No. 95-117

Train 600

Pukehou

12 November 1995

Abstract

On Sunday 12 November 1995 at about 1240 hours Train 600, the Northbound "Bay Express" express passenger service between Wellington and Napier, derailed at Pukehou between Waipukurau and Hastings on the Palmerston North Gisborne Line. The train was travelling at approximately 90 km/h when the locomotive, power/baggage van and an empty passenger carriage left the tracks on a right hand curve. The two rear carriages carrying passengers remained on the rails. A member of the public riding in the cab of the locomotive was fatally injured and nineteen passengers or crew suffered shock or minor injuries. The causal factor was the excessive speed of the train.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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Transport Accident Investigation Commission

Rail Accident Report No. 95-117

Train type and number:	Express Passenger, 600.	
Locomotive:	DX 5310.	
Date and time:	12 November 1995, 1240 hours.	
Location:	Near Pukehou, at 130.312 km Palmerston North Gisborne Line.	
Type of occurrence:	Derailment of locomotive, van and carriage.	
Persons on board:	Crew:	3
	Passengers:	32
	Other *:	1
Injuries:	Crew:	2 minor
		1 nil
	Passengers:	17 minor
		15 nil
	Other:	1 fatal
Nature of damage:	Locomotive: major	
	Train:	1 carriage minor
		1 van minor
		2 carriages nil
	Track:	minor
Information sources:	Transport Accident Investigation Commission field investigation	
Investigator in Charge:	R E Howe	

* Locomotive cab rider

1. Factual Information

1.1 On Sunday 12 November 1995 Tranz Rail Limited (TRL) Train 600, the Wellington to Napier "Bay Express" express passenger service, was hauled by DX 5310 and consisted of power/baggage van AG 176 and three passenger carriages (or cars), A 3303, AO 60 and ASO 1. On board at the time of the accident were a locomotive engineer (LE) and a member of the public in the cab of the locomotive, the train crew of Train Manager (TM) and Stewardess, and 32 passengers. All of the passengers and the train crew were in the two rear cars.

1.2 Departure from Wellington Station was at 0827 hours, 27 minutes late due to an air supply problem with the locomotive attached to the "Overlander" express passenger service (on 12 November 1995 the 'Bay Express' towed the "Overlander" service to Levin to minimise disruption to track work between Otaki and Manakau).

1.3 The "Overlander" was uncoupled at Levin and the "Bay Express" continued on to Palmerston North arriving at 1038 hours, 34 minutes behind schedule.

1.4 A change of locomotive crew took place at Palmerston North where the LE involved in the accident took control of Train 600.

1.5 Before departure from Palmerston North the LE was joined in the cab by a friend of his with whom an arrangement had been made previously. The TM was not aware of the presence of the cab rider.

1.6 Train 600 departed Palmerston North at 1042 hours, 28 minutes behind time for the timetabled 3 hour 6 minute trip to Napier.

1.7 Following stops for approximately one and a half minutes at Woodville, one and a half minutes at Dannevirke and two minutes at Waipukurau the train left Waipukurau at 1222 hours, then approximately 10 minutes behind time. During the journey from Palmerston North the TM had been updating passengers on progress in relation to bus connections at Napier. On leaving Waipukurau he announced the train was then 10 minutes behind time and that he anticipated arrival at Napier approximately 5 minutes late.

1.8 At Dannevirke the LE spoke to the TM and requested information regarding timing of intermediate stops. The TRL Working Timetable which was held by the LE had previously listed detailed times for each intermediate stop between Palmerston North and Napier but a recent amendment in effect on 12 November 1995 limited information to Palmerston North, Woodville and Napier. LE's were supplied with information on intermediate stops by means of a copy of the "Bay Express" Passenger Form for Trains 600/601. This was usually supplied to the LE who took Train 600 out of Wellington and remained in the cab for the return journey for reference.

1.9 Due to the distraction of the late departure from Wellington the TM had forgotten to supply this form and the LE in control from Wellington to Palmerston North did not request this information. The TM radioed the relevant information to the LE as the train left Dannevirke and the LE recalled writing down details for Hastings and Napier. The LE's recollection was that the TM commented on the fact that they were running 20 minutes late and would probably be 20 minutes late into Napier.

1.10 At approximately 1238 hours after leaving a 60 km/h curve at 128.500 km the LE stated he took his Working Timetable from his workbag and "thumbed through" it to check his arrival and departure times from Hastings, his arrival time in Napier and the departure time for his return trip on Train 601 (the return "Bay Express").

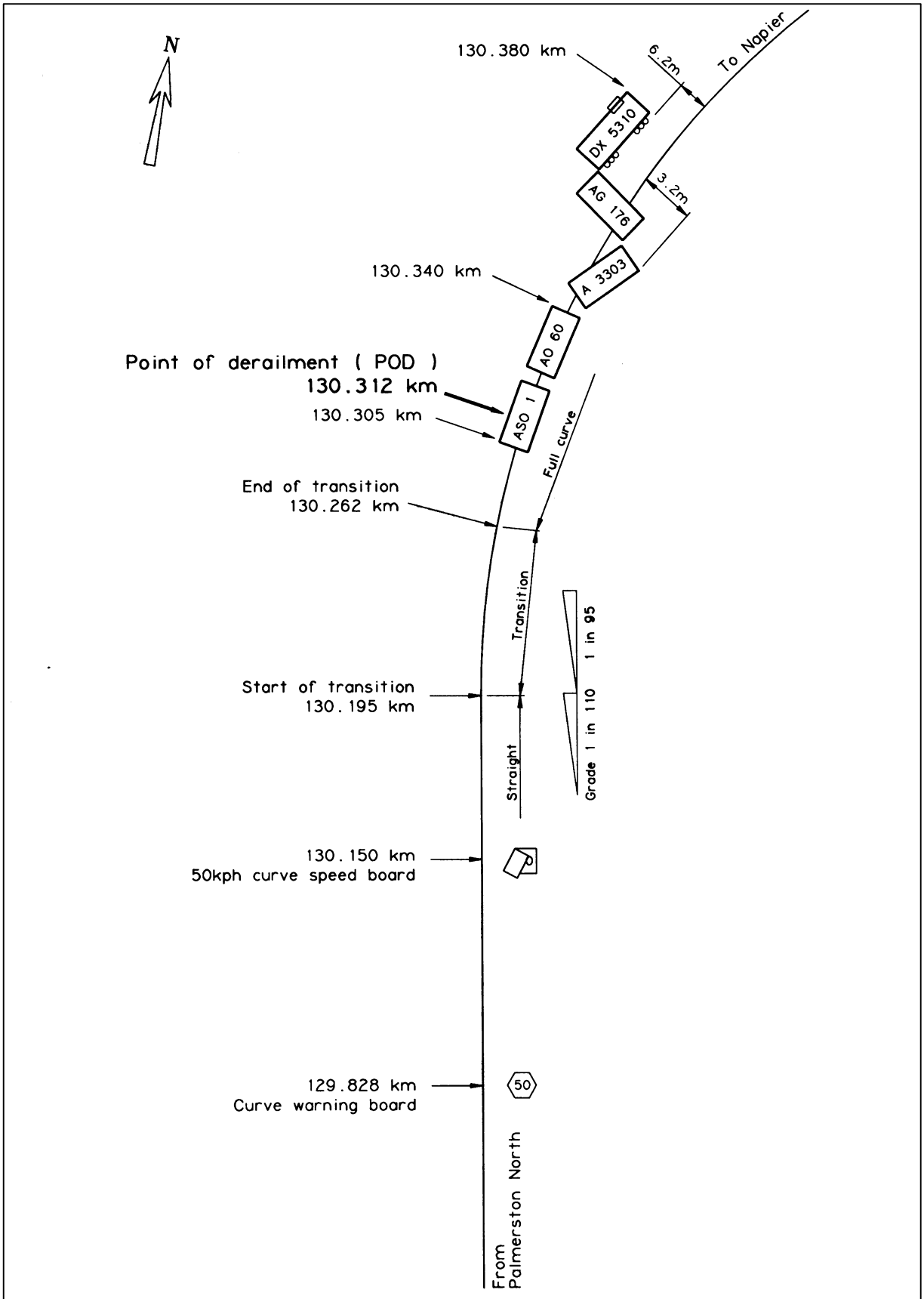

Figure 1

Site details

(Not to scale)

1.11 The track alignment from 128.500 km to the point of derailment (POD) consisted of a left hand 800m radius curve with a maximum authorised speed of 95 km/h before entering the Pukehou straight at 129.200 km. This ran to 130.195 km with a maximum authorised speed of 100 km/h for an express passenger train. The track then curved to the right into a 200m radius curve with a posted maximum authorised speed of 50 km/h.

1.12 As the train traversed the Pukehou straight the LE stated he continued to refer to his Working Timetable with occasional glances up. He did not notice the Curve Warning Board for the approaching 200m radius curve which was sited on the right hand side of the track at approximately 129.828 km, or the Curve Speed Board which was sited on the right hand side of the track at approximately 130.150 km.

1.13 The LE's first indication of the approaching curve was looking up and seeing it some 75m ahead at which point he stated he applied emergency braking. Braking took effect progressively as the train entered the curve transition at 130.195 km and an 8% speed reduction occurred before the locomotive derailed at approximately 130.312 km, 50m into the body of the curve. (TRL curves include a transition length from curve entry to full curve radius over which radius and cant are progressively applied. In the case of the derailment curve this transition was 67m in length from 130.195 km to 130.262 km, refer Figure 1).

1.14 The LE stated he was sitting in the right hand side driver's seat and the cab rider was sitting in the left hand side train operator's seat as the train approached the curve. Both stood up prior to derailment as they realised the train was going too fast into the curve.

1.15 The locomotive overturned onto its left hand side and slid forward finally coming to rest 68m from the POD with its leading end opposite 130.38 km and in the position indicated in Figure 1. The locomotive was extensively damaged.

1.16 The speed of the train as provided by the locomotive electronic event recorder was 98 km/h approaching the curve and approximately 90 km/h at POD.

1.17 The right hand curve was on an embankment with the ground level on the left hand side between two and three metres below rail level.

1.18 As a result of DX 5310 overturning van AG 176 attached to DX 5310 was derailed all wheels. A 3303 was attached to AG 176 and the leading bogie and trailing axle of the trailing bogie of this car were derailed. The two cars containing passengers and train crew at the rear of the train remained on the rails. The final position of all vehicles is shown in Figure 1. DX 5310 came to rest horizontally on its left hand side, AG 176 was leaning approximately 40° to the right in direction of travel, and A 3303 approximately 7° to the right in direction of travel, (Figure 2). Both AG 176 and A 3303 suffered minor damage.

1.19 When the locomotive came to rest on its side following the derailment the LE and cab rider were both still in the cab. The LE suffered only minor injuries and when he asked the cab rider whether he was all right he was told he was. The doors and windows in the cab were twisted and would not open and the LE kicked out the front window at low level to allow exit. This was done speedily as he could smell diesel fuel which was starting to trickle into the cab.

1.20 As the LE started to exit out of the window gap the cab rider told him his leg was jammed. The LE's recollection was that the cab rider was lying on equipment towards the left hand side of the cab with his leg caught between debris and a back-wall cabinet. Together they pushed the cabinet back and freed the cab rider's leg. The cab rider confirmed that he was "okay" and the LE exited taking a portable radio kept in the cab.

Figure 2
Position of Train 600 following derailment

1.21 The LE stated the locomotive engine shut down before he was out of the window. Later inspections revealed the main power cables were severed and the battery knife switch was jammed in the open position leaving the locomotive electrics safe.

1.22 The LE walked to the rear of the train while attempting to contact Train Control. He was not able to make contact but on joining the TM outside the rear carriages was advised emergency services and Train Control had been contacted. The LE stated he then advised the TM he had a friend in the cab who was all right, although he was not sure what his injuries were. He then returned to the locomotive cab to find the cab rider outside of the cab and in the LE's words "deteriorating rapidly". The LE spent time with the cab rider and walking around the site before being directed into an ambulance and eventually being taken to Hastings Hospital.

1.23 The derailment was witnessed by a nearby farm worker who was on his front lawn at the time. He stated he saw the locomotive leave the track first followed by the van and first carriage before the locomotive hit the ground and that as soon as the carriage left the tracks "the whole train seemed to speed up". He rode to the scene by motorcycle arriving approximately two minutes after the derailment. The Train Manager was outside the train talking on his mobile telephone and the LE was walking south down the track towards some approaching people. On checking with the TM he was advised there was one person injured and everyone else was all right. On being advised where the injured man was he went to the cab to find the cab rider lying on his side on the ground just outside the cab. He covered him and stayed with him until emergency services arrived. The cab rider was found to have suffered severe abdominal injuries which proved fatal on 13 November 1995.

1.24 At the time of the derailment the TM and Stewardess were in the kitchen in the rear car. The TM could see the derailed carriage and immediately called 111 and Train Control. The TM and Stewardess checked the passengers in the two rear carriages for any injuries and found that apart from shock and minor abrasions and bruising the passengers were uninjured. Emergency services were soon on the scene and the train crew assisted as required in the support and follow up.

1.25 Following a 111 call at 1241 hours the first Fire Service unit was on site at 1253 hours and the first ambulance at 1306 hours. Police assumed control of the site on arrival at 1256 hours. In all four fire appliances were in initial attendance and four ambulances. The rescue helicopter from Hastings was activated at 1246 hours and on site at 1310 hours. It was used to transfer the injured cab rider to hospital.

1.26 Passengers and crew requiring attention were taken to Hastings Hospital by ambulance. The remainder of the passengers were bussed to Hastings and received victim support.

1.27 The Fire Service sprayed foam and remained on site to ensure clearance operations were not made hazardous by diesel spill in the vicinity of the locomotive.

Weather

1.28 The weather was fine with good visibility. The general area was subject to westerly winds up to gale force in the morning but these had eased by midday.

Train riding

1.29 Neither the TM nor the Stewardess noticed anything untoward in the speed and associated comfort of the journey from Palmerston North to the POD on that day.

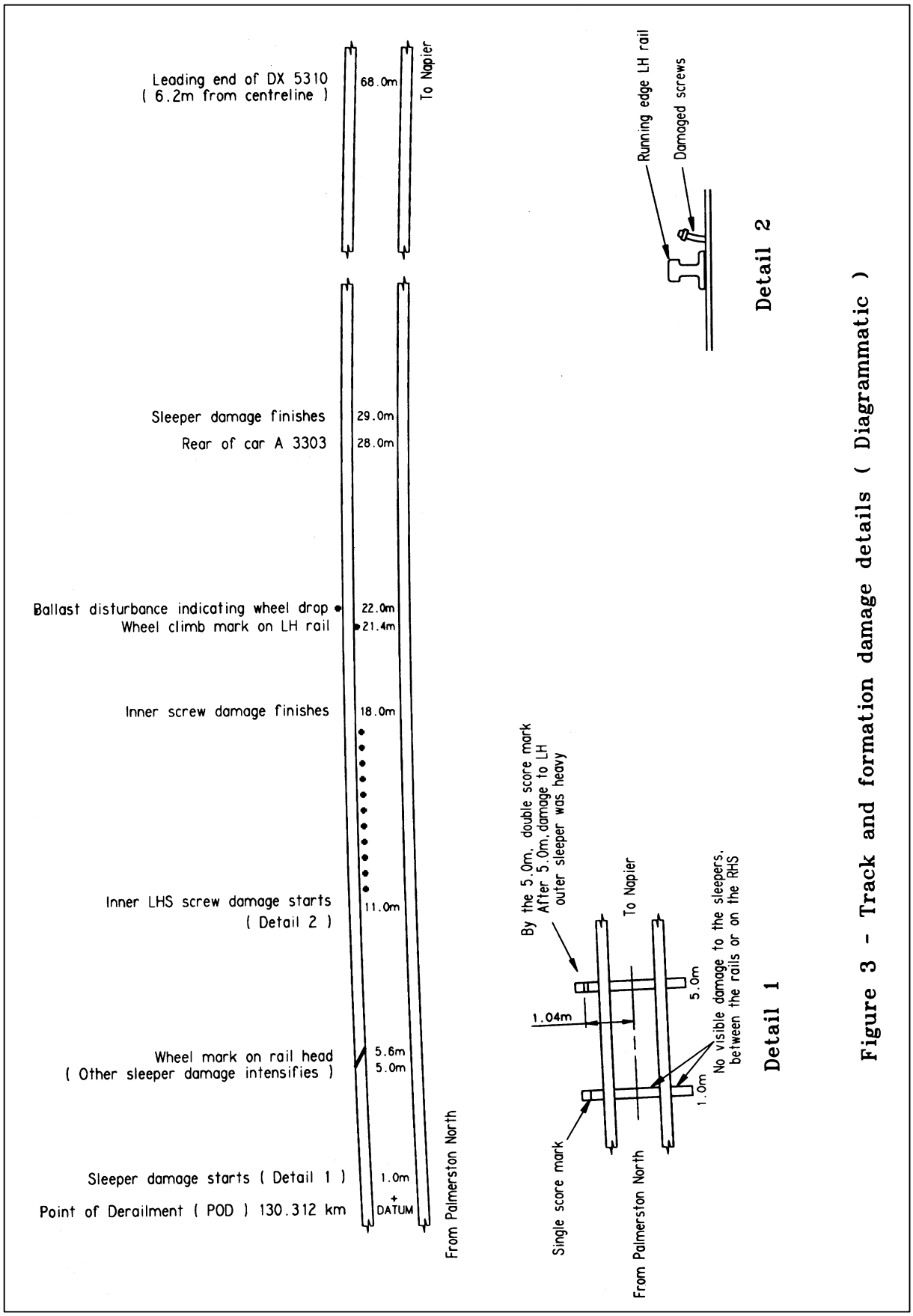

Figure 3 - Track and formation damage details (Diagrammatic)

1.30 Of the 28 adult passengers on board 13 classed themselves as regular users of the "Bay Express." Of these seven did not notice anything unusual about this particular trip and six considered the trip on 12 November 1995 was noticeably faster than any previous trip.

1.31 Two witnesses reported what they considered unusual behaviour as the train crossed Makotuku viaduct (Bridge 155 at 70.920 km). The witnesses lived adjacent to the viaduct and were used to the regular passage of Train 600. They stated that on 12 November 1995 it "was travelling at least twice as fast as any other trip" and discussed the possibility it might "come off the rails" as they watched its progress over the viaduct.

Track and formation marks

1.32 Figure 3 details the relevant derailment marks on the track and formation in the vicinity of the assumed POD.

Track details

1.33 The Pukehou straight was on level grade before a change to a 1 in 110 ascending grade just before the derailment curve.

1.34 The straight was laid in continuous welded rail (CWR) with 91 pound per yard rail on treated pinus radiata sleepers using N and A type fastenings and with 1 in 4 sleepers rail anchored. The CWR had been destressed approximately four weeks prior to the accident. The derailment curve was laid in 38m lengths of 50 kg/m rail on treated pinus radiata sleepers using N type fastenings with 1 in 4 sleepers rail anchored. Rail wear on the highleg rail in the vicinity of the POD was one increment of side wear and one of top, ie virtually negligible. Rail and sleepers were all in good condition and fastenings were tight.

1.35 A detailed measure up of track geometry was made following the derailment. Curvature and gauge were within acceptable limits for a nominal 200m radius curve. The Standard Cant (height of the high rail above the low rail) for a 200m radius curve was defined by TRL in Code Supplement CSP 33 (Curves - Design Criteria) as 70 mm. The actual cant on the curve at the time of the derailment "averaged" 45 mm with a maximum of 49 mm and minimum of 30 mm prior to the POD.

1.36 CSP 33 required authorised curve speeds to be set taking account of less than Standard Cant to contain cant deficiency within defined limits. To obtain the comfort associated with this controlled cant deficiency the authorised curve speed for this curve, based on 45 mm cant and after being rounded downwards, was 45 km/h.

1.37 The actual curve speed posted was 50 km/h, the normal speed for a 200m radius curve with Standard Cant of 70 mm.

1.38 As required by TRL's Rules and Code requirements a Curve Warning Board and Curve Speed Board were correctly positioned to warn LE's of the approaching curve. The Curve Warning Board was 367 m from the entrance to the curve and complied in all respects with the requirements laid down for a 200m radius curve with Standard Cant. The Curve Speed Board was 45m from the entrance to the curve and similarly complied in all respects with the requirement laid down, except that site inspection approximately 2 hours after the derailment revealed the Curve Speed Board was bent in half and that the posted speed was not visible (Figure 4). The board was straightened to its original condition immediately (Figure 5). The Curve Warning Board is shown as Figure 6.

Figure 4
Curve Speed Board at 130.150 km as found following the derailment

Figure 5
Curve Speed Board following reinstatement

Figure 6
Curve Warning Board at 129.828 km

Figure 7
Damage to cab of DX 5310

Inspections

1.39 The last Track Recording Car run over the area was on 3 October 1995. Apart from minor gauge irregularities reported as a low priority for action there were no track geometry exceedances reported in the vicinity of the POD as requiring attention.

1.40 The last specific inspection for checking the siting and suitability of Curve Warning Boards and Curve Speed Boards was in July 1995 at which time the Curve Speed Board at 130.150 was recorded as erected correctly, numbers clearly visible and with no growth obscuring it.

1.41 The last length ganger's inspection was carried out on 13 October 1995 with no recorded defects in the vicinity of the POD.

1.42 The last track patrol over the line was on Friday 10 November 1995 and carried out from north to south. The last south to north patrol was on Monday 6 November 1995. On neither occasion did the ganger notice a bent Curve Speed Board at 130.150 km. He considered it most unlikely that he would have failed to notice such an anomaly as the track in the area was good and it was unlikely his attention would have been diverted. The Ganger stated that it was common to find Curve Boards damaged or missing and he estimated such findings on 10% of his patrols.

1.43 TRL have a formal system for LE's to report track faults, including damaged or missing Curve Boards, to the Track Supervisor (loco 346 form). The last such speed board irregularity reported for the Palmerston North to Napier section was on 4 July 1994 and did not relate to the curve on which the accident occurred.

1.44 LE's who had travelled over the accident site south to north week ending 12 November 1995 could not recall any bent or obscured Curve Speed Board at 130.150 km.

Rolling stock details

1.45 Locomotive DX 5310 entered service in 1975 as part of an order from General Electric USA. The supply specification did not include any specific requirement for cab crashworthiness and no such details were submitted by General Electric to support their offer. The left hand side of the cab was crushed in the accident (Figure 7). This was the area occupied by the cab rider as the derailment occurred.

1.46 The three passenger carriages on the train were variants of Tranz Rail standard passenger stock, having been constructed originally in 1939 (A 3303 and AO 60) and 1941 (ASO 1), to a 1937 design. The cars consisted essentially of a steel underframe, wooden body framing with sheet steel sheathing and steel anti-collision ends. The latter were steel frames, attached directly to the underframes, which enclosed the vestibule area at each end of the cars and were incorporated primarily to protect the cars from telescoping in the event of a longitudinal collision.

1.47 The car body consisted of hardwood uprights, bolted to steel brackets welded to the underframe at the bottom, and bolted at the top to steel brackets connected to a timber rail which formed the edge of the plywood and timber roof diaphragm. Timber framing between the uprights and around the windows incorporated steel bracing which enhanced the longitudinal bracing. Transverse bracing was effected by the uprights themselves, and by the roof diaphragm and its connection to the steel frames. The uprights were 100 mm by 100 mm of good quality hardwood.

1.48 Carriages AO 60 and ASO 1 were converted to observation window vehicles in 1989, with the addition of steel members the length of the body to support the structural modifications and tie the two anti-collision ends to each other. This steel framing was bolted to existing timberwork above and below the new window opening, and welded to the existing anti-collision framing at each end. In addition the anti-collision end at the tail-end of ASO 1 was rebuilt to a new design

to maximise the viewing area and eliminate the side doorways, adding strength in case of end collision and roll-over.

1.49 This type of carriage has been the mainstay of Tranz Rail's express passenger fleet since the early 1940s, and with progressive modernisation and modification, has continued to be so to the present day. Improvements to the basic carriages in recent years included the replacement of the bogies by smoother-riding high-speed bogies, soundproofing, fixed seating as opposed to the earlier reversible seats, the use of fire-resistant materials in the interior finishing, and the replacement of the original opening window with fixed double glazed windows and pressure ventilation on carriages AO 60 and ASO 1.

1.50 Carriage ASO 1 had been converted from its original configuration as a class "A" passenger carriage into an ASO servery, observation windowed, tail-end car with seating for 24 in a "club" arrangement, with tables between each facing set of seats, and approximately 10 further passengers in the tail-end lounge. AO 60 had been converted to seat 51 passengers in a club arrangement similar to ASO 1. A 3303 seated 41 passengers in forward facing reclining seating.

1.51 AG 176 was a former "FM" brake van ("guards van") built in 1981. It was the train's "hotel" power and luggage van supplying 400/230 volt electricity from a diesel-powered alternator.

1.52 Although some passengers had been booked into A 3303, the leading carriage, the low passenger numbers on Train 600 prompted the TM to direct all passengers to the rear two carriages and lock the inter-connecting door on the leading end of AO 60 to stop internal access. This ensured all passengers had the best available facilities and kept A 3303 clean and ready for increased passenger numbers expected on the return trip as Train 601 from Napier.

1.53 The locomotive, van and carriages had all been inspected and had received the maintenance checks laid down by TRL Code requirements prior to the derailment. Locomotive wheel profiles as checked on C Service Routine on 26 October 1995 were well within defined limits. Inspection following the derailment did not reveal any specific defects which may have contributed to the accident.

1.54 The majority of minor injuries reported by passengers were caused by sliding into tables or onto the floor during the sudden stop. No specific injuries were reported relating to loose fittings or fixtures.

Locomotive event recorder

1.55 DX 5310 was fitted with an electronic event recorder in accordance with standard TRL practice for main line locomotives. The event recorder was removed and secured following the derailment.

1.56 The locomotive log extraction from data stored in the event recorder was carried out at the Palmerston North Locomotive Depot at 0910 hours on Monday 13 November 1995.

1.57 As a result of calibration based on the wheel diameter of DX 5310 the corrected (actual) speed as printed out on extraction was 4 km/h greater than the "log' speed at an actual speed of 99 km/h and 5 km/h greater at 101 km/h. (The "Log" speed is that shown on the locomotive's speed indicator). The calibration was based on TRL independently witnessed laboratory tests. TRL Mechanical Code required that Speed Indicators be accurate to within ± 5 km/h between 25 km/h and 100 km/h and DX 5310 complied with this Code requirement.

1.58 The log was certified as extracted at 0910 hours on 13 November 1995. The equivalent log time on extraction was certified as 0805 hours on Day 2. The difference can be attributed to the log time being based on NZST (1 hour behind actual time on 13 November 1995) and a five minute error on log time recording. When analysing the long log output 0105 hours were added to the logged time to derive arrival and departure times at specific locations and other timed information, used in the analysis.

1.59 Early in 1995 TRL adopted a policy of randomly checking event recorder output for compliance with authorised speeds and following up any apparent anomalies with the particular LE if necessary. At the same time TRL introduced a system of spot checking locomotive speeds using hand held radar, again with a follow up with the particular LE of the service if any exceedences were involved. In the case of the LE concerned in this derailment there had been no need for any specific follow up since these systems were introduced.

Operating details

1.60 Train 600 was operating under Track Warrant Control and held a valid warrant at the time of the derailment.

1.61 Details supplied by TRL on the running of train 600 over the six months June 1995 to November 1995 showed the 27 minute late departure from Wellington was an unusual event. The following departures 10 minutes late or greater occurred during this period, with corresponding time made up noted.

Date	**Departure Mins late** (Wellington)	**Arrival Mins late** (Napier)	**Time made up en route**
5/6/95	10	0	10
2/9/95	55	36	19
17/9/95	14	0	14
12/11/95	27	Pukehou derailment	
27/11/95	15	0	15
28/11/95	10	-2	12

Personnel

1.62 The LE had joined NZR in 1980 and obtained his second grade LE's qualification in 1985 and his first grade LE qualification in 1987. His latest "re-certification" was carried out on 21 July 1995 with expiry date of December 1997. He met TRL requirements for Road Knowledge and was entered in the Road Register as competent for the Palmerston North to Napier section. He had been driving passenger and freight trains on the section since 1987. His last trip from Palmerston North to Napier was on 29 August 1995 and his last trip between Palmerston North and Waipukarau was on 18 October 1995. The LE estimated he spent at least 10% of his rostered hours on the Palmerston North to Napier section and considered he had Road Knowledge of that section.

1.63 The LE had worked a night shift roster during the week prior to the derailment. The last of his four rostered shifts finished at 0750 hours on Friday 10 November 1995. At that time he had worked a 36 hour 40 minute week over six days and was rostered off duty until the return "Bay Express" trip on Sunday 12 November 1995. Sunday 5 November 1995 was a rostered shift not worked by the LE due to illness. He was suffering from a recurring chest infection although

this did not require him to take any medication during the week ending 12 November 1995. On the night of Saturday 11 November 1995 the LE was looking after his 2½ year old son who suffered from asthma. He stated his son was coughing through the night and as a result the LE woke at 0545 hours and could not get back to sleep. Apart from this his sleep and recreational patterns were reported as usual.

1.64 The LE underwent a urine test at TRL's request following the accident but declined a blood test. No results of the urine test were available due to loss of sample.

1.65 The TM and Stewardess were both experienced staff. The TM had been with TRL for 16 years and the Stewardess for seven years, five years of which had included Stewardess duties on the "Bay Express".

1.66 The cab rider had previously been employed by NZR as a locomotive engineer and was a friend of the LE's. He was visiting Palmerston North from New Plymouth and stayed Friday night with the LE before spending Saturday night in Levin. Before leaving Palmerston North he had asked the LE whether he could come for a ride on his Sunday shift to which the LE agreed. A loose arrangement was made to meet on Sunday morning at Palmerston North. The cab rider was late arriving at Palmerston North but Train 600 was also running late and he was able to join the LE in the cab. The cab rider did not hold a ticket of travel or a cab pass authorising him to ride in the locomotive cab.

1.67 TRL had a formal system for authorising travel in the cab of locomotives by means of a cab pass. This system was clearly defined and promulgated and widely known to operating staff. TRL advised a liberal interpretation was made when allocating cab passes. Although restrictions were sometimes required for group applicants or for particularly young or old applicants, every effort was made to meet reasonable requests. TRL have advised that if a particular request had been made for the circumstances relating to 12 November 1995 a cab pass would have been issued. Issued cab passes were accompanied by safety notices giving common-sense advice to recipients. This included advice to not disturb the LE but that he may converse when he was not busy.

2. Analysis

2.1 Score marks on the left hand side of the sleepers at 1.04 m from centreline between 130.313 km and 130.318 km were consistent with a contact made by the left hand side of the cowcatcher as the locomotive heeled, and indicated a POD at 130.312 km. The lack of any wheel markings climbing the left hand rail gauge face or crossing the rail head in the vicinity of the POD indicated derailment occurred when the locomotive heeled to the left as it entered the curve and all weight was transferred to the left hand wheels which then formed a fulcrum for over turning.

2.2 The markings and the relationship of the POD to the final position of Train 600 following derailment indicated derailment had occurred at high speed. Similar overturning derailments have occurred in New Zealand previously, the most notable being the derailment of a DA locomotive at Raurimu on 5 November 1975 and the derailment of the Silver Fern rail car at Waiouru on 18 August 1981. Both of these fatal accidents were subject to Boards Of Inquiry and in each case it was necessary to make assumptions regarding train characteristics and handling to deduce speed at derailment. In the case of the "Bay Express" on 12 November 1995 the electronic event recorder was available to reconstruct key train handling characteristics, including speed.

2.3 In the case of the Raurimu derailment the inquiry concluded overturning took place at 105 km/h on a 240 m radius curve with an authorised sped of 55 km/h, ie a safety factor of 1.9 existed. In the case of the Waiouru derailment the inquiry concluded overturning took place at 95 km/h on a 240 m radius curve with an authorised speed of 55 km/h, ie a safety factor of 1.7. The safety factor is a variable depending on the amount of rounding down in defining authorised speeds, the particular rolling stock and its loading and springing details, and instantaneous track characteristics.

2.4 In the case of the "Bay Express" on 12 November 1995 derailment took place at 89 km/h, ie a safety factor of approximately 1.8 on the posted speed of 50 km/h. This is considered a predictable outcome and one not requiring specific overturning calculations to substantiate cause.

2.5 The track leading up to the POD was in good condition and within acceptable tolerances, except for the undercanting of the curve (nominal 45 mm cant compared with 70 mm Standard Cant with a ± 15 mm tolerance upper limit). This had the effect of lowering the overturning speed by 1%, ie approximately 1 km/h. It is considered this had no appreciable bearing on the accident.

2.6 The maintenance history of the rolling stock and inspection following the accident did not reveal any factors which may have contributed to the derailment.

Train handling

2.7 The nature of the derailment (2.2) and the witness reports (1.30 and 1.31) prompted a check of the progress and performance of Train 600 from Palmerston North to the POD on the day in question to see if this indicated any pattern which might assist in establishing the reason for the high speed entry into the curve at 130.95 km.

2.8 The locomotive electronic event recorder supplied two printed logs for analysis:

a) The Short log, which gave details of speed, air pressure and throttle position every second for six minutes prior to the completion of recording.
b) The Long log, which gave day, time and speed every ten seconds for seven days prior to the completion of the recording.

2.9 Analysis of the Short log enabled confirmation of events immediately preceding the derailment. Speed and time were used to determine the kilometrage of the locomotive at any particular set of readings using the final locomotive position as datum.

2.10 Approximately eight seconds prior to derailment the locomotive was under power in notch 3 with normal 550 kpa brake pipe pressure and zero brake cylinder pressure and travelling at 98 km/h at a derived kilometrage of 130.102 km, ie some 93 m before entering the curve.

2.11 Approximately seven seconds prior to derailment the locomotive was still travelling at 98 km/h but brake pipe pressure had dropped to 320 kpa and the throttle position was zero. The derived kilometrage was then 130.129 km, ie, some 66 m before entering the curve, confirming the LE's recollection of seeing the curve 75 m ahead (1.13) and making an emergency brake application.

2.12 Over this period of seven seconds speed dropped uniformly over six seconds to 89 km/h before a sharper drop to 83 km/h over the last second. Speed then fell away to zero over two seconds from which it was deduced that derailment occurred at a speed of 89 km/h.

2.13 Analysis of the Long log enabled actual train speed over the section Palmerston North to POD to be compared to the various factors, such as maximum line speed, curve speed and speed restrictions, of which the LE was required to be aware and respond to appropriately. Again speed and time were used to calculate kilometrage and thus relate speed to location. For various reasons, including speed readings at ten second intervals and short and long kilometres[1], the accuracy of this relationship was assessed as ± 200 m (based on calibration checks at stopping locations). To make a conservative allowance for this the minimum speed attributed to any particular restricted location for comparative purposes was taken to be the lowest speed ± 300 m from the location.

2.14 Comparisons were made in three categories:

a) with maximum line speed on straight track,
b) with specific permanent or temporary speed restrictions,
c) with curve speeds.

The following details summarise the specific localities in the three categories showing maximum differences between authorised speed and actual speed.

Kilometrage	**Authorised Speed (km/h)**	**Likely Speed Indicator Reading (km/h)**	**Actual Minimum Speed (km/h)**	**Comment**
12.2 km to 12.4 km	25	60	63	Temporary Speed Restriction (TSR) Hillcrest Road Level Crossing
56.45 km to 56.55 km	40	68	71	Permanent Speed Restriction (PSR), Bridge 145.
58.9 km to 59.1 km	25	51	54	PSR Bridge 146
64.6 km to 64.9 km	50	60	63	200 m radius curve
70.92 km to 71.23 km	25	41	43	PSR Bridge 155 (see witness report, para 1.31)
73.98 km to 74.40 km	15	32	34	PSR Bridge 156
84.95 km to 85.06 km	10	20	21	TSR Bridge 162
93 km to 95 km	100	107	113	Actual max. speed on straight track over 2 km
121.15 km to 121.26 km	25	46	48	TSR, Otane South end turnout

[1] Short and long kilometres occur when track deviations occur between fixed kilometre pegs.

2.15 Analysis indicated that throughout the course of the journey from Palmerston North to POD the LE was aware of areas requiring restricted speed but was either not seeing, or ignoring, authorised speeds and using his own interpretation of appropriate speeds. This was particularly noticeable for permanent or temporary speed restrictions (generally taken at twice the authorised speed) but also evident by his negotiating curves at 26% above authorised speed. The LE was aware Train 600 was behind time and his desire for information of timings indicated by his Dannevirke request and his referral to his Working Timetable while negotiating the Pukehou straight, when viewed in conjunction with train speed throughout restricted areas, are considered indications of a strong desire to make up lost time.

2.16 The following table summarises information available covering actual arrival and departure times at various localities from Palmerston North to the POD on 12 November 1995.

Location	**Arrival Time Source**			**Departure Time Source**			**Times used for assessment**	
	1	2	3	1	2	3	**Arr.**	**Dep.**
Palmerston North	10.38	10.39	-	10.42	10.42	-	10.38	10.42
Woodville	11.13½	11.14	-	11.15	11.16	-	11.14	11.16
Dannevirke	11.33½	-	-	11.35	-	-	11.34	11.36
Takapau*	-	12.08*	-	-	12.08*	-	12.08	12.08
Waipukurau	12.19½	-	-	12.21	-	12.22	12.20	12.22

Sources
1. Locomotive event recorder (Refer 1.58)
2. Hand-written entry by TCO on Train Control Diagram
3. Train Manager's statement

Note: *Time through Takapau (non stopping) entered by TCO on panel indication of signal passed

2.17 The following summarises time made up by Train 600 following its arrival at Palmerston North based on the arrival and departure times derived above unless otherwise stated.

Locality and scheduled time (hours)	**Actual minutes behind time**	**Comments**
Palmerston North: arr 10:04	34	Normal 10 minute stop reduced to 4 minutes
dep 10:14	28	
Woodville: dep 10:54	22	Normal 3 minutes stop reduced to 2 minutes. 5 minutes made up in running PN - Woodville (27 km)
Dannevirke: dep 11:17	19	Normal 2 minute stop. 3 minutes made up in running Woodville - Dannevirke (26 km)

Locality and scheduled time (hours)		Actual minutes behind time	Comments
Takapau	11.55[2]	13	Approx. 6 minutes made up in running Dannevirke - Takapau (34 km). Normal two minute stop at Waipukurau.
Waipukurau	dep 12:12	10	3 minutes made up in running Takapau - Waipukurau (21 km)
POD	(12:35)	5	Derived based on timing of train 600 to timetable from train control diagram (12:35) and time of derailment (12:40). 5 minutes made up in running Waipukurau to POD (22 km)

Total time made up: 30 minutes
Made up at stops 8 minutes
Made up in running 22 minutes

2.18 The LE stated he was consulting his Working Timetable from approximately 128.5 km to 130.12 km, a distance which would have taken approximately 65 seconds to cover at the speed Train 600 was travelling. His stated purpose was to obtain arrival and departure times for Hastings (the only intermediate stop left before Napier) and arrival time for Train 600 at Napier and departure time of Train 601 from Napier. Why the LE needed to check his Working Time Table is not clear since he already had information supplied on leaving Dannevirke and was also aware that the Working Timetable did not contain information for Hastings. The only new information the LE would have derived would have been his departure time from Napier as Train 601 on the return journey.

2.19 The bent and obscured Curve Speed Board at 130.150 km was correctly sited 45 m before the entrance to the derailment curve. The LE stated he saw the approaching curve on looking up approximately 75 m before entry. If the Curve Speed Board had been in normal condition and displaying a 50 km/h authorised speed it is considered this would have had no effect on the end result. The key warning for the LE was the Curve Warning Board at 129.828 km, 367 m before the curve entrance. This was correctly sited and clearly visible but not noticed, or responded to, by the LE.

2.20 The left hand side of the DX cab was crushed during the derailment as a result of the high speed. The cab rider travelling on the left hand side of the cab was not trapped in the crushed cab although his leg was trapped initially. It is not known whether the severe abdominal injuries suffered by the cab rider were a result of the cab crushing or the impact arising from the derailment. Crashworthiness features of locomotive cabs have received increasing attention in locomotive design over recent years, particularly in North America. The design of the DX locomotive goes back to the late 1960s and is typical of many North American locomotives currently and widely used throughout world railways. Although the cab design does not reflect state of the art rollover resistance it is considered the resulting damage associated with a high speed derailment was consistent with a cab adequate for the purpose.

[2] Based on assessment of Train Control Diagram plot of train 600 running to timetable

2.21 The minimum damage suffered by the wooden body frame carriages was a function of the nature of the accident, ie. high speed locomotive rollover in generally easy terrain, which did not require the advantages of all steel bodies to minimise damage and any possible associated casualties due to direct collision.

2.22 The LE's statement indicated no discussion took place between himself and the cab rider after Otane (approximately 8½ km, ie 6 minutes, prior to the POD) which would indicate no direct distraction was caused by the cab rider's presence.

2.23 While it is clear that the primary cause of the derailment was excessive speed due to error of judgement on the part of the LE the investigation has not been able to clearly determine a factor, or combination of factors, which explain why such an error occurred and for this reason no specific safety recommendations are associated with the report. However it is considered notable that the only factors which appeared to distinguish this trip from many others made by the LE was the 34 minutes late running at Palmerston North and the presence of a cab rider who was not only a personal friend but an ex-locomotive engineer. The possibility that the LE's actions may have been influenced by these factors could not be discounted.

2.24 It is relevant that these two factors featured in the findings of the Board of Inquiry into the Silver Fern derailment in 1981. They were described as "lesser causes, but still significant" to the primary cause of error of judgement and "the next most powerful and significant cause was the incorrect and missing curve speed boards and curve warning board".

2.25 At the time of the Silver Fern inquiry no recommendation was made with regard to the possible distraction of the driver by the tourist in the cab or to the drivers desire to make up lost time. However the following was recorded as "steps already taken by the Department as a result of the accident and the inquiry"

> "2. Silver Fern drivers have been reminded of the provisions prohibiting unauthorised persons from travelling in the cab, and that provision is now being strictly enforced.
>
> 3. Notices prohibiting unauthorised persons from entering the driver's cab have been given greater prominence by placing such Notices on each of the doors entering the cab."

It is understood the action under 2 was not restricted to the cab of the Silver Fern but related to any cab riding. The notices referred to in 3 were related only to the Silver Fern and were not displayed in locomotive cabs.

2.26 The "Bay Express" investigation has indicated an apparent change of emphasis since 1981 with regard to the issue of cab passes to the extent that a tourist such as that associated with the Silver Fern derailment who applied for a cab pass could have a pass granted under the advised current TRL policy (1.67). It is considered this apparent conflict with the findings of the Silver Fern inquiry and action arising indicate it may be timely for TRL to consider a critical review of the advantages and disadvantages of their reported liberal regime for issuing cab passes with particular regard to the current high proportion of single man crewing in TRL operations.

3. Findings

3.1 The derailment occurred due to the excessive speed of Train 600.

3.2 Train 600 had exceeded authorised speed frequently throughout its journey from Palmerston North to the POD on 12 November 1995.

3.3 The LE was correctly certified for the duties concerned.

3.4 The LE failed to use his training, Road Knowledge and the line speed postings to control the progress of Train 600 safely.

3.5 The LE's apparent desire to make up lost time may have contributed to his failure to control the train safely.

3.6 The presence of the cab rider may have influenced the LE's actions.

3.7 The bent and obscured Curve Speed Board at 130.150 km did not contribute to the derailment.

3.8 The non-standard cant on the derailment curve did not contribute to the derailment significantly.

3.9 The condition of the track and rolling stock did not contribute to the derailment.

3.10 The fortuitous restriction of passengers to the two rear carriages minimised the potential for more serious passenger injuries arising from the derailment.

3.11 There was no indication in the LE's medical, work or recreational pattern of any factors which may have affected his fitness for duty on 12 November 1995.

3.12 The damage to the cab of DX 5310 was consistent with that expected in a high speed derailment for a locomotive of this age and type.

4. Safety Actions

4.1 The LE was immediately removed from operating duties by TRL.

4.2 As a result of the derailment TRL initiated a programme to identify all fittings and fixtures within passenger rolling stock which were not secured to withstand the forces which can be expected in incidents of this nature (including collisions and level crossing accidents). The relevant standards have now been incorporated into the Design Manual for the guidance of future work.

4.3 TRL have initiated a specific check of cant on curves as related to authorised speed and will take appropriate action to ensure compatibility where anomalies are found.

26 June 1996

M F Dunphy
Chief Commissioner