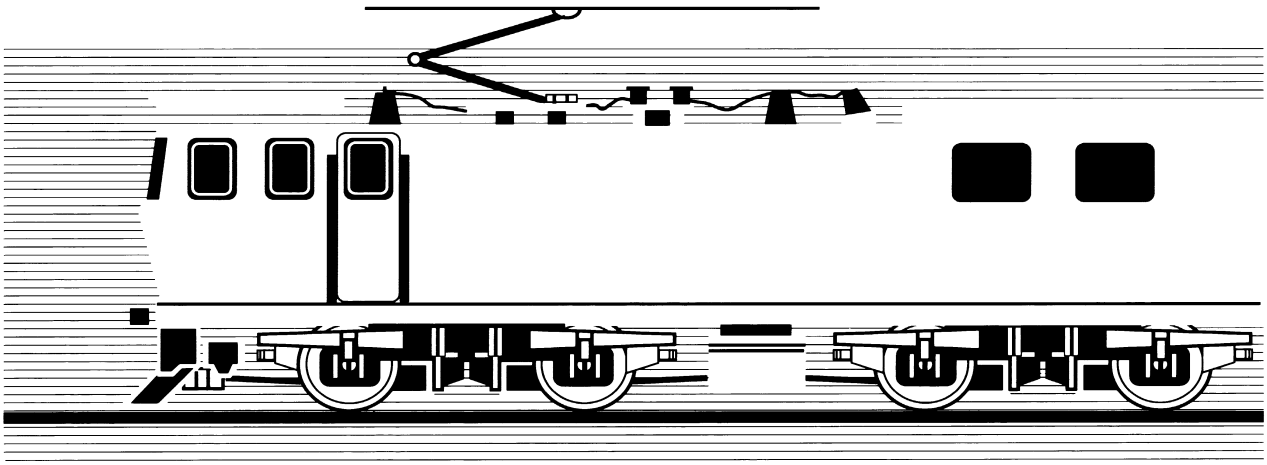
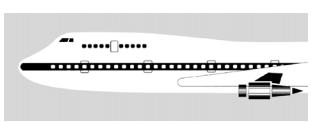
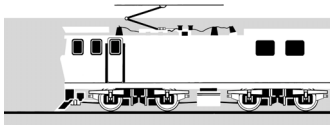


RAILWAY OCCURRENCE REPORT

05-105 **express freight Train 829, track occupation irregularity, Kokiri** **3 February 2005**


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

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.

Report 05-105

express freight Train 829

track occupation irregularity

Kokiri

3 February 2005

Abstract

On Thursday 3 February 2005, at about 0714, Train 829, a Christchurch to Greymouth express freight service, entered the limits of an authorised track occupation area at Phoenix Meat Company siding, Kokiri. The locomotive engineer became aware of the occupation only when he approached the siding to perform a scheduled shunt.

One of the track maintenance personnel working at the site within the authorised area was alerted to the proximity of Train 829 when he contacted train control to seek an extension to the occupation.

There were no injuries or equipment damage.

Safety issues identified included:

- fatigue arising from rostering procedures for train controllers
- the use of rostered off duty train controllers to meet short-term staff shortages in train control
- safeguarding track occupations in Single Line Automatic Signalling areas.

One safety recommendation has been made to the Chief Executive of ONTRACK[1] to address these issues.

[1] ONTRACK were the rail access provider and controller of the rail network.

Contents

Figures

Abbreviations

ASL	annual sick leave
CTC	centralised traffic control
HRV	hi-rail vehicle
km	kilometre(s)
m	metre(s)
ML	Midland Line
OJT	on the job training
Phoenix siding	Phoenix Meat Company siding
RDO	rostered day off
SLAS	single line automatic signalling
TWC	track warrant control
Toll Rail	Toll NZ Consolidated Ltd
UTC	coordinated universal time
VDU	visual display unit

Data Summary

Train type and number:	express freight Train 829
Date and time:	3 February 2005, at about 0714[2]
Location:	191.80 km Midland Line, between Kokiri and Stillwater
Person on board train:	1
Person at worksite:	2
Injuries:	nil
Damage:	nil
Operator:	ONTRACK
Investigator-in-charge:	Vernon Hoey

[2] Times in this report are New Zealand Daylight Time (UTC+13) and are expressed in the 24-hour mode.

1 Factual Information

1.1 Narrative

1.1.1 On Thursday 3 February 2005, at about 0615, two Transfield Services[3] track workers arrived by road at 191.06 km, between Kokiri and Stillwater on the Midland Line (ML), to replace a pair of failed insulated rail joints[4] at 191.88 km that had been causing intermittent failures to the signalling system in the area (see Figure 1).

Figure 1
A pair of insulated rail joints similar to those replaced at 191.88 km

1.1.2 Shortly afterwards, one of the track workers radioed train control and requested track occupation authority to work on track between 191.00 km and Nos. 5 and 7 points at Stillwater for as much time as possible, adding that an hour was minimally required to complete the work.

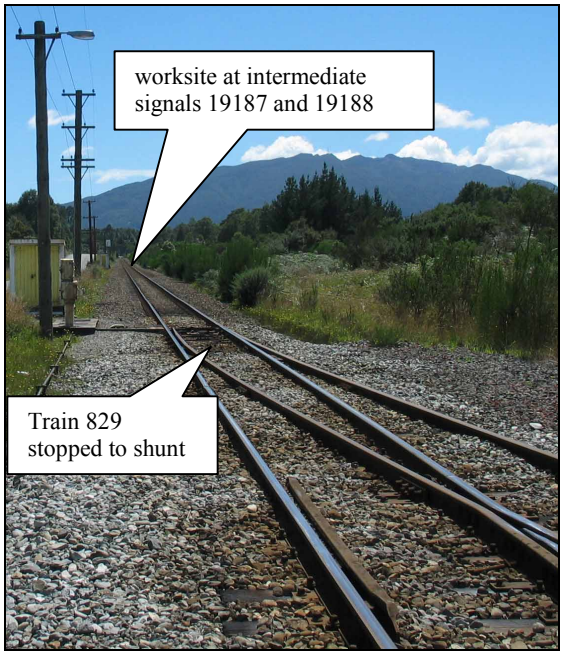


Figure 2
West end of Phoenix meat company siding looking towards intermediate signals 19187 and 19188

1.1.3 The train controller confirmed the limits and the work-between[5] nature of the request and said that he expected Train 829, the next train through the area, to arrive at Moana at about 0700. The track worker acknowledged the information regarding Train 829 and reiterated that he was seeking as much occupation time as possible.

[3] Transfield Services were responsible for the inspection, maintenance and renewal of the rail infrastructure.
[4] A device that prevented the flow of electrical current in a signalling circuit from passing from one rail to an adjoining rail.
[5] Work-between allowed the track workers to travel in either direction between the limits of, and for the duration of, the occupation.

1.1.4 At 0619, the train controller authorised the track occupation until 0715 with the track worker to call at that time. He recorded the occupation on the train control diagram. The track worker replied that he would call clear at 0715. The train controller confirmed the 15-minute buffer[6] ahead of Train 829.

1.1.5 The track workers on-tracked their hi-rail vehicle (HRV) at a level crossing at 191.06 km and travelled about 800 m to the worksite adjacent to intermediate signals 19187 and 19188 (see Figure 2).

1.1.6 The train controller recorded the progress of Train 829 as the locomotive engineer made his compulsory calls[7] through Jackson at 0625 and through Moana at 0654.

1.1.7 Shortly after 0700, there was a handover on the ML desk and the incoming train controller was briefed among other details that the occupation should be off and clear at Nos. 5 and 7 points at Stillwater at 0715.

1.1.8 At 0714, following a series of minor delays with equipment failures and a twisted rail, the track worker radioed train control seeking an extension to the occupation. The incoming train controller replied that he thought they were clear, and told him that Train 829 had arrived at Phoenix Meat Company siding (Phoenix siding).

1.1.9 The incoming train controller instructed Train 829 to remain at Phoenix siding while the track workers competed their work and off-tracked. Once this was done, Train 829 was permitted to continue its journey.

1.2 Site information

1.2.1 The ML between Rolleston and Greymouth was single line over a distance of 211.23 km. Train movements and track occupations on the line were controlled from the national train control centre in Wellington.

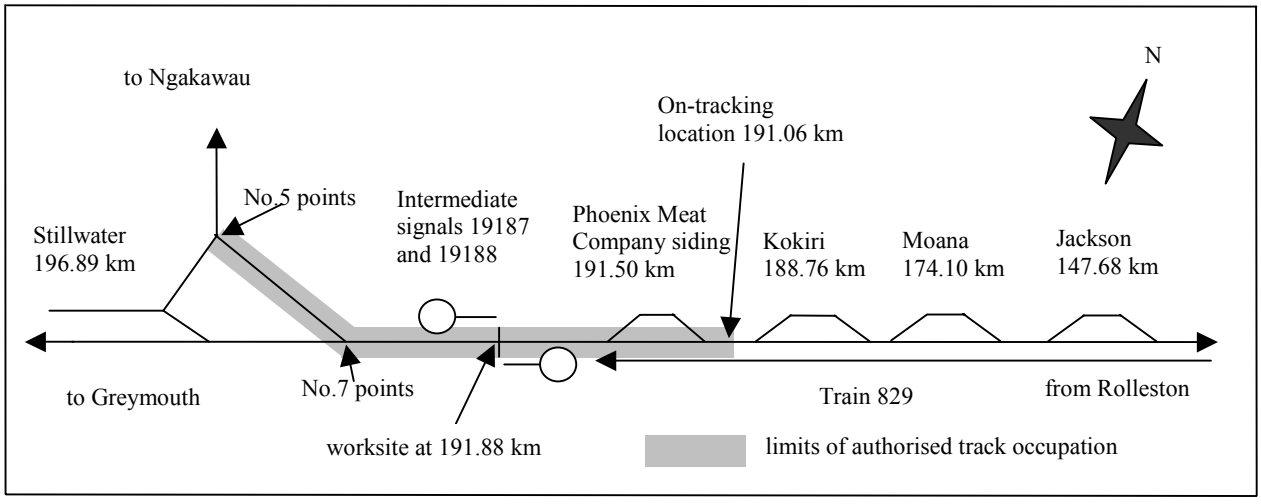


Figure 3
Track layout between Jackson and Stillwater (not to scale)

[6] The 15-minute buffer was based on a train not advancing beyond an entry point of an authorised track occupation until the track clearance had been received or the buffer time had expired.
[7] Locomotive engineers are required to lodge a radio base call to train control and advise when they have departed the designated locations.

1.3 Signalling information and track occupation procedures

1.3.1 On the ML, the principal signalling system was single line automatic signalling (SLAS), except for one small section of centralised traffic control (CTC) and one small section of track warrant control (TWC). The ML was the only line in New Zealand where SLAS was in operation.

1.3.2 Unlike CTC, SLAS was an automatic signalling system that was not remotely monitored or controlled from a visual display unit (VDU). Track circuits detected the presence of trains between crossing stations. Signals automatically cleared to proceed when a train was detected approaching a station, and a portion, or all of the section about to be entered, was unoccupied by another train.

1.3.3 Train controllers governed the running order of trains by issuing operating instructions to locomotive engineers at the entry into the SLAS areas and at other locations as necessary. There were 2 operating instruction forms; the Mis.50 was the train controller's copy and the Mis.51 was the locomotive engineer's copy. With few exceptions, a single operating instruction was issued and remained active right through one of the 2 portions of the SLAS areas between Rolleston and Arthur's Pass, or between Otira and Stillwater.

1.3.4 Control blocking was a system that enabled a train controller to block out an occupied section of track to provide an enhanced level of protection for track occupations in CTC and some remotely controlled interlocked stations in double line automatic signalling areas. However, control blocking was not available in SLAS except at a small number of interlocked stations that were now controlled and monitored on a VDU in train control.

1.3.5 ONTRACK's Rule 915 stated in part that:

> **(e) Single Line Automatic Territory**:
>
> Blocking cannot be used to protect track occupancies in SLAS territory.
>
> Train Control will ensure that the movement will not conflict with rail service movements (trains, hi-rail vehicles etc).
>
> The location of conflicting rail service vehicle movements must be verified by train control prior to the movement being authorised.
>
> For authorised occupations the designated clear time MUST include a safety buffer of 15 minutes before the anticipated arrival time of the next train.
>
> When authorising movements Train Control will confirm:
>
> - authority is either to proceed or work between.

Train control diagram

1.3.6 Train control diagrams showed the timetable of all scheduled trains, printed in green on the route where they ran. Information such as time allowed for scheduled shunts en-route and crossings with opposing trains was also shown.

1.3.7 Train controllers drew plot lines in pencil on the diagram to show an anticipated path of the train based on actual movement information, rate of progress and other influencing factors. This enabled train controllers to calculate times at en-route stations where train crossings could be optimized. When a train was ready to depart and a train path had been successfully plotted, the train controller issued the Mis.50 operating instruction to the locomotive engineer.

1.3.8 This same plotted information, which was replaced in red ink to record the actual train journey as locomotive engineers made their compulsory calls, was used to determine the safe terminating time limits for track occupations ahead of approaching trains.

1.3.9 In SLAS areas, train controllers had only this plotted information as determined by the distance and time axis on the train control diagram together with the application of the 15-minute buffer, to safeguard track occupations.

1.3.10 ONTRACK's rail operating code, section 6, stated in part that:

> **2.2 Identify Limits of the Authority**
>
> **Working between metrages/locations** – a box indicating the extent of the limits by either metrage, intermediate board, points or signal reference with the call-sign identifier in the box.
>
> **15.1.2 Pre Authorisation check and use of Train Control Diagram for Track Occupancy**
>
> Before an occupation is authorised the Train Controller must establish positively whether any conflict exists with either existing occupations, track maintenance machinery or trains within any part of the area requested.
>
> All movements and work authorised MUST be plotted on the Train Control Diagram as prescribed in the Code.
>
> The Train Controller MUST establish by reference to these plot lines that:
>
> - There is no conflict with a train or trains for any part of the area covered by the plot line that is about to be authorised.
>
> **15.1.2 Designated Time - Safety Buffer**
>
> The Train Controller must verify the location of any conflicting RSV movement prior to the occupation being authorised.
>
> **Procedure**
>
> - When conflicting RSV is a train:
>   - Dark territory[8] – except where the location of the conflicting train has been verified verbally within the previous 15 minutes a call must be made to the locomotive engineer concerned in order to obtain the current location of the train.
>
> The Train Controller must provide the caller with the most up to date information in regard to the next train or trains (where it is unsure which will arrive first).
>
> **Trains MUST NOT be dispatched into an area inside the 15-minute buffer unless "clearance" has been received from the Track User.**

1.3.11 Track occupations in SLAS areas were recorded in black pen. For a proceed occupation, a solid line was drawn in the same manner as a recorded train journey in the direction of travel ending at the agreed time and terminating location. For a work-between occupation, a box was drawn to denote the limits and duration of the occupation. In both instances, the responsibility was on the person in charge of the occupation in the field to comply with the termination limits as authorised by the train controller.

1.3.12 The track occupation was drawn as a proceed from 191.00 km to Nos. 5 and 7 points Stillwater from 0615 to 0715. The occupation should have been drawn as a box between the same limits and times (see Figure 4).

[8] Dark territory described operating areas such as SLAS where the progress of trains was not displayed on a VDU in train control.

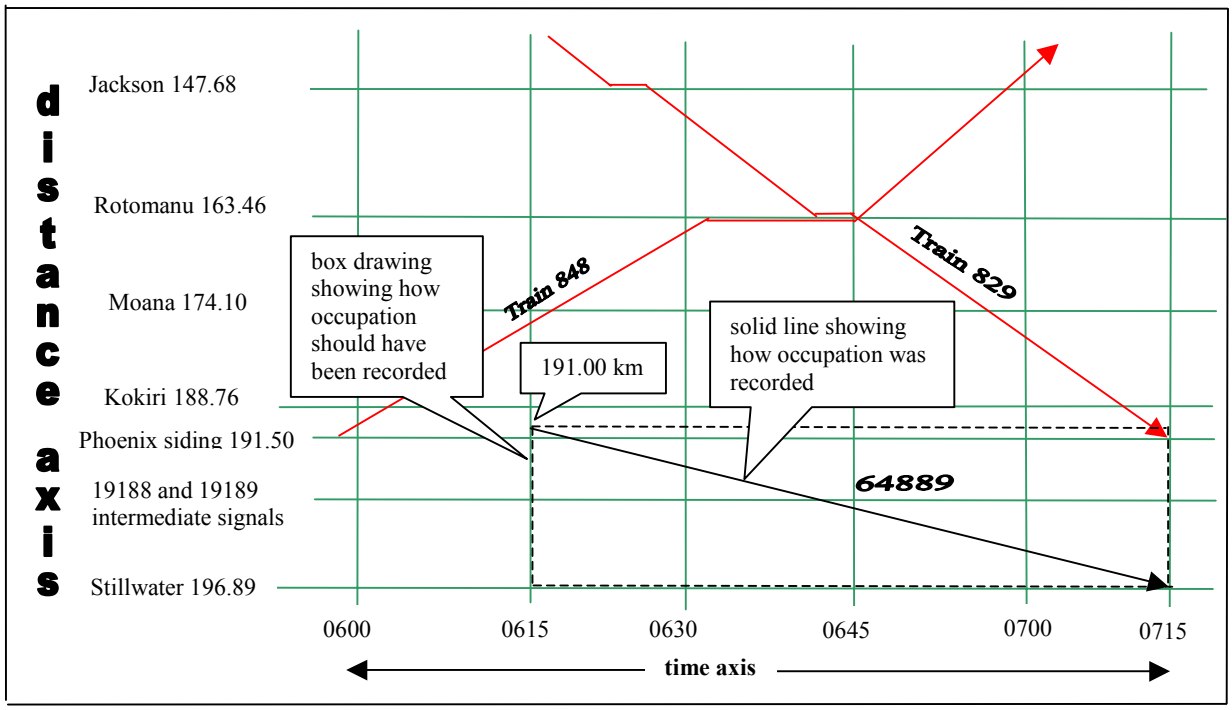


Figure 4
Train control diagram (not to scale)
Note the dashed boxed lines are for clarity only

1.4 Personnel

Track workers

1.4.1 Transfield Services had employed the track workers in 2003 and both held Level C certifications. This level of certification allowed them to on-track and operate an HRV in SLAS areas.

1.4.2 On the day of the incident, the track workers booked on earlier than normal so they could undertake the replacement of the insulated joints while the rails were still cool, and the gaps at the joints had not closed with the rising temperature of the day.

1.4.3 The track workers had allowed themselves about an hour to complete the task, but were unaware of the whereabouts of any trains at that time in the morning. When it was known that Train 829 had not passed Jackson, 44.20 km away, they accepted the 60-minute occupation window offered by the train controller ahead of the approaching train.

1.4.4 When the track worker called the train controller at 0714 seeking an extension to the occupation, he was told that Train 829 had just arrived at Phoenix siding and on looking around, noticed the locomotive headlight behind the HRV.

1.4.5 The requested extension was authorised by the train controller, and when they had completed the work, the track workers off-tracked the HRV at a farm level crossing immediately beyond their worksite.

Locomotive engineer

1.4.6 The Toll NZ Consolidated Ltd (Toll Rail) locomotive engineer was a certified Grade 1 locomotive engineer with 47 years service, all in the South Island's West Coast. He attained his Grade 2 certification in 1978 and then progressed to Grade 1 and held a current operating certificate.

1.4.7 The locomotive engineer booked on at 0500 in Greymouth and went by road to Jackson where he took over the driving duties of Train 829. At the changeover, the outgoing locomotive engineer brought his attention to the active Mis.51 operating instruction, which authorised Train 829 to continue to Stillwater.

1.4.8 When he approached Phoenix siding for the shunt, the locomotive engineer saw the HRV on track and overheard the conversation between the train controller and the track workers.

Train controller

1.4.9 The train controller had extensive experience in train control duties, having been first certified in 1975. In 1999, he transferred from train control Dunedin to the national train control centre in Wellington and soon afterwards gained certification to the ML desk. The train controller underwent a tape safety audit in July 2004 and a desk safety observation in November 2004. Both observations were satisfactory.

1.4.10 The train controller booked on at 2250 on Wednesday 2 February and controlled the ML, the Stillwater-Ngakawau Line and the Main South Line between Lyttelton and Studholme. He said that the workload experienced during shift was not taxing and a locomotive failure on a train on the ML was the only extraordinary event that he had to contend with.

1.4.11 When the train controller told the track worker that he estimated Train 829 would depart Moana at about 0700, it became evident to the train controller there was an opportunity for the track workers to undertake their work before Train 829 arrived at the site. He confirmed with the track worker that the nature of the occupation was a 'work between', but for some reason recorded the occupation on the train control diagram as a 'proceed'[9] occupation (see Figure 4).

1.4.12 The train controller said he did not re-plot the expected path of Train 829 when the locomotive engineer made his compulsory call at Moana. However, he said that he recalculated that after a 10-minute stoppage for the shunt, Train 829 should depart Phoenix siding at about 0730, which was 15 minutes after he had recorded the termination of the occupation at 0715.

1.4.13 Because of the number of weekly night shift rotations he had worked in the 5-week period leading up to the incident, the train controller said that he had experienced difficulties sleeping. Additionally, he said that as it was the height of summer he had to contend with sleeping during the heat of the day. He added that he had applied a number of measures to keep his bedroom cool and dark and was in the habit of returning to bed after dinner for about 90 minutes before getting up at 2100 to prepare for work.

1.4.14 The train controller said that in the 5-week period up to the incident the normal shift rotation had not been followed. Instead his roster had been changed to free up other experienced train controllers to be available for on the job training (OJT) duties for new train controllers. It was his long-standing preference to not be considered for OJT duties.

1.4.15 The train controller said he also had to change his transport arrangements for his night shifts following the recent removal of late night suburban train services at his local station. So instead of being able to catch a train in the late evening to work and home in the morning, he said that he now had to drive to and from Wellington, a situation that he said he found "a terrible strain". Occasionally on the 30-minute journey home, he said that he pulled over and walked to refresh himself as he felt he could have fallen asleep at the wheel. It was his preference to travel by train for his night shifts.

[9] Proceed permitted the track worker to travel in one direction only to the end limit of the occupation.

Train controller's master roster and posted roster

1.4.16 The master roster was the basic roster that encompassed the shifts required to operate each train control desk. The master roster had built-in, but limited, capacity to provide relief so train controllers could take annual leave, depending on relief availability, throughout the year.

1.4.17 The posted roster covered a fortnight period and was formed from the master roster. It included known alterations due to booked annual leave. In the 5 weeks leading up to and including the week of the incident, the train controller worked the following posted rostered shifts:

Date 2005	Master roster	Posted roster	Actual hours worked
Sun 2 Jan	0650-1500	1450-2300	8 hours 10 minutes
Mon 3 Jan	0650-1500	**rostered day off (RDO)**	
Tue 4 Jan	0650-1500	1450-2300	8 hours 10 minutes
Wed 5 Jan	**RDO**	1450-2300	8 hours 10 minutes
Thu 6 Jan	0650-1500	1450-2300	8 hours 10 minutes
Fri 7 Jan	0650-1500	1450-2300	8 hours 10 minutes
Sat 8 Jan	**RDO**	1450-2300	8 hours 10 minutes
Sun 9 Jan	2250-0700	2250-0700	8 hours 10 minutes
Mon 10 Jan	2250-0700	2250-0700	8 hours 10 minutes
Tue 11 Jan	**RDO***	2250-0700	8 hours 10 minutes
Wed 12 Jan	**RDO**	2250-0700	8 hours 10 minutes
Thu 13 Jan	0630-1500	**RDO***	
Fri 14 Jan	0630-1500	1450-2300	8 hours 10 minutes
Sat 15 Jan	0650-1720	**RDO**	
Fortnight total	**84.40**		**89 hours 50 minutes**
Sun 16 Jan	2250-0700	0650-1500	8 hours 10 minutes
Mon 17 Jan	2250-0700	0650-1500	8 hours 10 minutes
Tue 18 Jan	2250-0700	0650-1500	8 hours 10 minutes
Wed 19 Jan	2250-0700	0650-1900	12 hours 10 minutes
Thu 20 Jan	**RDO***	0650-1500	8 hours 10 minutes
Fri 21 Jan	**RDO**	0650-1500	8 hours 10 minutes
Sat 22 Jan	0650-1720	**RDO**	
Sun 23 Jan	0650-1500	2250-0700	8 hours 10 minutes
Mon 24 Jan	**RDO**	2250-0700	8 hours 10 minutes
Tue 25 Jan	0630-1500	2250-0700	8 hours 10 minutes
Wed 26 Jan	0630-1500	2250-0700	8 hours 10 minutes
Thu 27 Jan	**ASL**[10]	2250-0700	8 hours 10 minutes
Fri 28 Jan	**ASL**	**RDO***	
Sat 29 Jan	**RDO**	1450-2300	8 hours 10 minutes
Fortnight total	**92.50**		**102 hours 00 minutes**
Sun 30 Jan	2250-0700	2250-0700	8 hours 10 minutes
Mon 31 Jan	2250-0700	2250-0700	8 hours 10 minutes
Tue 1 Feb	2250-0700	2250-0700	8 hours 10 minutes
Wed 2 Feb	2250-0700	2250-0700	8 hours 10 minutes
Thu 3 Feb	plotting of track occupation occurred at about 0619		

Note: RDOs endorsed with an asterisk indicate the train controller worked until 0700 on the morning of the RDO.

[10] ASL means annual/sick leave and described the planned remunerated capacity in the roster for available personnel to cover shifts left vacant by train controllers on leave. If not required to work the person is paid anyhow.

1.4.18 In the 5 weeks prior to the incident, the train controller had 5 days off as RDOs, 2 of which included days when the train controller had finished work at 0700. Between Tuesday 4 January and Wednesday 12 January inclusive, he worked 9 consecutive days, the last 4 of which were night shifts. The train controller had worked 16 out of the 18 days prior to and including the day of the incident, and 10 out of the prior 11 days.

1.4.19 In the 18-day period leading up to and including Wednesday 2 February, the train controller's master roster provided 4 RDOs and 2 ASLs. Two of the 4 RDOs were consecutive. If not required to cover a shift on the days he was rostered ASL, the train controller would have been utilised to cover other rostered train controllers who were due for safety audits or theory examinations. However, the train controller's posted roster only provided 2 RDOs, which were not consecutive and provided 56 and 32 hours away from work, respectively.

1.4.20 In the 11 days prior to the incident, the train controller worked 9 night shifts and one late shift. He worked 5 consecutive night shifts, had one full day off, allowing him 32 hours away from work, and then worked an evening shift followed by 4 consecutive night shifts, including the shift on which the incident occurred.

1.5 Rostering of train controllers

1.5.1 There was no definition for RDOs in ONTRACK's policy and procedure for rostering. Rostering was set around 'work periods' and 'minimum time off'. Where RDOs were shown on the roster, these were provided for the purpose of completing the fortnightly timesheets.

1.5.2 A review of rosters covering the 5 weeks prior to the incident showed that the rostering of train controllers for 5 consecutive night shifts was common practice throughout the train control centre. The number of consecutive night, or at-risk, shifts worked by locomotive engineers had been the subject of a separate internal review by Tranz Rail (now Toll Rail), following a series of derailments and collisions arising from fatigue and sleep issues during 2000.

1.5.3 On 7 June 2005, Toll Rail advised in part:

> At-risk shifts are all shifts that start between 2000 hours and 0300 hours. If three at-risk shifts are worked in a row then a mandatory off duty time of 54 hours minimum is required.
>
> This arrangement was implemented in early 2001. These principles have not been formally documented, however a rostering standard document has been drafted and it is hoped that this will be published formally in the near future.

This recovery period following a sequence of at-risk shifts recognised the need to restore sleep debt accumulated during those shifts.

1.5.4 ONTRACK's Rail Operating Manual outlined the following rules for the initial construction of train control master rosters:

- a maximum of 10 shifts per fortnight
- each shift is to be of generally 8 hours 10 minutes duration. This may be relaxed at weekends to satisfy the social needs of the persons operating the roster
- each fortnight is to be generally made up of a maximum 80-85 hours actual
- mandatory minimum 11 hours 30 minutes continuous time off between shifts.

[11] Source - Rail Operating Manual, Tranz Rail, 1998.

1.5.5 The Rail Operating Manual included the following rules for medium and short notice changes to the master roster:

Mandatory maximum shift length / number of consecutive shifts:

	Up to 8 hr 10 min	10 hr 10 min	12hr 10 min
Day	12	10	3
Late	12	10	3
Night	7	6	3

Mandatory rest time off

- total actual hours not to generally exceed 110 per fortnight
- mandatory 11 hours 30 minutes minimum time off between shifts[12]
- mandatory 12 shift maximum consecutive shift pattern regardless of length of shifts.

1.5.6 The Collective Employment Agreement between ONTRACK and the train controllers provided for:

- an absolute maximum work period of 14 hours
- a minimum rest period between shifts of 10 hours
- a maximum number of 12 consecutive shifts before an off-duty day.

1.5.7 Train control rosters did not provide for scheduled breaks away from the desk for rest periods or personal needs breaks while on duty. However, refreshment and toilet facilities were located nearby, and breaks regularly occurred, depending on workload, although these were not at consistent or regular times across the shifts.

1.5.8 On 25 November 2005, Toll Rail advised that in 2003 its predecessor, Tranz Rail, had initiated discussion with Rail, Maritime and Transport Union delegates regarding the consecutive number of at-risk shifts and mandatory rest periods. However, the proposal was not supported by the delegates, in part because the concept might have been unworkable given the turnover of train controllers at the time.

1.5.9 Toll Rail said that at that time the train control environment was seen as unstable because of a planned relocation to Auckland and this seemed likely to result in more staff turnover and some resistance to the implementation new track occupancy procedures. Because of this it had been decided to defer further discussion on the issue until some stability had been restored. However, a new management report had been introduced to monitor hours of work on an ongoing basis to identify and manage instances where train controllers worked excessive hours or regular shift extensions.

[12] The collective employment agreement between ONTRACK and the train controllers provided for a mandatory minimum rest time of 10 hours.

1.5.10 On 2 December 2005 ONTRACK advised that the key issues that needed to be overcome were:

- the variability of qualifications and experience amongst staff
- the actual number of staff available through shortage or having not yet reached Level 3 qualification[13], and
- the fact that while the staff complement was set at 34, some roster rotations consisted of 5 staff due to the skills required to control multi areas.

To implement a roster with fewer night shifts and minimum hours off over a 24/7 roster required additional staff qualified at Level 3 for which the training period was a minimum of 18 months.

In December 2004, some shift rotations within train control master rosters started to include three consecutive night shifts followed by rostered time off-duty. However, the extent to which this could be trialled was severely limited by the mix of qualifications. Since less qualified staff can only work certain shifts and to maintain shift coverage there was still a need to exceed the 3 consecutive night shift goal. This trial continues along with ongoing recruitment and training to increase the staff establishment and mix of competencies.

1.6 Sleep and fatigue

1.6.1 Fatigue can be defined as a progressive loss of mental and physical alertness that can end in sleep. Lack of sleep, sleeping at different times of the day, mental stress or high mental workload will quickly result in mental fatigue. A person becomes increasingly inattentive while trying to concentrate on their tasks. As fatigue increases, their short-term memory becomes less effective and they may forget vital information.[14]

1.6.2 Fatigue is used as a catch-all term for a variety of different experiences, such as physical discomfort from overworking a group of muscles, difficulty concentrating, difficulty appreciating potentially important signals, and problems staying awake. In the context of an investigation, fatigue is important if it potentially reduces efficiency, erodes the safety margin, or otherwise impairs cognitive or physical performance.[15]

1.6.3 Every aspect of human performance can be degraded by sleep loss and sleepiness, including physical and mental performance. Once sleep debt or fatigue builds, only sleep can maintain or restore performance levels.

1.6.4 Lack of sleep and/or a reduction in sleep quality is one of the main factors affecting levels of fatigue, mood, health, and ultimately performance. A person looses sleep either by reducing a single sleep period by a large amount (acute sleep loss) or by building up a sleep debt over time by reducing sleep on consecutive sleep periods (accumulated sleep loss). Attempting to sleep at times when the body is less inclined to do so will disrupt sleep. The duration of the sleep period will be shorter, and the structure will be altered, resulting in further lost sleep.[16]

[13] A train controller qualified to operate 3 train control desks within the train control centre.
[14] Source - Fatigue Management Guide for Canadian Pilots, Transport Canada, 2003.
[15] Source - A Guide for Investigating for Fatigue, Transportation Safety Board of Canada, 1997.
[16] Source - Fatigue Management for Canadian Pilots, Transport Canada, 2003.

1.6.5 A paper entitled "Fatigue Management in the New Millennium"[17] stated that:

- Night work – as the amount of night work increases, so does the amount of sleep that must be attempted at biologically inappropriate times. Sleeping 'out of synch' with the body's biological clock results in reduced duration and quality of sleep. This in turn reduces the restorative value of sleep obtained.
- Research data indicates that shift workers obtain significantly less sleep than those who are not shift workers. Moreover, the quality of that sleep is also significantly reduced. Sleep loss during night work is typically 1 – 3 hours per day. Furthermore, sleep deprivation can accumulate across a block of shifts, which leads to higher fatigue.
- Taken together, both employers and employees have clear responsibilities with respect to managing fatigue. The basic responsibilities of both parties relate to ensuring that adequate sleep can be obtained between shifts so that fatigue does not reach dangerous levels during shifts. Thus, lack of sleep causes fatigue and sleep allows recovery from fatigue.
- Research by the Centre for Sleep Research at the University of SA has clearly demonstrated that fatigue-related impairment is not dissimilar to the effects of moderate alcohol intoxication. That is, significantly delayed response and reaction times, impaired reasoning, reduced vigilance [and] hand-eye co-ordination.

1.6.6 Most people who are fatigued do not realise how tired and impaired they are. The warning signs of fatigue are often disregarded. Major indicators of severe fatigue include:

- incorrect reading of equipment
- missing a reference point
- not remembering the last command given
- giving wrong commands
- degraded mental abilities (including memory, decision making and perception).[18]

1.7 Sleep/wake information

1.7.1 The train controller's apparent loss of situational awareness prompted a close look at the possible role of fatigue in this incident. The Commission engaged Ms Leigh Signal, PhD, Associate Director of the Sleep/Wake Research Centre at Massey University in Wellington to assist in analysing the likelihood that sleep loss and fatigue were casual factors. Her input is included in Section 2, Analysis, paragraphs 2.15 to 2.21 inclusive.

1.8 Locomotive event recorder

1.8.1 The locomotive event recorder was not downloaded because train handling did not contribute to this incident.

[17] Author - Professor Drew Dawson, University of South Australia Centre for Sleep Research.
[18] Source - Fatigue Management Guide for Canadian Pilots, Transport Canada, 2003.

2 Analysis

Train controller rostering and fatigue

2.1 The train controller was an experienced shift worker who had developed a pattern of sleep arrangements to cope with night shifts, including the recommended best practice of returning to bed for a sleep before preparing and travelling to work. He had also attempted to make his bedroom more conducive to sleeping during the day, particularly during the height of summer.

2.2 The strategies he put into place to obtain quality sleep were practical, and if they had achieved the desired results, would have been beneficial to the train controller. However, the unfavourable roster arrangements he experienced would have been counterproductive to the train controller's attempts to gain quality sleep. Therefore, the sleep debt that he had gradually accumulated was very likely not being repaid. It was likely that by 0615 on the morning of the incident, the accumulated sleep debt probably affected the train controller's cognitive ability. Likewise his fatigue probably did not allow him to recognise the incorrect transference of the track occupation authority on the train control diagram during subsequent graph work with Train 829 and the changeover with the incoming train controller. When the posted roster had been compiled, insufficient consideration had probably been given to the effects of successive night shift rotations would have had on the train controller's personal ability to cope with these rostering demands.

2.3 The 'split sleep' pattern as practiced by the train controller was common among shift workers and there was considerable scientific evidence to indicate that a sleep period immediately before a night shift was very effective in improving alertness and performance across the shift. However, it probably had little effect on the train controller's accumulated sleep debt because of the successive night shift rotations.

2.4 Additionally, following a train timetable change some months previously, the train controller had to commit to driving his car to and from his night shifts. He had found the train commute relaxing and it probably provided him with the opportunity to wind down and possibly snooze. Against his personal preference after completing his night shift, he now drove on a busy highway, which required his full concentration, something that he occasionally struggled with. It is possible this unwelcome change probably added some personal stress to his life and increased in some small way to his sleep debt.

2.5 Nevertheless, subjecting the train controller to a high frequency of night shifts, for whatever reason, was unhealthy and undesirable. Although on this occasion it was probably a short-term measure to accommodate OJT requirements, it probably placed him under some strain as he coped with the demands of getting quality sleep during the hottest part of the day, over successive weeks.

2.6 The 89 and 102-hour fortnights and roster rotations worked by the train controller in the 4 weeks prior to the incident bore little resemblance when compared to the master roster. The master roster for the 2 fortnights contained a mix of 6 night shifts and 12-day shifts interspersed with 8 RDOs and 2 ASLs. However during this period the posted roster contained only 5 RDOs, two of which were worked by the train controller until 0700 in the morning. This meant that in those 28 days, the train controller only had 3 uninterrupted days where he was not on duty.

2.7 There can be numerous reasons why train controllers agree to requests to work extra shifts over and above those for which they are originally rostered. They are:

- remunerative incentives
- loyalty to fellow train controllers, who may be unwell, less rested or have important commitments away from work
- concern about possible effects of refusal on relationships with other train controllers
- professional motivation to ensure that the system runs smoothly
- loyalty to the business
- ability to do so by qualification.

2.8 The relatively small group within the total numbers of train controllers who were level 3 qualified made those train controllers more often suitable for covering staff shortages. However, working additional shifts reduces the time available for all other activities away from work, including opportunities for recovery sleep. More limited off-duty time may further increase the pressure to sacrifice sleep to meet other time demands such as household and family responsibilities, or recreational activities.

2.9 The use of staff on RDOs to fill vacancies to meet operational requirements was historical and not uncommon and was not unique to the train control office. However, the inclusion of RDOs in the train control roster should have been primarily to ensure that train controllers had sufficient time off duty to recover from shifts worked, to rest for future shifts and for recreational purposes. These days should have been used as a counter to fatigue, but the regular practice of calling train controllers back to work negated the value of the RDOs.

2.10 Working additional shifts reduces the time available for all other activities away from work, including opportunities for rest and relaxation. Limiting off duty time may further increase the pressure to sacrifice sleep, rest or relaxation to meet other demands such as household and family roles.

2.11 The train controller had only one 32-hour break between finishing at 0700 on Friday 28 January and starting at 1450 on Saturday 28 January after completing 5 consecutive night shifts in the week preceding the incident. When he started another week of night shifts and it is likely that he carried over a residual amount of sleep debt from the previous week of night shifts.

2.12 For locomotive engineers, Tranz Rail had addressed the practice of working excessive consecutive at-risk shifts with the introduction of a maximum number of such shifts that could be worked before a mandatory rest period. However, attempts to introduce similar rostering protocols for train controllers had been unsuccessful because of the mix of train controller competencies and a general shortage of resources.

2.13 The risk for locomotive engineers suffering from fatigue while working at-risk shifts was to fall asleep at the controls of the locomotive. That for train controllers in the same situation was more likely to be that of deterioration in performance caused by accumulated fatigue, which in turn could lead to a decline in operational proficiency and cognitive impairment, as was probably the case in this incident. Such a situation was an unacceptable risk in an operating environment and to reduce the possibility of this happening the train control roster procedures should have included both restrictions on the number of consecutive at-risk shifts which could be rostered as well as a requirement for a mandatory rest period following such a shift rotation.

2.14 Following its establishment on 1 September 2004, ONTRACK inherited the issues relating to rostering and actual hours worked by train controllers were inherited from Toll Rail. From that time the train control function was separated from the operator's responsibility. However, Toll Rail had inherited the train control function from Tranz Rail Limited following its purchase of that company in May 2004, at which time the function still rested with the operator.

2.15 The rules applying to medium and short notice changes to the master roster enabled fortnightly shifts to be increased from 10 to 12, maximum actual hours to be increased from 85 hours to 110 hours and the maximum length of a shift to be extended from 8 hours 10 minutes to 12 hours 10 minutes. The mandatory minimum time off of 11 hours 30 minutes remained the same but was reduced to 10 hours by the Collective Employment Agreement. Although the train controller's posted hours and hours worked regularly exceeded the parameters determined in the master roster compilation process, they did remain within those parameters applying to medium and short notice changes, and those conditions included in the Collective Employment Agreement. However, given present-day knowledge of sleep and fatigue effect on shift workers, the hours of work permitted beyond the mast roster compilation conditions were excessive and overdue for review with a view to better reflect advances made in this field.

2.16 For a diurnally adjusted individual[19], 0615 was on the rising part of the circadian cycle, at a time where performance would be expected to be improving from its lowest point in the 24-hour cycle. Because the train controller had worked a large number of night shifts in the previous days, interspersed with a day off and an evening shift, it was difficult to know where his circadian biological clock would have been relative to the 24-hour day/night cycle. Nevertheless, previous research suggests his circadian clock was unlikely to have shifted far, and in fact his circadian low point in functioning was likely to have been slightly later than the normal 3-5 am low point. It was therefore likely that his performance was impaired due to the influence of the circadian biological clock.

2.17 The train controller was also likely to have switched from sleeping during the day to sleeping at night while on his RDO on Friday 28 January and working the evening shift, then switched back to sleeping during the day again. As a result of changing work/rest pattern the train controller was likely to have experienced disruption to his circadian system and associated performance impairment.

2.18 With the exception of knowing that the train controller napped in the evening prior to beginning the night shift, there was no other information on his sleep patterns. However, if the train controller had not been able to achieve some quality sleep during this short time, then he could have experienced a prolonged period of wakefulness. If wakefulness was prolonged this would have increased the risk of a fatigue-related error.

2.19 There was no information available on the frequency or duration of rest breaks taken by the train controller during his shift. Although he commented that the workload during the night shift was not taxing, his ability to remain vigilant would decline across the course of the shift if insufficient rest breaks were taken.

2.20 The large number of night shifts, many of which were consecutive, was likely to have resulted in the train controller obtaining less sleep than normal. The train controller commented that he had difficulty sleeping during the heat of the day, although he had made an effort to improve his sleeping environment. Even though there was no information available on the amount of sleep the train controller required to feel fully rested, or the amount of sleep he actually obtained when working night shifts, it was likely the train controller accumulated a sleep debt across the first series of 5 consecutive night shifts between Sunday 23 to Thursday 27 January inclusive (or added to an existing cumulative sleep debt due to the infrequency of days off in the preceding 3 weeks). This was supported by the comment that he had difficulty sleeping.

2.21 The single day off on Friday 28 January (32 hour break) following the 5 consecutive night shifts would have provided some opportunity for recovery, but the first and also possibly the second night of sleep following the last night shift are likely to have been disturbed. Sleep after the evening shift may have been shortened due to the late finishing time of the shift. It was therefore unlikely that full recovery from any accumulated sleep loss would have occurred during this break. A sleep debt is likely to have continued to build rapidly across the 4 night shifts immediately prior to the occurrence of the incident.

[19] Adjusted to sleeping at night and being awake during the day.

2.22 The performance of the train controller was therefore likely to have been impaired by the combined effects of an accumulated sleep debt, the disruption to his circadian rhythms, and working close to his circadian low point.

Track occupation irregularity

2.23 The application of Rule 915 was appropriate for the work that was being undertaken by the track workers on this occasion, and they had valid reasons for an earlier than normal start. The train controller could not explain why he recorded the occupation on the train control diagram as a 'proceed' instead of a 'work-between', after he had come to clear understanding with the track workers that they could work between the limits of the occupation. The slip was probably a result of his fatigue caused by accumulated sleep debt.

2.24 Although the introduction of dedicated forms for track workers had enhanced procedures for track occupations in SLAS areas, there had been no development of a correspondingly enhanced system safeguard as had been implemented in the other 2 automatic signalling systems. Control blocking had limited application on the ML because only 4 of the 16 crossing stations were interlocked and monitored from train control, giving train controllers the ability to physically hold signals at stop. Therefore, for the majority of such occupations on the ML, train controllers had at their disposal only time and distance parameters from the train control diagram with which to protect the occupations.

2.25 Once the authorisation process was completed between the train controller and the track worker, the recorded information on the train control diagram assumed critical importance. The 'proceed' endorsement did not alert the train controller to the developing situation as he recorded Train 829's progress through Jackson 7 minutes later at 0625 and through Moana 36 minutes later at 0654. Additionally, shortly after 0700, the train controller related details of the occupation as a 'proceed' during the handover to the incoming train controller in line with the 'proceed' occupation recorded on the train control diagram. Therefore, opportunities to see and rectify the recorded nature of the occupation during these events were missed by the train controller, indicating that fatigue had probably affected his ability to notice the difference between the recent verbal exchange and the recorded information.

2.26 Despite the fact that he had allowed for the 15-minute buffer, the train controller should have instructed Train 829 to stop at Kokiri until track clearance was received or the 15-minute buffer had expired. Had he drawn the occupation as a 'work-between', then it is very likely he would have realised the potential conflict and stopped Train 829 at Kokiri anyhow. However, being unable to apply a control block in SLAS areas left track occupations without a secondary safety defence and a safety recommendation has been made to the Chief Executive of ONTRACK to address this issue.

2.27 The incoming train controller was unaware of the 'work-between' nature of the occupation and acted correctly when the track worker advised him of the situation at 0714.

2.28 The track worker had not advised the train controller where he had planned to off-track. However, having been given track occupation to work between 191.00 km and Nos. 5 and 7 points Stillwater, he was authorised to travel in either direction as the work required up to the time the occupation was scheduled to terminate. When the work was completed, it was his responsibility to advise train control when he was off and clear of the track, which could be at any location within the limits of the occupation.

3 Findings

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

3.1 The track occupation irregularity occurred because the train controller plotted the track occupation as a 'proceed' rather than a 'work-between' authority on the train control diagram.

3.2 The performance of the train controller was probably impaired due to a cumulative sleep debt.

3.3 The recording of the occupation as a 'proceed' instead of a 'work between' on the train control diagram led the train controller into believing that it was safe to continue to advance Train 829 to Phoenix siding despite the 15-minute buffer conditions.

3.4 Had the train controller correctly recorded the occupation as 'work between', or later recognised the error on the train control diagram, the incident would probably not have occurred.

3.5 Although the posted rostered rotation and hours for the train controller for the 2 fortnights before the incident met the guidelines for medium and short-term changes, they were excessive.

3.6 The train controller's multi desk qualification made him one of the few train controllers available to fill vacancies and ultimately contributed to the excessive hours he worked.

3.7 ONTRACK's documented limits of hours worked and minimum time off for train controllers was not appropriate.

3.8 The use of staff on RDOs to cover staff shortages within train control reduced their recovery time, preparation time and recreation time between shift rotations to an inadequate level.

3.9 Although ONTRACK, had a system for monitoring total posted rostered hours and actual hours each fortnight by train controllers, the system was reactive and did not restrict or control shifts or total hours worked.

3.10 The train controller had adopted initiatives to improve his sleeping environment at home, but the warm temperatures during the day and his successive night shift rotations had nullified these initiatives.

3.11 The use of Rule 915 was appropriate for the occupation, but train controllers had no secondary defence system available to provide a greater level of safeguard for track occupations as was available in other signalling areas.

3.12 All personnel held current certification for the tasks they were undertaking.

3.13 The actions of the track workers, the locomotive engineer of Train 829 and the incoming train controller did not contribute to the incident.

4 Safety Recommendations

Safety recommendations are listed in order of development, not in order of priority.

4.1 On 15 July 2003 the Commission made the following safety recommendation to the Managing Director of Tranz Rail relating to train control rostering procedures and was included in rail occurrence report 02-118, regarding a near collision between an express freight train an HRV at Tauranga on 7 August 2002.

> Put in place control measures to ensure:
>
> - posted rosters are controlled within defined criteria compatible with the principles used in compiling base rosters
> - defined criteria are met before offering extra shifts to train controllers
> - actual hours are monitored and immediate corrective action is taken when operating or other factors increase rostered shifts beyond defined acceptable levels (008/03)

4.2 On 9 July 2003, the Managing Director of Tranz Rail accepted the preliminary safety recommendation, which was subsequently adopted unchanged as the Commission's final safety recommendation.

4.3 On 15 March 2005, the Commission redirected this safety recommendation to the Chief Executive of ONTRACK. This safety recommendation is equally applicable to this incident.

4.4 On 6 December 2005, as a result of Rail Occurrences 05-101 and 05-102, the Commission made the following safety recommendations to the Chief Executive of ONTRACK:

> introduce into existing train control rostering procedures a defined maximum number of consecutive at-risk (night) shifts that may be worked together with provision for a mandatory rest period before commencing the next shift rotation (097/05)
>
> and
>
> ensure that adequate appropriately trained staff are available to enable relief for vacancies amongst train controllers as a result of sickness etc to be undertaken without calling on staff rostered for, or already on, time off duty on rostered days off (098/05)
>
> and
>
> ensure that where a train control shift is extended beyond 8 hours a mandatory break of at least 15 minutes is available to the train controller as close as practicable to the start of the shift extension (099/05)
>
> and
>
> ensure that existing fatigue management training programmes include, but are not limited to, issues such as sleep practices, lifestyle, family commitments and the use of drugs including alcohol and stimulants etc (100/05).

These safety recommendations are equally applicable to this incident.

4.5 On 19 December 2005 the Chief Operating Officer of ONTRACK replied in part:

> ONTRACK accept and will implement recommendations 097/05, 098/05 and 100/05. The timeframe for implementation of these recommendations is yet to be determined.
>
> In regard to recommendation 099/05, a further review is required to be carried out before ONTRACK can decide whether this recommendation can be implemented.

4.6 On 8 December 2005 the Commission recommended to the Chief Executive of ONTRACK that he:

> develop a safety defence system for track occupations in SLAS areas in line with systems that provide a similar level of safeguards in other signalling areas (102/05).

4.7 On 16 December 2005 the Chief Operating Officer of ONTRACK replied in part:

> ONTRACK accepts this recommendation, and considers that it will be satisfied through the development and implementation of Project Kupe. This project will see Global Positioning System (GPS) date for all locomotive and other self propelled rail vehicles being available to National Train Control.
>
> Project Kupe Phase 1 has been approved for implementation. Installation of ONTRACK infrastructure to support the transmission and display of GPS position information will be completed by the 3rd quarter of 2006. The installation of GPS receivers on Toll's rail vehicles and ONTRACK's hi-rail vehicles is expected to take two to three years.

Approved on 16 December 2005 for publication

Hon W P Jeffries
Chief Commissioner

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