckle under the 39th wagon approximately 10 metres prior to the POM (see *Photograph 2*). At the apex of the buckle the track had displaced 70 mm towards the Up (eastern) side. The radius of the curvature was estimated to be between 100 and 150 metres. (The design speed for such a radius would generally be less than 15 km/h).

2.6 Due to the severity of the curvature it is likely that the loaded grain wagon WGBY 1083 lurched violently and at km 289.850 the wheels of the wagon's rear bogie mounted the Up rail. It travelled for approximately two metres before the wheel set dropped off and derailed. The resulting damage to infrastructure caused the next trailing nine wagons to also derail.

Photograph 2: Buckle visible under the 39th wagon

2.7 Because it was travelling at a low speed, the train stopped in a relatively short distance under the automatic application of the train's brake. Contributing to the short braking distance was the effect of wheels acting as ploughs when some derailed bogies twisted at 90° to the track (see *Photograph 3*).

Photograph 3: Wheel from the 36th wagon acting as a plough

Heat Conditions

2.8 One of the strategies for mitigating risk associated with hot weather is the imposition of speed restrictions when the Bureau of Meteorology (BOM) forecasts air temperatures of 38ºC and above (“WOLO conditions”). With some exceptions this applies to all classes of track within NSW. In most circumstances, the speed restriction is a reduction in the allowable train speed of 10 kph.

2.9 Rail is designed to be in a stress-free condition at a particular temperature, i.e., it is neither in tension nor in compression. The current nominated stress-free temperature (SFT) is 38ºC. Above this temperature the rail will be in compression and below this temperature it will be in tension. However, there are many sections in NSW where the SFT is 35ºC due to an earlier standard.

2.10 Track in high compression is prone to buckling; 40-43 kg/m rail like that at the derailment location experiences a compressive force of approximately one tonne per ºC as it rises above the SFT. After a period of prolonged high temperature, it can be expected that when the air temperature is approximately 40ºC, for example, the rail temperature will be approximately 70ºC due to the retention of heat in the steel.

2.11 Track stability at high temperatures relies on the quality and the interaction of the various track components to resist buckling caused by high compressive forces; the rail, sleepers, fastenings, ballast and the formation all play a part.

2.12 The intent of declaring “WOLO conditions” is to minimise the potential for a derailment due to a buckled rail in circumstances of high temperatures. A reduction in the allowable train speed due to a predicted or actual temperature above 38ºC reduces the likelihood of a buckle by reducing the impact forces that rolling stock imposes on the track. A lower speed also gives a driver more time in which to react to the presence of a buckle.

2.13 OTSI has previously observed the limited effectiveness of this risk control measure. The BOM temperature monitors are spread sparsely throughout remote areas of the State. As a consequence, it is not necessarily possible to accurately predict or detect a high temperature at a particular location. Hence, the WOLO risk control is not always applied where it might be most needed. The location of the derailment site at Rennie is such a place.

2.14 Rennie had experienced persistently hot conditions in the week leading up to the derailment, and temperatures overnight were not sufficiently low to prevent rail temperature build up.

2.15 On 4 January 2013, the day investigators arrived on site, the BOM forecast for Oaklands and the surrounding area was 41ºC. However, when investigators checked the ambient temperature, it was 45ºC. Local residents who were interviewed stated that it was often the case that the temperature at Rennie would range from four to six degrees above the official BOM temperature recorded at Oaklands some 23 km away.

2.16 On 3 January 2013, the day of the derailment, the BOM recorded a maximum temperature of 35.9ºC in the general area. However, it is possible that the actual temperature at the derailment location may have exceeded this if the experience of the local residents and the observations of investigators on the following day is taken into account.

2.17 Another risk mitigation strategy is the use of a Track Stability Management Plan. Such a plan relies on the local track managers' experience and detailed knowledge of the track for which they are responsible. Using their plan, track managers can choose to apply speed restrictions to locations they have identified as presenting higher than normal risks of track buckling. Track managers can also apply speed restrictions where they consider extra precautions are warranted due to prolonged heat conditions. This can range from localised sites such as railway cuttings to lengthy sections of track.

2.18 However, in some locations in NSW, track managers can apply for exemptions from the application of WOLO or the use of a track stability management plan because of the proven robustness and resilience of their respective tracks under heat conditions.

2.19 Given that compressive stress in rail increases with increase in temperature, it is arguable whether the imposition of a single standard speed restriction at a single forecast temperature threshold is an adequate response in mitigating track failure due to hot weather.

2.20 However, as a more comprehensive safety measure, OTSI is of the view there is a case for developing a sliding WOLO scale – the imposition of increasingly more severe speed restrictions as the temperature rises progressively above the prevailing SFT. Based on known local conditions, and in the case of prolonged periods of hot weather, there is also some justification for imposing WOLO at forecast temperatures under the prescribed 38ºC. Given their local knowledge and experience, it would be the task of local track managers to investigate and identify particular locations to be so treated.

2.21 The Cooperative Research Centre (CRC) for Rail Innovation has undertaken research into the effects of temperature on rail. Project R3.112 *Track Stability Management: Development of Rail-Temperature Prediction Model and Software* was initiated in 2009 with the goal of developing ‘a model and software to accurately predict rail-track temperatures 24 hours in advance, so that this data can be used to help manage rail-track buckling’. It was planned to be a two stage study. The first stage was completed but, due to a change in the rail industry’s priorities, the second stage never proceeded. The second stage is necessary before the outputs of the study could be used by industry.

2.22 The CRC is winding up on 30 June 2014. However, the rail industry is in the process of setting up a new research entity, the Australasian Centre for Rail Innovation (ACRI), which is expected to be fully established on 1 July 2014.

Track Condition

2.23 According to ARTC standards, approximately 60% of track stability can be attributed to the integrity of the sleepers and ballast, and approximately 30% is provided by the fastenings of the rail to the sleepers.

2.24 An inspection of the broken sleepers revealed that many had rotted underneath. This had resulted in the hollowing out of the under surface, thereby reducing the extent and effectiveness of the sleeper–ballast interface. No recent sleeper replacement was evident in the vicinity of the derailment site.

2.25 The track formation was composed primarily of a mixture of clay and sand (see *Photograph 3*). The ballast on the formation was fouled in places and its depth was found to be around 180 mm at best. Ballast shoulder widths were inconsistent and below standard in some place.

2.26 The fastenings on the rails were generally poor. Many of the dog spikes were loose and could be moved by hand. Although the number of track anchors in place was in accordance with track standards, many were no longer effective because they were loose, rather than being hard up against the sleepers.

2.27 A walking inspection of the track in the hottest part of the day found significant variation in the gaps between rail ends. In some locations, the gap between the rail ends at the joints exceeded the 12 mm standard (rail in tension); at other joints there were no visible gaps at all (rail in compression). This absence of uniformity in gap size indicates variability of stresses in the rail throughout the line. Track in correct adjustment would be expected to be uniformly in compression and have all joints closed at rail temperatures above approximately 42ºC.

Track Examination

2.28 The track between Oaklands and Benalla was inspected weekly by a road-rail vehicle patrol as part of ARTC's scheduled maintenance regime. This inspection involved a visual check of track conditions with any obvious defects being investigated in more detail. A patrol was conducted on the day of the derailment and was in the vicinity of the derailment location at approximately 1100. No notable defects were observed during this patrol.

2.29 A limitation of such patrols is that they cannot replicate the effects of the passage of a train on the track. They may also not be conducted under the most demanding conditions which occur at the hottest part of the day.

2.30 According to the local track manager, the small maintenance gang responsible for the area was only able to undertake reactive maintenance in the preceding 12 months due to being fully committed in other locations on higher priority tasks. In his view there was no capacity to undertake programmed or preventative maintenance. Further, 2011 had been largely taken up with rectifying the damage caused by wide-spread flooding.

2.31 On three occasions in the previous two years the track condition had been recorded using an AK Car, a specially equipped rail vehicle which takes measurements of a number of track geometry parameters every 200 mm. Measurements are taken of the vertical and horizontal alignment of each rail, the track gauge and the track twist. Any measurements that exceed limits nominated in ARTC's track geometry standards are listed and passed to the team manager for attention in accordance with ARTC's standards and procedures. No specific defects were reported in any of the individual parameters measured in the latest recording in the vicinity of the POM that required ARTC to respond within a limited time frame.

2.32 The parameters measured are also further analysed to produce a comparative index – Track Condition Index (TCI) – for a nominated length of track. The lower the TCI, the better the track. Although the TCI provides track managers with a comparative scale of track condition, no standards or guidelines are available to track managers to mandate a particular response within a particular timeframe. The individual track owners or managers are free to respond as they see fit within their overall duty of care and considering other track related factors that may influence the level of response, including condition of sleepers, fasteners, rail and ballast.

	TCI		
Kilometrage	**22 Mar 2011**	**01 May 2012**	**20 Nov 2012**
287.800 – 288.000	55.5	64.5	67.6
288.000 – 288.200	46.6	48.6	53.5
288.200 – 288.400	40.0	41.4	45.9
288.400 – 288.600	45.4	46.3	51.6
288.600 – 288.800	63.6	65.2	71.2
288.800 – 289.000	49.6	51.4	56.9
289.000 – 289.200	37.3	40.6	43.5
289.200 – 289.400	43.3	48.8	55.1
289.400 – 289.600	44.5	55.9	56.7
289.600 – 289.800	52.2	65.3	79.1
289.800 – 290.000	73.5	77.6	84.9
290.000 – 290.200	59.0	66.2	59.3
290.200 – 290.400	45.6	47.6	57.4
290.400 – 290.600	57.4	62.6	66.9
290.600 – 290.800	82.0	81.3	89.9
290.800 – 291.000	66.6	75.6	91.7

Figure 4: TCI measurements

2.33 *Figure 4* shows the TCI measurements over three successive AK Car recording runs between March 2011 and November 2012 in the vicinity of the derailment. It can be seen that the TCI can change considerably over 200 metres. Given that maximum track stability is achieved when a track is in its original design condition, OTSI was advised by a member of the Independent

Transport Safety Regulator's Technical Panel that the higher the TCI figure the less stable is the track.[4] The table shows a TCI of 84.9 in the 200 metres including the derailment site (highlighted). This is among the highest of the TCI's recorded in the surrounding three kilometres in November 2012, and more than double the lowest figure recorded in the last three sets of measurements.

Track Creep

2.34 Track creep is the longitudinal movement of rail through the fastening system. It can be induced over time in a number of ways, including the forces involved in the braking or acceleration of rail vehicles and/or the effect of laden trains all travelling in the same direction, as was the case on the Oaklands line. Various aspects of track structure may also contribute to the development of creep, e.g., improperly consolidated formation, poor quality and/or inadequate ballast, poor quality sleepers and inadequate or ineffective fixing of rail to sleepers. Creep effectively lowers the SFT of a section of rail because it results in a nett addition to the length of the steel rail.

2.35 The presence of creep in mechanically jointed rail can be readily detected by observing the rail joint gaps and measuring movement of rail relative to a fixed point. If creep is left uncontrolled, compressive stress will build up in the rail, ultimately resulting in lateral buckling of the track. The most common method of constraining creep in mechanically jointed rail is the installation of additional anchors to the rail or the use of improved fastenings.

2.36 Non-uniform rail creep was evident in the vicinity of the derailment. There were scrape marks of different lengths on the foot of the rail where the rail had dragged through the anchors, the lengths depending on the effectiveness of the anchoring system.

2.37 ARTC had no standard dealing with the effect of creep in the particular class of track in place on the Oaklands line. However, as an indication of the magnitude of the effect of creep, it is noted that ARTC engineering standard ETM-06-07 *Managing Track Stability – Timbered Sleepered Track* states that rail creep of 100 mm in 500 m of long welded rail produces a loss of track stability of 60 percent.

4 A TCI of less than 20 may be achieved by newly laid and well maintained track while a TCI of greater than say 70 indicates a need for priority of maintenance intervention.

2.38 Records of the results of the 'annual' creep measurements taken since September 2009 in the vicinity of the derailment show the existence of an increasing degree of creep (see *Figure 5*). [No measurements were taken in 2010.]

Kilometrage	Up Rail			Down Rail		
	Oct/Nov 09	Sep-11	Sep-12	Oct/Nov 09	Sep-11	Sep-12
291	+47	+70	+95	+44	+125	+155
290	+97	+110	+85	+79	+105	+115
289	+86	+105	+110	+57	+80	+130
288	no measure	no measure	+140	no measure	no measure	+160

Figure 5: Creep measurements (mm)

2.39 Rail creep is not a uniform process. Rail movement within a kilometre is likely to be irregular. While rail is measured entering and leaving a particular kilometre, rail behaviour within the kilometre can be quite different. Even if rail creeping into a particular kilometre of track is measured to be the same as the rail measured coming out of the kilometre of track, there is no guarantee that rail stresses within the kilometre have not been affected. Creep can be stopped or slowed at various points within the kilometre where rail is prevented from continuing to move longitudinally by an effective anchoring point. These become stress concentration points and may occur at bridges, turnouts, level crossings, where a weld comes into contact with a well anchored sleeper or simply at points where a group of effective fastenings prevent the rail's continued longitudinal movement.

2.40 As a result of the extensive damage from the derailment, it was not possible to determine whether a simple anchor ('bunching') point existed in advance of the observed buckle in the vicinity of the POD. There were no turnouts or bridges at the POD or in the area after the POD to provide a bunching point but the formation of a buckle at that particular point is indicative of an alternative bunching point within the track structure causing a concentration of compressive stress.

Track Stability

2.41 A track buckle creates a small radius curve which rolling stock cannot negotiate at posted track speed. The rolling stock may lurch violently or derail. A buckle usually occurs when the forces caused by thermal expansion of the rail overcome the strength of the track structure that is designed to resist lateral movement. Buckling forces in the rail are minimised by laying and keeping the rail at or near its SFT. The track structure is designed to resist buckling through the combined actions of the rails, the fastenings, the sleepers and the ballast. Resistance is maximised by keeping these components in good condition and close to their design geometry.

2.42 A track buckle is usually the result of a combination of factors and the likelihood of a track buckle increases as rail creeps longitudinally, sleepers and fastenings deteriorate and the track geometry worsens. In this case, evidence shows that in the vicinity of the POD:

- rail creep of up to 155 mm had been occurring for at least three years
- a high proportion of rail fastenings were loose
- track geometry (TCI) had been progressively degrading over at least the previous three years.

In the absence of evidence of other contributory factors, it is concluded that the combination of the listed track conditions was the primary cause of a buckle which lead to the derailment.

2.43 The track maintenance industry employs controls to mitigate the risk of track buckling. The weighted effect of the various factors is usually regularly assessed in a systematic manner in order to detect when the risk of a buckle is reaching an unacceptable likelihood.

2.44 Different railways apply different controls depending on their perceptions of the risk. The most stringent level of control involves training of track maintenance staff in documented standards and procedures that prescribe the methodology of stability assessment, together with the monitoring of the remedial response by the responsible level of senior management. At the lower level, local track managers are relied upon to determine the necessary course of action based on their experience, observations and analysis.

2.45 ARTC engineering standard EMT-06-07 *Managing Track Stability – Timber Sleepered Track* is applicable ‘ARTC Network Wide’. It provides much guidance on the various factors that influence track stability and the actions required to correct any deficiencies. However, according to the inspection requirements set out in its Table 2, for lines with a maximum line speed of 60 km/h or less, 'Detailed inspection [of track stability is] not mandatory'.

2.46 ARTC's control of the track buckling risk relies heavily then, on the knowledge and skill of the local track manager. In relation to this section of track, the local track manager did not recognise the significance of the combined effect of the individual pieces of information that were available to him.

2.47 ARTC has numerous documented engineering standards and procedures. Many of the documents tend not to be fully self-contained in that often the reader is required to access other documentation in order to gain a complete understanding of the intent of the original instructions. The contents do not link naturally and to reference one document to another is cumbersome. Their engineering publications are now accessed via their extranet but this too was found to be cumbersome and not intuitive to use.

Condition of Wagons

2.48 The 10 derailed wagons were extensively damaged. The treads and flanges on all wheels were inspected but no evidence was found of scale, abnormal wear or of the wheels having skidded prior to the derailment. The flange thickness and rim thickness of all wheels were within specified tolerances.

2.49 There was no evidence of any of the centre castings on any of the derailed wagons having seized. None of the wagons showed any indication of significant wear on the automatic couplings, wheel flanges or bolster gibbs which would suggest that they may have been hunting prior to the derailment. Further, there was no evidence that the bogie frames had twisted. The damage to the derailed wagons was entirely consistent with the effects of forces they were subjected to during the derailment.

Train Crew

2.50 There was no evidence indicating the crew of 5CM7 had operated the locomotives in other than a competent manner and in accordance with El Zorro Work Instruction EZ-WI-263: *Defensive Driving Techniques to Reduce*

SPADs.[5] At the time of the derailment, the train was travelling below the posted speed. There was no evidence that would suggest the actions of the crew members contributed to the derailment in any way.

2.51 Recordings of communications between the train crew and the network controller were reviewed and found to have been conducted in accordance with the relevant ARTC network rules and procedures.

2.52 An examination of the crew's rosters revealed no anomalies or departure from standard industry practice that would indicate fatigue could have affected their performance.

Data Loggers

2.53 Both locomotives were fitted with data loggers. However, the data logger on the EL Class locomotive was not operating and the data could not be accessed initially from the G Class locomotive's data logger. About three months elapsed before software problems with the equipment on the G Class locomotive were resolved, allowing verification of the speed of the train at the time of derailment as 44 km/h.

2.54 In its investigations, OTSI has regularly encountered data loggers not working or producing inaccurate or inconsistent records. In 2011, the Independent Transport Safety Regulator (ITSR) issued *Rail Safety Compliance Code – Data Loggers* to 'provide railway operators with a set of minimum requirements'. The aim of the code included that:

- rolling stock operating on the rail network are fitted with functioning, reliable and accurate data loggers
- in the event of an accident or incident the data logger will be capable of providing investigators with a minimum amount of accurate information
- data loggers be used effectively as a proactive safety tool to gather data.

Remedial Action

2.55 ARTC has developed a rail and joint replacement program which it intends to apply to identified locations on the Oaklands – Benalla line.

2.56 CFCLA, as the owner of the EL Class locomotive, has advised that it is 'reviewing its maintenance practices, maintenance requirements and defects

5 Though the title refers to SPADs, it has the additional general purpose to 'reinforce defensive driving techniques'.

management to mitigate the inability to provide locomotive speed records at any point in time'. The company also intends to enhance the GPS technology deployed on its locomotives which will allow continuous live access and downloading of data.

PART 3 FINDINGS

Causation

3.1 El Zorro grain service 5CM7 derailed when the train traversed a buckle in the track at 289.852 km.

Contributing Factors

3.2 The track buckle was likely to have been caused primarily by rail creep that had accumulated in the last three years, producing excessive compressive (or buckling) stress during periods of high temperature. The ability of the track structure to resist buckling had been progressively diminished by:

- deteriorating track geometry as measured by the Track Condition Index (TCI); and
- poor sleepers with loose fastenings not holding the rail to the sleepers, thereby compromising the rigidity of the track structure.

3.3 ARTC does not have a standard or guideline to assist track managers in responding to an unfavourable aggregate of individual track geometry measurements, as expressed by the TCI.

3.4 In the absence of mandatory detailed inspection of factors that govern track stability on “Light Weight Lines”, ARTC’s governance and performance monitoring arrangements did not provide a level of oversight of track stability management sufficient to detect and correct the sort of deficiencies that were discovered to exist during this investigation.

Other Safety Issues

3.5 One locomotive’s data logger was not working and it took about three months before data could be downloaded from the other.

3.6 The decision to impose WOLO conditions is based on a single forecast temperature threshold and the condition consists of a single reduction of 10 kph in allowable track speed.

PART 4 RECOMMENDATIONS

To improve the safety of rail operations and prevent a recurrence of this type of incident, it is recommended that the following remedial safety actions be undertaken by the nominated entities:

Australian Rail Track Corporation

4.1 Convey the findings of this investigation to the Alliance Board which administers the Benalla-Oaklands Infrastructure Agreement, advising it of the need and means to implement measures to contain creep and other track characteristics that influence the likelihood of track buckling.

4.2 Develop a standard or guideline to assist track managers to respond appropriately to high aggregate TCIs, including escalating protection and correction requirements.

Rail Industry Safety and Standards Board

4.3 Strongly encourage the rail industry to reinvigorate the work on Project R3.112 undertaken by the Cooperative Research Centre for Rail Innovation. Project completion should be assigned as a high priority to the Australasian Centre for Rail Innovation when established, with the aim of producing guidelines for the mitigation of the risk of rail buckling in heat conditions, taking into account the broadest possible set of parameters including ambient temperature, speed of rail traffic and type and condition of track.

Office of the National Rail Safety Regulator

4.4 Reinforce the requirement for reliable data loggers to be installed in all locomotives in an appropriate communication to the rail industry, such as by updating and re-issuing ITSR's *Rail Safety Compliance Code – Data Loggers* as an ONRSR directive.

PART 5 APPENDICES

Appendix 1: Sources and Submissions

Sources of Information

- Australian Rail Track Corporation
- Bureau of Meteorology
- Chicago Freight Car Leasing Australia
- Cooperative Research Centre for Rail Innovation
- Downer EDI Rail
- El Zorro Transport Pty Ltd
- NSW Branch - Office of the National Rail Safety Regulator

Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- Australian Rail Track Corporation
- Chicago Freight Car Leasing Australia
- Downer EDI Rail
- NSW Branch - Office of the National Rail Safety Regulator
- Rail Re-Zolve Pty Ltd (on request in lieu of El Zorro Transport Pty Ltd)

Submissions were received from the Australian Rail Track Corporation, the Office of the National Rail Safety Regulator and Rail Re-Zolve Pty Ltd. The Chief Investigator considered all representations made by DIPs and responded to the author of each of the submissions advising which of their recommended amendments would be incorporated in the Final Report, and those that would not. Where any recommended amendment was excluded, the reasons for doing so were explained.