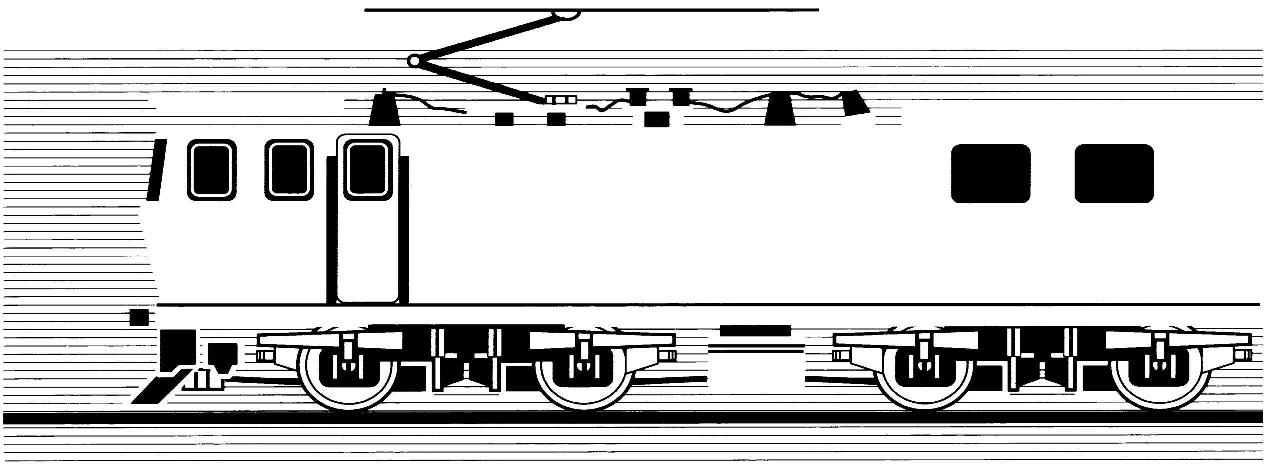

RAILWAY OCCURRENCE REPORT

05-109 **tourist Trains *Linx* and *Snake*, derailments, Driving Creek Railway, Coromandel** **20 February 2005 - 3 March 2005**

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-109

tourist Trains *Linx* and *Snake*

derailments

Driving Creek Railway

Coromandel

20 February 2005 - 3 March 2005

Abstract

On Sunday 20 February 2005 at about 1300, the Driving Creek Train *Linx* derailed at Peg 1660. The rear bogie of the last passenger set derailed and was dragged about 15 m before one of the derailment bars hit a rail joint fishplate, causing the rear bogie to jump further to the left-hand side of the track. One passenger received moderate injuries.

In the afternoon of Sunday 27 February 2005, the rear bogie of the last passenger set of the Train *Linx* derailed to the inside of a tight right-hand curve at Peg 1270 on the Driving Creek Railway. There were no injuries.

In the afternoon of Tuesday 1 March 2005, the leading axle of the Train *Snake* derailed at a rail joint at Peg 600 on the Driving Creek Railway. There were no injuries.

The safety issues identified were:

- track condition
- design of the steering linkage ratio on the front and rear bogies of the *Linx*
- lack of a requirement for regular independent track inspections by qualified people.

In view of the safety actions taken by the operator to rectify the deficiencies in the track and the self-steering linkage ratios, no safety recommendations covering these issues have been made. One safety recommendation regarding annual inspections of track, structures and mechanical equipment by independent, qualified persons has been made to the Director of Land Transport.

The *Linx* on the double bridge of the Driving Creek Railway

Contents

Figures

Abbreviations

DCR	Driving Creek Railway Limited
km/h	kilometres per hour
m	metre(s)
POD	point of derailment

Data Summary

Train types and names:	Train *Linx*	Train *Linx*	Train *Snake*
Dates:	20 February 2005	27 February 2005	1 March 2005
Persons on board:			
crew:	1	1	1
passengers:	about 30	about 30	about 30
Injuries:			
crew:	nil	nil	nil
passengers:	1 moderate	nil	nil

Location:	Driving Creek Railway, Coromandel
Operator:	Driving Creek Railway Limited
Damage:	nil
Investigator-in-charge:	D L Bevin

1 Factual Information

1.1 Introduction

1.1.1 On Sunday 20 February 2005, the Driving Creek Railway (DCR) Train *Linx* derailed, resulting in one passenger being injured. At that time the Commission decided that it would not investigate.

1.1.2 On Sunday 27 February 2005, the *Linx* derailed again, this time with no injuries. Given the apparent similarities, the Commission opened an investigation on 28 February 2005 to cover both accidents.

1.1.3 On Tuesday 1 March 2005, the DCR Train *Snake,* also derailed, again with no injuries.

1.1.4 All three occurrences are covered in this one report, with the factual information for each being dealt with separately.

1.1.5 The DCR was a narrow gauge (381 mm) tourist railway located about 2.5 km from the township of Coromandel. It was owned and operated by Driving Creek Railway Limited.

1.1.6 The railway was originally built to provide access to pine wood fuel and clay from the steep hills to serve the kilns at the Driving Creek potteries. The railway was later upgraded and lengthened to also become a tourist attraction. The DCR obtained a licence from Land Transport Safety Authority (now Land Transport New Zealand) for public operation in 1990.

1.1.7 The *Linx* was a 3-carriage articulated train and had entered service on 30 December 2004. It had a centre-mounted 60 horsepower Perkins diesel engine supplying power to the 8 sets of 2-wheeled sub-bogies. It featured independent hydraulic drive to each wheel. The bogies had a linkage system to steer the wheelsets (self-steering) to reduce the wear on the wheel flanges and side wear on the high-leg rail on the tight radius curves. The axle spacing on the bogies was 650 mm.

1.1.8 The *Snake* was of similar design, but did not have independent hydraulic drive to each wheel or self-steering wheelsets. It had entered service in December 1992.

1.1.9 Both the *Linx* and the *Snake* had a driver's cab at each end for full reversibility when negotiating switchbacks. Both units had capacity for up to 36 adult passengers. They were both built on-site by DCR, including the self-steering bogie components for the *Linx,* which were installed by DCR staff.

1.1.10 Under the provisions of its license, DCR operated to an approved safety system. Before the *Linx* entered service, DCR should have applied to the Land Transport Safety Authority[1] for a variation to its original safety system. However, this was not done before the *Linx* started service, nor had it been done at the time of the first derailment, 2 months later.

1.2 Licensing requirements

1.2.1 The Transport Services Licensing Amendment Act 1992 introduced the following definitions into the principal Act, The Transport Services Licensing Act 1989:

> Railway line – means one rail or a set of rails having a gauge of 550 mm or greater between them and used by a rail service operator…
>
> Rail service – means the provision or operation of vehicles which travel on or use one rail or a set of rails having a gauge of 550 mm or greater between them…

[1] Predecessor to Land Transport New Zealand.

1.2.2 The Transport Services Licensing Amendment Act 1992 also introduced provision for…

> Prescribing any service or class or category of service as a rail service for the purposes of this Act…

1.2.3 Although the gauge of the DCR was 381 mm, because of the nature of its operation it had applied for, and been granted, an operating license under the Act. Section 111 of Railways Act 2005, which came into effect on 1 July 2005 and repealed the Transport Services Licensing Act 1989, preserved those regulations for license holders such as DCR.

1.2.4 Regulation 59 of the Railways Act 2005, provided for the designating of a set of rails with a gauge of less than 550 mm between them as a railway line.

1.3 Site information

General

1.3.1 The DCR wound for nearly 3 km through regenerating native forest as it climbed about 100 m from the potteries to the terminus at Eyefull Tower, 173 m above sea level.

1.3.2 The railway was in rugged hills and passed through 3 tunnels and over 8 bridges, including one double-deck bridge. A spiral, a horseshoe curve and 5 switchbacks were incorporated on the network to cope with the difficult terrain. The steepest grade was 1 in 14 and the tightest curve had a radius of about 9 m.

1.3.3 The railway had been built and extended progressively with the completion of the route at the Eyefull Tower in 2002. The dates (with all localities shown in Figure 1) were:

- Ravington — built prior to 1982
- Chipmans — reached 1983
- Hoki Mai — reached 1991
- Cascade — reached 1994
- No 4 Reversing Point — reached December 1995
- No 5 Reversing point — reached June 2001
- Eyefull Tower — reached 2002.

1.3.4 The maximum speed of trains on the railway was 10 km/h. The trains were not equipped with speedometers.

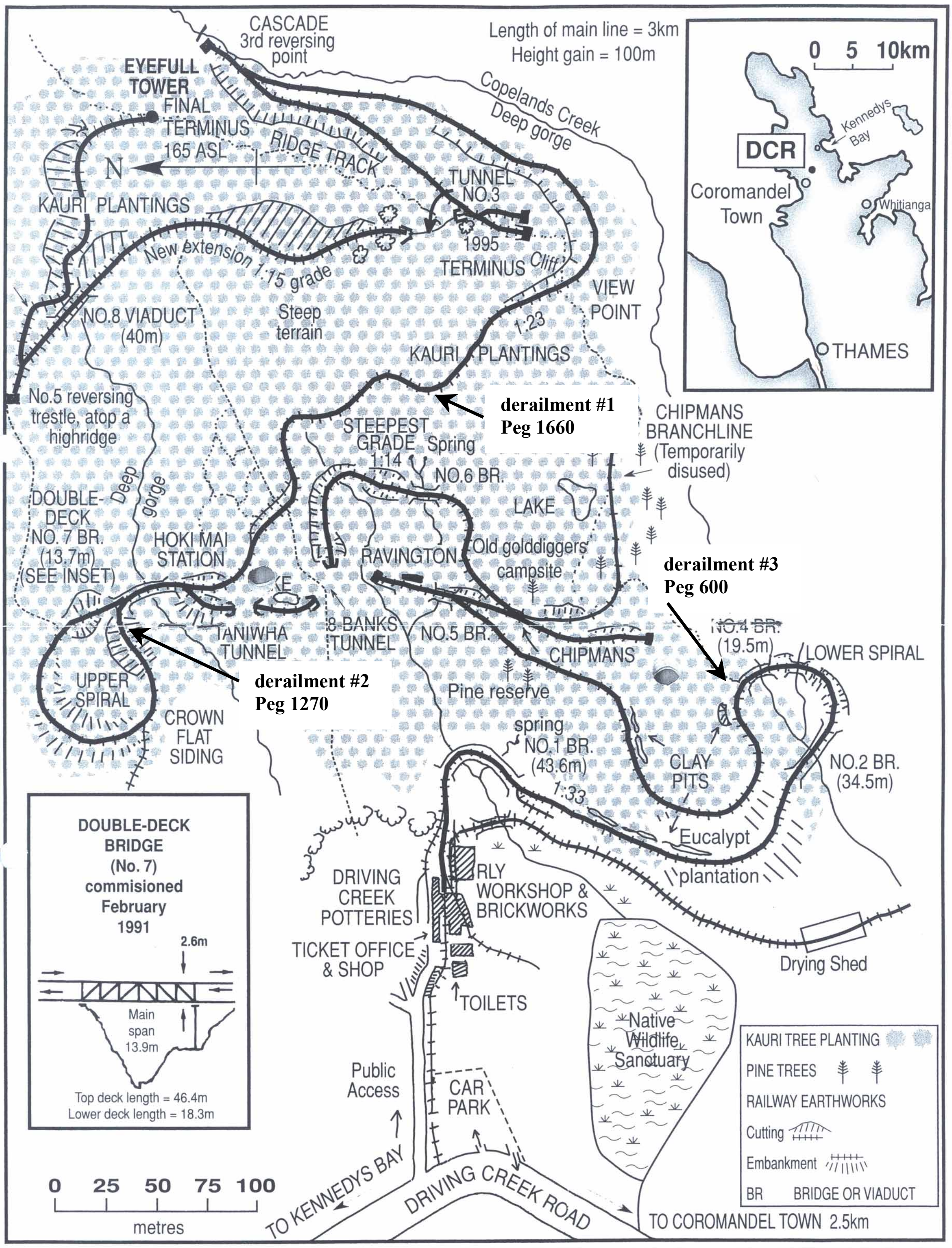

Figure 1
Site plan (courtesy Driving Creek Railway)

Track information

1.3.5 On Thursday 3 March, in parallel with the Commission's site investigation, an independent track engineer undertook a track review on behalf of Land Transport New Zealand. The following comments are based on his report, which Land Transport New Zealand made available to the Commission.

1.3.6 The main weakness in the original track from the potteries to Ravington, which included the point of derailment (POD) at Peg 600, was the quality of the fishplates. The original plates, still in existence on much of this section of the track, were thin and corroded. The operator was aware of the problem and there was an ongoing "as needed" replacement program with much heavier plates. Additional supplies of heavier plates had been received and a continuing replacement program had been commenced following the completion of other projects on the railway, most notably the construction of the *Linx* and the Eyefull Tower.

1.3.7 Other track materials were generally in good condition with new lightweight Korean rail on site for re-railing. Rail to sleeper fastenings were good although some fastenings on the gauge side of the rail had been omitted, probably during construction.

1.3.8 The purpose of a rail joint was to provide a connection between the rails to provide a continuous girder with uniform surface and alignment. At many rail joints there was one sleeper beneath one rail and the rail joint was directly above the edge of the sleeper (see Figure 2). This gave different support conditions at each side of the joint and put additional stress on the fishplate.

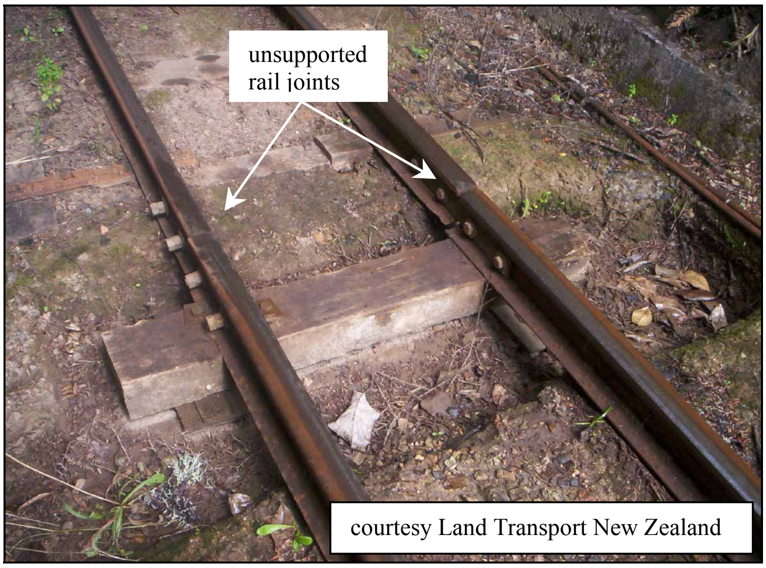

Figure 2
Sleeper under one side of joint only

1.3.9 Sleepers provided a connection between the rails, holding them to correct gauge, and transferred the rail load to the ballast and roadbed. Uneven support conditions were also identified in the newer track where sleepers were half-round tanalised posts laid flat side down (see Figure 3). While this gave the best ground bearing surface underneath, the contact for the rail foot was a very narrow strip (often 0 – 50 mm) from one rail end while the other side of the joint remained unsupported.

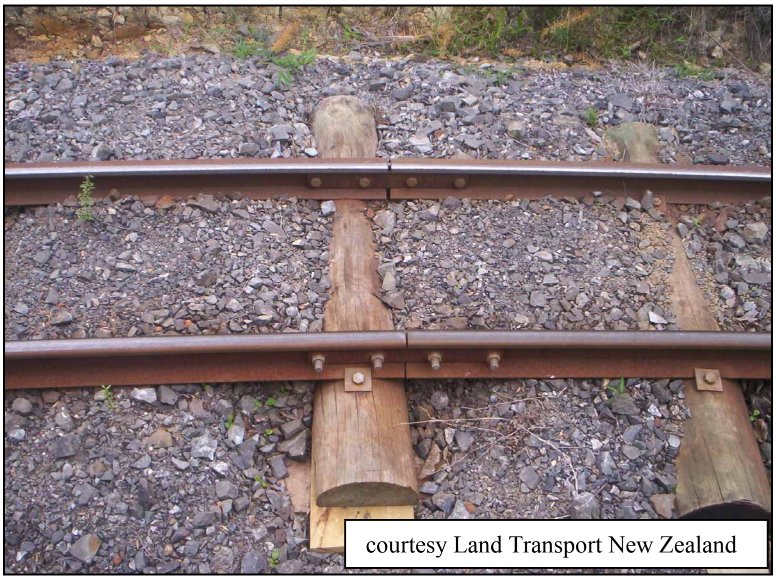

Figure 3
Half-round sleeper under one side of joint (also note packing)

1.3.10 Extensive use had been made of pieces of timber of all shapes, sizes and thicknesses to pack under sleepers where settlement had occurred (see Figure 3). While sleeper support had been restored by this means most were not fastened in position and required regular maintenance.

1.3.11 Expansion joints were observed at several places. The bolts were less than finger tight and were locknutted. This degree of slackness was unnecessary, particularly in the bush where temperature range was not great.

1.3.12 Damaged rail at one location had been replaced by a 600 mm length of rail which spanned between adjacent sleepers only. Two permanent dollys[2] of 10 mm and 20 mm length were also noted.

1.3.13 The track engineer visited DCR again for Land Transport New Zealand on 9 March 2005, at which time he did another track inspection. He reported satisfactory progress on maintenance issues and recommended that no further follow-up action was required at that time.

1.3.14 The operator was responsible for formal track inspections and for track maintenance. However there was no requirement within existing legislation for the competency of people undertaking track building, maintenance or inspection to be audited. Safety system audits by Land Transport New Zealand verified that inspections were carried out and on time by the nominated person but did not verify the competency of the person, nor include an independent track inspection.

The *Linx*

1.3.15 The design engineer from the company that designed and manufactured the bogie steering linkage system conducted a review of the system on 3 March 2005 at the request of DCR. The results of the review were made available to the Commission.

1.3.16 The design engineer inspected and tested the bogie self-steering system. He identified that on tight radius curves, the front and rear bogies were over-steering and thus following the inside rail. There was no wear on the wheel flanges of the inner bogies to suggest any problems. As a result, the engineer recommended a change to the steering linkage ratio on the front and rear bogies to reduce the self-steering ratio by 25%.

[2] Very short pieces of rail to provide continuity.

1.3.17 On 9 March the design engineer returned to DCR to inspect the changes made to the *Linx* by DCR staff. After satisfying himself that the changes had been completed to the required standard, he supervised a test run of the *Linx* over the entire railway system to observe the effect of the modified linkage ratio on the bogie self-steering mechanism on all curves.

1.3.18 The test run showed that the previous over-steering of the rear bogie in either direction just before it entered a curve had been rectified and that the wheel flanges now floated between the rails in all situations without any bias.

1.3.19 A second test run was carried out in the presence of the track engineer, who confirmed that the over-steering appeared to have been corrected and authorised, on behalf of Land Transport New Zealand, that the train be returned to service.

1.4 Narrative

Derailment of Train *Linx* at Peg 1660

1.4.1 On Sunday 20 February 2005, the *Linx* was operating a tourist service from the potteries to Eyefull Tower and return. It was carrying about 30 passengers and was crewed by a driver.

1.4.2 At about 1300, as the *Linx* rounded a left-hand uphill curve, the rear bogie of the last passenger carriage derailed to the left-hand side of the track. Once derailed, the bogie frame rested on a set of derailing bars, which slid along the railhead and prevented the derailed wheels from digging in to the ballast.

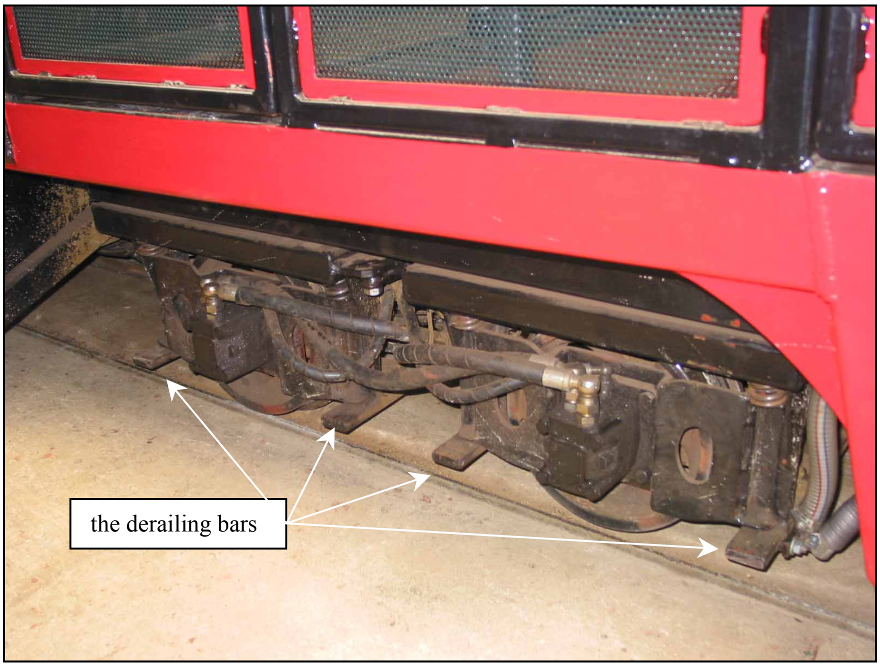

Figure 4
The derailing bars on the bogie

1.4.3 As the *Linx* exited the curve the derailed bogie straightened up but the projecting end on the first derailing bar on the rear bogie lodged under the right-hand railhead where it slid along for about 17 m until it struck a fishplate. On impact, the bogie was jerked further to the left-hand side.

1.4.4 When the bogie jerked, the carriage jack-knifed and a passenger was thrown from her seat, receiving moderate injuries as a result. The driver was alerted to the derailment by the sound of the bar striking the fishplate, and he stopped the train within about 3 m.

1.4.5 The *Linx* had successfully completed about 220 return trips between the potteries and Eyefull Tower between commencing operations in December 2004 and the derailment.

Track

1.4.6 A track measure-up at the POD showed that the cant had increased from a regular 10 - 15 mm to a maximum of 25 mm over a distance of 1.5 m around the curve, resulting in a twist in the track. There were no rail joints in the immediate vicinity of the POD that could have contributed to the twist.

1.4.7 On 4 November 2005, DCR advised that track twist could be a factor in derailments, but without a device for measuring it accurately over the entire length of the line, it was almost impossible to discern it. DCR therefore intended to make a track-twist gauge which, when pushed up or down the line, would accurately measure the degree of twist.

Personnel

1.4.8 The driver of the *Linx* had been driving at DCR for about 5 years. He had not noticed any fault in the track as he approached the POD nor detected any alarm amongst the passengers.

1.4.9 He had not realised the train was derailed until he heard the derailing bar strike the fishplate, at which point he stopped the train. The limited visibility to the rear for the driver because of the winding nature of the track meant he could not always see the rear of the train and, because it was the rear bogie that derailed, he had no immediate warning of the derailment.

Derailment of Train *Linx* at Peg 1270

1.4.10 On Sunday 27 February 2005, the *Linx* was operating a tourist service from the potteries to Eyefull Tower and return. It was carrying about 30 passengers and was crewed by a driver.

1.4.11 As the *Linx* travelled downhill at Peg 1270, the rear bogie of the last passenger carriage derailed to the inside on the entry to a tight right-hand curve approaching the bottom level of the double deck bridge.

1.4.12 The *Linx* travelled a further 15 m before the driver became aware of the derailment and stopped the train. Once derailed the bogie frame rested on the derailing bars, which slid along the railhead and prevented the derailed wheels from digging in to the ballast or damaging the sleepers.

1.4.13 There were no injuries.

Track

1.4.14 A track measure-up at the POD showed that the gauge and top were good and that the cant was a constant 10 - 15 mm.

1.4.15 There were no marks on the sleepers to suggest that the track had been regauged following the derailment, or that the track had been out of gauge prior to the derailment, although there were marks where the derailed wheel flange had made contact with the sleepers.

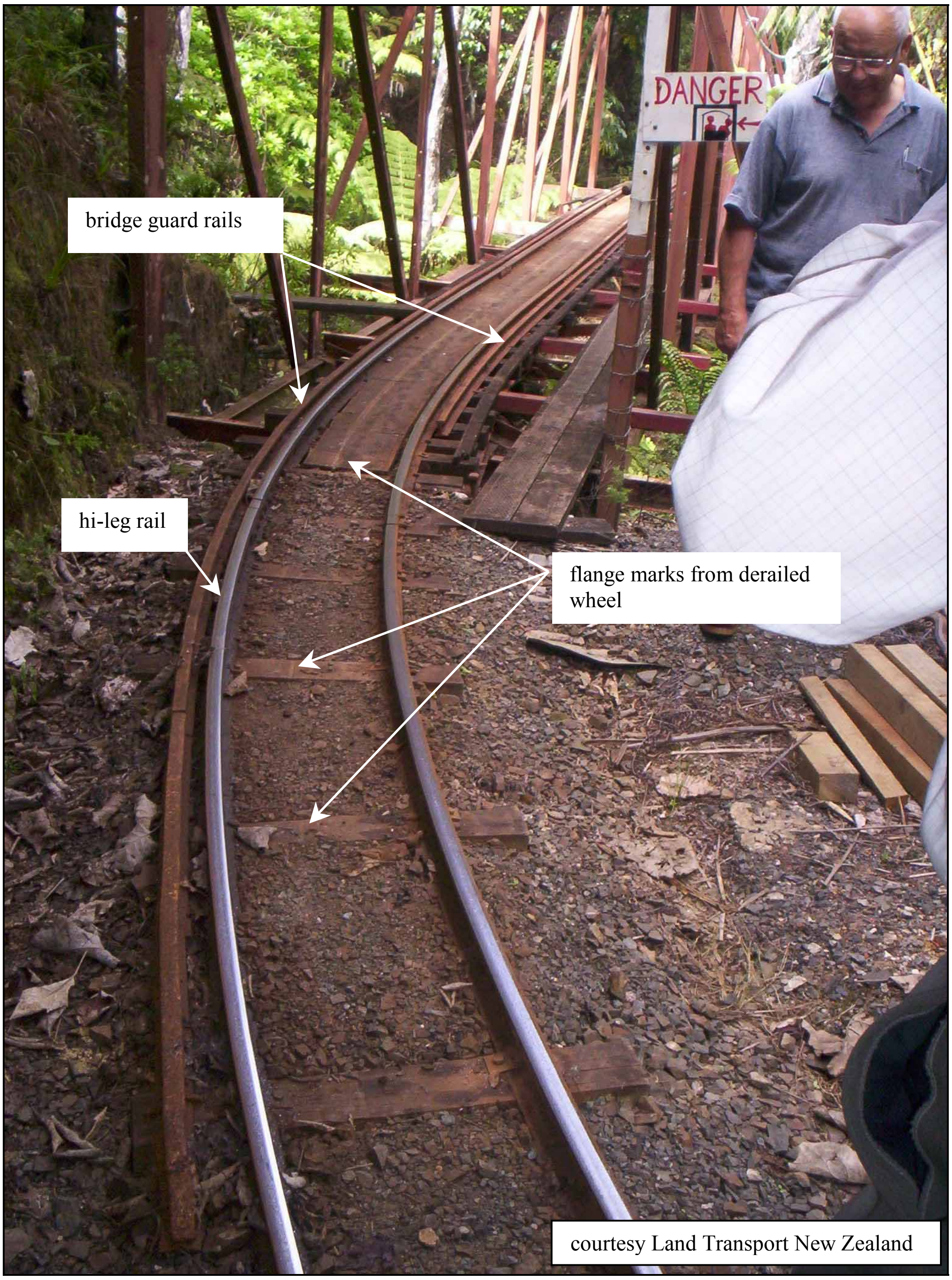

Figure 5
Track immediately beyond the POD at Peg 1270

1.4.16 There was no evidence to suggest any weakness in the rail to sleeper fastenings that could have contributed to the derailment.

1.4.17 Bridge guide rails were fitted to the outside of, and parallel to, the running rails on the approaches to and across the bridge (see Figure 5) to prevent derailed wagons from moving beyond the edge of the bridge sleepers.

Personnel

1.4.18 The driver of the *Linx* was the same driver as for the previous derailment. He said he had not noticed any fault in the track as he approached the POD and was unaware of the derailment until he heard the derailment bar under the derailed bogie strike a sleeper.

Derailment of Train *Snake* at Peg 600

1.4.19 On Tuesday 1 March 2005 the *Snake* was operating a tourist service from the potteries to Eyefull Tower and return. It was carrying about 30 passengers and was crewed by a driver.

1.4.20 As the *Snake* traversed the track at Peg 600 the leading axle of the leading bogie derailed to the outside of a curve.

1.4.21 The driver stopped the train, and no injuries were sustained.

Track

1.4.22 A heavily corroded and fractured fishplate measuring 32 mm wide x 6 mm thick was recovered from the derailment site. The matching surfaces were rough and rusty.

1.4.23 The fishplate fragments accounted for only 3 boltholes instead of the usual four. There was evidence that the end section containing the fourth hole had rusted and broken off previously.

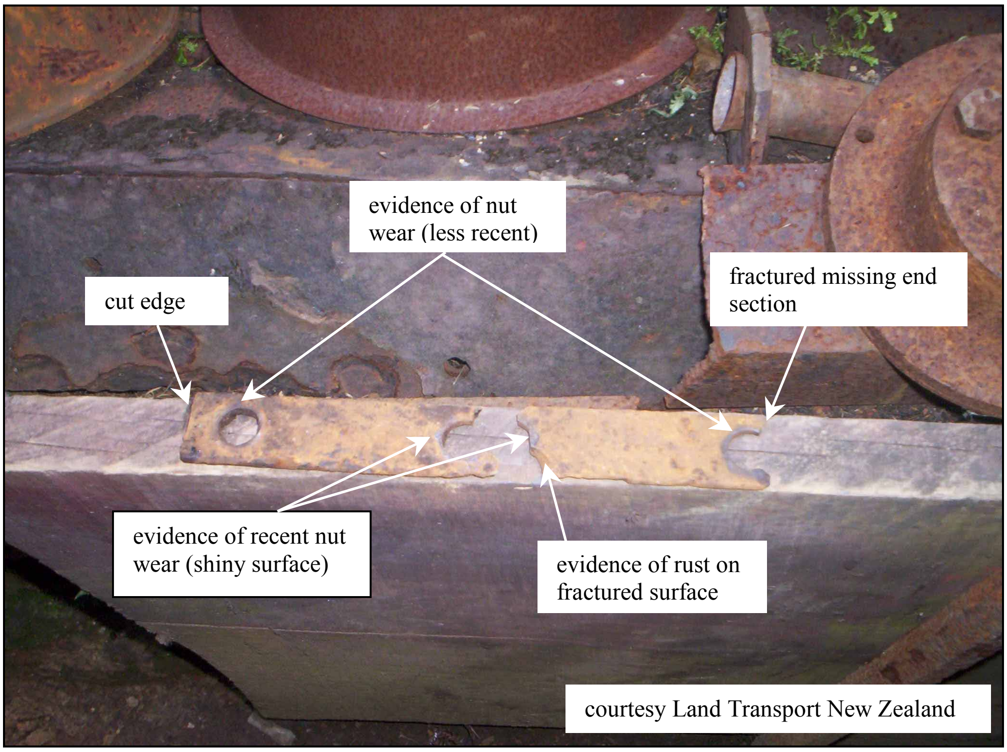

Figure 6
The fractured fishplate

1.4.24 DCR staff had been aware of the fishplate problem, and only recently new supplies of 40 mm wide x 10 mm thick plates had been received for use in progressively replacing the old plates. DCR confirmed a major fishplate replacement programme had been implemented immediately following the derailment of Train *Snake* at Peg 600.

1.4.25 The distance between sleepers at the broken joint was about 150 mm, with the joint supported only by the fishplate across that gap. Figure 7 shows the new 40 mm x 10 mm fishplate used to replace the old fractured one.

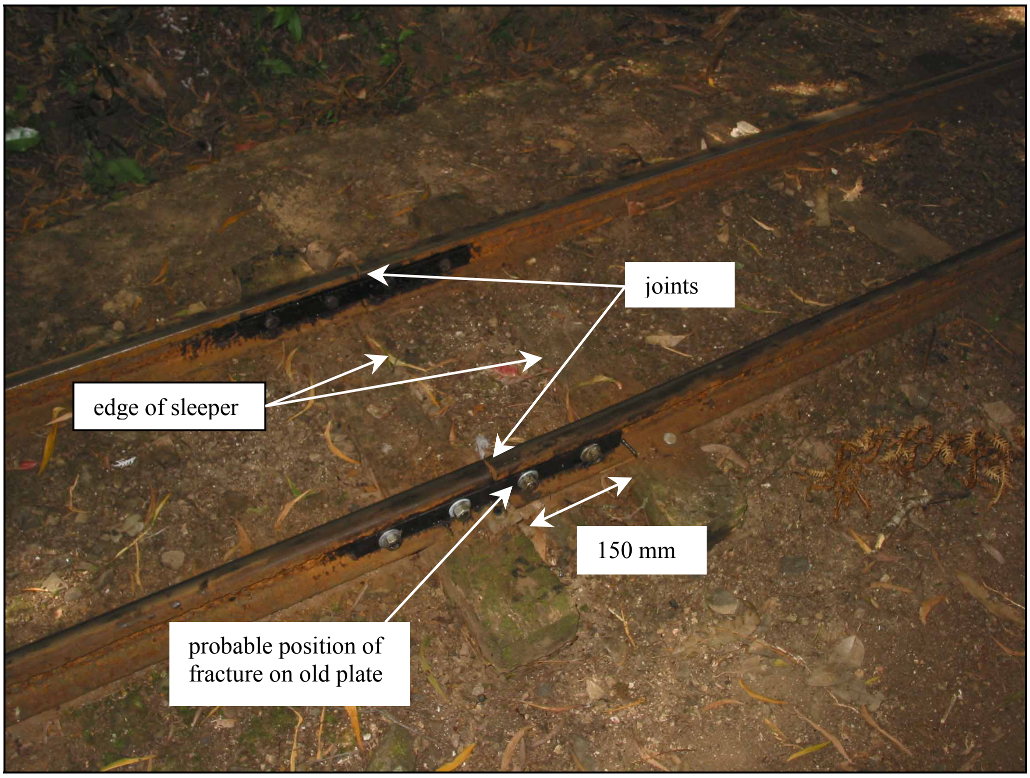

Figure 7
The replacement joint

Personnel

1.4.26 The driver of the *Snake* had been driving at DCR for 2 months. He had not noticed any fault in the track as he approached Peg 600.

1.4.27 It was the leading bogie that derailed so he was immediately aware of it and stopped the train.

2 Analysis

Derailment of Train *Linx* at Peg 1660

2.1 The over-steering of the rear bogie was probably not enough on its own to cause the derailment. However, when combined with the twist in the track it contributed to the sequence of events leading to the derailment. The over-steer in the bogie axles would have resulted in excessive flange pressure on the low leg[3], exacerbating any track deficiency.

2.2 Trains, including the *Linx*, had been successfully traversing the POD prior to the incident, which suggested that the condition of the track at the POD had probably deteriorated gradually. The deterioration was probably a combination of inclement weather in bush conditions and continual heavy traffic during the tourist season.

2.3 The many tight curves that the *Linx* negotiated during the course of the trip meant that the driver could not always see the rear of the train. It was therefore not surprising that he did not see any alarm amongst the passengers and was initially unaware of the derailment. If he had been immediately aware, the slow speed of the train meant that he could probably have brought it to a stop before the protruding derailing bar struck the fishplate and the passenger would probably not have been injured.

[3] The inside rail on a curve.

2.4 The derailing bars had been installed to prevent any derailed wheels from digging in to the ballast, and at the time of the derailment this was achieved. However, after the bogie had derailed there was nothing to alert the driver that the derailing bar was resting on the railhead. Had there been a warning device attached to the derailing bars, it is likely that the driver would have stopped the train before the rear bogie jackknifed and the passenger was injured. Following the derailments the operator addressed this issue, and no safety recommendation has been made.

Derailment of Train *Linx* at Peg 1270

2.5 After the derailment 7 days earlier, the self-steering bogies on the *Linx* had continued to successfully negotiate the tight curves of the network. However, the design over-steer was still present, and as the trailing bogie left the straight to enter the curve on this particular trip it probably followed the line of the preceding bogies that had already entered the curve, ran up on to the inside railhead and derailed.

2.6 There was no evidence to suggest a track fault, which could have contributed to the derailment, existed at the time.

Derailment of Train *Snake* at Peg 600

2.7 Although the corroded and broken fishplate had been replaced before investigators arrived on site this did not affect the investigation as the fishplate had been retained for inspection. The replacement, new and stronger, fishplate had been attached to the rail on both sides of the joint in exactly the same way as the replaced fishplate had been.

2.8 The fishplate had fractured through corrosion behind the bolt washer. The washer had initially been tight enough to prevent the 2 sections of the fractured fishplate from separating. The small shiny area on the face of the fishplate showed that it had until recently been in contact with the washer and had only very recently been separated. The rusty appearance of the metal on both sides of the fracture indicated that the fracture had occurred as a result of corrosion of the fishplate over some considerable time.

2.9 The lack of a sleeper to provide support beneath the joint meant that the fishplates securing it largely carried the weight of trains passing over the 150 mm gap between the sleepers. The fishplates would have responded to the trains passing over the gap by moving up and down and this movement would have vibrated through the corroded fishplate and hastened the ultimate fracture.

General

2.10 Many deficiencies had been identified, particularly in the oldest section of track between the potteries and Ravington. The operator had been involved in other major projects, and track maintenance over this section had probably suffered resulting in the standard of the track gradually deteriorating. These other projects have been completed, and both staff and material resources were being utilised to upgrade the track in this section. As a result the Commission has made no safety recommendation regarding track condition.

2.11 Although the condition of the track was not up to standard in many places, it is unlikely that this would have contributed to an incident because of the slow speed of the trains and the lightweight axle loadings. However, the lack of a requirement for independent regular track inspections of DCR track infrastructure by a suitably qualified and competent independent inspector, had the potential for unsuitable practices, perhaps resulting from inexperience or lack of knowledge on the part of the operator, to go unchecked. This also made it difficult for the operator to be aware of and adopt best-practice standards and procedures.

2.12 The track maintenance recovery plan and actions taken following the review by the track engineer reinforced the benefit to be gained when access to such expertise was available to the operator. There was no doubt that such inspections on a regular basis, as was required with mechanical plant, bridge and structures, would assist DCR to establish and maintain acceptable standards in track infrastructure. A safety recommendation covering this issue has been made to the Director of Land Transport New Zealand.

2.13 Each derailment of the *Linx* involved a different bogie, but in both cases the affected axle was the rear bogie in the direction of travel. This confirmed that the design fault in the steering linkage connection was present in each end bogie of the train, but that to cause a derailment the defective bogie had to be at the rear where it was probably most affected by in-train forces while rounding curves.

2.14 As a new rail service vehicle, the *Linx* should have been approved to operate by Land Transport New Zealand authorising a variation to DCR's existing safety system before the train commenced service. However, this process would probably not have prevented the incidents, as the self-steering bogie design deficiency was present, but not obvious, when the *Linx* entered service and operated without incident for at least 220 trips.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 The train drivers were appropriately qualified for the duties they were carrying out and their actions did not contribute to any of the derailments.

3.2 Track audits of DCR were process audits in accordance with operating licence requirements.

3.3 There was no requirement for an independent inspection of the track infrastructure that was designed, built, maintained and inspected by the operator, in accordance with the safety case.

3.4 The *Linx* had not been approved to operate by Land Transport New Zealand.

3.5 The derailment at Peg 1660 was caused by a track fault that was exacerbated by the design deficiency in the self-steering bogies.

3.6 The over-steering of the trailing self-steering bogie immediately before it entered the curve probably caused the derailment at Peg 1270.

3.7 The derailment at Peg 600 was caused by the failure of old track materials, the deterioration of which had not been identified because of inadequate inspections and maintenance.

4 Safety Actions

4.1 Following the derailments, DCR introduced a derailment warning system consisting of an insulated wire secured underneath each of the derailing bars (see Figure 8). If a bogie derailed, the wire would be trapped between the bar and the railhead and would break, triggering an alarm in the driver's cab.

4.2 On 9 August 2005, DCR advised that the derailment alarm warning system had been fitted to the *Linx* and tested on 18 March 2005. The system would be fitted to the *Snake* during its overhaul in September 2005.

4.3 On 7 March 2005 the design engineer recommended to DCR that the self-steering linkage ratio on the front and rear bogies on the *Linx* be reduced by 25%. The modifications (see Figure 9) were undertaken by DCR engineering staff and on 9 March test runs of the *Linx* were undertaken over the network under the supervision of the design engineer. The test confirmed that the over-steering of the rear bogie, which had previously been apparent when it entered a curve, had been eliminated and that the wheel flanges were now floating between the rails without any bias.

Figure 8
The derailment warning system fitted to the derailing bar

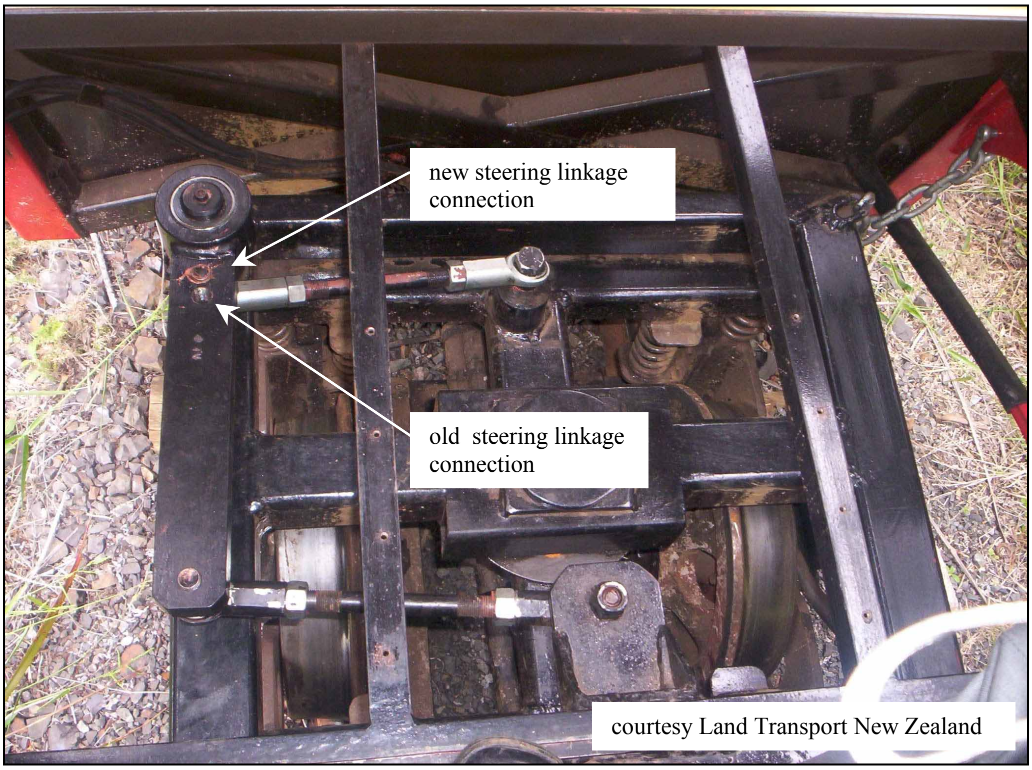

Figure 9
The adjusted steering linkage connection

5 Safety Recommendation

5.1 On 14 November 2005, the Commission recommended to the Director of Land Transport New Zealand that he:

> ensure that Driving Creek Railway, and any other licensed railways of less than 550 mm track gauge where warranted, include in their safety case a requirement for an annual inspection of track, structures and mechanical equipment by independent, qualified persons to confirm that acceptable safety standards are being maintained (103/05).

5.2 On 29 November 2005 the Director of Land Transport New Zealand replied in part:

> As indicated in my pervious letter regarding this recommendation, Land Transport NZ accepts that this recommendation is intended to improve safety on narrow gauge railways, accordingly we will contact all such railways recommending that they adopt the above recommendation. This will be carried out when Report 05-109 is formally issued.
>
> As you are aware Land Transport NZ can require railway operators to undertake certain actions if the Director considers it necessary in accordance with the Railways Act 2005 (Section 34 refers). In regard to this particular recommendation we are unsure if the threshold as set out in the Act has been met.

Approved on 17 November 2005 for Publication

Hon W P Jeffries
Chief Commissioner

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