

# Australian Government

# Australian Transport Safety Bureau



ATSB TRANSPORT SAFETY REPORT Rail Occurrence Investigation RO-2007-006 Final

# **Derailment of Freight Train 6413**

near Stewart, Western Australia

17 August 2007



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# CONTENTS

THE AUSTRALIAN TRANSPORT SAFETY BUREAU vi				
ТЕ	RMINO	DLOGY US	SED IN THIS REPORT	. vii
EX	ECUTI	VE SUMM	IARY	ix
1	FACT	UAL INFO	ORMATION	1
	1.1	Overview		1
		1.1.1	Location	1
		1.1.2	Track Information	2
		1.1.3	Train and crew information	2
		1.1.4	Train control and signalling	3
		1.1.5	Environmental conditions	4
	1.2	The occur	rence	4
	1.3	Post occurrence		
	1.4	Toxicolog	y tests	7
	1.5	Loss and c	lamage	7
2	ANAI			9
	2.1	Sequence	of events	9
		2.1.1	Sequence of events analysis	. 10
		2.1.2	Examination of rolling stock	. 10
		2.1.3	Examination of the track	. 10
		2.1.4	Summary	. 16
	2.2	Train crew and train handling		. 16
		2.2.1	WestNet Rail operational rules	. 17
	2.3	3 Track maintenance		. 18
		2.3.1	Ultrasonic rail flaw detection	. 18
		2.3.2	Visual inspection/track patrol	. 20
		2.3.3	Removal of defect and insertion of replacement rail	. 20
		2.3.4	Rail records	. 21
3	FIND	INGS		. 23
	3.1	Context		. 23
	3.2	Contributing safety factors		. 23
	3.3	Other key findings		. 23

4 SAI		ЕТҮ АСТ	'IONS	
	4.1 WestNet Rail			
		4.1.1	Management of infrastructure records	
		4.1.2	Inspection and management of rail quality	
		4.1.3	Management of train speed	
AP	PEND	IX A : SO	URCES AND SUBMISSIONS	29

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#### Abstract

At about 0400 on 17 August 2007, the 48th wagon of Australian Railroad Group iron ore train 6413 derailed on a right-hand curve in a cutting 595.9 km from Perth in the Stewart to Bonnie Vale section of the Defined Interstate Rail Network in Western Australia. Thirty one wagons in total were derailed and 25 of those wagons were seriously damaged. There were no injuries. The track sustained significant damage and was closed for 4 days.

Train 6413 consisted of three locomotives and 126 wagons loaded with iron ore. It was travelling from Koolyanobbing to the port of Esperance, via Kalgoorlie. Rail traffic in this area includes fast passenger trains, general interstate freight and iron ore trains.

Train 6413 had been authorised by train control to pass a signal that had failed to clear following the passage of the previous train. Both the train controller and the train crew were aware that one possible cause of the signal failure was a broken rail.

The Australian Transport Safety Bureau (ATSB) investigation determined that the derailment occurred when a piece of rail containing a large, previously undetected vertical split head defect, disintegrated under train 6413. A rail insert that had recently been used to replace a section of defective rail found during a routine track inspection probably contained the defect. Alternatively, it was possible, but less likely, that the parent rail on either side of the insert may have contained an undetected vertical split head.

As a result of the investigation, the Australian Transport Safety Bureau identified a number of safety issues concerning train operations, record keeping and rail replacement practices.

# THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external organisations.

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

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

#### Purpose of safety investigations

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

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

### **Developing safety action**

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

# **TERMINOLOGY USED IN THIS REPORT**

Occurrence: accident or incident.

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

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

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

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

**Safety issue**: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

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

Critical safety issue: associated with an intolerable level of risk.

**Significant safety issue**: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable.

Minor safety issue: associated with a broadly acceptable level of risk.

# **EXECUTIVE SUMMARY**

At 0400<sup>1</sup> on Friday 17 August 2007, 31 wagons of train 6413 derailed in a cutting 595.9 km by rail east of Perth, between Stewart and Bonnie Vale on the Perth to Adelaide interstate main line. The derailment caused considerable damage to wagons and the track. The interstate main line was closed as a consequence for a period of 4 days.

On the day of the derailment, the down departure signal at Stewart, 10RA, failed to clear following the passage of train 5PM5. The next train through the section was 6413, which was following about 90 minutes behind 5PM5.

Train 6413 passed through Stewart and came to a halt at signal 10RA, which was displaying a red aspect. In accordance with the applicable WestNet Rail operational rules, train control authorised train 6413 to pass the signal by issuing a Proceed Order<sup>2</sup>. Train 6413 proceeded past signal 10RA, accelerated to 60 km/h, then later decelerated to 45 km/h before entering the curve where the train derailed.

Train 6413 travelled over a broken rail in the curve until the 48th wagon derailed, as did another 30 wagons behind it. Damage to wagons and the track was extensive. The broken rail was not seen or felt by the train drivers as the locomotive traversed the site.

The Australian Transport Safety Bureau (ATSB) investigation determined that the derailment occurred when a piece of rail containing a large, previously undetected vertical split head<sup>3</sup> defect, disintegrated under train 6413. A rail insert that had recently been used to replace a section of defective rail found during a routine track inspection, probably contained the defect. Alternatively, it was possible that the parent rail on either side of the insert may have contained an undetected vertical split head.

The ATSB determined that the speed of the train probably contributed to the severity of the derailment and that the WestNet Rail operating rules do not stipulate an appropriate speed associated with the issuing of a Proceed Order. It was further established that the WestNet Rail infrastructure test procedures were probably not followed in that a section of worn rail<sup>4</sup> had been used in the track but it had not been ultrasonically tested before allowing the passage of unrestricted traffic. It

(b) occur throughout the remainder of the rail and therefore result in multiple breaks.

<sup>1</sup> The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST).

<sup>2</sup> Proceed Order – Authorisation by an qualified officer, usually a 'train controller', for rail traffic to pass a signal displaying a stop indication and enter a single line section of track.

<sup>&</sup>lt;sup>3</sup> Vertical split head - An internal defect within the head of the rail. It is a progressive vertical fracture in the rail, where separation along a seam spreads vertically through the head, parallel to the side of the rail. It can:

<sup>(</sup>a) result in a long section of the rail head falling out; and

<sup>4</sup> It is common practice to use 'worn rail' to replace a defective section of rail. The section of 'worn rail' is selected on the basis of having a profile matching that of an existing rail rather than using new rail that may have an incompatible profile.

would also have been desirable to ultrasonically check the parent rail on either side of the insert.

As a result of the investigation, the ATSB has identified a number of safety issues concerning train operations, record keeping and rail replacement practices. The ATSB acknowledges that WestNet Rail has been proactive in implementating a number of safety initiatives in advance of this final report to enhance rail safety on its network.

## **1 FACTUAL INFORMATION**

### 1.1 Overview

At 0400 on 17 August 2007, the 48th wagon of eastbound train service 6413 derailed in a cutting 595.9 km by rail east of Perth, while travelling between Stewart and Bonnie Vale on the Perth to Adelaide interstate rail line. The 49th wagon also derailed, as did the 53rd wagon and the following 28 wagons. The train parted between the 45th and 46th wagons, and between the 52nd and 53rd wagons. The derailment caused considerable damage to the wagons and the track. The interstate rail link was closed as a consequence for a period of 4 days.

### 1.1.1 Location

The derailment site was located on the Perth to Adelaide standard gauge Defined Interstate Rail Network (DIRN), about 55 km by rail west of Kalgoorlie. This section of the DIRN is maintained and managed by WestNet Rail and runs in an east-west direction and links Western Australia with the eastern States.



Figure 1: Location of Stewart

Map - Geoscience Australia. Crown Copyright ©.

#### Figure 2: Location of derailment site



Map - Geoscience Australia. Crown Copyright ©.

### 1.1.2 Track Information

The track structure through the derailment site consisted of continuously welded rail weighing 47 kg/m, supported on ballasted concrete sleepers spaced at approximately 660 mm, and secured using resilient clips.

The derailment at Stewart occurred on a right-hand 2400 m radius curve, in the direction of travel. The curve extends from 595.23 km<sup>5</sup> to 596.06 km and is mostly contained within a cutting that is up to 10 m deep. The transition area at each end of the curve extends for a further 50 m.

The track to the west of the curve, and leading into the curve, was straight for 6.6 km with a falling grade of 1 in 660 for 2.8 km. The track through the curve had a falling grade of 1 in 656, with the track to the east of the curve having a falling grade of 1 in 664 for 400 m followed by a rising grade of 1 in 661 for a further 1.1 km.

Trains travelling on this section of the DIRN have maximum speed limits, defined in the working timetable. These range from 90 km/h for loaded ore trains to 160 km/h for passenger railcars.

Travelling in an easterly direction, the track leading into the curve had a maximum allowable speed limit of 125 km/h for passenger trains. Loaded iron ore trains, such as the derailed train, are limited to 90 km/h.

### 1.1.3 Train and crew information

### Freight train 6413

Train 6413 is a regular iron ore train service operated by the Australian Railroad Group (ARG), a subsidiary of Queensland Rail (QR). The train was fully loaded, carrying iron ore for overseas export. It commenced its journey from

<sup>5</sup> Distances are track kilometres measured from Perth terminus.

Koolyanobbing East at 2350 on Thursday 16 August and was travelling to Kalgoorlie, then on to the port of Esperance. The train comprised three locomotives (Q4009 leading, Q4018 second and Q4011 trailing) and 126 loaded wagons. The train was 1407 m long with a total weight of 11 600 t.

### Train drivers

The train crew consisted of two drivers. The driver at the time of the derailment had accumulated about 13 years train driving experience; 11 years experience in South Africa followed by 2 years in Australia. The driver assisting at the time of the derailment had 2 years driving experience, preceded by 1 year as a trainee driver. Both train drivers were appropriately qualified, assessed as competent and medically fit for duty. Both drivers had a good service history.

### 1.1.4 Train control and signalling

The track over which train 6413 was travelling consisted of bi-directional single line with crossing loops (short sections of double track, see Figure 3) provided at regular intervals to allow trains to pass each other.

The safe-working system used to manage track access in the section where train 6413 derailed, was Centralised Train Control (CTC). The signals reading into and out of the crossing loops are 'Absolute' signals. The signals were remotely controlled from a train control operations centre located at Northam, 467 km to the west of Stewart.

Trains are not permitted to pass an 'Absolute' signal when it displays a 'Stop/Red' aspect unless authorised by the train controller by means of a 'Proceed Order'. The single line track section between the crossing loops was further divided by automatic signals; 'Permissive' signals. These signals can show a proceed (green or yellow) aspect for fleeting train movements (trains travelling in the same direction) if the track in advance of the signal is clear of train movements. The 'Absolute' signals are interlocked to prevent opposing train movements entering the single line section simultaneously.





Signals and points in the CTC area are remotely operated by commands issued by the CTC train control computer. Train position is detected by track circuitry and indicated on an electronic display in the train control complex. Train controllers communicate with train crews and track workers using UHF radio or telephone.

Signal circuits are designed to fail-safe, that is, if a fault occurs a signal viewed by a train driver should revert to a more restrictive or 'Stop' indication until the fault is identified and the system is repaired. For example, a discontinuity in a track circuit caused by a broken rail will generally cause the signal reading over the broken rail to display a 'Stop' indication to the train driver. This information is repeated on the train control display and will appear as if a train or a wagon is located in the affected track section.

Train crews or workers do not usually operate the points at crossing loops, unless there is a fault with the signalling system. They then operate the points as detailed in written instructions, the WestNet Rail operational rules, and as directed by the train controller.

### 1.1.5 Environmental conditions

At the time of the derailment, it was dark with no background lighting, the moon was below the horizon and there was no source of external illumination, other than the train's headlight. The air was clear and visibility was good. Weather in the vicinity of Kalgoorlie was fine with a temperature of about 3.8 degrees Celsius. The lowest temperature for the day was recorded at 0600 and was fractionally lower at 3.7 degrees Celsius. Wind speed was 3.8 km/h from the east.

### 1.2 The occurrence

On Thursday 16 August 2007, train 6413 departed Koolyanobbing East at 2350 bound for Esperance. The passage of the train from Koolyanobbing East to just west of Stewart was uneventful.

Prior to the arrival of train 6413 at Stewart on Friday 17 August, freight train 5PM5, running from Perth to Melbourne, passed through Stewart at 0240. Following the passage of this train through the Stewart to Bonnie Vale section, the train controller at Northam noticed that the track indication leading into the single line section, immediately in advance of the down departure signal (10RA), was showing occupied and that the signal could not be cleared, that is, it remained set at 'Stop'.

At 0310, just before train 6413 arrived at Stewart, the ARG train controller contacted the train driver to advise him that the Stewart signal, 10RA, was at 'Stop' and the driver would require a Proceed Order to pass it. Train 6413 came to a stand just in front of signal 10RA (at about 0327) and the driver confirmed to the train controller that the signal was at 'Stop'. At 0336 the train controller issued a Proceed Order to the driver in accordance with the WestNet Rail rules. While issuing the order, the train controller clearly advised the train driver that the track fault was between the Departure signal (10RA) and the next signal in advance (D598) and that he should keep a lookout. The train resumed its journey at 0343, accelerating steadily to 60 km/h then decelerating to 45 km/h just before entering the sweeping right-hand curve located within a cutting just in advance of the point of derailment.

The train accelerated on exiting the curve until the driver felt a slight jerk. He then noticed that the brake pipe air pressure was dropping rapidly. As the cause of the brake pipe pressure drop was unknown and could have been due to the train parting at a broken coupling, the driver initially maintained the locomotive throttle at notch 4, then throttled off allowing the brakes to bring the train to a halt. The train came

to a stand 600 m beyond the first point the driver felt the jerk and saw the associated decrease in brake pipe pressure. After bringing the train to a stand, the driver walked back with torch in hand to determine what had caused the decrease in brake pipe pressure. The second driver contacted train control to advise that the train had lost brake air pressure and come to a stand in the section.

The driver walked towards the rear of the train and found that the coupling knuckle on the back of the last wagon in the front portion of the train was broken. He continued walking a further 300 m and found a string of seven wagons, several of which were derailed. The driver then walked a further 200 m and came to derailed wagons stacked in the cutting. He advised the second driver of his findings and returned to the locomotive, applying handbrakes on all wagons of the first two portions of the train as he passed them. The second driver contacted train control at 0433 to advise the extent of damage. Train control closed the line and alerted ARG and WestNet Rail regarding the derailment.

The train crew requested that the driver of the first on-site recovery vehicle travel to the rear of the train and apply protection (place detonators and a red flag on the track).



Figure 4: View looking east into derailment site

### 1.3 Post occurrence

Following the derailment, the first road vehicle to arrive on site was an ARG train crew car that had been despatched from Kalgoorlie by train control. The ARG local operations co-ordinator arrived shortly after and a full derailment response was initiated.

The Australian Transport Safety Bureau (ATSB) was notified of the derailment at 1035, six hours after the derailment was reported. A response team was launched

from Adelaide and Canberra, arriving on site at 0900 on Saturday 18 August. Earthworks machinery from Kalgoorlie was on site at that time constructing access roads and pads for cranes. Cranes were despatched from Perth and began arriving on site and setting up on Friday afternoon. Construction of replacement track sections adjacent to the site was also underway by Friday afternoon.



Figure 5: View from embankment showing some track damage

Figure 6: View from embankment showing damage to wagons



Due to the extent of damage to rolling stock and track (Figure 5 and Figure 6), the collection of site evidence needed to be co-ordinated along with site recovery operations. Evidence from the locomotives and the 45 wagons that had not derailed was gathered first. The undamaged vehicles were released and were able to proceed to Kalgoorlie. Following this, evidence was collected from the damaged section of track and the detached group of 7 wagons located on the Kalgoorlie side of the cutting. This part of the site was then released for recovery and track reconstruction. Rail from this section was recovered and set aside.

In parallel with this work, initial removal of wreckage from the cutting commenced. The compacted nature of the wagons made recovery difficult, with the metal of the wagons distorted and wrapped together. Some wagons were embedded into the cutting walls. Large excavators were used to remove the iron ore, tear the wreckage apart and clean out the cutting.

The derailment in the cutting had shattered the rails and concrete sleepers, and ploughed the track, ballast and formation layers. Pieces of rail that were intermingled with the wagon wreckage were identified and set aside. Following the removal of wreckage, the cutting bed was excavated down to undisturbed material prior to commencing track reconstruction. As the excavated material was stockpiled adjacent to the rail corridor, any additional rail fragments that were discovered were retrieved and set aside.

The site was revisited by an ATSB investigator following the completion of recovery and cleanup operations. All recovered rail was photographed, examined and details recorded.

### 1.4 Toxicology tests

Drug and alcohol tests were administered on site to the two train drivers by the ARG local operations co-ordinator. The tests indicated zero blood alcohol content for both drivers.

### 1.5 Loss and damage

As a result of the collision, there was extensive damage to rolling stock and the track. Twenty eight wagons sustained damage ranging from moderate to severe. Approximately 300 m of rail and concrete sleepers had to be replaced. Fifty metres of formation was reconstructed. The track was re-opened for traffic on 21 August 2007.

## 2 ANALYSIS

Following the derailment of ore train 6413 at Stewart at 0400 on Friday 17 August 2007, the Australian Transport Safety Bureau initiated an investigation under the *Transport Safety Investigation Act 2003* (TSI Act).

ATSB investigators arrived on site at approximately 0900 on Saturday 18 August 2007. Evidence was gathered from various sources, including WestNet Rail and the Australian Railroad Group (ARG). Evidence included train control graphs, train control voice and data logs, locomotive data logs, organisational documentation, network rules and procedures, technical documents, site drawings, maintenance records and track upgrading records. The investigation team also examined and photographed the accident site.

The preliminary examination of this evidence established that:

- There were no mechanical defects or deficiencies with the train that would have contributed to the accident.
- The two drivers were medically fit at the time of the derailment.
- The signalling system was operating properly and did not contribute to the accident.

### 2.1 Sequence of events

#### Figure 7: Extract from Q4009 locomotive data log, Stewart to 'Point of Derailment'



### 2.1.1 Sequence of events analysis

The train driver and second driver commenced work at Kalgoorlie West at 1845 on Thursday 16 August. They crewed train 5416 (three locomotives and 126 empty iron ore wagons) from Kalgoorlie West, departing at 1920, to Koolyanobbing, arriving at 2210. The train was then loaded with iron ore and re-designated as train 6413.

Train 6413 departed Koolyanobbing East at 2350 for Esperance. The trip was uneventful until train 6413 arrived at Stewart where signal 10RA was displaying a 'Stop' indication. At 0336, the train controller at Northam issued a Proceed Order to the driver authorising the train to pass signal 10RA, displaying a 'Stop' indication, in accordance with the WestNet Rail rules. Train control recordings show that while issuing the order, the train controller clearly advised the train driver that there was a track fault between the Departure signal (10RA) and the next signal in advance (D598) and that he should keep a lookout. The Proceed Order required that the train driver 'proceed cautiously' in accordance with the WestNet Rail rules and to look for obstructions on the track, including the possibility of a broken rail.

The locomotive data log for Q4009 (Figure 7) shows that after receiving the Proceed Order, the train steadily accelerated using throttle setting notch 1, followed by notch 2. The train accelerated to 50 km/h on a falling grade. At that time, dynamic braking was applied. The train continued to accelerate to a maximum speed of 60 km/h until the effects of the dynamic brakes combined with a change in track gradient slowed the train to 45 km/h. The dynamic braking was reduced to maintain this speed through the curve commencing at 497.45 km. As the lead locomotive exited the curve and the green indication of signal D598 came into view, the train driver throttled up and started to accelerate the train. Shortly after, the train driver felt a slight jerk and the brake air pipe pressure began dropping.

The brakes on train 6413 applied automatically. The driver kept the throttle on notch four until he was satisfied that any loose wagons would not overrun the train, he then decreased the throttle and the train came to a halt.

### 2.1.2 Examination of rolling stock

All rolling stock involved in the derailment was examined, with a particular focus on vehicle suspension, wheel profiles, braking performance, wagon loading and integrity of the ore wagons and locomotives. No issues were identified that would have had any direct or indirect causal effect on the derailment.

Weighbridge records showed that none of the loaded ore wagons in the train consist exceeded an axle load of 22.5 t. The locomotive axle loads were below 22 t. Therefore the axle loads were below the maximum load limit specified for trains on this section of the DIRN. Observation of the loaded wagons that had not derailed revealed that loading was relatively uniform between the front and rear of the wagons.

### 2.1.3 Examination of the track

In general, the track structure through the derailment site was considered to be in good condition with the ballast crib and shoulder being full. The rail at the derailment site had been severely damaged during the derailment, with much of it

buried beneath spilled iron ore and ploughed into the formation material. During the restoration of the track and clean-up of the site, all rail recovered was laid out adjacent to the site. The various pieces of rail that were recovered as wagons and debris were removed from the cutting were set aside for detailed examination.

The longer sections of rail recovered from beneath the derailed wagons in the cutting area were 94 lb/yard AIS branded rails, manufactured between 1965 and 1967. One leg of a section of rail was dated 1968. Closure rails<sup>6</sup> were also identified and dated within this range, with three exceptions. One closure rail was rolled in April 1963, one in August 1972 and one in November 1941.

Rail removed from the damaged track to the east of the cutting was also examined. Again, most of the long rail was manufactured between 1965 and 1967, except for one leg dated February 1964. A further closure rail was found and dated April 1942.

Track construction in this area was consistent with that built in 1968/69 as part of the provision of a standard gauge rail link between the east and west coasts of Australia. However, the records that might indicate when the older closure(s) were placed into service were not available and presumed lost (See Section 2.3.4).

The curve through the derailment site carried a superelevation of 35 mm consistent with achieving good comfort for a passenger train travelling at 125 km/h. As a consequence of the relatively light 47 kg/m rail section and the bogie capabilities of ore wagons, the speed of ore trains was limited to 90 km/h. Consequently, the vertical loads exerted by the wheels of ore trains on the low leg of the rail of curves on this section of track were greater than if the train was travelling at passenger train speeds.

The rail on the low leg of the curve where the derailment occurred had deteriorated, probably as a result of diverse rolling stock traffic running at suboptimal speeds. The rail itself was relatively light in cross section (47 kg/m) when considering the tonnage carried over this track.

The heavy loading on the low leg of the rail caused considerable head flow<sup>7</sup> (Figure 8) on the curve in this section. The rail at the location of the derailment exhibited considerable deformation, which probably facilitated the widening and propagation of a vertical split head crack.

Some of the pieces of rail that exhibited a vertical split head (Figure 8) defect were removed by ATSB investigators for subsequent examination. Those pieces were fragmented and damaged in ways that indicated they had probably been at or near the initial break and point of derailment (POD).

The high rail was less severely worn. All rail was within specified wear limits.

<sup>6</sup> Closure rail –Refers to a matching section of rail that is inserted/used for replacing a section of rail within a running line – it closes the gap resulting from the removal of rail.

<sup>7</sup> Head flow – the deformation of the steel in the head of a rail as the result of wheel loads over time.



#### Figure 8: Vertical split in rail head

The investigation noted that the derailment occurred during a cold part of the morning when the rail would have been under significant tensile stress and therefore most likely to break under the dynamic load of a train. It is likely that the first detectable signs of catastrophic rail failure may have been a transverse break which occurred immediately before or during the passage of the previous train (5PM5) and which was the cause of signal 10RA failing to clear, due to this break in the electrical path through the rail.

The crew of the derailed train reported that they did not hear or feel any irregularity during the passage of the lead locomotive as it passed over the derailment site. This indicated that any rail break gap was not significantly wide at this point in the event sequence and that the rail ends were not vertically displaced to any appreciable extent by the passage of the locomotives. It is possible that the break occurred over a sleeper, rather than between sleepers. The lack of any report by the train drivers of an audible indication and thumping, was indicative that no part of the rail had broken away until after the passage of the locomotives.

Thirteen pieces of recovered rail were subjected to metallurgical examination at the Metlabs Limited facilities in Perth. Some of the fractures involved were horizontal through the rail web and resulted in head/web separation (Figure 9). The most notable feature, present in several of the sections of track examined, was a large, vertical split through the head and web of the rail. The entire length of the split could not be determined because some pieces of rail from this location were never found.



Figure 9: Vertical split in rail head with secondary cracking into rail web

Selected samples were also taken to the ATSB test facilities in Canberra for further examination. A metallographic section was prepared through the split rail head (Figure 10). There was a significant difference in grain size locally adjacent to the split, compared to the bulk of the material. This indicated possible alloy segregation.

Visible in the same section of rail were secondary cracks, progressing from the web section through to the running surface (Figure 11). Those cracks were opened to expose the fracture surface by cutting the opposite side of the head (Figure 12).

The rail chemistry was analysed by optical emission spectroscopy and was found to conform to the requirements of Australian Standard E22-1964 for steel rails (Table 1).

	Spectroscopy results	AS E22-1964
Fe	balance	balance
С	0.69	0.60 - 0.73
Mn	0.64	0.60 - 0.90
Si	0.11	< 0.30
Р	0.02	< 0.05
S	0.02	< 0.07

#### Table 1: Rail spectroscopy results compared to AS E22-1964 requirements



Figure 10: Cross section showing coarse/fine grain structure segregation



Figure 11: Secondary/transverse crack in rail head

Figure 12: Section through crack shown in Figure 11



From an examination of the rail sections, it was found that the rail fracture was almost certainly caused by a vertical split head defect.

It was likely that the vertical split opened up over a considerable period of time and spread longitudinally along the rail length as well as vertically through the rail web.

Cracks then emanated from the split in the rail, both along the horizontal plane through the web and transversely through the rail head, resulting in the liberation of significant sections of rail.

The origin of the vertical split head was probably a pre-existing manufacturing defect such as the grain segregation shown in Figure 10. There were no other obvious material flaws detected and the chemistry of the rail was in accordance with the manufacturing specification, AS E22-1964.

### 2.1.4 Summary

An examination of the evidence suggests the following as the probable derailment sequence:

- A vertical split head defect was present in the low rail. The defect progressively grew under traffic until cracks began to develop in the rail perpendicular to the initial defect.
- The perpendicular cracks then eventually led to the rail breaking while under tension on the cold night of 16 17 August, probably as the train (5PM5) preceding the derailed train passed over it.
- The rail break probably occurred over a sleeper, as the crew of train 6413 reported that they did not hear any significant noise or feel any rolling wheel contact jolt as would have been expected if the break was between sleepers.
- The rail faces at the break parted sufficiently for the electrical track circuit to be broken and signal 10RA to display a 'Stop' indication.
- The rail probably failed catastrophically as the 48th wagon passed over the broken rail at the derailment site. At this time the train was accelerating, which would have increased lateral forces on the low rail as the in-train forces pulled the wagon inwards on the curve. It is likely that either the head of the rail or a piece of rail broke out at this time. This would have allowed the wheels to derail to the inside of the curve.
- The following wagons then progressively derailed, with the derailment forces further fracturing and then completely destroying the rail.
- The derailed wagons caused sufficient drag forces to part the train between the 45th and 46th wagons, and the 52nd and 53rd wagons.
- The 53rd and following wagons were concertinaed between the walls of the cutting by the inertial forces in the rear of the train.

### 2.2 Train crew and train handling

Based on interviews with the drivers, as train 6413 approached the broken rail the rail head probably appeared intact. From the viewpoint of the drivers in the locomotive cabin, travelling at 45 km/h and at night, it would have been difficult if not impossible for the them to see a broken rail defect.

The driver's actions following the derailment, that is, noticing the drop in brake air pipe pressure and maintaining locomotive speed for a period to ensure that trailing wagons would not overrun the front of the train if the train had parted, showed good situational awareness and judgement.

An examination of the drivers' roster established that the crew had the opportunity for ample rest prior to the accident. It was therefore considered that fatigue was not a factor in this accident.

The investigation examined the appropriateness of allowing train 6413 to accelerate to 60 km/h after being issued a Proceed Order.

### 2.2.1 WestNet Rail operational rules

When signal 10RA did not clear, the train controller at Northam authorised train 6413 to pass it in accordance with WestNet Rail Rule 18(4) which states:

When a Departure Signal has been passed at Stop in accordance with subrule 3 of this rule, the Driver must:

- (a) Proceed cautiously being prepared to fin d the section occupied or obstructed, points wrongly set, a broken or displaced rail until arrival at a further signal.
- (b) Stop and examine the points in the track section to which the signal applies to ensure they are correctly set for the passage of the train.
- (c) Examine switchlock doors to see they are properly closed.
- (d) Approach any protected level crossing in the vicinity of the Departure signal cautiously and ensure the protection is activated before passing over the crossing.

There was no clear guidance within the WestNet Rail rules for train drivers that defined an allowable speed associated with 'proceed cautiously'. Had the train been travelling at a slower speed, it is probable that the extent of damage caused by the derailment would have been considerably less.

Loaded iron ore trains are already speed limited to 90 km/h and the curve where the derailment occurred is of a large radius and thusdoes not require a reduction in speed limit.

The speed at which train 6413 was travelling when the derailment occurred had a direct bearing on the track failure and the severity of the damage. Travelling at 45 km/h exerts five times the dynamic force on the track structure, compared to travelling at 20 km/h. A broken rail on concrete sleepers is much more likely to shatter and spread under higher dynamic forces.

Given the probability of a broken rail as a cause for the signal failure, the speed of train 6413 through the section was probably too high. The WestNet Rail rules did not provide train drivers with clear advice on an appropriate train speed in these circumstances. Although the driver's actions fell within the guidance provided by the rules, it is considered that the speed of the train contributed to the extent of damage and was probably not consistent with sound defensive driving practice.

It is noteworthy that in some states operational rules make specific reference to low speed<sup>8</sup>, or to a speed generally not exceeding 25 km/h, in similar circumstances. The Code of Practice for the Defined Interstate Rail Network published by the Rail

<sup>8</sup> Low speed is a speed which will enable a train movement to be stopped within half the distance that the line is seen to be clear ahead, but which does not exceed 25 km/h.

Industry Safety and Standards Board<sup>9</sup>, states under 'PROCEED AT CAUTION handsignals':

....rail traffic crews to proceed at a maximum of 25 km /h, unless told otherwise (ANRP NGE 202).

### 2.3 Track maintenance

The integrity of track is fundamental to running a safe railway, as is the routine maintenance and inspection of the track in guarding against track failure and possible train derailment.

Track integrity is dependent on the inter-relationship of many track elements including the sub-base, ballast bed, sleepers, rail/rail joints, and fastening systems. The failure or degradation of any one of those elements can compromise the safe operation of the railway. Inspection and maintenance strategies are therefore essential in guarding against the risk of track failure.

Existing rail maintenance strategies used by WestNet Rail relied on three primary areas of inspection to detect rail faults:

- visual inspection/track patrols
- mechanised track geometry testing/measurement, and
- rail flaw detection/ultrasonic inspection.

Prior to the derailment, the most recent visual inspection of the track at the derailment location was on 11 August 2007, and a visual inspection from the adjacent access road took place on 15 August 2007. The most recent mechanised track geometry inspection was on 21 June 2007. The most recent ultrasonic inspection took place on 6 June 2007.

Following the detection of a fault, it is essential that the risk represented by the fault be assessed, and an appropriate and effective action plan be implemented to ensure continued track integrity. Track integrity was not maintained in this incident.

### 2.3.1 Ultrasonic rail flaw detection

The mechanised ultrasonic testing of rails on the line was carried out under contract by Rail Technology International (RTI) in accordance with WestNet Rail guidance *Specification for Ultrasonic Testing of Rail in Railway Applications 2006*. This contract called for RTI to examine the track by ultrasonic means to identify flaws, including cracks in the rail. Cracks are predominantly caused by fatiguing of the rail under working load and often grow over time from a small initiating flaw in the rail metal.

The contract required that the section of track between Kalgoorlie and Koolyanobbing be tested twice a year. Those inspections were carried out as scheduled.

RTI provided the ATSB with the following information on their testing processes:

<sup>9</sup> A wholly owned subsidiary of the Australasian Railway Association (ARA).

- 7 probes (Channels) per side (Rail) i.e. per rail = 2 x 70 degree (forward/reverse), 2x 38 degree (forward/reverse), 1 x 0 degree, 2 x 45 degree lateral (across rail)
- Lubricant or Couplant is water with the addition of a wetting agent (detergent based).
- Once detected via the 8000SX system, these reflectors are confirmed by hand sizing techniques.
- When a defect is found, it is hand sized utilising a digital ultrasonic hand set (method to Australian Standard) and results are classified and reported as per the WestNet Rail standard.

The 2 x 45 degree lateral probes (Figure 13) are positioned to detect vertical split head defects in the rail, that is, cracks that are vertical and run within the head and web of the rail, parallel to the face of the rail. They are additional to the basic requirements of RTI's contract with WestNet Rail.



Figure 13: RTI Ultrasonic test car

A review of the data collected by the ultrasonic on-track test car on 6 June 2007, revealed that a small vertical split head defect had been detected in the area most likely to have been near the point of derailment. At that time, the recording vehicle had reversed over this defect and re-tested it to ensure that the reading was not due to distortion or loss of signal arising from poor rail condition.

The data resulting from the RTI inspection run of 6 June 2007 is shown at Figure 14. The three passes over the vertical split head are highlighted. The disparity in location on track is due to inaccuracies in the spatial location parameters of the recording vehicle. The recording system overlays the results of multiple runs into a composite picture based on kilometerage.

Analysis of the data confirms that the three traces were from one vertical split head fault. As the fault was below the minimum reportable size it was documented by RTI within a summary of the work carried out during the inspection run, but not reported to WestNet Rail.



Figure 14: Portion of RTI inspection run of 6 June 2007

### 2.3.2 Visual inspection/track patrol

Visual inspection and ultrasonic inspection are the main methods for detecting most rail defects. Ultrasonic testing and measurement has not always proved effective in detecting vertical split head defects, however, it is a very effective tool when used in conjunction with an overall inspection strategy. Visual inspection can be effective in detecting cracks at the rail surface and deformations in the rail, provided there is physical evidence of deformation at the rail surface as may occur with a vertical split head defect. The WestNet Rail standards<sup>10</sup> state:

Visual detection is by seeing a widening in the top of the rail head, or the dropping of one side of the rail head.

WestNet Rail indicated that a vertical split head deformation, close to the derailment site, was visually detected by the local track patroller and was being monitored in accordance with WestNet's Code of Practice (CoP). This defect corresponds with the defect detected by the ultrasonic inspection on 6 June. The severity of the defect was raised in status by the patroller on 25 July 2007 and removed the same day, this was approximately one month before the derailment occurred.

### 2.3.3 Removal of defect and insertion of replacement rail

Following the raising of the severity of the defect on 25 July 2007, a section of rail was removed and a 6-metre replacement rail section inserted in the track on the same day.

Due to the heavy head flow on the curved rail section at this location, a similar rail profile/worn rail had to be located for insertion in order to provide a smooth rail surface for train wheels, without the need for resurfacing the rail. If a suitable rail

<sup>10</sup> WestNet Rail CoP Track & Civil Infrastructure, section 6.11.3.2.8

section had not been found, both the high rail and the worn low rail would have required resurfacing.

No record of the origin of the insert, nor of any ultrasonic testing of the rail insert for defects prior to installation, was available as is mandated in the WestNet Rail Standard Gauge Mainline CoP. It is therefore probable that the rail insert contained a large undetected vertical split head defect<sup>11</sup> at the time of welding into track. Alternatively, it is possible, but less likely that the parent rail on either side of the insert may have still contained a vertical split head defect which was undetected at the time of the previous ultrasonic inspection and not visible at the time of the subsequent track inspections or maintenance.

The failure to ultrasonically check either the parent rail in the vicinity of the original defect at the time of the repair, or the insert, meant that the opportunity to detect the vertical split head defect was probably missed and a latent rail defect remained in the track.

### 2.3.4 Rail records

The track in the area of the derailment was constructed in its present form in the late 1960's under the direction of the Western Australian Government Railways. Employees from that era stated that detailed records of the work, including manufacturing details of the rail used and of the welding processes to install the rail, were made and kept by those responsible for the infrastructure.

The rail network infrastructure in Western Australia is owned by the Western Australian Government and leased for 49 years to WestNet Rail. WestNet Rail is part of the WestNet Infrastructure Group, which is in turn owned by the publicly listed Babcock and Brown Infrastructure group. During the evolution to this corporate structure, the records of rail infrastructure were 'rationalised' with some records consigned to State Library archives. Some records were preserved by managers on their own initiative, but many were destroyed, even though the assets that they related to were still in operational use.

For the section of track relevant to this derailment, only the contract documentation for construction could be located in the archives. Additionally, information detailing what rail had been used during construction was only available from the personally maintained records of a WestNet Rail manager. However, details on closure rails, the welding processes, rail temperatures, and track adjustment details, could not be found.

Records of rail repairs for the previous ten years in this area were provided by WestNet Rail. There were seven recorded rail repairs for the area from 595 to 596 kilometres. The records for two repairs prior to 2003 do not record the exact nature of the rail defect, and the record for a repair in 2004 is ambiguous. The remaining four repairs were for vertical split head defects, and were achieved using closures between 4 and 7.4 m long. The source of these closures, and details of any tests performed on them, were not documented.

<sup>11</sup> The detection of vertical split head defects within rails requires testing techniques that differ from that for most other internal rail defects. In particular, the testing signal must be angled and perpendicular to the length of the rail, not parallel to it, in order to detect reflected signals from the crack surface.

In particular, it was also noted that there was no record of the source of the 6.1 m closure rail placed in the track on 25 July 2007 near the point of derailment and there was no evidence to indicate that the insert was tested as being suitable for reuse, as prescribed in the WestNet Rail Standard Gauge Mainline CoP. The code mandated that where the history of an inserted rail section is unknown, it must be ultrasonically tested before being used in unrestricted traffic.

The lack of construction and past maintenance documentation can severely compromise the ability to maintain infrastructure safely and places greater importance on complying with, or exceeding, mandated test procedures.

# 3 FINDINGS

### 3.1 Context

Freight train 6413 derailed near Stewart, WA at 0400 on 17 August 2007, as a consequence of traversing a broken rail. The train and the rail track were extensively damaged, and the trans-Australia rail link was closed for a period of 4 days.

From the evidence available, the following findings are made with respect to the derailment of freight train 6413 and should not be read as apportioning blame or liability to any particular organisation or individual.

### 3.2 Contributing safety factors

- A broken rail, resulting from a vertical split head defect, probably caused the derailment of train 6413 near Stewart, WA on 17 August 2007.
- There was no record to indicate that a worn section of rail, inserted into the track on 25 July 2007, was tested as being suitable for reuse as prescribed in the WestNet Rail Standard Gauge Mainline Code of Practice. The lack of construction and past maintenance documentation compromises the ability to maintain railway infrastructure safely and places greater importance on adhering to mandated test procedures. *[Safety issue]*
- It is probable that the rail insert contained a large undetected vertical split head defect. Alternatively, it is possible that a vertical split head defect existed in parent rail at either side of the insert. As a large defect had been removed at this location, some additional/localised ultrasonic testing by hand of the rail may have been effective in identifying a further defect in the parent rail. [Safety issue]
- There was no clear guidance within the WestNet Rail rules for train crews that defined an allowable speed associated with proceeding 'cautiously'. Had the train been travelling at a slower speed it is probable that the extent of damage caused by the derailment would have been less. [Safety issue]
- Although the train driver's actions fell within the guidance provided by the WestNet Rail rules, the speed of the train was probably not consistent with good defensive driving practice.

### 3.3 Other key findings

- There were no mechanical defects or deficiencies with the train that would have contributed to the derailment.
- The actions of the train controller did not contribute to the derailment. The train controller issued a Proceed Order in accordance with WestNet Rail rules and while issuing the order, he clearly advised the train driver that there was a track fault between the Departure signal (10RA) and the next signal in advance (D598) and that he should keep a lookout.

- The signalling system was operating properly and did not contribute to the accident.
- The track at the derailment site was tested by Rail Technology International (RTI) in accordance with WestNet Rail *Specification for Ultrasonic Testing of Rail in Railway Applications 2006.* The inspections were carried out as scheduled, with the last inspection run being conducted on 6 June 2007. This inspection run identified a small vertical split head at this location that was below the reportable size and therefore was not communicated to WestNet Rail.

# 4 SAFETY ACTIONS

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

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

### 4.1 WestNet Rail

### 4.1.1 Management of infrastructure records

### Safety Issue

There was no record to indicate that a worn section of rail, inserted into the track on 25 July 2007, was tested as being suitable for reuse as prescribed in the WestNet Rail Standard Gauge Mainline Code of Practice. The lack of construction and maintenance documentation compromises the ability to maintain railway infrastructure safely and places greater importance on adhering to mandated test procedures.

### Action taken by WestNet Rail

WestNet Rail has advised:

A complete review of WestNet Rail's ultrasonic testing regime is being conducted by Monash University's Institute of Railway Technology to ensure best practice is being followed.

WestNet Rail has also advised that it is establishing an electronic track asset management system.

### ATSB assessment of action

The Australian Transport Safety Bureau notes that WestNet Rail has taken action in response to this safety issue. These actions are still in the formative stage. WestNet Rail does not yet have systems in place that address the specific safety issue.

### ATSB Safety recommendation RO-2007-006-SR-008

The Australian Transport Safety Bureau recommends that WestNet Rail takes action to address this safety issue.

### 4.1.2 Inspection and management of rail quality

#### Safety Issue

It is probable that the rail insert contained a large undetected vertical split head defect. Alternatively, it is possible that a vertical split head defect existed in parent rail at either side of the insert. As a large defect had been removed at this location, some additional/localised ultrasonic testing by hand of the rail may have been effective in identifying a further defect in the parent rail.

### Action taken by WestNet Rail RO-2007-006-NSA-006

WestNet Rail has advised:

In light of WestNet Rail's own investigation of this and other rail break incidents the following safety actions have been implemented.

1 When Vertical Split Head (VSH) defects are detected, which according to the Code of Practice require removal

- either the whole rail (to welds either side of the defect) is replaced or
- the whole rail (to welds either side of the defect) is ultrasonically tested by hand to ensure the defect does not extend beyond the area to be replaced.

2 The replacement rail must be either new rail or have a known history of ultrasonic testing.

3 The removed rail must be rendered unsuitable for reuse.

And

(i) Until further notice, all Vertical Split Head (VSH) defects detected by whatever means (including those that have already been detected but not yet removed) shall be removed immediately OR alternative action taken to ensure the safe passage of all trains. Alternative action may include the imposition of a severe speed restriction with daily inspections up to the removal of the defect;

(ii) Rail defect data records shall be examined to identify all VSH defects that have been detected and subsequently removed by welding in a rail plug of less than the full rail length. At all such locations, the parent rail either side of the rail plug shall be tested by manual ultrasonic equipment to ensure VSH defects are not present in the parent rail. If VSH defects are detected in the parent rail then the defects shall be removed as per (i) above;

(iii) In conjunction with (ii), rail defect data records shall be examined to identify any VSH defect that has not had any remedial action carried out to that VSH defect AND has not been detected in subsequent ultrasonic recording runs. If any such VSH defects are identified, then the defects shall be removed as per (i) above; and

(iv) For all fut ure ultrasonic recording runs, a summary list of ALL def ects identified in a previous ultrasonic recording run/s and that have subsequently been removed shall be provided to the contractor providing ultrasonic recording services prior to the contra ctor undertaking the next ultrasonic recording run. The summary list shall include, as a minimum, the contractor's defect identification number, the date of detection, the date of removal of the defect and a brief description of the remedial action undertaken (e.g. 6m plug welded in, full length rail replaced, defect plated and speed restricted, etc.,)."

A complete review of WestNet Rail's ultrasonic testing regime is being conducted by Monash University's Institute of Railway Technology to ensure best practice is being followed.

### ATSB assessment of action

The Australian Transport Safety Bureau notes that WestNet Rail has taken action to address this safety issue.

### 4.1.3 Management of train speed

### Safety Issue

There was no clear guidance within the WestNet Rail rules for train crews that defined an allowable speed associated with proceeding 'cautiously'. Had the train been travelling at a slower speed it is probable that the extent of damage caused by the derailment would have been less.

### Action taken by WestNet Rail RO-2007-006-NSA-007

WestNet Rail advised:

Immediately after the derailment WestNet Rail implemented, on the 4 7 kg/m track equipped with CTC, between Koolyanobbing and West Kalgoorlie, the following instruction –

Upon any unexplained illumination of a tra ck or block s ection in the above section the Train controller must not permit any train to enter the section concerned until the Infrastructure person and the Safeworking Technician on call have both been advised and attended to ascert ain the ca use and corrective action implemented.

The above instruction applies 24 hours a day until further notice.

### ATSB assessment of action

The Australian Transport Safety Bureau notes that WestNet Rail has taken action in response to this safety issue. However, WestNet Rail has not addressed the lack of guidance within their rules for train crews who are requested to proceed 'cautiously'. WestNet Rail's rules in this regard are not best practice when compared to rules in other rail systems.

### ATSB Safety recommendation RO-2007-006-SR-009

The Australian Transport Safety Bureau recommends that WestNet Rail undertake further work to address this safety issue.

# **APPENDIX A : SOURCES AND SUBMISSIONS**

### Sources of information

- Australian Railroad Group
- Office of Rail Safety WA
- Train drivers
- Western Australian Department for Planning & Infrastructure
- WestNet Rail.

### References

- WestNet Rail Pty Ltd Standard Gauge Mainline Code of Practice Track and Civil Infrastructure, Document No. W190-400-001 dated 10 April 2001.
- WestNet Rail Pty Ltd 'WestNet Rail operational rules', Document No. C100-000-005 dated 17 April 2000.

# Submissions

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

A draft of this report was provided to:

- Australian Railroad Group
- Office of Rail Safety WA
- Train drivers
- Western Australian Department for Planning & Infrastructure
- WestNet Rail.

Submissions were received from:

- Australian Railroad Group
- Office of Rail Safety WA
- Western Australian Department for Planning & Infrastructure
- WestNet Rail.

The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Derailment of Freight Train 6413 near Stewart, Western Australia 17 August 2007