Rail Accident Investigation Branch

Rail Accident Report

Derailment of a passenger train near Cummersdale, Cumbria
1 June 2009

Department for Transport

Report 06/2010
March 2010

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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* Cover photo courtesy of Network Rail

Derailment of a passenger train near Cummersdale, Cumbria, 1 June 2009

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Preface

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame, liability or carry out prosecutions.

Key Definitions

3 References to ‘right’ or ‘left’ side of the train or track are made relative to the direction of travel of the trains involved, which was towards Carlisle.

4 Appendices at the rear of this report contain the following:

- abbreviations, in appendix A;
- technical terms (shown in *italics* the first time they appear in the report), in appendix B.

The Accident

Summary of the accident

5 On 1 June 2009, at approximately 14:20 hrs, train 2C31, which formed the 13:05 hrs Whitehaven to Carlisle service, was travelling on the Maryport and Carlisle section of the Cumbrian Coast line, heading towards Carlisle. The driver of train 2C31 had been requested to visually examine the line between Dalston and Cummersdale near Carlisle (figure 1) to find a defect in the track which had been reported by the driver of the preceding train, 2C47, to the signaller. While scanning the line, the driver of train 2C31 noticed a severe track buckle approximately 200 metres ahead. He applied the emergency brake but was unable to stop before the buckle. The leading bogie of train 2C31 derailed and ran on for approximately 25 metres. The trailing bogie was not derailed.

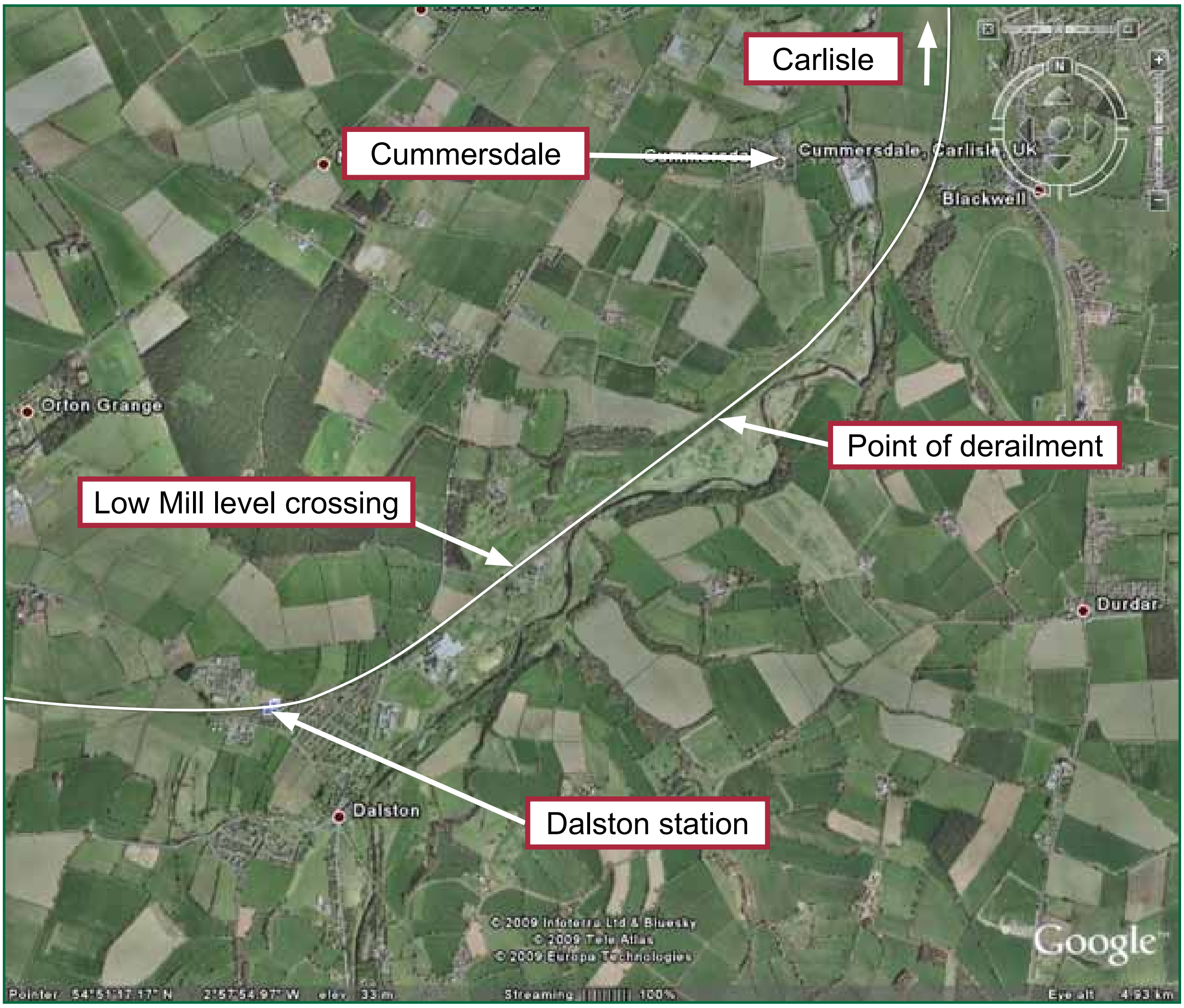

Figure 1: Location of the derailment between Dalston and Cummersdale

6 There were no injuries among the 15 passengers and two crew on board. Damage to the single car train was principally around the leading bogie and surrounding vehicle body. Damage to the track arising directly from the track buckle and derailment was confined to a length of about 30 metres around the point of derailment. However, more extensive repairs to stabilise the track over a distance of approximately 1.6 km were carried out. Figure 2 shows the track buckle and derailed train.

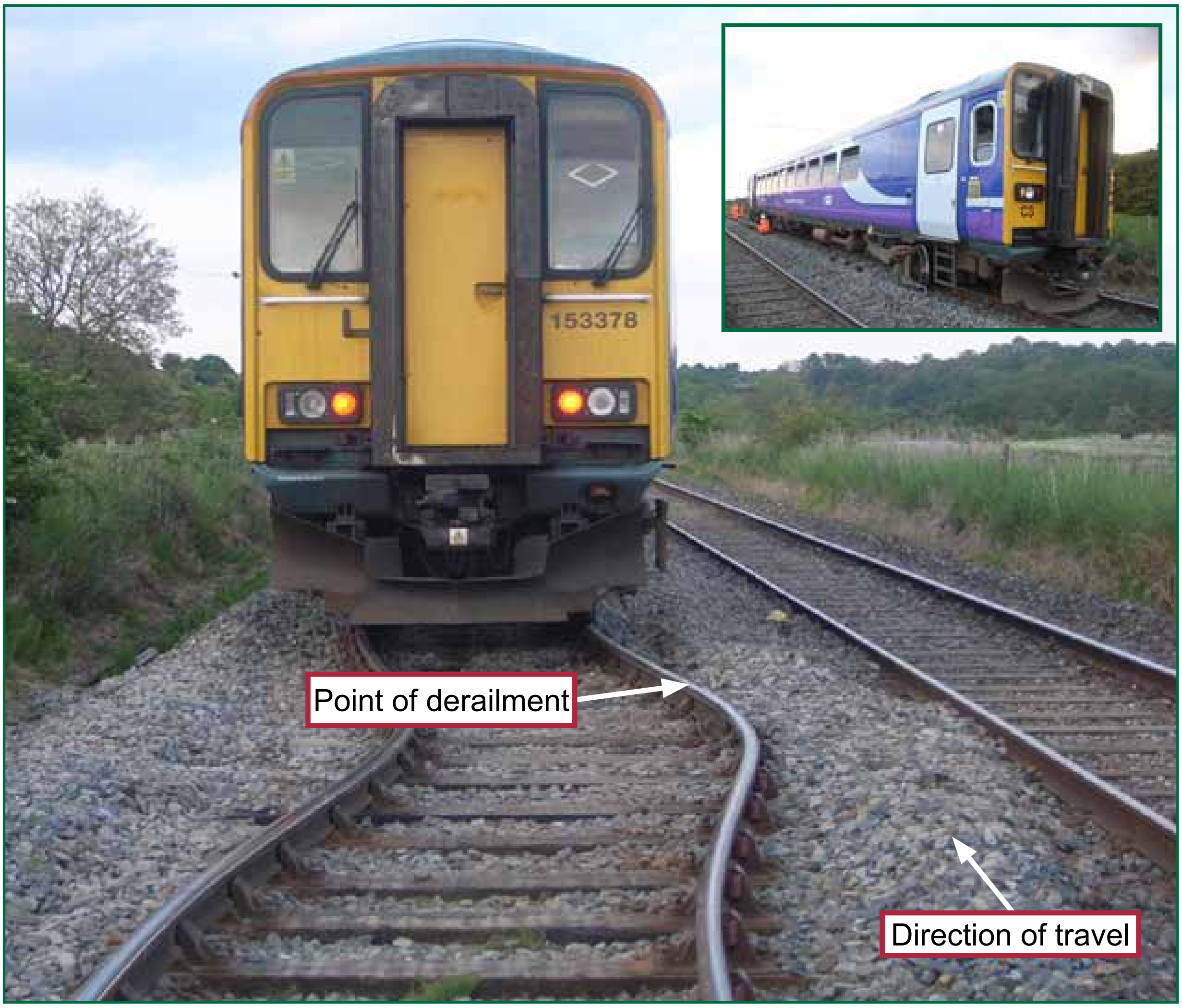

Figure 2: The derailed train showing the track buckle and the rear of the train 2C31 and (inset) the front of the train and derailed leading bogie

7 The line was closed until 05:00 hrs on 3 June 2009 when it was initially opened with a temporary speed restriction of 20 mph (32 km/h). Full line speed operation was restored on 10 June 2009, after the track had been *tamped*.

The parties involved

8 Train 2C31 was maintained and operated by Northern Rail, which also employs the driver of the train.

9 The track and signalling infrastructure of the Cumbrian Coast line are owned, operated and maintained by Network Rail which also employs the signallers controlling that route.

10 Network Rail's maintenance of the track on the Cumbrian Coast line is locally managed from Whitehaven and is carried out by two twelve-man production teams, one based in Whitehaven and the other at Workington. Track inspections are carried out by a six-man team based at Whitehaven. These three teams are jointly managed by two Assistant Track Section Managers and a Track Section Manager based at Whitehaven. The latter reported to a Track Maintenance Engineer based at Carlisle.

11 Both Northern Rail and Network Rail freely co-operated with the RAIB investigation.

Location

12 The Cumbrian Coast line runs between Barrow-in-Furness and Carlisle via Whitehaven, Workington and Maryport. The Maryport and Carlisle section comprises an 'up' line towards Maryport (where the zero milepost is located) and a 'down' line towards Carlisle. The point of derailment was located approximately 2.5 miles (4 km) from Carlisle station on the down line between Dalston and Cummersdale, at 25 miles, 01 *chains*. Figure 2 shows the point of derailment in relation to the rear of the derailed vehicle and the adjacent up line. The line speed is 60 mph (96 km/h).

13 The track on approach to and just beyond the point of derailment is straight on a falling gradient of 1 in 309. The construction of the track is shown in figure 3. The section of line relevant to this investigation is located between 24 miles 52 chains and 25 miles 36 chains. The first part, up to 15 sleepers before the point of derailment, has *bull head rail* mounted on concrete sleepers and the remainder of the section up to 25 miles 36 chains has bull head rail on timber sleepers. North of the bull head rail section is *jointed track* with *flat bottomed rail* and south of this section is *continuously welded* (CWR) flat bottomed rail. The connection with the bull head rail at the southern end is by means of an *adjustment switch*, and at the northern end is by means of a *fishplated* joint.

14 From the adjustment switches at 24 miles 52 chains to the point of derailment, there are 14 contiguous lengths of 120 ft (36.6 metres) bull head rail. North of this section, standard 60 ft (18.3 metres) rail lengths are used[1]. Throughout the site *Panlock* keys (figure 4) are used to fasten the rails to the *chairs*.

15 Trains are signalled under *track circuit block* regulations with colour light signalling throughout. Train movements are controlled by Carlisle signal box.

External circumstances

16 The weather at the time of the derailment was warm, sunny and dry. On the day, the air temperature reached 21°C by 11:00 hrs and peaked at 25.5°C at 16:00 hrs. Visibility was good at the time of the derailment and there was no evidence of sun glare affecting the driver's visibility.

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[1] Rail lengths are usually referred to by their imperial lengths and these terms are used without metric equivalents throughout the rest of this report.

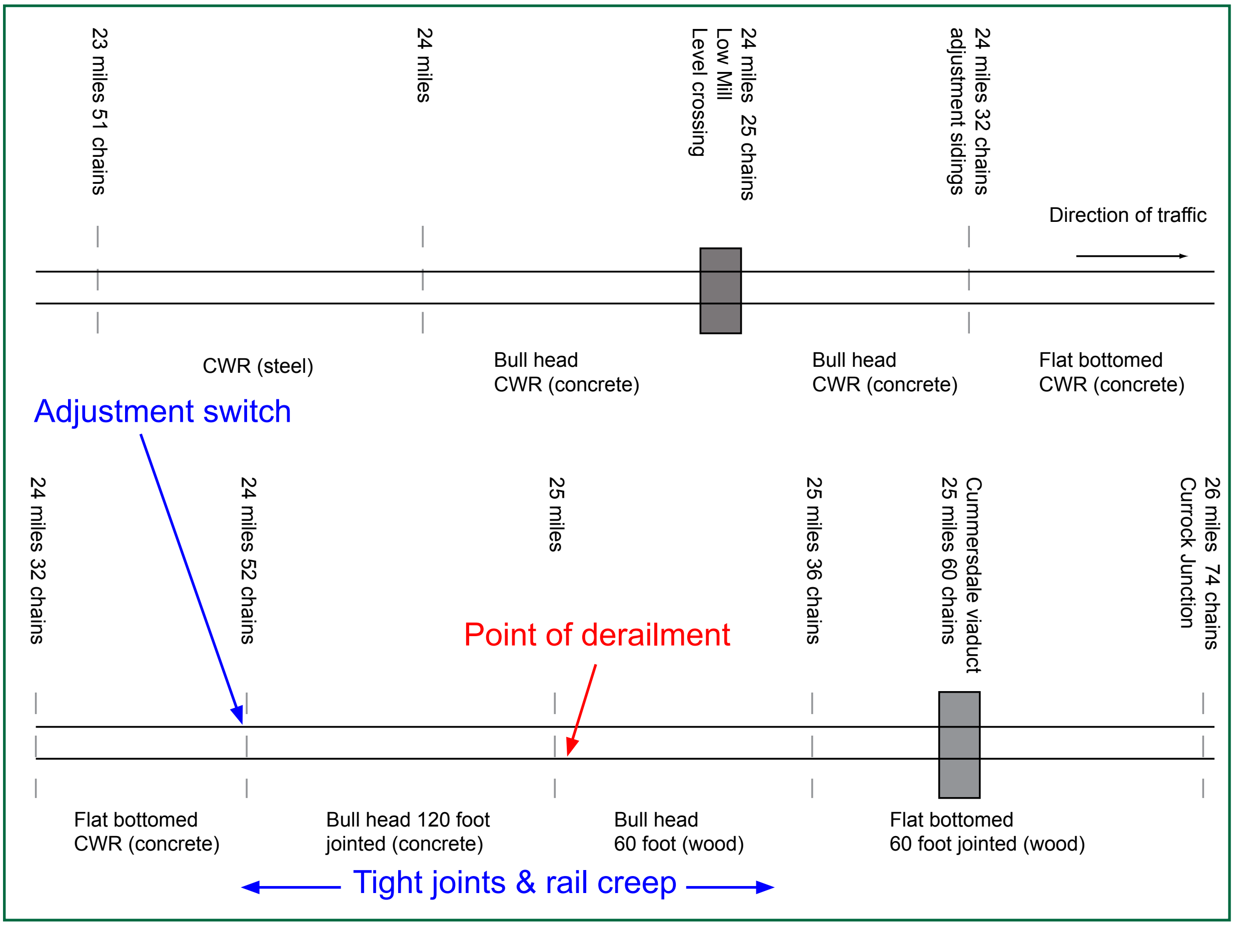

Figure 3: Track schematic showing variation in construction in relation to point of derailment

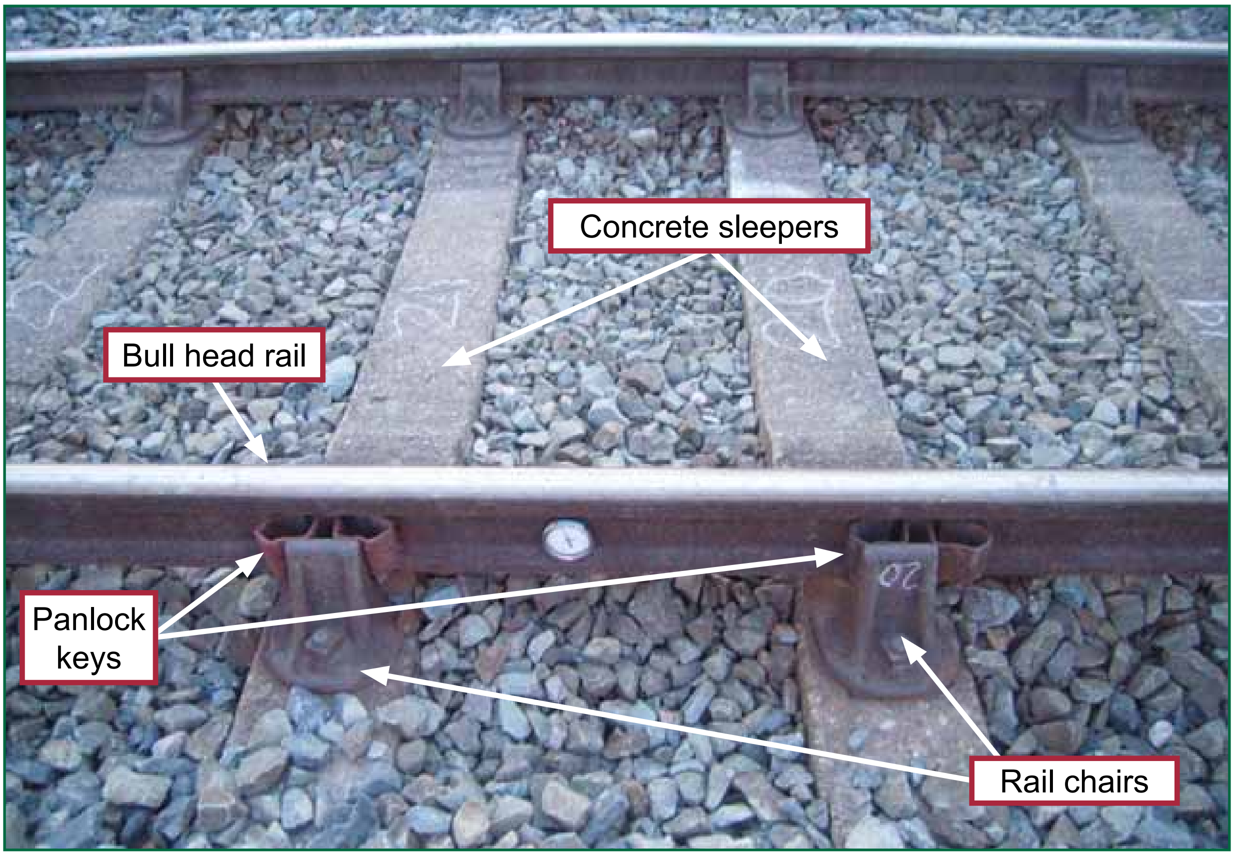

Figure 4: Construction of the down line on approach to the point of derailment

The trains involved

17 Train 2C31 which derailed was a single car class 153 diesel unit (153378). It has a maximum speed of 75 mph (121 km/h) and a *three-step brake*.

18 The preceding train, 2C47, was the 11:19 hrs Barrow to Carlisle and comprised a two-car diesel multiple unit (156443). It also has a maximum speed of 75 mph (121 km/h) and a three-step brake.

Events preceding the accident

19 At approximately 13:57 hrs on 1 June 2009, train 2C47 ran past milepost 25 on the down line at a speed of 50 mph (80 km/h). The conductor in the rear cab was thrown to the floor by a severe lateral lurch and, on getting up, looked backwards out of the rear cab windscreen and saw that the track had a large kink in it and was displaced towards the *six-foot*. The passengers in the rear coach also felt the lurch but neither the driver nor the front coach passengers felt anything unusual.

20 The conductor then contacted the driver on the cab-to-cab phone and asked him if he had felt anything to which he replied he had not. The conductor told him that there was "a bad kink in the line", and what had happened to those in the rear coach and said that they needed to report the problem as soon as they got into Carlisle.

21 At approximately 14:05 hrs, train 2C47 arrived at Carlisle Station, 22 minutes late for reasons unrelated to this accident. The driver immediately contacted the signaller and reported that they had experienced a "real bad kick in the line after Low Mill crossing" and that passengers in the rear coach had been thrown from their seats. The driver repeated the severity of the kick in the line twice more.

22 The signaller repeated the message back, told the driver of 2C47 that he would get it looked at and then made an entry in his log that the driver of 2C47, on arrival, had reported a bad kick just past Low Mill crossing. It was reported that at 14:12 hrs the signaller placed the word 'bump' on a label on his signaller's panel to remind himself of the reported track defect.

Events during the accident

23 At 14:14 hrs, the same signaller then stopped train 2C31 by placing signal CE349, located at 23 miles 22 chains on the approach to Dalston station, at danger (red). He informed the driver of train 2C31 that there was a 'bump' in the line ahead and that it was located somewhere between Low Mill crossing and Cummersdale. He instructed the driver to examine the line and report back if he saw or felt anything once he got to Carlisle and gave permission for train 2C31 to pass signal CE349 at danger. He did not mention any maximum speed limit or that the driver should proceed at caution.

24 The driver of train 2C31 repeated the message back to the signaller, as required, to check that he had understood it correctly and then, at 14:17 hrs, continued towards Carlisle. The on-train data recorder (OTDR) shows that train 2C31 accelerated up to around 50 mph (80 km/h) and maintained that speed while the driver was looking for the track defect. Meanwhile the signaller arranged for the track to be checked by a track examiner. Network Rail's Whitehaven Track Section Manager's office received a fault report at 14:15 hrs which described the fault as a 'kick' on the Carlisle side of Low Mill level crossing.

25 At 14:20:04 hrs, while travelling at 49 mph (79 km/h), the driver saw a severe track buckle on the down line, approximately 200 metres ahead of his train, and applied the emergency brake. At 14:20:16 hrs, train 2C31 derailed at the track buckle at a speed of approximately 24 mph (38 km/h), and came to a stop at 14:20:20 hrs.

26 At about the same time, the Assistant Track Section Manager at Whitehaven left the office to attend the site of the reported fault, there being no other staff nearer the Cummersdale area. He arrived at Low Mill crossing at 15:10 hrs.

Consequences of the accident

27 The leading axle of unit 153378 derailed toward the six-foot as it ran over the track buckle. The leading bogie *yawed* to the right and the trailing axle derailed towards the *cess*, the right-hand wheel dropping into the *four-foot*. The vehicle ran for a distance of approximately 25 metres with the leading bogie derailed. The right-hand edge of the snow plough fitted to the leading end of the vehicle, engaged with the six-foot rail (figure 5) and the vehicle deviated very little from the down line.

28 There were no injuries among the 15 passengers and two crew on board. The train was damaged principally around the wheels, leading bogie suspension and surrounding vehicle body. The track was damaged in the area of the derailment, where wooden sleepers and chairs had been broken by the derailed wheels.

Events following the accident

29 After the train came to rest, the driver and conductor checked on the welfare of the passengers. Then, having seen that the trailing bogie was still on the track and therefore that it would be operating the *track circuits*, the driver placed *track circuit clips* on the up line to prevent trains approaching the site from the opposite direction.

30 The driver then used the emergency button on the cab *NRN radio* twice but was unable to get through to anyone (due to a failure of the NRN system in Network Rail's Route Control in Manchester earlier that day, which was being repaired at the time). He then tried to contact Carlisle signal box by the NRN radio and was successful. He spoke to the same signaller who had asked him to examine the line a few minutes earlier at CE349 signal. The driver reported the derailment and obtained assurance from the signaller that his train was protected.

Figure 5: Leading end of unit 153378, showing positions of right-hand wheels and engagement of snow plough with right-hand rail

31 At approximately 14:25 hrs, on-call staff from Network Rail were despatched to site and arrived at 14:45 hrs. Northern Rail staff arrived on site at 15:30 hrs and organised the detraining of passengers to Low Mill crossing and their onward transportation by taxi, which was completed by around 16:25 hrs.

32 The line was opened for traffic at 05:00 hrs on 3 June 2009 with a 20 mph (32 km/h) temporary speed restriction and was returned to normal line speed operation on 10 June 2009 after tamping work to consolidate the ballast and stabilise the track.

The Investigation

Sources of evidence

33 Information for the RAIB's investigation was obtained from the following sources:

- on-site inspections;
- interviews of relevant staff undertaken by the RAIB;
- download of the OTDR from train 2C31;
- track patrolling and maintenance records;
- Network Rail company standards and procedures;
- correspondence with Network Rail staff regarding the use of relevant standards and procedures;
- research into the history and operation of 120 ft rails on the mainline UK network;
- Northern Rail train maintenance records;
- Network Rail and Northern Rail operational documents and rosters;
- historical information on previous track buckles, obtained from Network Rail and the Rail Safety and Standards Board (RSSB);
- hourly air temperatures from 1 March 2009 to 6 June 2009 for the southern Carlisle area and predicted hourly rail temperatures for 27 May - 6 June 2009 provided by Meteo Group; and
- relevant modules of Railway Group Standard GE/RT8000, 'The Rule Book'.

Previous occurrences of a similar character

34 There have been three recent track buckle incidents on the same section of track (Maryport to Carlisle), none of which resulted in derailment.

- On 22 July 2006 at 15:33 hrs, a track buckle occurred on the down line in the Cummersdale area at 24 miles 79 chains (40 metres south of the location of the derailment on 1 June 2009). The buckle occurred on a section of straight jointed track with bull head rail laid on concrete sleepers. The amount of lateral misalignment was 50 mm over a distance of 3 metres. The cause was attributed by Network Rail to '*tight joints*, *rail creep* or the absence of *rail anchors*'; one of a number of standard causes in a Network Rail track buckle reporting form. The site had not been disturbed by maintenance work prior to the buckle forming. Remedial realignment and *rail adjustment* were carried out to repair the track.

- On 27 July 2006 at 15:17 hrs, a track buckle occurred on the up line near Bulgill at 4 miles 20 chains. The buckle occurred on a section of curved track with bull head rail laid on softwood sleepers and fitted with Panlock keys. The amount of lateral misalignment was 25 mm over 3 metres. The rail temperature was 34°C. The site was subject to rail creep and had been rail adjusted on 23 April 2006. The principal cause was attributed to 'tight joints, rail creep or absence of rail anchors'. The site had not been disturbed by maintenance work prior to the buckle forming. Remedial realignment and rail adjustment were carried out to repair the track.
- In the late afternoon of 2 April 2005, a buckle occurred on the up line at 23 miles 50 chains near Dalston station. The buckle occurred on a section of curved track with 120 ft bull head rail laid on concrete sleepers and fitted with Panlock keys. The location was adjacent to a set of points. The amount of misalignment was 80 mm over a distance of 8 metres. This site had a history of rail creep and had been rail adjusted on 13 February 2005. The principal cause was attributed to 'tight joints, rail creep or absence of rail anchors'. The site had been disturbed by maintenance work just prior to the buckle forming. Remedial realignment, rail adjustment and installation of rail anchors were carried out to repair the track.
- Across the Network Rail infrastructure there have been a total of 445 track buckle incidents between 2000 and June 2009 (appendix D). During a similar period, 1999 – 2009, RSSB report there were six derailments attributed to track buckles on the mainline network, four involving freight trains and two involving passenger trains. None resulted in injuries but in some cases significant track and vehicle damage occurred. Network Rail reports that there have been 12 track buckle incidents since 1994 on the Cumbrian Coast line.

Analysis

Identification of the immediate cause[2]

35 The immediate cause of the derailment was *flange climb* of the right leading wheel over the six-foot rail as train 2C31 ran over the severe track buckle. Flange climb marks on the six-foot rail and corresponding tread corner marks on the cess rail started at the apex of the buckle misalignment, which was measured at approximately 550 mm over a distance of approximately 18 metres. There were no other track or wheel defects which could have caused the derailment.

Identification of causal[3] and contributory[4] factors

36 The RAIB identified ten causal factors which led to the derailment of train 2C31:

- the warm weather on 1 June 2009;
- insufficient expansion gaps in the jointed track;
- control of rail creep in the area of the derailment was not effective;
- the tight joints in the vicinity of the derailment site were not reported;
- the track was disturbed at a naturally weak point on the day before the derailment;
- there was a lack of recognition of the risk being imported by disturbing the track;
- the speed of train 2C31, whilst examining the line was too high due to a lack of caution by the driver;
- the signaller instructed the driver of train 2C31 to examine the line, instead of waiting for a track examiner to check it;
- the signaller omitted to instruct the driver of train 2C31 not to exceed 20 mph; and
- the signaller did not accurately convey to the driver the nature of the track defect.

Each of the above causal factors and their associated contributory factors are discussed in the following paragraphs.

[2] The condition, event or behaviour that directly resulted in the occurrence.

[3] Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

[4] Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

37 The condition of both train 2C47 and train 2C31 was discounted as being a factor in the derailment. Post accident checks on train 2C47 showed that the wheels were within the normal operating tolerances specified in Railway Group Standard GM/RT2466, 'Railway wheelsets', Issue 2, August 2008. There were no relevant faults reported prior to, or found after the accident on this train, which could have adversely affected its ride performance or contributed to the formation of the track buckle. Similarly, the wheel profiles of the leading bogie of train 2C31 were also found to be within the requirements of GM/RT2466. Train 2C31 had been examined on 22 May and 17 April 2009 during *A and B exams*, both of which involve inspection of the wheels, brakes and bogies. Neither of these exams found any faults which could have affected the vehicle's derailment resistance or braking performance.

The temperature on 1 June 2009

38 The warmest weather in the Carlisle area during the first half of 2009 led to a peak in rail temperature and was a causal factor.

39 Steel rails expand as the temperature increases. The increase in length depends on the original length of the rail, its thermal expansion characteristic and the temperature rise. The longer the length of the rail, the more it will expand for a given temperature rise. Allowance must be made in designing and maintaining track to accommodate such thermal expansion in hot weather. In jointed track, expansion gaps are provided at each fishplate joint to provide the necessary room for expansion so that the track is stable up to a rail temperature of 53^{o}C, the *critical rail temperature* for both CWR and jointed track on Network Rail. If the gaps are insufficient or if the joints have seized, then compressive stresses build up in the rail as the temperature rises. If the stresses become too large for a particular section of track, it will tend to buckle laterally and form a 'kink' in the line, known as a track buckle.

40 The rail temperature at which a buckle may form is dependant on the design and condition of the track and its supporting ballast. The highest risk period for track buckling is usually between the beginning of May and the end of August and the highest risk time of day is between 14:00 hrs and 18:30 hrs (extending to 13:30 hrs to 19:00 hrs during June and July)[5]. There are several factors which are known to increase the vulnerability of a section of track to buckling[5]:

- tight or seized joints;
- rail creep;
- the natural resistance of the track to lateral buckling, which is dependent on:
  - track construction (i.e type of rail, sleepers, fasteners, ballast);
  - condition of the track and ballast (e.g ballast shortage or *voided sleepers*
  - presence of transitions between bull head and flat bottomed rail which can create weak points; and
- disturbance of the ballast which also reduces the lateral stability provided by the ballast to the track.

[5] D L Cope and J B Ellis, 'British Railway Track, Volume 4, Plain line maintenance', published by the Permanent Way Institution, June 2001.

41 Air temperature data for the southern Carlisle area shows that during the first half of 2009, the maximum was reached on 1 June 2009, peaking at 25.5°C. This temperature is not abnormal. The variation of temperature between 1 March and 6 June 2009 is shown in figure 6.

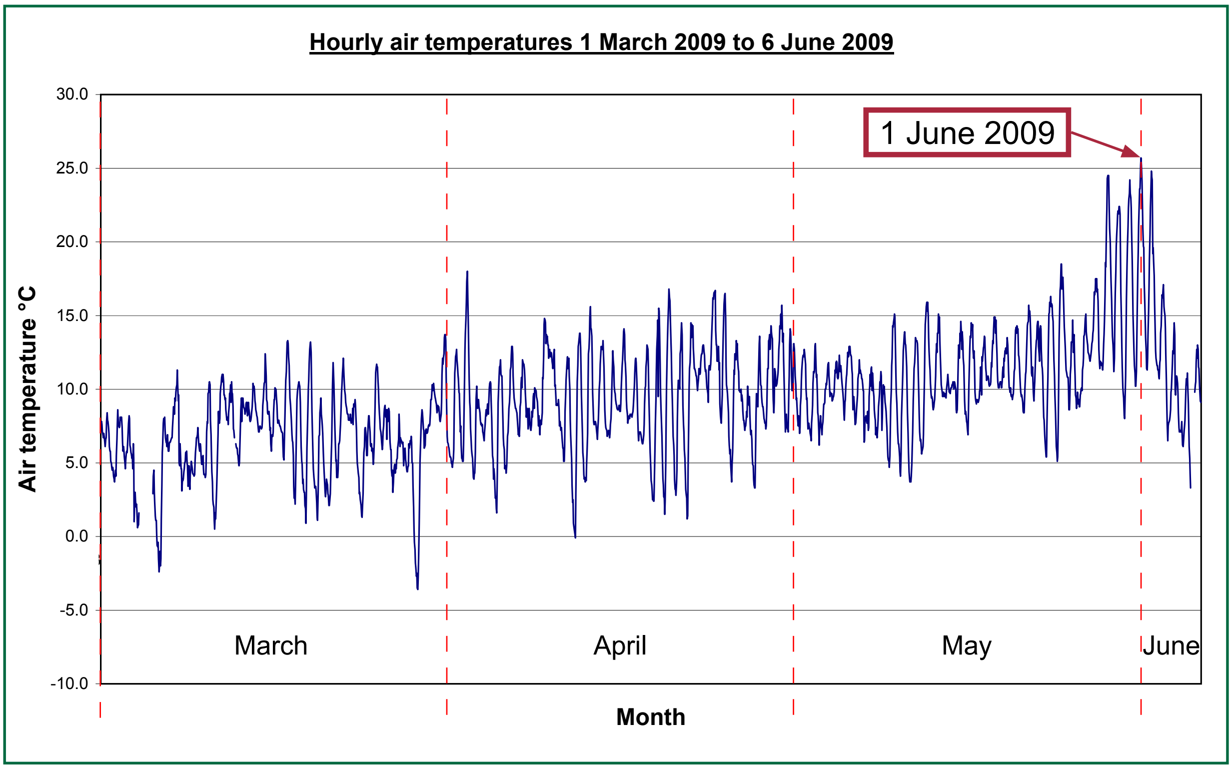

Figure 6: Air temperatures for South Carlisle area 1 March - 6 June 2009

42 Rail temperature modelling (using a computer model to predict rail temperatures from air temperatures, sunshine, cloud cover and topography) was used to predict the hourly rail temperatures at the location of the derailment for the period 27 May to 3 June 2009. This showed that the highest rail temperature also occurred on 1 June 2009 with a peak value of 41°C, predicted to occur at 14:00 hrs. The maximum rail temperature rise (i.e minimum in the previous night to the maximum), which also occurred on this day, was 35°C. As part of its standard measurements following a track buckle, Network Rail measured rail temperatures at three locations around the point of derailment, between 16:00 hrs and 20:30 hrs. This showed an average maximum value of 41°C at 16:45 hrs.

Insufficient expansion gaps in the jointed track

43 The buckle formed because the expansion gaps were insufficient and this was a causal factor.

44 A survey of joint gaps covering a distance of 800 metres around the point of derailment was undertaken by Network Rail between 19:00 hrs and 19:45 hrs on the day of the accident, when the rail temperature was around 31°C. There were 12 pairs of tight joints (i.e. joints at which the gaps had closed) on approach to the point of derailment (figure 7), and 8 pairs of tight joints after the point of derailment. A further survey undertaken at around 21:20 hrs, when the rail temperature was around 19°C, showed no significant change to the rail gaps. The joints being closed up at around 19°C indicates the *joint closure temperature* of the track around the point of derailment was significantly lower than the value of 38°C when joint closure would be expected, in accordance with Network Rail company standard NR/SP/TRK/102, 'Track Construction Standards', Issue 5, February 2002.

The sensitivity of 120ft rails to joint closure

45 The sensitivity of 120 ft rails to joint closure during thermal expansion, was a contributory factor.

46 Rail lengths of 120 ft rails are formed by welding two 60 ft rails together, the latter being the normal standard rail length. 120 ft rails are used in jointed track to reduce the amount of maintenance work related to fishplated joints. Maintaining rail joints is one of the most time consuming and labour intensive aspects of *permanent way* maintenance. Bolted joints are also a source of weakness in jointed track, affecting both the geometry of the track and the risk of rail failures at bolt holes. Between Whitehaven and Carlisle, a length of approximately 39 miles, a total of 1.6 miles is made up of 120 ft lengths, distributed in six different sections. The longest contiguous length of 120 ft rails is 800 yards (730 metres) long.

47 For a given size of expansion gap, unrestrained 120 ft rails (i.e rails which are relatively free to expand longitudinally) have a lower joint closure temperature than the standard 60 ft rails, on which Network Rail standards are based.

48 In the Cummersdale area, rail adjustment to reset the expansion gaps around the derailment site was last carried out on 1 February 2009 between 24 miles 52 chains and 25 miles 12 chains. NR/SP/TRK/102 specifies what the gaps should be, depending on the rail temperature at the time of adjustment. Table 1 contains the expansion gaps specified in that standard. The gaps were set to 10 mm on 1 February 2009 to suit the 6°C rail temperature measured at 04:00 hrs, when the work started. There is no evidence to suggest that the gaps were not set correctly.

Rail temperature (°C)	Expansion gap (mm)
below 10	10
10 – 23	6
24 – 37	3
38 or above	0

Table 1: Rail expansion gaps specified in NR/SP/TRK/102

49 The expansion gaps in Table 1 apply irrespective of the length of the rails but are based on the expansion characteristics of 60 ft rails. As far as the RAIB has been able to ascertain, there does not appear to be any formalised logic for adopting the same gaps for 120 ft rails, which if free to expand, would tend to expand by twice the amount of a 60 ft rail. However, whilst larger gaps would accommodate the greater expansion of 120 ft rails, they also cause greater impact loads when wheels run over them and this in turn leads to more track damage and maintenance. Additionally, there is a limit on the size of gap which is determined by the clearances between the bolts at the joints and the holes in the fishplates and rails. In practice rails are fastened down to the sleepers and are not able to expand freely. By using the expansion gaps for 60 ft rails on 120 rail lengths, there is an increased sensitivity to track buckling where:

- the 120 ft rails are not effectively restrained longitudinally by the rail fastenings; and
- there is rail creep, which also causes closure of expansion gaps in addition to thermal expansion.

In such cases, joints will close up more quickly with the onset of hot weather. This appears to be what occurred in the Cummersdale area on 1 June 2009.

Control of rail creep

50 The control of rail creep at the derailment site had not been effective, resulting in accelerated closure of the installed expansion gaps and this was a causal factor.

51 There was clear evidence of extensive rail creep at several joints on the approach to the point of derailment. Figure 7 shows the degree of rail creep at one of these joints on the down line. The rail joint, which should be in the middle of the space between the sleepers, had moved longitudinally in the direction of traffic such that it was bearing on and pushing out the Panlock key. The effect of rail creep could be seen on most of the joints on the approach to the point of derailment, although some of the movement seen after the derailment could have resulted from the formation of the track buckle itself.

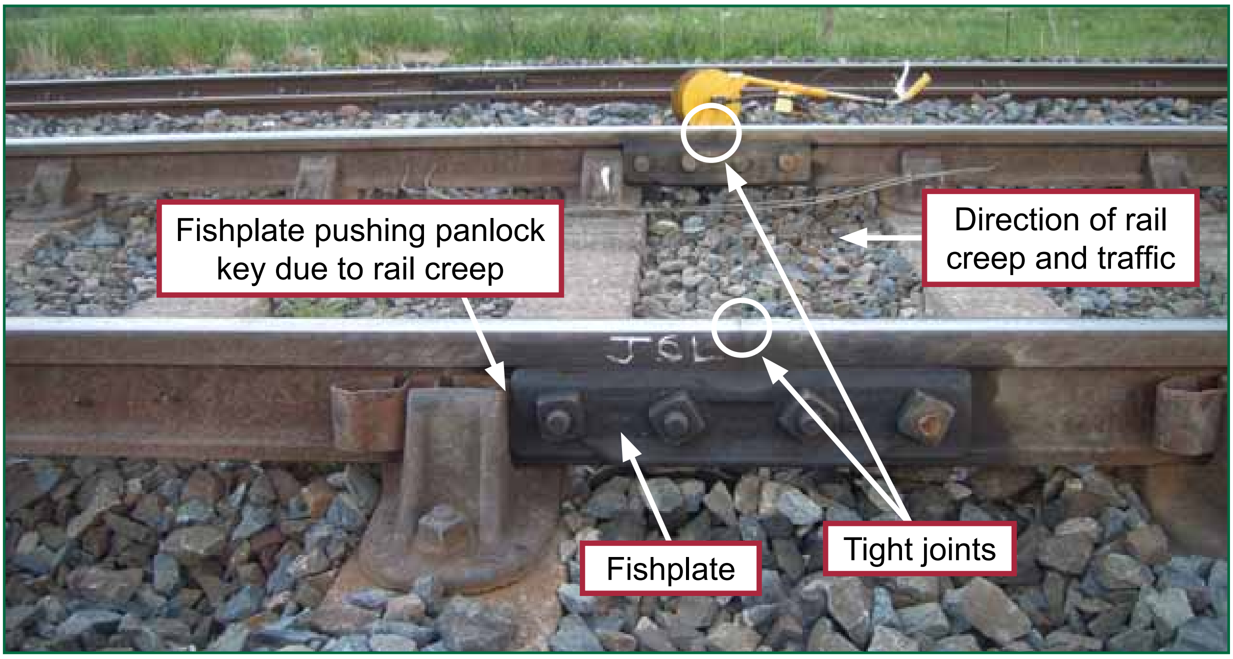

Figure 7: Tight joints and rail creep at the Cummersdale site

52 Rail creep usually occurs over a long period of time. Evidence from the previous track buckle incident at Cummersdale on 22 July 2006 (paragraph 34) and the track patrol records indicate that the occurrence of rail creep in the Cummersdale area is not new. However, the maintenance team and track patrollers were surprised at the extent of rail creep on 1 June 2009. It is possible that the rate of creep had increased suddenly during the weeks before the derailment but there is no precedent or reason for this, given that the traffic patterns have not changed recently.

53 The approach to managing rail creep at the site was confined to annual rail adjustment. This appears to have been adequate in 2007 and 2008 but was not in 2009. Evidence for the inadequacy of the rail creep management at the site is as follows:

- Panlock keys were still being used throughout the site and there were no plans to replace these prior to the derailment. NR/SP/TRK/102 specifies that Panlock keys must not be used in locations where there is a tendency to rail creep because Panlock keys do not provide effective restraint against rail creep.
- Despite the vulnerability of the site to track buckling (paragraph 34), there was no specific monitoring regime to gauge how much the rail was creeping, except for the routine, fortnightly, track patrols of the down line. Track patrol records from June 2008 onwards indicate that the rails continued to move.

The tight joints were not reported prior to the derailment

54 Tight joints observed in the vicinity of the derailment site were not reported because patrollers and maintainers were not aware of the sensitivity of this site to joint closure and buckling. Had they been reported, timely remedial action might have been taken and this was a probable causal factor.

55 The derailment site falls within a track patrol section between 23 miles 40 chains at Dalston and 26 miles 60 chains at Currock. Each of the up and down lines is inspected fortnightly in accordance with Network Rail standards by track patrollers who are trained and passed as competent for this role by Network Rail. The patrol of the down lines commences at Currock, usually at about 08:00 hrs and ends at Dalston some 3 to 4 hours later, depending on the weather and what is found during the patrol.

56 Patrol records going back to June 2008 show that all inspections had been undertaken by patrollers deemed by Network Rail to be competent and experienced. No tight joints were reported; however, other evidence provided to the RAIB indicates that some patrollers did see tight joints on this section of track. There is also evidence that on 31 May 2009 at around 08:00 hrs (when the track was repaired at the derailment site), eight pairs of tight joints were observed on the approach to the derailment site, although it is not known how many of these were consecutive. The air temperature at this time was around 13°C and the rail temperature was likely to have been around 22°C and therefore the joints should have had a 3 - 6 mm gap.

57 The reasons why the tight joints were not reported, although they were detected, are:

- Track patrollers use the Track Inspection Handbook, provided by Network Rail, which specifies that where more than five consecutive closed joints are observed when the rail temperature is less than or equal to 20°C, action should be taken to plan for rail adjustment. Any necessary correction should be complete by 1 May; if not hot weather precautions (using watchmen to monitor the track or temporary speed restrictions) should be applied. There is no differentiation in the handbook between 120 ft and 60 ft rails and therefore track patrollers would not necessarily report tight joints unless there were more than 5 consecutively.
- Patrollers were not aware of the sensitivity of the derailment site to joint closure and track buckling as this site was not a designated *hot weather site*. Had they been aware, they are likely to have been more vigilant about any tight joints below a rail temperature of 38°C (table 1).
- Judgements about the adequacy of expansion gaps are usually made during the early morning when track patrolling is usually undertaken at this site. Small gaps seen at this time of day may be passed as acceptable but could then close up at a lower temperature than specified in NR/SP/TRK/102 later in the day. For example, at 09:00 hrs on 28 May 2009, the approximate time of the last routine track patrol of the derailment site, the air temperature was 14°C and the rail temperature was likely to have been around 25°C. The expansion gaps should have been around 3 mm (table 1). From data provided in Network Rail letter of instruction NR/BS/LI/142, 'Management of disturbance and calculation of critical rail temperatures', 11 June 2009, the joint closure temperatures for 120 ft rails and 60 ft rails with 3 mm gaps, are 35°C and 40°C respectively. The former is below the 38°C threshold at which correctly set gaps should start to close.

58 Fatigue of track patrollers, possibly leading to them missing tight expansion gaps is discounted as a factor; track patrollers' shifts in the Cummersdale area usually start at about 07:30 hrs and finish at around 16:00 hrs. Analysis of the actual hours worked by the patroller who last inspected the track on 28 May 2009, indicates that fatigue was very unlikely to have been a factor.

The track was disturbed at a weak spot near the point of derailment on 31 May 2009

59 The track was disturbed at a naturally weak point on the day before the derailment and returned to service without any form of mitigation; this was a causal factor.

60 Disturbance of the ballast is known to reduce the resistance of the track to lateral buckling (paragraph 40), due to a reduction in the friction between the sleepers and ballast. If there are insufficient expansion gaps, there is an increased risk of track buckling in hot weather. Transitions between concrete sleepers and lighter wooden sleepers also cause weak points in the track with respect to lateral buckling. Therefore, disturbing the track near the point of derailment, where there was a transition between concrete and wooden sleepers, would have increased the risk of buckling, particularly when there were pre-existing tight joints.

61 During a routine run on 21 May 2009, Network Rail's Track Recording Unit (TRU) had identified a 1:176 *level 2* twist fault on the down line, at the location of the derailment. Such a twist fault is required, by Network Rail company standard NR/L2/TRK/001, 'Inspection and maintenance of permanent way', Issue 3, 26 August 2008, to be repaired within 14 days (i.e. by 4 June 2009).

62 Repair work was undertaken between 07:30 hrs and 08:30 hrs on 31 May 2009. In planning the work, no cognisance was taken of the impending hot weather. A standard process known as *measured shovel packing* (MSP) was used to repair the twist fault. The ballast between eight sleepers was dug out and the track was lifted. Measured amounts of ballast chippings were then added before replacing the track down onto the ballast. This was the only task involving track disturbance carried out between the adjustment switches at 24 miles 52 chains and the point of derailment on that day. The rail temperature was not measured before work commenced because the air temperature displayed on a building at Dalston read 10°C when the gang first got to site at around 04:00 hrs. The rail temperature during the work at the point of derailment (indicated by rail temperature modelling) is likely to have been between 23°C and 25°C at this time and the corresponding air temperature would have been around 16°C.

63 The track-chargeman in charge of the work at the time noted that the rail joints at the repair had a gap of 3 - 4 mm on both rails and that there were eight pairs of tight joints on the approach to the point of derailment in the down direction. However, he did not recognise the vulnerability of the track. Although the track-chargeman had been briefed about the effect of track disturbance on the stability of track, he believed the repair team had been careful to make sure there was sufficient ballast at the sleeper ends so that track stability would not be jeopardised.

Insufficient recognition of the risk being imported by the track disturbance

64 There was a lack of recognition of the risk being imported by disturbing the track and this was a probable causal factor.

65 Prior to the derailment there was no mandated Network Rail company standard for jointed track which laid down the requirements for when work could take place in hot weather. However, Network Rail company standard NR/L2/TRK/3011, 'Continuously welded (CWR) Track', Issue 6, 1 June 2008, was current at the time and warned about the reduction in lateral resistance of the track due to work which loosens the ballast. It specifies that work which may reduce the stability of track that is to remain open to traffic:

- shall not be started when the rail temperature exceeds 32°C;
- should not take place when the rail temperature is likely to exceed 32°C during the work; and
- should not take place when the rail temperature is likely to exceed 38°C within the next three days.

Rail temperatures should be checked for 3 days after the work is done. Similar guidance is also given in a Network Rail track work instruction, TWI 2T007, 'How to carry out measured shovel packing (MSP)'. This document, which is not mandatory, also adds that work must not be started if the rail temperature is greater than the critical rail temperature (the temperature at which measures to protect trains should be taken) if that is less than 32°C.

66 The maintenance work which was done on 31 May 2009 was commissioned by the local team management at Whitehaven on 29 May 2009. No-one took responsibility for checking the predicted air temperatures in the weather forecast provided to the Whitehaven office on that day when planning the work. The forecast had anticipated maximum air temperatures of 22.5°C on 31 May in the Lancashire and Cumbria areas, but no specific high temperature warnings were raised for these areas at that time. However, a subsequent forecast issued on Sunday 31 May (which was not seen by anyone at the Whitehaven office) listed 'high temperatures' as a hazard for the Lancashire and Cumbria area and anticipated peaks of 25°C on 1 June 2009.

67 The first temperature limit of 32°C in NR/L2/TRK3011 (paragraph 65) can be monitored by fitting rail temperature gauges at the site being worked on. The second temperature limit of 38°C requires an estimate of peak rail temperatures to be made from forecast air temperatures. A general rule of thumb is that on a clear day and in still air, the rail temperature could reach around 18°C above the air temperature[6]. Had the forecast air temperatures been taken into consideration when planning the work, rail temperatures of up to 41°C on 31 May and 43°C on 1 June 2009 should have been anticipated and the work postponed.

Workload pressure of remedial work

68 An increased workload on the Whitehaven team around the time of the derailment may have led to a lack of focus on the impending hot weather and was a possible contributory factor.

69 The TRU runs on the Cumbrian Coast line between Carlisle and Barrow in each direction twice a year, usually in May and November. The Whitehaven team were expecting the TRU run on 21 May 2009, and had booked *possessions* to carry out remedial work after this run. The 21 May run found 176 level 2 faults, which NR/L2/TRK001 requires to be repaired within 14 days. In addition to the TRU run, this year saw the first runs of the Ultrasonic test unit (UTU) on the Cumbrian Coast line. The UTU detects internal rail flaws which could develop into significant cracks in the rail. There have been previous runs of the UTU on the Cumbrian Coast line but these did not require remedial action to be undertaken within set timescales. The UTU ran through on 3 March and again on 16 April 2009 and found 56 suspected rail flaws which needed investigation and possible remedial action if verified. The arrival of the UTU was not expected locally and the resulting remedial work had not been planned into local work programmes.

The speed of train 2C31 whilst examining the line

70 The speed of train 2C31 whilst examining the line was too high to be able to stop before the track buckle, due to a lack of caution by the driver, and this was a causal factor.

71 Evidence from the OTDR record shows that train 2C31 was travelling at 49 mph (79 km/h) when the driver saw the track buckle approximately 200 metres ahead and applied the train's emergency brake. The train slowed down to about 24 mph (39 km/h) at the track buckle. There were no deficiencies in the performance of the emergency brake.

[6] D L Cope and J B Ellis, 'British Railway Track, Volume 4, Plain line maintenance', published by the Permanent Way Institution, June 2001.

72 The driver of train 2C31 did not proceed at a cautionary speed after being instructed to examine the line. The OTDR evidence shows the train proceeded at around 50 mph (80 km/h) up to a maximum of 53 mph (85 km/h) after being authorised to pass signal CE349 at danger. The driver had convinced himself, after speaking to the signaller, that he needed some speed to feel the 'bump' in the line and be able to accurately report its location and chose this as a reasonable speed. His perception of a cautionary speed when examining the line was dependent on the nature of the obstacle or defect he was looking for and the prevailing visibility and line curvature.

73 Clause 16.1 of Railway Group Standard GE/RT8000-TW1, 'Preparation and movement of trains: General', Issue 8, October 2008 (appendix E), requires the driver, if instructed by the signaller to examine the line, to 'proceed over the affected portion of the line at caution being prepared to stop short of any obstruction'. This is emphasised again in the same clause in red, 'You must always be able to stop within the distance you can see to be clear on the line ahead'. There is also a requirement in module S5 of GE/RT8000, "Passing signals at danger", for the driver to proceed at a safe reduced speed based on the train's braking capability and visibility, when instructed to do so by the signaller.

74 Notwithstanding the omission by the signaller to state the maximum speed at 20 mph (32 km/h), had the driver 'proceeded at caution, being prepared to stop short of any obstruction' (or track defect in this case), he should have maintained a significantly lower speed. The visibility conditions at the time were good and the track was straight. Using the emergency braking rate obtained on the day from the OTDR record and assuming the same sighting distance of the track buckle ahead, it is estimated that even if train 2C31 had been travelling at a speed of about 30 mph (48 km/h), the emergency brake would have been able to bring the train to a stop before the track buckle.

75 Although train 2C31 was running approximately 15 minutes late, there is no evidence from the driving style, the voice communications between the driver and signaller at signal CE349, or from other witness evidence, that the driver was rushing to make up time.

76 The driver of train 2C31 was competent to drive the train and had six years experience as a driver. He had no previous safety related incidents on his record. He felt rested at the time and his working hours during the previous month do not indicate any fatigue issues. Tests undertaken after the derailment show he was not under the influence of drugs or alcohol.

The signaller's instruction to examine the line

77 The instruction by the signaller to the driver to examine the line was a causal factor.

78 When the signaller received the report of a problem with the track from the driver of train 2C47, he had to consider whether to:

- stop traffic on the down line and ask for a rail defect examiner to inspect the line and determine the nature of the problem and if appropriate a suitable reduced speed for trains to continue running; or,
- request the next train to examine the line by driving at a cautionary speed such that the driver could stop in the distance he could see the line ahead to be clear.

79 Railway Group Standard GE/RT8000-TS1, 'General signalling regulations', Issue 5, April 2009, states in clause 17.1 (appendix E) that where there is a broken, distorted or damaged rail or broken fishplates, the signaller must arrange for a rail defect examiner or rail defect nominee to examine the rail or fishplates concerned'. A track buckle is a form of distorted track and therefore the correct action in the event of a reported defect resembling distorted track would be to stop traffic and have the line inspected by a rail defect examiner. In this case, the signaller was not sure about the nature of the defect reported to him. Although he thought that the defect could have been a distortion of the track, he does not appear to have understood its severity (paragraph 88). Rather than erring on the side of caution by invoking Clause 17.1, he chose to have the line examined by train 2C31.

Lack of clarity about when the Rule Book requirement to stop trains for track defects should be applied

80 There was a lack of clarity at Carlisle signal box as to when the Rule Book requirement to stop a train and have the line examined by a rail defect examiner applied to track problems, and this was a contributory factor.

81 The signaller's decision to use a train to examine the line for a defect which resembled a track buckle was in line with the expected response at Carlisle signal box in such cases. The interpretation of Clause 17.1 used there is that trains must be stopped when a reported defect is known or believed to be a broken rail but trains can be used to examine the line for a reported track buckle. However, the intention of Clause 17.1, as clarified to the RAIB by the Rail Safety and Standards Board (RSSB) who manage GE/RT8000 (the Rule Book) on behalf of the UK rail industry, is that 'distorted track' applies to track buckles. Therefore, trains should not be used to examine the line for suspected track distortions such as buckles.

The signaller omitted to instruct the driver not to exceed 20 mph

82 The signaller omitted to instruct the driver of train 2C31 that he should not exceed 20 mph (32 km/h) whilst examining the line, and this was a causal factor.

83 Having decided to use train 2C31 to examine the line for the reported track defect, the signaller did not follow the applicable procedure laid down in clause 20.3.2 of module GE/RT8000-TS1, (appendix E) which requires him to instruct the driver not to exceed 20 mph (32 km/h) while examining the line for a track defect. The signaller was aware of this rule but forgot to apply it on this occasion. The signaller also incorrectly instructed the driver of train 2C31 to pass signal CE349 signal at danger instead of clearing the signal in accordance with clause 20.4.1 of module TS1 (appendix E). Authorising a driver to pass a signal at danger should only be used in a limited number of defined circumstances which are laid down in module S5 of GE/RT8000, none of which include checking the line for a track defect.

84 Had the driver been instructed by the signaller to limit his speed to 20 mph (32 km/h), it is likely that he would have complied and would have been able to bring the train to a stop within the 200 metres sighting distance of the track buckle on the day.

85 The signaller had approximately 16 years experience at Carlisle signal box and had no previous safety related incidents on his record. He had cautioned trains through track problems such as track circuit failures on numerous occasions in the past, although the last time he had cautioned a train through for a track defect was about 3 or 4 years ago. His competency as a signaller and knowledge of the Rule Book was in date. He felt well on the day and his working hours during the previous month indicate that fatigue was not an issue. Tests undertaken after the derailment show he was not under the influence of drugs or alcohol.

The information conveyed to the driver of train 2C31 about the track fault

86 The signaller did not accurately convey to the driver of train 2C31, the description of the track fault that had been reported to him and this was a causal factor.

87 The driver of the preceding train (2C47) had reported to the signaller that there was a "real bad kick in the line" and that passengers had been thrown out of their seats. The phrase "real bad kink" was also used in the same conversation with the signaller. After the conversation, the signaller noted in his log that there was a 'bad kick' in the line (paragraph 22); however, when he spoke to the driver of train 2C31, he described it as a 'bump' in the line and thereby did not follow standard safety critical communications protocols[7], the requirements of which include conveying key information accurately.

88 The signaller stated that he did not know why he changed the description of the defect. It does not appear to have been intentional. He imagined the defect to be a slight lateral misalignment up to about 150 mm of distortion, or a dip in the track, or both, indicating that he had not fully understood the severity of the track defect.

89 The effect of this revised description of the track fault was to mislead the driver of train 2C31 into believing the defect was likely to be in the vertical rather than the horizontal plane. Had the signaller described the nature and severity of the defect accurately, the driver would probably have proceeded at a significantly reduced speed and been able to stop before the track buckle.

[7] At the time of the accident, these were set out in Network Rail Procedure NR/L3/OCS/041/3-08, "Voice recording checks – messages concerning safety", Issue 6, December 2008.

Identification of underlying factors[8]

The lack of a comprehensive standard for the maintenance and repair of jointed track

90 The lack of a comprehensive consolidated standard for the maintenance of jointed track in hot weather was an underlying factor.

91 Front line track maintenance staff at Whitehaven looked to mandatory standards to specify what they should do. However, prior to the derailment some key aspects of jointed track maintenance for hot weather, such as evaluating critical rail temperatures for 120 ft rail lengths, limitations on working on lines open to traffic and monitoring and managing rail creep were not covered in a mandated standard. This was because priority had been given to a standard for continuously welded rail after track maintenance was brought in-house into Network Rail by 2004. Track work instructions provide guidance on many aspects of maintaining jointed track in hot weather and preventing track buckles but these documents are not mandatory and their guidance was not faithfully followed by the front line staff at Whitehaven because their focus had tended to be the mandated standards.

The general lack of awareness at local level about the potential for track buckling at the site

92 There was a general lack of awareness of the potential for track buckling that existed at this site and this was an underlying factor.

93 Despite the previous track buckle in July 2006 (paragraph 34) which occurred at 24 miles 79 chains (i.e approximately 40 metres south of the point of derailment on 1 June 2009), there were several factors which increased the risk of a recurrence of a track buckle and which reflected this general lack of awareness:

- there was no monitoring of the rail creep;
- Panlock keys were left in place without any plans for replacement;
- there was no 'hot weather' briefing of staff in 2009 to focus minds on the impending warm weather;
- there was no adequate system for monitoring weather forecasts locally; and
- the remote rail temperature monitoring station at Dalston had been allowed to fall into disuse.

Lack of clarity in the Rule Book for drivers about speed when examining the line

94 There is a lack of clarity in module TW1 of the Rule Book for drivers about the maximum speed when examining the line for track defects, which was an underlying factor.

95 When the signaller omitted to specify a maximum speed of 20 mph (32 km/h) (paragraph 83) as he instructed the driver of train 2C31 to examine line, there was no back-up requirement in Module TW1 for the driver to drive to a particular maximum speed, nor to challenge the signaller about the maximum speed.

[8] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

96 Module TW1 does not specify the same 20 mph (32 km/h) speed limit for line examination for a track defect, as is specified in the signaller's rules in module TS1. This is unlike some other cases in the Rule Book; for example the examination of the line in tunnels, where both modules TS1 and TW1 specify a 10 mph (16 km/h) maximum speed; if the signaller should forget to mention the speed, there is still a back-up rule for the driver to obey.

97 The RSSB has indicated to the RAIB that such duplication of rules may be undesirable because it may detract from the signaller taking lead responsibility for the conversation with the driver; consequently where such duplication currently exists in the Rule Book, these may be removed in future revisions. The RAIB considers that it is necessary to have a requirement in the driver's rules for the driver to come to a clear understanding with the signaller as to what the maximum speed should be when examining the line for a track defect. This is to avoid a potentially dangerous situation arising in the event that the signaller forgets to instruct the driver about the maximum speed. The RAIB has therefore made a recommendation on this issue to the train operating company involved.

Severity of consequences

98 The consequences of the derailment were mitigated by the following factors:

- The train speed at the point of derailment was about 24 mph (39 km/h) and therefore the subsequent running distance, whilst the wheels were ploughing through ballast, was only about 25 metres.
- The derailed vehicle stayed close to the down line partly because a recess in the lower right-hand edge of the snow plough engaged with the six-foot rail and provided guidance for the leading end of the vehicle. The RAIB has previously made recommendations on examining the practicability of design elements on the bogie which limit the degree of deviation from the track, following other derailments[9],[10]. The RSSB, to which those recommendations were addressed, reported that its conclusion from an initial technical study was that the current risk is as low as reasonably practicable and therefore no changes to vehicle design standards could be recommended; however consideration should be given to providing infrastructure based protection at sensitive locations.
- The trailing axle of the leading bogie derailed to the four-foot side of the six-foot rail and this probably also helped to restrain the lateral movement of the leading end of the vehicle.

[9] Collision of a train with a demolished footbridge, Barrow upon Soar, 1 February 2008, RAIB Report 18/2008, September 2008.

[10] Derailment near Moy, Inverness-shire on 26 November 2005, RAIB Report 22/2006, November 2006.

Additional observations[11]

99 The preceding train 2C47 did not stop immediately and report the incident as required in the Rule Book. Clause 20.4 of module TW1 (appendix E) places duties on train drivers to stop immediately and inform the signaller if they believe a following train might be put in danger. In this case the driver was not immediately aware of the danger until the conductor reported it to him. The time that elapsed between the driver of train 2C47 becoming aware of the track fault (at approximately 13:58 hrs) and him ringing the signaller (at approximately 14:05 hrs, paragraph 21) was some 6 -7 minutes. If he had stopped at the next stop signal and contacted the signaller via the *signal post telephone*, he may have been able to pass his message around 4 - 5 minutes earlier. In the event, the delay did not have any bearing on this derailment because train 2C31 was about 15 minutes behind train 2C47. However, in different circumstances, on a more heavily trafficked route, the delay in reporting could have had more serious consequences.

100 The way in which the track patrols were being managed was not compliant with a recent Network Rail company standard NR/L3/TRK/1015, 'Management of track patrolling activity', Issue 1, 1 December 2008, in several respects. For example, the number of different patrollers used for a section of line was greater than the standard allows, and the use of *Ellipse walk-out reports* by patrollers during patrolling, which was normal practice at Whitehaven, is not permitted. There is no evidence that these non-compliances were a factor in this accident, however, they do demonstrate that developments in company standards are not being briefed to front line staff early enough to meet the compliance date of the standard.

101 Network Rail has advised the RAIB that replacement of Panlock keys from some sites prone to rail creep (paragraph 53) may introduce risks from other types of track fault, such as wide gauge. Therefore it may not be safe to replace Panlock keys in some rail creep sites.

[11] An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

Conclusions

Immediate cause

102 The immediate cause of the accident was the right leading wheel flange climbing over the six-foot rail as train 2C31 ran over a severe track buckle.

Causal factors

103 Causal factors were:

a. the warm weather on 1 June 2009, which was a normal condition (paragraph 38);

b. the expansion gaps in the jointed track were not sufficient (paragraph 43 and recommendation 1);

c. the control of rail creep in the area of the derailment was not effective, resulting in accelerated closure of installed expansion gaps (paragraph 50 and recommendations 1 and 3);

d. the tight joints were not reported prior to the derailment because track patrollers and maintainers were not aware of the sensitivity of the site to joint closure and buckling; this was probably causal (paragraph 54 and recommendations 1 and 2);

e. the track was disturbed at a naturally weak point on the day before the derailment and returned to service without any form of mitigation (paragraph 59 and recommendations 1 and 2);

f. there was a lack of recognition of the risk being imported by disturbing the track on 31 May 2009; this was probably causal (paragraph 64 and recommendation 1);

g. the speed of train 2C31, whilst examining the line was too high, due to a lack of caution by the driver (paragraphs 70, 114 and recommendation 5);

h. the signaller instructed the driver of train 2C31 to examine the line instead of waiting for a track examiner to check it (paragraph 77 and recommendation 4);

i. the signaller omitted to instruct the driver not to exceed 20 mph (32 km/h) (paragraphs 82, 113, no recommendation); and

j. the signaller did not accurately convey to the driver the nature of the track defect (paragraphs 86, 113, no recommendation).

Contributory factors

104 Contributory factors were :

a. the sensitivity of the 120 ft rails to joint closure in hot weather (paragraph 45 and recommendation 2);

b. the increased workload pressure on the track maintainers in the lead up to the derailment, which was a possible contributory factor (paragraphs 68, 112, no recommendation); and

c. there was a lack of clarity at Carlisle signal box as to when the Rule Book requirement to stop trains and have the line examined by a rail defect examiner, applied to track problems (paragraph 80 and recommendation 4).

Underlying causes

105 The underlying causes were:

a. there was no consolidated mandatory standard for the management and maintenance of jointed track which covered all the key preparation and maintenance tasks necessary for hot weather (paragraph 90 and recommendation 1);

b. there was a general lack of awareness at local level about the potential for track buckling at this site (paragraph 92 and recommendation 2); and

c. there is a lack of clarity in the Rule Book for drivers' rules about the maximum speed when examining the line for track defects (paragraph 94 and recommendation 5).

Other factors affecting the consequences

106 The following factors mitigated the severity of the accident (paragraph 98):

- the low train speed at the point of derailment;
- the derailed vehicle stayed close to the down line and did not foul the up line; and
- the leading and trailing axles derailed to opposite sides of the six-foot rail, restraining lateral movement.

Actions reported as already taken or in progress relevant to this report

107 Network Rail repaired the track at the derailment site, carried out rail adjustment, installed additional rail anchors and removed Panlock keys to minimise the risk of further track buckles. It also made organisational changes and carried out briefings to front line staff on relevant track standards.

108 Network Rail issued internal safety bulletin IGS 201 on 27 July 2009 to remind track maintenance engineers that a number of factors may contribute to track buckling. Attention was drawn to the following:

- Panlock keys should not be used on rail creep sites and where they are already fitted, expansion gaps should be monitored throughout the summer months;
- ongoing monitoring of expansion gaps after rail adjustment;
- the dangers of over tightening of fishplate bolts and seizing the joint; and
- track buckles occurring on recent worksites.

109 Network Rail issued a letter of instruction NR/LI/BS/142 'Jointed track - Management of disturbance and calculation of critical rail temperatures' on 11 June 2009. A draft of a similar document had been in circulation since August 2006 but was never formally issued or briefed out to front line track maintenance staff. In NR/BS/LI/142, the joint closure temp (JCT) is lower for 120 ft rails than 60 ft rails for a given expansion gap; this will alert track maintainers in future to joint closure sensitivity in 120 ft rails. NR/LI/BS/142 has now been absorbed into the existing mandated standard NR/L2/TRK/001 and will address some of the shortcomings identified at paragraph 103; however, there remains an absence of a consolidated standard for jointed track as exists for continuously welded track.

110 Northern Rail re-briefed the driver and conductor of train 2C47 on safety critical communications, timely reporting of incidents, and stopping a train immediately in such circumstances. It is also reviewing its training and assessment procedures for drivers and conductors to give clearer directions on actions following discovery of hazards encountered during service running.

111 The RSSB undertook a video reconstruction of the incident as part of a series of videos aimed at maintaining awareness of operational safety issues. The video comments on various lessons learned from this incident in respect of correct actions and communications. The reconstruction was circulated within the railway industry in February 2010.

Actions reported which address factors which otherwise would have resulted in an RAIB recommendation

112 The UTU inspection regime is now established on the Cumbrian Coast line and the Whitehaven permanent way office are aware its output will be a regular feature of their remedial work (paragraph 104b).

113 Network Rail re-briefed the signaller involved in this accident on passing signals at danger and examination of the line. A review of the signaller's safety critical communications, including when allowing trains to pass signals at danger, was also undertaken (paragraphs 103h - j).

114 Northern Rail re-assessed the driver of train 2C31 on his knowledge of the rules and instigated a monitoring programme for him. It is also including guidance on running at caution in the company's professional driving policy (paragraph 103g).

115 In the light of the actions identified in paragraphs 112 - 114, the RAIB has decided not to issue further recommendations in those areas.

Recommendations

116 The following safety recommendations are made[12]:

Recommendations to address causal and contributory factors

1 Network Rail should develop a comprehensive document for the maintenance and repair of jointed track, which brings together best practice, existing, and any new requirements and implement procedures so that it is used by relevant staff as the principal reference for jointed track. The document should include monitoring and controlling rail creep, setting and checking of expansion gaps in 120 ft rails in rail creep sites, ballast disturbance in hot weather, seasonal briefings to track patrollers and maintainers and rail temperature monitoring.

The purpose of this recommendation is to provide a consolidated document which provides maintainers with the necessary instructions and guidance to manage the risk of buckles in jointed track.

2 Network Rail should identify all sections of jointed track on its infrastructure which have 120 ft rail lengths in rail creep sites and introduce a process for monitoring such sites, undertaking remedial work as necessary in preparation for the 2010 hot weather season onwards.

The purpose of this recommendation is to minimise the risk of track buckles on other jointed track sites with similar characteristics to Cummersdale.

3 Network Rail should identify rail creep sites at which Panlock keys should be replaced (in accordance with NR/SP/TRK/102) and those sites at which they should be retained (to prevent risks from other types of track faults) and arrange for replacement at the identified locations, monitoring such sites in the interim.

The purpose of this recommendation is to remove the risk from Panlock keys at sites prone to rail creep, where it is safe to do so.

continued

[12] Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable them to carry out their duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

4 Network Rail should re-brief its signallers on the requirements of GE/RT8000, module TS1, clause 17.1, to clarify that when a track defect is reported which, by its nature and severity, could endanger trains (including track buckles), trains should not be used to examine the line, and include this in signallers' competency based assessments.

The purpose of this recommendation is to provide clarity to signallers on dealing with track buckles or other reported track defects that could endanger trains.

5 Northern Rail should promote appropriate changes to clause 16.1 of module TW1 of GE/RT8000, so that there is a specific requirement on drivers to come to a clear understanding with signallers as to what the maximum speed should be when examining the line.

The purpose of this recommendation is to reduce the risk of a dangerous situation arising as a result of an omission by a signaller to specify the maximum speed.

Appendices

Appendix A - Glossary of abbreviations and acronyms

CRT(W)	Critical rail temperature (watchmen)
CWR	Continuously welded rail
OTDR	On-train data recorder
MSP	Measured shovel packing
NRN	National Radio Network
TRU	Track recording unit
UTU	Ultrasonic test unit

Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com.

A exam (of a vehicle)	A scheduled examination of the whole vehicle in accordance with the vehicle maintenance plan. For Northern Rail Class 153 units, it is carried out every 5,250 miles (or 2 - 3 weeks).
B exam (of a vehicle)	A scheduled examination of the whole vehicle (more detailed than an A exam) in accordance with the vehicle's maintenance plan. For Northern Rail Class 153 units, it is carried out every 21,000 miles (2 - 3 months).
Adjustment switch	A scarf joint installed in the rails at the junction of continuous welded rail (CWR) and jointed track, and between CWR and some switch and crossing units, to isolate the adjacent track from longitudinal movement caused by temperature changes in the CWR.*
Bull head rail	A rail section which was first introduced around 1860 and which has a rail foot and rail head of similar shape. It has gradually been replaced by flat bottom rail but is still used on some lines.
Cess	The part of the track bed outside the ballast shoulder that is deliberately maintained lower than the sleeper bottom to aid drainage, provide a path and sometimes (but not always) a position of safety.*
Chains	A unit of length equal to 66 feet or 22 yards (approximately 20.117 metres). There are 80 chains in one standard mile.*
Chair (rail)	A cast or fabricated support for bull head rail.*
Continuously welded rail	Rail sections longer than 36.6m (120') manufactured by welding together shorter rail lengths.
Corrugation (rail)	A pattern of alternate high and low areas spread along the running surface of the rail caused by interaction of the wheel and rail.
Critical rail temperature (watchman)	The maximum rail temperature before measures to protect traffic should be taken. The CRT varies with track type and condition. The CRT(W) is the temperature at which a watchmen should be appointed to monitor the affected section of track.
Ellipse walk-out report	A summary report produced by a computer based asset management system used by Network Rail to record and prioritise what maintenance work is required to be done and when it needs to be done by.*
Fishplate	Specially cast or forged steel plates used in pairs to join two rails at a fishplated rail joint. Two, four or six fishbolts are used through the fishplates and rail ends to secure the fishplates to the rail ends.*

Flange climb	A situation where the flange of a rail wheel rides up the inside (gauge) face of the rail head while rotating. If the wheel flange reaches the top of the rail head, the wheelset is no longer laterally constrained and this usually leads to derailment.
Flat bottom rail	A common rail section which has a lower rail foot or flange which is wider and thinner than the rail head.
Four-foot	The area between the two running rails of a standard gauge railway.*
Hot weather site	A section of track designated by the infrastructure owner as vulnerable to buckling in hot weather and for which rail temperatures are monitored and special track patrols are conducted during the highest risk period of the day.
Joint closure temperature	The rail temperature at which two thirds or more of the rail joints on the section of track under consideration are fully closed.
Jointed track	Track constructed from lengths of rail shorter than 36.6 m (120 feet) in length and connected together with fishplated joints.
Level 2 fault (track)	A severity of track geometry fault defined by Network Rail and which has set repair timescales.
Measured shovel packing	A manual technique for accurately addressing small vertical errors in the track. The lift required is measured, and an appropriate number of cans of chippings are introduced under the sleeper to achieve this lift.*
National Radio Network	A dedicated railway communications system operated and maintained by Network Rail that allows direct communication between driver and network controller.
Panlock key	A spring steel W-shaped replacement for the traditional wooden key. It is shaped in such a way as to positively lock itself into the chair.*
Permanent way	The track, complete with ancillary installations such as rails, sleepers, ballast, formation and track drains, as well as lineside fencing and lineside signs.*
Possessions	A period of time during which one or more tracks are blocked to trains to permit work to be safely carried out on or near the line.*
Rail anchors	A manufactured steel clip fitted to the underside of the rail foot which bears against the vertical face of a sleeper or chair, fitted to increase the assemblies' resistance to longitudinal rail creep.*
Rail adjustment	The activity of moving jointed rails longitudinally to obtain the correct expansion gaps and to square the fishplated rail joints.

Rail creep	The longitudinal movement of a rail caused by one or more of a number of factors: traffic loading, thermal effects, rail *corrugation*, the effects of track gradient or train handling[13]. In jointed track rail creep causes bunching up of rails and this reduces the expansion gaps, making the rails more vulnerable to buckling.
Signal post telephone	A telephone located on or near a signal that allows a driver or other member of staff to communicate only with the controlling signal box.
Six-foot	The term for the space between two adjacent tracks, irrespective of the distance involved.
Tight joints	A fishplated rail joint in which the installed expansion gap has closed up.
Tamp	The operation of lifting the track and simultaneously compacting the ballast beneath the sleepers.*
Three-step brake	The different positions on the driver's brake controller representing progressively greater brake demands.*
Track circuit	An electrical or electronic device used to detect the absence of a train on a defined section of track using the running rails in an electric circuit.*
Track circuit block	A signalling system where the line beyond is proved clear to the end of the overlap beyond the next signal using track circuits.*
Track circuit clips	A pair of spring clips connected by a Wire, used to short out track circuits by connection across the rails in times of emergency.*
Voided sleepers	A track fault caused by gaps in the ballast under the sleepers, reducing the vertical support provided to the sleepers.
Yaw	A rotational motion in the horizontal plane about a vertical axis.

[13] British Railway Track Terminology, Volume 9, The Permanent Way Institution.

Appendix C - Key standards current at the time

Network Rail company standard NR/SP/TRK/102 Issue 5, February 2002.	Track construction standards
Network Rail company standard NR/L2/TRK/001, Issue 3, 26 August 2008.	Inspection and maintenance of permanent way
Network Rail company standard NR/L2/TRK/3011, Issue 6, 1 June 2008.	Continuously welded (CWR) track
Railway Group Standard GE/RT8000-TS1, Issue 5, April 2009.	General signalling regulations
Railway Group Standard GE/RT8000-TW1, Issue 8, October 2008.	Preparation and movement of trains: General
Network Rail company standard NR/L3/TRK/1015, Issue 1, 1 December 2008.	Management of track patrolling activity
Network Rail Operations Manual Procedure, NR/L3/OCS/041/3-08, Issue 6, December 2008.	Voice recording checks – messages concerning safety
Railway Group Standard GM/RT2466, Issue 2, August 2008.	Railway wheelsets

Appendix D - Track buckle derailments and statistics

Network Rail data on numbers of track buckles incidents 2000 - 2009

Year	Number of track buckles
2000/01	29
2001/02	49
2002/03	21
2003/04	137
2004/05	32
2005/06	55
2006/07	85
2007/08	4
2008/09	17
2009/10 (to end June 2009)	16
Total	**445**

RSSB data on track buckle incidents which resulted in derailment

Data provided by the Rail Safety and Standards Board (RSSB) indicates there have been six derailments attributed to track buckles since 1999 as follows. None resulted in injuries.

Middlewich, 24 June 1999: At 22:30 hrs, train 6S75, the 10:40 Sheerness - Mossend became derailed on a single line of a diversionary route approximately one mile north of Middlewich loop. The third wagon from the locomotive had become derailed whilst the train was travelling at 20 mph (32 km/h). The derailed vehicle had also become buffer locked with the second and fourth vehicles on the train. The cause of the derailment was initially unclear but was attributed to a track buckle.

Milford (N Yorks), 25 June 1999: At 16:00 hrs, train 6E41, the 12:05 hrs Warrington to Lackenby, became derailed on the down line by Milford signal box. The last eight wagons derailed on a track buckle. Dangerous goods in the form of caustic soda was being conveyed on the train. There were no injuries. The weather was exceptionally hot and sunny.

Rufford Junction, 11 February 2002: At 13:25 hrs four vehicles of freight train 6K70, the 12:48 hrs Worksop Yard to Clipstone became derailed on plain line approaching Clipstone C111 points at Rufford. The incident is indicated as being caused by a track buckle.

Quarry line (south), 30 June 2003: At 05:28 hrs the driver of passenger train 1U22, the 05:20 hrs Gatwick to Victoria reported that his train had run through buckled rails on the Up Quarry Line on approach to signal T200. 1U22 was the first train over the Up Quarry Line after possession work. The rear locomotive derailed and there were no injuries to any of the 26 passengers on the train. The cause was a track buckle just north of Redhill tunnel, the rails being reported to have moved 1 ft (0.3 metres) to the cess. It was later found that 1U22 became derailed because the track alignment after track maintenance the night before had not been checked and was not fit for line speed.

Lichfield Trent Valley (WCML), 15 July 2003: At 16:35 hrs the rear 15 wagons of freight train 4L92, the 13:30 hrs Ditton to Ipswich, derailed at Huddlesford and two wagons ran down the embankment. The train consisted of 22 loaded container wagons. No dangerous goods were involved. The cause of the derailment was attributed to a loss of track integrity resulting from a temperature induced track buckle.

West Sutton, 31 August 2004: At 13:50 hrs passenger train 2O57 was contacted by the signaller from Victoria Area Signalling Centre while at Sutton station. The signaller told him that earlier trains on the line from Sutton to Wimbledon had reported a rough ride between West Sutton and Sutton Common. The driver was asked to report back what he saw when he arrived at Sutton Common. On slowing for the 30 mph (48 km/h) speed restriction between West Sutton and Sutton Common, the driver noticed that the track was buckled. He made a full brake application but reported that two wheelsets of his train had become derailed on the sixth and seventh coach. There were no injuries to any of the 30 passengers on board.

Appendix E - Relevant extracts from GE/RT8000 (the Rule Book)

GE/RT8000 Module TS1, Issue 5, April 2009, General signalling regulations

17.1 Broken, distorted or damaged rails or broken fishplates

17.1.1 Signaller's actions

If you are told about a broken, distorted or damaged rail or that both fishplates are broken on the same rail, you must:

- stop trains from passing over the affected line
- tell Operations Control
- arrange for a rail defect examiner or rail defect nominee to examine the rail or fishplates concerned.

20.1 When the line is to be examined

20.1.1 Where the train signalling regulations require a line to be examined, this can be achieved by one of the following:

- you can see the line is safe for trains to pass
- getting a competent person to check the line is safe for trains to pass
- getting the driver of a train passing over the affected line to check the line is safe for trains to pass.

20.1.2 If a train is used for this purpose, the instructions shown in this general signalling regulation must be carried out.

20.1.3 If broken, distorted or damaged rails or broken fishplates are reported, you must not use a train to examine the line. You must instead carry out general signalling regulation 17.1.

20.3 Dealing with the train that will be used to examine the line

20.3.1 Before you allow the train that will be used to examine the line to enter the affected section, you must:

- tell the driver why the line is to be examined
- reach a clear understanding with the driver as to which portion of the line is to be examined.

20.3.2 You must instruct the driver that when the signal is cleared or you give permission to pass the signal at danger, the driver must:

- proceed at caution over the affected portion of line, being prepared to stop short of any obstruction
- if the affected portion of line is in a tunnel, not to exceed 10 mph through the tunnel
- if the overhead line equipment is to be examined, or the line is being examined because of a reported track defect, not to exceed 20 mph
- report the state of the affected line at an agreed location beyond the affected portion of line.

20.4 Signalling the train being used to examine the line

20.4.1 Where no other signaller is involved

When the driver has been given the necessary information, you may clear the signal for the train to proceed.

If it is not possible to clear the signal, you must carry out the instructions in Part A of module S5, *Passing a signal at danger*, before authorising the driver to pass the signal.

GE/RT8000 Module TW1, Issue 8, October 2008, Preparation and movement of trains

16.1 How to carry out an examination of the line

If instructed by the signaller to examine the line, you must:

- reach a clear understanding with the signaller about what is required
- if instructed to do so by the signaller, pass the signal at danger as described in the instructions in module S5 *Passing a signal at danger*
- proceed over the affected portion of the line at caution being prepared to stop short of any obstruction.
- carry out any other instructions given to you by the signaller.

You must always be able to stop within the distance you can see to be clear on the line ahead.

If the affected portion of line is within a tunnel, you must proceed through the tunnel at a speed not exceeding 10 mph, and be prepared to stop short of any obstruction.

After passing over the affected portion of the line, you must tell the signaller:

- whether the line is clear or not, and
- any other information that the signaller needs to know.

16.5 Broken, distorted or damaged rails and broken fishplates

If there is a broken or defective rail on the line on which your train is to travel, the signaller will have made arrangements for the rail to be examined.

The signaller will then:

- tell you what is happening, and
- the location of the broken rail.

When you are told to proceed, you must do so at the speed the signaller tells you.

20.3 When another train is put in danger

[Driver] If you see something wrong with another train, you must warn the driver of the other train if possible by:

- sounding the horn
- showing a red light to the driver of the other train
- switching on the hazard warning indication, if provided.

[Guard] If you see something wrong which could put another train in danger, you must alert the driver of the other train if possible by the most appropriate means.

20.4 When a following train is put in danger

[Driver] If you see an obstruction or something wrong which could put a following train in danger, you must:

- stop your train immediately at the next stop signal
- not proceed until you have told the signaller about the circumstances.

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