Rail Accident Investigation Branch

Rail Accident Report

Derailment at Epsom
12 September 2006

Department for Transport

Report 34/2007
September 2007

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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Change control	Date of change	Page no.	Paragraph no(s).	Description of change
v2	02/03/10	15	54	Correction to rail profile

Derailment at Epsom, 12 September 2006

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Introduction

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.

3 Access was freely given by Network Rail and South West Trains to their staff, data and records in connection with the investigation.

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

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

5 References to left and right throughout the report are to these directions looking in the direction in which the train was travelling.

6 In this report, locations are referred to by their position, in the form of a distance in miles and *chain*s from zero at London (Waterloo), in accordance with standard practice on the UK national network. There are 80 chains in one mile.

Summary of the report

Key facts about the accident

7 A South West Trains service from London Waterloo to Effingham Junction became derailed as it approached Epsom station, Surrey, at 19:42 hrs on Tuesday 12 September 2006.

8 One *bogie* of the fourth coach of the eight-carriage train derailed towards the left as the train was travelling at about 17 mph (27 km/h). The train came to a stop partly in Epsom station, and the passengers (estimated at between 300 and 400 people) were able to alight onto the platform. There were no injuries, and minor damage to the train and track.

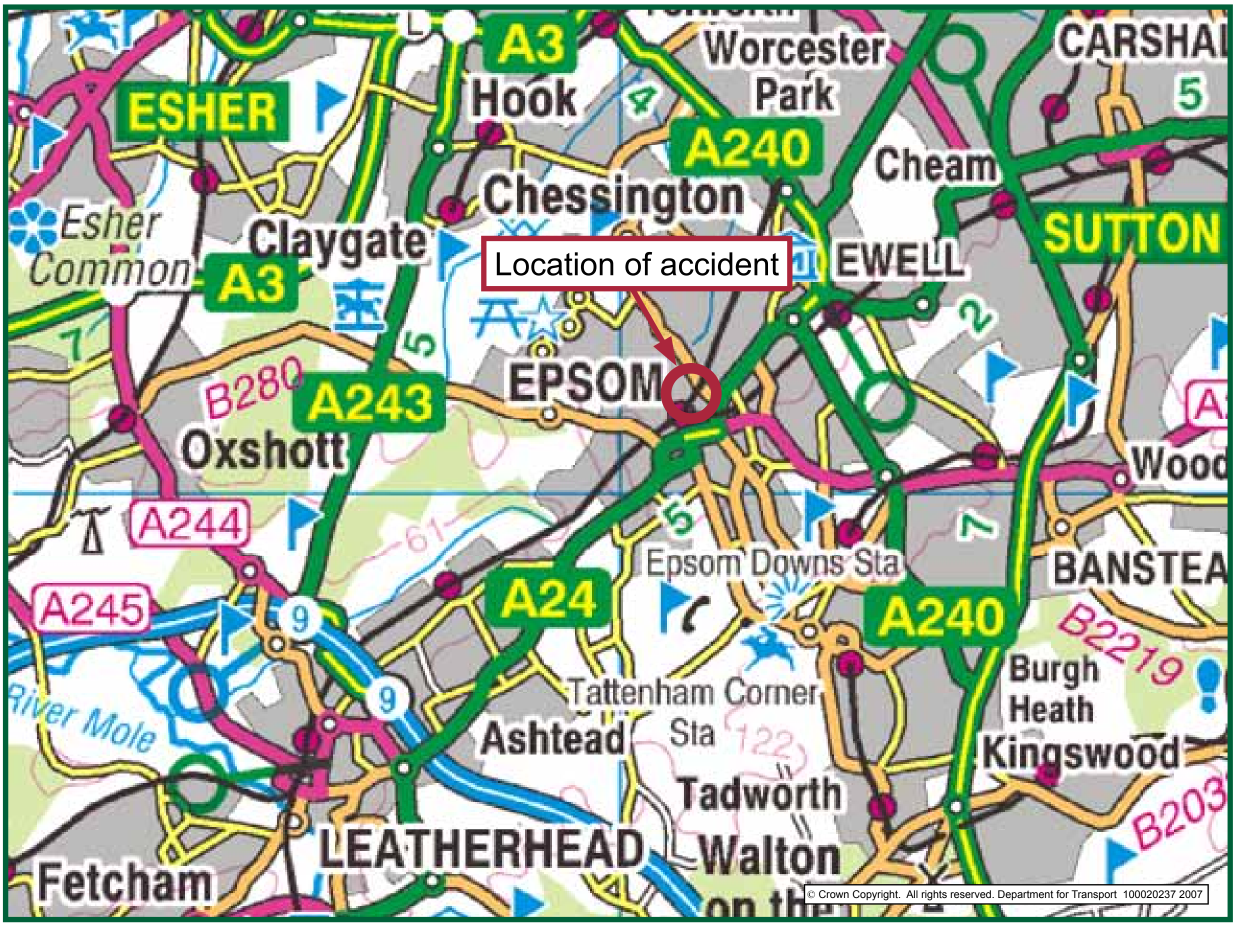

Figure 1: Extract from Ordnance Survey map showing location of accident

Immediate cause, causal and contributory factors, underlying causes

9 The immediate cause of the derailment was that two wheel flanges climbed the rail head immediately beyond the *heel joint* of points 840B.

10 Causal factors were:

- Poor track geometry created by a combination of lateral and vertical misalignment, local rail damage and *sidewear*. These defects were apparent from visual inspection, and measurement by inspection staff and the *track recording coach*, and were covered by standards which required action to be taken.
- The absence of rail lubrication at the point of derailment, following removal of the local lubricator and the failure of the remote lubricator.
- The lack of proper maintenance attention to the track at the point of derailment.
- The non-renewal of the right hand *half set of switches* in points 840B, which had been planned for several years. This was a result of the poor resource situation in the maintenance organisation.
- The lack of effective follow-up to *facing point* inspections which had identified various faults at points 840B over a period of two years .

11 The following factor was considered to be contributory:

- The loss of the planned re-railing of the plain line on the approach to 840B points in June 2006.

12 The underlying causes were:

- The shortage of track maintenance staff in the area and the workload of staff at all levels in the maintenance organisation.
- The failure of staff to understand the consequences of the removal of the lubricator on the curve approaching the points.
- The absence of proper maintenance attention to a defective lubricator.

Recommendations

13 Recommendations can be found in paragraph 143. They relate to the following areas:

- The resourcing of the track maintenance organisation in Network Rail's Wessex area.
- The guidance given to track inspection staff on action to be taken when defects are found.
- Revision of Network Rail's standard for the provision, use and maintenance of rail mounted lubricators.

The Accident

Summary of the accident

14 Train 2D57, the 19:09 hrs service from London Waterloo to Effingham Junction, became derailed on the approach to Epsom station, Surrey, at about 19:42 hrs on Tuesday 12 September 2006.

15 The train was formed of 8 coaches, consisting of two four-car class 455 *electric multiple units* (EMUs). The leading bogie of the fourth coach was derailed by both axles towards the left as it passed over a set of *trailing points* on a right-hand curve, while the train was travelling at about 17 mph (27 km/h).

16 The train came to a stop partially in Epsom station, and all the passengers on board were quickly evacuated onto the station platform. There were no injuries, and there was only minor damage to the train and the track.

Figure 2: Third and fourth carriages of train, showing fourth carriage derailed and in contact with station platform

17 Investigations into the derailment commenced immediately. The train was re-railed by 03:00 hrs the following morning, and after repairs to the track, normal services resumed at 07:45 hrs.

The parties involved

18 The train was operated by South West Trains. The infrastructure was owned, operated and maintained by Network Rail (Wessex Route).

Location

19 Epsom station is the junction between two double line routes from London: the line from Waterloo, via Raynes Park, and the line from Victoria, via Sutton. It has four platforms, arranged as two *islands* serving *up* and *down* trains: the actual convergence of the tracks is south of the station, but the down line from Waterloo crosses the up line to Victoria immediately north of the platforms (Figure 3).

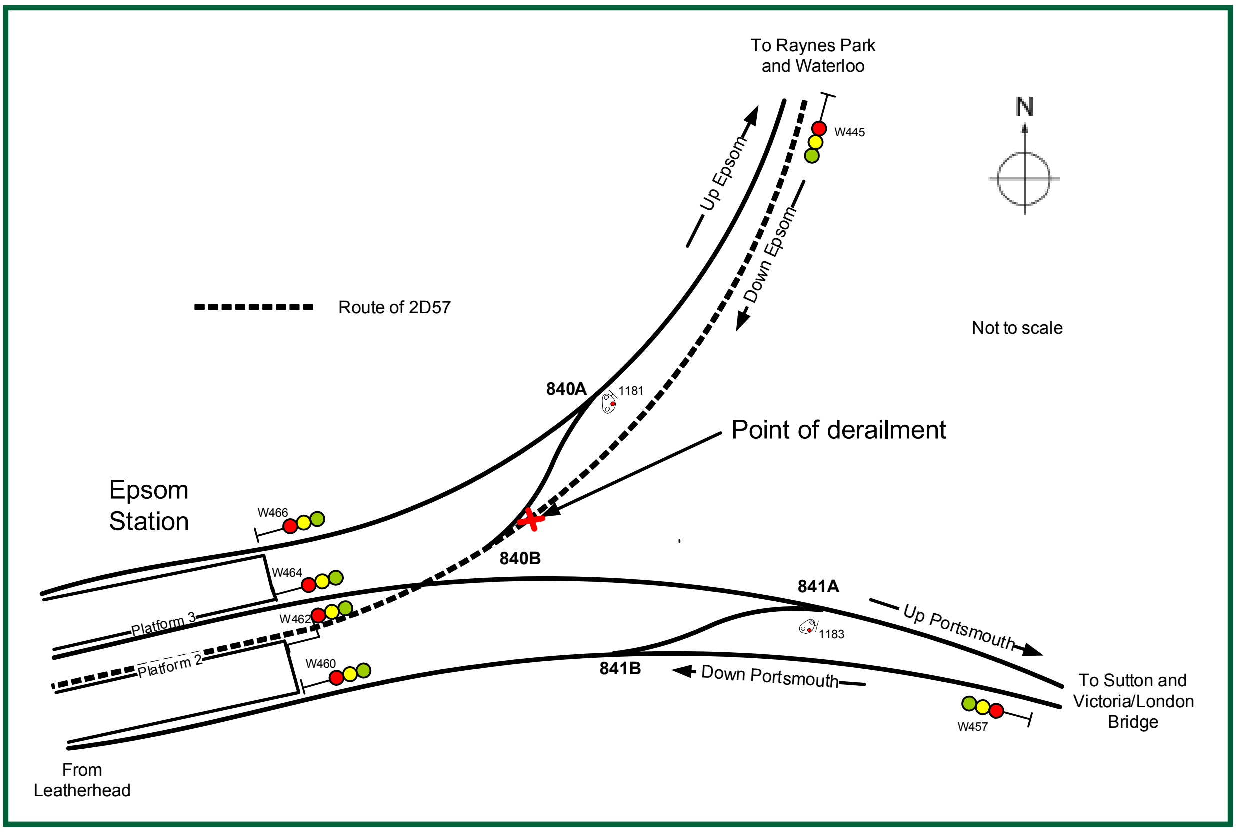

Figure 3: Location plan

External circumstances

20 The weather on 12 September was dry and clear.

The train

21 The train was formed of two class 455 EMUs: 455905 (leading) and 455866 (trailing). They are owned by Porterbrook Leasing and operated by South West Trains (SWT). The units were built by BREL at York between 1982 and 1985. They have run ever since on the Waterloo suburban services, and are allocated to SWT's Wimbledon depot for maintenance purposes.

The track and signalling

22 The line from Raynes Park (8 miles 49 chains) to Epsom (14 miles 18 chains) is served only by local passenger trains. There are intermediate stations at Motspur Park (9 miles 57 chains), Worcester Park (10 miles 53 chains), Stoneleigh (11 miles 74 chains) and Ewell West (12 miles 78 chains).

23 For down trains, the line speed is 60 mph (100 km/h) from Raynes Park (8 miles 68 chains) as far as the curve approaching Epsom, where there is a permanent speed restriction of 20 mph (32 km/h) from 13 miles 70 chains as far as the station itself at 14 miles 18 chains. This curve, which is to the right in the down direction, is of approximately 300 m radius. In the curve, at 14 miles 9 chains, is a trailing *crossover*, consisting of two sets of points numbered 840A and 840B (Figure 3).

24 This crossover is used by trains which have terminated in platform 2 at Epsom and are returning towards Raynes Park. There is only one daily passenger train scheduled to make this movement. The crossover may also be used at times of disruption to services.

25 At this point the line is on a gradient of 1 in 90 rising toward Epsom. Points 840B are laid with BS 113A *flat-bottom* rail on timber *bearers*, supported on granite *ballast*. The right-hand (viewed from the *toe* of the points) switch half set consisted of austenitic manganese steel (AMS) rail, and was installed in 1984. The down line from 13 miles 4 chains is laid with *jointed track* as far as 13 miles 68 chains, from where *continuous welded rail* (CWR) extends around the curve as far as 840B points outside Epsom station.

26 Signalling is by the *track circuit block* system with three and four aspect colour light signals, controlled from panel 4 at Network Rail's Wimbledon Area Signalling Centre.

Events preceding the accident

27 Train 2D57, the 19:09 hrs suburban service from Waterloo to Effingham Junction, started on time and had a normal journey as far as Ewell West, its last calling point before Epsom. It left Ewell West at 19:39 hrs with between 300 and 400 passengers on board.

Events during the accident

28 As the train approached Epsom, the driver shut off power and reduced speed to comply with the 20 mph permanent speed restriction round the curve into the station, entering the curve at 19.2 mph (30.9 km/h). He felt a judder, and looked back, observing blue flashes and smoke from the rear of the train. He assumed there was a fault with the train, and attempted to coast into the station. As the fourth coach came into his field of vision, the driver saw that it was derailed and made an emergency brake application. The train then stopped within five seconds.

29 Both axles of the leading bogie of the fourth coach were derailed to the left. The leading end of the fourth coach struck the edge of platform 2 as the train came to a stop, about 100 m from the point of derailment. The driver made an emergency call, using the Cab Secure Radio (CSR) system, to the signalling centre at Wimbledon, to advise the signaller of the situation and ensure that the train was adequately *protected*.

30 The driver contacted the guard of the train over the internal telephone to advise him of the derailment, telling the guard not to release the doors because the train was not fully in the platform. Both driver and guard made announcements over the public address system in the train, telling the passengers to remain seated.

31 The driver then released one set of doors on the fourth coach using the external handle, and passengers were detrained through these doors onto the platform, assisted by the guard. Many of the passengers were travelling to Epsom, and they left the station before the staff could record any details, so the number of passengers on the train can only be estimated (paragraph 27).

Consequences of the accident

32 There was slight damage to the train where it contacted the platform edge, and distortion to the damper brackets of the derailed bogie caused by the excessive bogie rotation which occurred during the derailment. One 'hopper' ventilator window was dislodged when its stay bracket was broken, and fell into the passenger saloon, but it did not shatter and there was no other interior damage or displacement of internal fittings.

33 There was some track damage beyond the point of derailment, with minor damage to 840B points, the *diamond crossing* and some track fastenings and sleepers, but superficial damage only to the edge of the station platform.

Events following the accident

34 Investigations into the cause of the accident began immediately. The Raynes Park – Epsom line was closed and services were diverted or curtailed. Epsom station was closed until 21:00 hrs, when it re-opened with platform 2 taped off.

35 Following examination of the train, re-railing commenced at 02:15 hrs and was completed by 03:00 hrs. The train was removed to Wimbledon Park depot at 04:45 hrs. Repairs to the train were carried out at Wimbledon depot and were completed by 18 October 2006, and the train was returned to service shortly afterwards.

36 Repairs to the track, involving the removal of the *switch rail* from 840B points and the fitting of a new *stock rail*, were completed in time for an empty test train to pass over at 07:46 hrs on 13 September. The line was re-opened for normal services at 08:16 hrs.

The Investigation

Investigation process and sources of evidence

37 The RAIB investigation into this derailment included:

- detailed examination and survey of the site before repairs were made;
- examination and measurement of the wheels of the train;
- analysis of sections of rail removed from the site; and
- modelling of the behaviour of the train.

38 In addition to the examinations listed above, the investigation obtained evidence from:

- Network Rail records of the inspection and maintenance of the track;
- evidence gathered for the joint formal investigation into the incident by Network Rail and South West Trains, including maintenance records and reports by staff;
- records of runs by the track recording train; and
- interviews with staff.

Factual Information

The condition of the track

Introduction

39 The Raynes Park to Epsom line is specified by Network Rail as category 3 for inspection and maintenance purposes, in a range where category 1 covers high-speed heavily trafficked lines, and lightly used freight-only lines are in category 6. Lines in category 3, with a line speed of 60 mph (100 km/h), are those which carry between 5 and 13 equivalent million gross tonnes per year. Routes are categorised by the Track Engineer for the Territory, according to criteria defined in Network Rail standard NR/SP/TRK/001 'Inspection and Maintenance of Permanent Way'.

40 The train derailed on the right-hand curve approaching Epsom station, as it passed over 840B points. The investigation involved detailed examination of the track in this area.

41 Marks on the head of the rail enabled the point of derailment to be accurately identified early in the investigation. It was clear that wheels had climbed over the high (outer) rail immediately beyond the *insulated block joint* (IBJ) between plain line and the right-hand (as viewed from the toe of the points) switch rail of 840B points, at 14 miles 9 chains.

Track geometry

42 The track was surveyed during the investigation, and static values for gauge, *cant*, left and right *top*, and radius were measured.

43 The survey showed that the radius of the curve varied between 200 m and 400 m on the approach to the point of derailment, and then decreased from 411 m to 222 m over the last 15 sleepers. The cant also decreased from 14 mm to zero over the same length. The highest *twist* value recorded is 1 in 333, five sleepers before the point of derailment.

44 The variation in gauge is shown in Figure 4. The gauge increased from 1436 mm two sleepers before the point of derailment, to 1460 mm at the point of derailment.

45 Network Rail has several vehicles which are used for recording track geometry. The Track Recording Coach (TRC) which is normally used on the electrified lines south of the Thames is usually locomotive hauled. It uses a non-contact measuring system to record the following parameters:

a) twist defects on 3 m wheelbase and 5 m wheelbase;

b) the vertical profile of the rails;

c) the horizontal alignment of the rails;

d) *dynamic track gauge.*

46 The results of TRC runs provide both identification of individual faults and a picture of the quality of the track on each line. Any serious faults (as defined in table 8 of NR/SP/TRK/001) requiring immediate action are telephoned to the section manager for the line by a representative of the maintenance organisation who travels on the train. The full results are sent to the section manager when the run is complete. Remedial action for defects is required, on defined timescales which range from 36 hours to 120 days. Emergency speed restrictions, as specified in the table referred to above, may be imposed for some defects, pending repairs. The TRC data supplements that from on-foot inspections as the TRC measures the geometry of the track and can identify both general condition and areas of poor geometry that need attention.

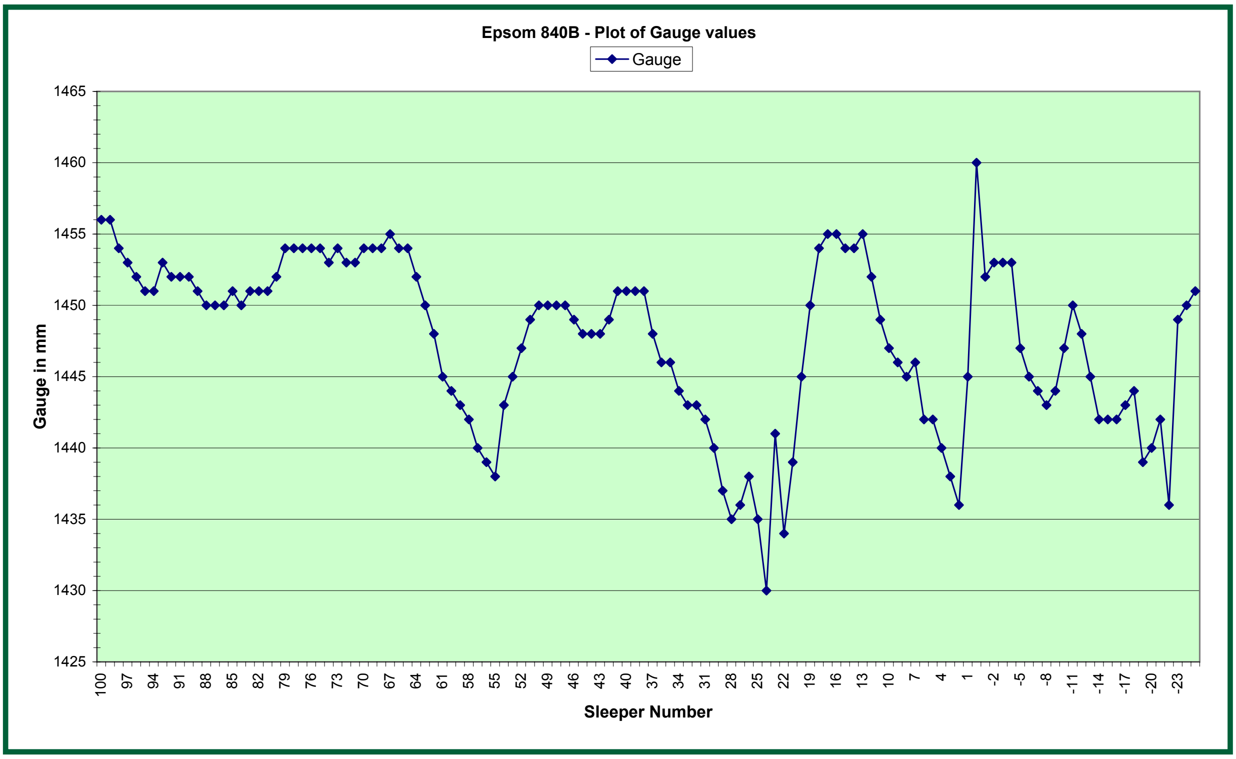

Figure 4: Track gauge at derailment site

Figure 5: Outer rail at point of derailment, showing misalignment

47 Track geometry quality in respect of vertical profile and horizontal alignment is expressed as a standard deviation value of measurements taken at frequent intervals over each eighth of a mile. Thus a value of zero would represent completely perfect track. Values of standard deviation which exceed the maximum permitted in table 10 of NR/SP/TRK/001 will require remedial action or a speed restriction.

48 The TRC is not intended to be relied on as the primary, or only, system for finding track geometry faults. Visual track inspections (normally weekly) and manual measurements of points are required to detect track faults within a timescale that ensures the safety of the railway, such as loose fastenings, decaying sleepers, drainage problems, and other faults that may develop between the runs of the TRC or may not be detectable by it. The TRC should provide confirmation of the conditions identified by visual inspection, and assist the track engineers in planning and prioritising repair and renewal works.

49 The TRC ran over the line from Raynes Park to Epsom on 26 April 2005 and 30 August 2006. The maximum interval for TRC runs over this class of line is 12 months (as specified in NR/SP/TRK/001, Table 1), although runs were planned on a six-monthly basis to ensure compliance with this standard. However, a weight restriction temporarily imposed during 2006 on the bridge immediately north of Epsom station (paragraph 124) caused locomotive-hauled trains to be prohibited from using the line until remedial work was completed, and meant that the TRC run planned for February 2006 was postponed until August. No alternative arrangements were made to inspect and record the track geometry on the routes where TRC runs could not take place.

50 The TRC run of 30 August 2006 identified a number of poor quality sections of track. The TRC divides the line into eighth of a mile lengths for the purpose of measuring quality. The eighth of a mile from 13 miles 70 chains to 14 miles 0 chains had both left and right top sufficiently poor to register as a '*super red*', and the eighth of a mile from 14 miles 0 chains to 14 miles 10 chains had right top poor enough to also bring it into this category. There were alignment faults recorded at 14 miles 10 chains and 14 miles 11 chains, corresponding (within the limits of error of position measurement of the track recording train) to the location of points 840B.

51 For the whole length of line between Raynes Park and Effingham Junction (27 miles 8 chains (43.6 km)), there were 365 defects identified by the TRC run of 30 August 2006. Five of these were in the vicinity of 840B points. These all fell into the category of defect that NR/SP/TRK/001 requires to be repaired within seven days.

52 A plan to deal with the defects, working from Effingham Junction towards Raynes Park, was developed by the assistant track section manager and by 5 September all 11 of the '36 hour' defects had been addressed, and work was continuing to deal with the remainder. None of the five defects at 840B points, which should have been corrected by 7 September, had been dealt with by the time the derailment occurred on 12 September.

Rail condition

53 During the investigation the rails at the point of derailment were examined. Two rails were involved: the plain line on the approach to the joint where derailment occurred (the *running-off rail*), and the stock rail of the right-hand half set of switches that formed part of points 840B (the *running-on rail*) (Figure 5). These were connected by an IBJ.

54 The running-off rail was marked as being made to the BS 113A standard profile, which is an appropriate section for this line and location. Measurements showed that it was, dimensionally, in accordance with this standard.

55 The running-on rail was marked as being made of austenitic manganese steel (AMS), and was magnetically verified as such. AMS is used for point components because of its greater wear resistance. Both the rail head and foot were approximately 3 mm wider than specified. Other dimensions were within the tolerances for BS 113A rail, although the rail height was reduced from the nominal size by about 6 mm by wear.

56 The effect of the wear on the head of the running-on rail was to produce a step of approximately 5 mm between the two rails when they were connected together with *fishplates*. This rail was also sideworn at the running-on end (Figure 6). There were heavy deposits of powdered metal on the gauge face and on the foot of the rail: these deposits were fresh and had not oxidised (Figure 7).

Figure 6: Section of end of running-on rail

57 On the running-on rail, there was evidence of 'batter' damage (localised plastic deformation generated by wheels passing over the stepped joint) to the top of the rail head. Damage to the top of the rail extended approximately 530 mm from the joint.

58 There was an area of damage to the head of the running-on rail, approximately 55 mm long extending from the rail end, consistent with the application of a rotary abrasive disc grinder (Figure 8).

59 There was also damage to the gauge face immediately below the grinding marks that appears to have been caused by 'spalling' of the surface, a phenomenon in which repeated impact loading of the surface material of the rail causes it to become work hardened and embrittled to the point where it breaks off (Figure 8).

Figure 7: Stock rail near point of derailment, showing sidewear and deposits of powder worn away fron rail head

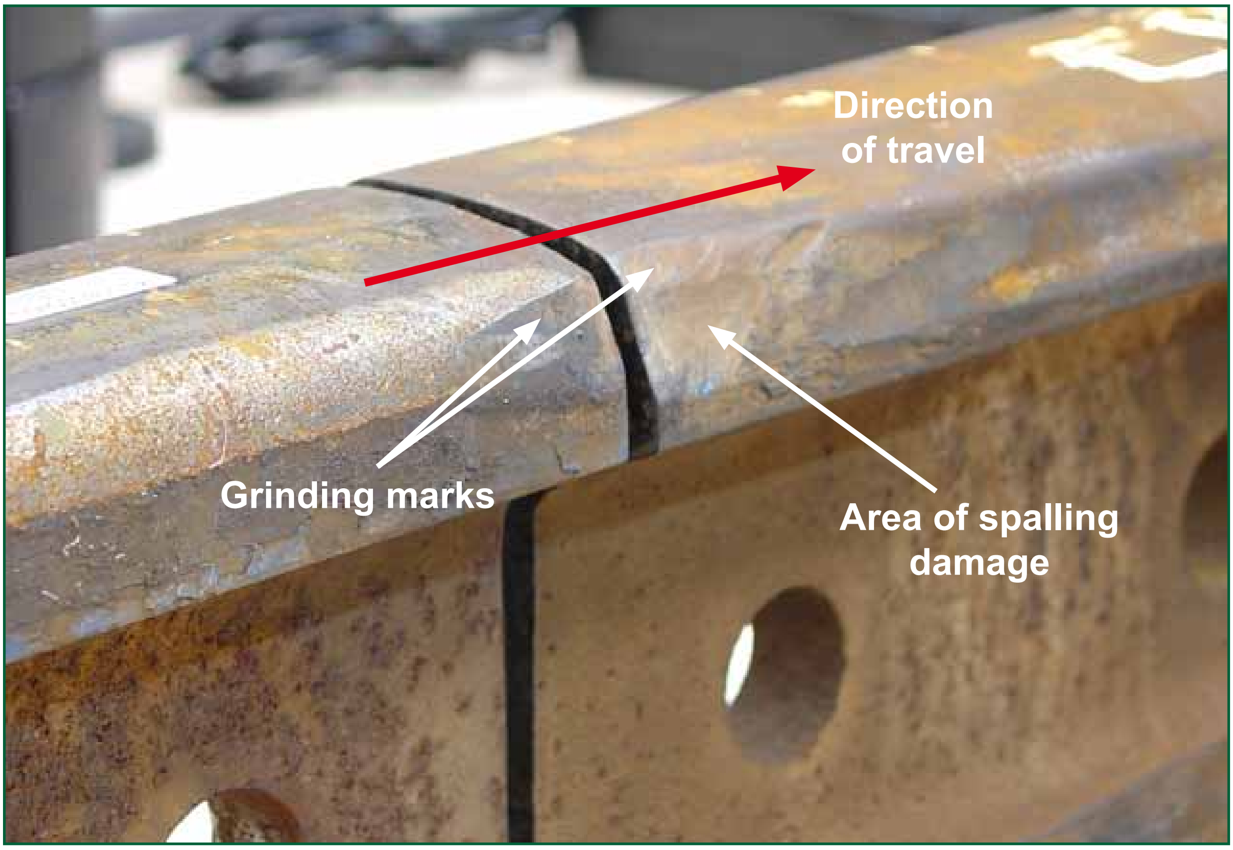

Figure 8: Wear and grinding damage on rail head adjacent to joint (photographed in laboratory)

60 Marks on the rail head showed that two wheel flanges had crossed it. The first mark began at a point 300 mm beyond the IBJ (the point of derailment), and extended to the fourth sleeper beyond the point of derailment. The second mark began five sleepers beyond the point of derailment, and crossed the rail head more steeply than the first mark, dropping off the outside two sleepers further on.

Lubrication

61 Rail mounted lubricators are provided to delay or slow the development of sidewear on curved sections of track. Lubrication will also reduce the risk of derailment, by reducing the coefficient of friction between the wheel flange and the rail, help prevent the incidence of block joint failure by reducing the risk of contamination by metal particles, and limit the initiation of *rolling contact fatigue* on the running surfaces of the rail.

62 Mechanical and hydraulic lubricators rely on physical contact or pressure from the passage of trains to activate a pump (directly or via hydraulic pressure), which supplies grease at pressure to a grease dispensing unit which is located at the correct position on the rail. Electronic lubricators usually detect the passage of train wheels by means of electronic sensors and distribute the grease by means of pumps and valves. Some electronic lubricators obtain power from wind turbines or solar cells, and these can be vulnerable to vandalism. Excessive grease, or application of grease to the wheel tread rather than the flange, may reduce adhesion and hence degrade vehicle braking performance.

63 Instructions for the siting, installation and management of lubricators are given in Network Rail document NR/SP/TRK/8006.

64 A mechanical lubricator had been located at 13 miles 75 chains, near the start of the curve into Epsom station, for many years. An additional lubricator, installed in 2004 or 2005, electrically operated and powered by solar panels and a windmill, is sited on the down line at 9 miles 45 chains (4 miles 43 chains (7.3 km) from the point of derailment at Epsom). The up and down lines diverge at this point to pass either side of the island platform of Motspur Park station, and this machine was intended to provide lubrication for the reverse curves through this station, and for the rest of the line towards Epsom.

65 The lubricator at 9 miles 45 chains is of modern design. The manufacturers claim that grease from these machines can be carried for up to 5 miles (8 km) over 8 reverse curves. The experience of the area track engineer, from information from other areas that he was aware of, was that 2½ to 3 miles (4 to 5 km) was the most that could be consistently achieved in practice, with 4 miles (6.4 km) being the absolute maximum.

66 Network Rail have a project in progress to modernise rail lubrication arrangements, which involves among other things the fitting of new lubricators to cover complete sections of track, and the removal of old machines that only affected short lengths (such as the curve at Epsom). Following the fitting of the new lubricator at Motspur Park, in 2004 or 2005, and reports from track inspection staff that grease from it was being carried as far as Epsom, the lubricator at 13 miles 75 chains was disconnected and laid in the cess. Since the new lubricator subsequently ceased to function (see paragraph 67), it was not possible for the investigation to establish whether or not the grease from it had actually reached Epsom.

67 During 2005 the Motspur Park lubricator ceased to function. When inspected on 12 October 2005 it was found to be non-operational because of flat batteries. The maintenance records indicate that the manufacturers were informed, but it is not clear from the records whether or not the machine was put into order at that stage. After the derailment the lubricator was alleged to have been out of action because of vandalism, but there were no further records to confirm this.

68 Maintenance of lubricators in the Clapham area was contracted to TMS Ltd. During the spring of 2006 TMS ceased trading, and the track maintenance engineer brought the lubricator maintenance in-house. There was a backlog of work which was being addressed at the time the derailment occurred, and because of the collapse of TMS the track maintenance engineer did not have full visibility of the condition of lubricators in the area. As a consequence of this, no remedial action had been planned in respect of the Motspur Park lubricator.

69 Consequently, at the time of the derailment there was no flange lubrication taking place on the Raynes Park – Epsom line. At the accident site there was very little evidence of grease on the rail: rapid sidewear was taking place and many of the resulting metal filings were falling to the foot of the rail.

The maintenance of the track

70 The track on the Raynes Park – Epsom line is maintained by Network Rail gangs based at Wimbledon depot. The track section manager at Wimbledon reports to the track maintenance engineer at Clapham.

71 The track maintenance engineer's area extends from Waterloo to Berrylands, near Surbiton, covering the main line and various branches. It is divided into two sections; the outer section, covered by Wimbledon depot, includes Epsom. The track maintenance engineer walked the Raynes Park – Epsom length on 31 January 2006, as part of his 2-yearly cycle for such inspections as prescribed by table 3 of NR/SP/TRK/001. No specific actions were noted for 840B points.

72 The Wimbledon section manager had agreed with the maintenance delivery unit manager for the area that Wimbledon should be raised to an establishment of 51 staff, but at the time of the derailment authority had not been given for all of these posts to be filled. In September 2006 there were only 37 staff available for duty because of long-term sickness, restrictions on recruitment, and difficulties in retaining staff.

73 The track section manager had last inspected the Raynes Park - Epsom line on foot on 10 April 2006. He was aware of the general state of the line, and considered that the risk of derailment was being controlled by the level of maintenance that was being applied. He did not raise any concerns relating to 840B points.

Inspection

74 The Raynes Park – Epsom line is scheduled to be patrolled weekly, in accordance with the requirements of table 2 of NR/SP/TRK/001. Patrolling inspections were carried out on 18 August, 1 September and 8 September 2006. The patrol on 25 August was not carried out because of a shortage of staff. The patrolling gang for the Wimbledon section has an establishment of seven staff, but in September 2006 there was only one person in post. Staff from other gangs were being used on an ad-hoc basis to cover the section's patrolling requirements.

75 Any significant defects which the patrolman cannot himself rectify are reported by the patrolman and subsequently entered on the MIMS computerised work management system. Network Rail now uses an updated version of MIMS, which has been renamed 'Ellipse'.

76 Section managers and track engineers take with them a 'walkout report' for the length of track being inspected, which is a printout from MIMS listing all outstanding work identified for the length. Information from each patrol, and from the section manager's and the track engineer's inspections, is entered on MIMS, and makes up what is referred to as the 'work bank', a description of all the outstanding defects for each length of track. At the time it is entered, a timescale for rectification is assigned to each item, in terms of weeks or months, based on the requirements of Appendix E of NR/SP/TRK/001 (for some classes of defect) and otherwise on the professional judgement of the person carrying out the inspection. The MIMS system converts this into a due date for completion of the work.

77 The section manager must allocate the resources that he has available to deal with the defects in the work bank. He, and his assistants, continually review the work bank and the items that are, or will soon become, overdue. It is permissible for the section manager, or his assistants, to 'reprioritise' items which in their judgement may safely be deferred to a later date for rectification if the resource situation necessitates it. This may be done following inspection by the section manager or another engineer, or as a desk-based decision based on experience. In each case the revised timescale is entered into MIMS. Where there is doubt about the appropriateness of the decision, the section manager may refer it to a more senior engineer.

78 The overdue items in each work bank are reported at least monthly (and in some cases more often) to the track maintenance engineer. They are one of the Key Performance Indicators (KPIs) for the section manager. The track maintenance engineer reviews trends and makes comparisons between sections, and in turn KPIs are reported upwards to the Area and Territory management, where further comparisons are made and the performance of each section is assessed. Each section manager and track maintenance engineer therefore has an interest in keeping the number of overdue workbank items to a minimum. One of the ways of doing this is by reprioritisation. Managers from assistant section manager level upwards have authority to do this. There are no controls in the system to prevent the same defect being reprioritised more than once, as in the case of the renewal of 840B points (paragraph 87), if the manager concerned believes that it is necessary.

79 For the track concerned in this accident, the relevant patrol covers both up and down lines on the 3.4 mile (5.5 km) length from Worcester Park to Epsom. In August 2006 there were 76 defects listed in the work bank for this length, dating back to February 2005. 61 of these defects had been reprioritised by the section manager or his assistants at various times. Information on the 18 August (week 20) walkout report for the down line between the 14 mile post and Epsom station (Appendix D) included notes about the condition of points 840B, the proposals for renewal of the switches, tamping in the area, and the re-prioritisation of work.

80 There is no record of any additional observations by the patrolman following the inspection of 18 August, covering the area of the derailment. The section manager at Wimbledon had not reviewed recent defects, or the content of the work bank, with the patrolman.

<u>Facing point inspections</u>

81 NR company standard NR/SP/TRK/053 'Inspection and Repair Procedures to Reduce the Risk of Derailment at Switches' requires points which may be used in the facing direction to be visually examined at intervals not exceeding three months. If evidence of wear is visible, a detailed inspection as defined in the standard must be carried out.

82 In the Wessex area of Network Rail there is a post of track inspector (special examiner) (TISE). In some depots the TISE manages an asset inspector (AI). Among other duties, these inspectors carry out the inspection of facing points required by NR/SP/TRK/053. In the sections covered by the Clapham office, the results of these inspections were recorded on a facing point inspection (FPI) form which was generated locally and does not correspond to any current Network Rail standard. This form is only used by the Clapham and Woking depots, and not elsewhere in the Wessex area. It requires a comprehensive examination of the points, and measurement and recording of the condition of many features, but does not require stock rail sidewear measurements.

83 At the Clapham depot there were two TISEs and no AIs, because of the complexity of the area. The TISEs reported to the assistant track maintenance engineer. One of them inspected Points 840B on 8 occasions between February 2005 and September 2006, working alone (under the protection of a *lookout*). He made comments associated with these inspections, in relation to the track gauge and sidewear where these were beyond the limits specified in NR/SP/TRK/001 of 1455 mm for wide gauge. The TISE also measured the stock rail sidewear, although this was not required by the FPI form, and entered the results in the 'comments' section of the form (these comments, and the recorded values, are in Appendix E). The comments, which were very similar at each successive inspection, highlighted the wide gauge and poor alignment at the *heel joint*, the sidewear on the stock rails, and the need for the ballast to be packed under the points.

84 The TISE filed the completed FPI forms at the track maintenance engineer's office at Clapham. He only submitted a report to the track maintenance engineer or his assistant if the TISE suspected, or had found, that a set of points failed the detailed tests defined in NR/SP/TRK/053, and as such represented an immediate risk of derailment. For this reason, neither the section manager at Wimbledon nor anyone else at Clapham was aware of the findings of the facing point inspections unless they went and looked at the files themselves. The TISE raised one Work Arising Instruction Form (WAIF) as a result of the inspection on 4 April 2006, detailing the need for *tie bars*. These forms are used to alert the section managers to defects requiring urgent action. The WAIF was input to MIMS for inclusion in the work bank for the section (paragraph 86), but other information from the facing point inspections was not put into MIMS.

<u>Planned maintenance</u>

85 The line through 840B points was last *tamped* in week 1 of 2004/05 (April 2004). Tamping is intended to improve the top and line of track, and in this case might have slowed the development of the lateral misalignment at the heel joint of the points, although manual intervention would have been necessary to eliminate it. Subsequently, the TISE identified the alignment of 840B points as being poor in February 2005, and tamping was scheduled for the area. This was not done before the derailment occurred in September 2006. It was planned three times, but not carried out. The following reasons for failing to tamp are given in the maintenance records:

- Week 46 2004/05 (February 2005): no crew available.
- Week 4 2005/06 (May 2005): location of tamping moved because of filming work.
- Week 1 2006/07 (April 2006): crew not available because of sickness.

86 The TISE identified the track gauge through 840B points, on 4 April 2006, as spreading and needing tie bars to correct it, pending renewal of the points (paragraph 84). Tie bars were not fitted, and the work was re-prioritised twice, to May and then July of 2006, by the section manager (or his assistants) as they were entitled to do if they judged that it was appropriate. At the time of the derailment the fitting of tie-bars was overdue, having last been scheduled to be done on 26 August 2006.

Renewal of 840B points

87 The right hand half set of switches in 840B points was first proposed for renewal on 5 March 2002. The renewal was re-prioritised to 14 April 2003, 23 March 2004, 4 February 2005 and September 2006, and at the time of the derailment was due to be carried out on 21 October 2006. The set of components had been ordered and was on site near to the points.

88 After the derailment, an attempt was made to replace the switches with the set on site, but this had to be aborted when they were found not to fit. It became apparent that the switches supplied had been made to size CV, while the size actually required was DV, which have a longer *planed length*, and would have fitted points 840A at the other end of the crossover. Examination of the records showed that the discrepancy was because of a mistake on the order form submitted through the then contractor's area track engineer's office in 2003.

The condition of the train

89 Unit 455905 was last overhauled (C4) in January 2004, since when it had run 256,000 miles (412,000 km). Its next overhaul was due in November 2007. The maintenance records for the unit showed that all scheduled examinations had been carried out up to the date of the accident.

90 The wheels of unit 455905 had most recently been reprofiled at Wimbledon depot on 17 January 2006. The unit is estimated to have run 60,000 miles (100,000 km) from then until the derailment. The profiles of all the wheels of the derailed vehicle were measured and were found to be within allowable wear tolerances and in good condition. There was no evidence that the wheel profile could have contributed to the derailment.

91 The primary suspension of the class 455 is through 'Metalastik' offset shear springs, in pairs, fitted at an angle to the vertical axis. Secondary suspension is by air cushions. Neither of these systems were damaged in the derailment.

92 The damage to the *rotation dampers* of the derailed bogie meant that it was not possible to obtain figures for the weight distribution or suspension stiffness before the derailment. However, visual examination of the wheels and suspension disclosed no defects which could have caused the train to behave in an abnormal manner or contributed to the derailment.

Other occurrences of a similar character

93 Derailments of class 455 trains occurred at Waterloo (south sidings) on 11 September 2006 (the day before the Epsom accident), and on the approach to platforms 1-4 at Waterloo on 24 October 2006. There were no injuries in either accident.

94 These two derailments are the subject of a separate RAIB investigation, but the performance of the Wessex area track maintenance organisation is a common factor in all three events.

Analysis

Identification of the immediate cause

95 The position of the derailed vehicle and the marks on the rail head showed that the flanges of two wheels had climbed over the railhead immediately beyond the IBJ at the heel of points 840B. The reason for this was the high ratio of lateral load to vertical load on the rail head at the IBJ, and this was the immediate cause of the derailment.

Identification of causal and contributory factors

Modelling of train behaviour

96 For a flange climb derailment to occur, there must be an increase in the ratio of lateral load to vertical load above a certain critical value, which is dependant on the friction and contact geometry between the wheel and the rail. Usually, this involves significant vertical wheel unloading (due to a track or vehicle fault or a combination of both) coinciding with lateral forces. If the amount of wheel unloading is high, even small lateral forces can induce a wheel into derailment.

97 The derailment was initiated at the bolted heel joint of the right hand switch of 840B points. Detailed knowledge of the response of the vehicle which derailed near this joint is important to understanding the cause of the derailment. As part of the investigation, the relevant vehicle/track dynamic interactions were predicted using VAMPIRE® rail vehicle dynamics software. VAMPIRE® is a UK rail industry standard program for evaluating dynamic vehicle/track interactions.

98 The VAMPIRE® analysis found that, in the conditions that existed at Epsom, the combination of high friction conditions and the rail misalignment at the heel joint can result in wheel tread lift of approximately 20 mm. This is consistent with imminent flange climbing.

99 The dynamic predictions are consistent with the derailment being caused by low speed flange climbing arising from the combination of high friction conditions and the local geometry of the heel joint at points 840B. The reason why this particular set of wheels derailed cannot be positively identified, but it is likely to have been related to interaction between a single flange and the 'ramp' produced on the gauge face by the grinding marks (paragraph 58) (Figure 8).

100 Once the first wheel had climbed the rail head at this point, the increase in the angle between the plane of the wheel and the rail caused by the resulting bogie misalignment would have created the conditions for the second wheelset of the bogie to derail in a similar manner.

Track condition and geometry

101 The survey carried out after the derailment shows that there was significant sidewear, beyond the permitted tolerances, and misalignment, both horizontal and vertical, at the joint between plain line and the right hand stock rail at the heel of the points.

102 The sidewear and misalignment had developed over a number of years, and had been identified by the patrol staff and the asset inspection team and recorded in their reports. Remedial work to realign the track and replace the rails had been planned, but had not taken place. The vertical misalignment was in the form of a step created by the head of the stock rail, worn down some 6 mm over the 22 years it had been in place, being adjacent to the rail on the curve which was relatively new, having been replaced in July 2005 (although it was already becoming sideworn to the point where it was proposed for re-railing in July 2006 (paragraph 123)). When this was done, the existing straight fishplates were used to form the joint. The use of stepped fishplates to bring the running surfaces into the same plane (in accordance with the relevant standard (paragraph 104)) would have reduced the impact loading on the end of the stock rail, and might have reduced the spalling which took place (paragraph 59).

103 Some work had been carried out to grind the rail ends at the joint. It is not certain who did this or when, although it is likely to have been done when the running-off rail was replaced in 2005. This grinding may have been an attempt to blend-in the mismatched rail profiles at the joint. However, the short length of the grinding would be insufficient to produce a smooth transition between the rails, which were worn to different section profiles.

104 Network Rail document NR/SP/TRK/001 states that 'when a sideworn rail is to abut a new or less sideworn rail, the step in the gauge profile shall be blended-in by grinding, as follows:

a) blended length to be 1.5 m from the weld or fishplated joint;

b) the sidewear angle of the more sideworn rail shall be maintained throughout the blended length;

c) the gauge corner shall be rounded throughout the blended length; sharp or square edges are not permitted;

d) a fully-supported grinder (i.e. mounted on both rails) shall be used; manual support alone is unlikely to achieve the desired result.

On completion of any joint the running surfaces, both rail head and running edge, shall be coplanar.'

105 The grinding carried out in this case did not meet any of these requirements. It is possible that this particular piece of grinding was carried out with the intention merely to remove an obvious sharp edge that would have been battered over by wheel flanges and might have caused failure of the IBJ.

106 Any fishplated rail joint is a potential source of horizontal misalignment because of the weakness of the joint as compared to a solid piece of rail. The horizontal misalignment at the IBJ arose from the weakness of the track associated with the rail joint, its position on a tight curve, the end of the check rail at the heel joint on the inner rail of the crossover, and the lack of any measures (such as *gauge stops* or tie bars) to maintain the geometry at this point.

107 The poor geometry created by the combination of vertical and horizontal misalignment and sidewear was a causal factor in the derailment (paragraph 98).

Lubrication

108 The down line at the curve approaching Epsom had originally been equipped with a lubricator to provide a suitable quantity of grease to reduce the effects of friction in this area (paragraph 64). Provision of a lubricator at this point complied with the Network Rail document NR/SP/TRK/8006, which specifies that lubricators should be provided on all curves with a radius less than 1500 m.

109 This lubricator had been removed in the belief that grease from a new, modern lubricator at Motspur Park was reaching the curve. In view of the distance involved this is unlikely to have been sufficient, and in any case that lubricator was out of action at the time of the derailment because it had been vandalised and had not been adequately maintained (paragraph 67). The facing point inspection of 840B points found that gauge face wear was occurring (paragraph 83), and if the section manager had seen these reports, he might have linked this to a lack of effective lubrication.

110 Because of the lack of lubrication, the rate of sidewear on the curve had increased, and after the derailment a large quantity of metal particles was found on the rail head and spread over the rail foot immediately beyond the heel joint.

111 The absence of grease on the rail increased the coefficient of friction between the wheel and rail, and therefore the propensity for derailment (paragraph 96).

112 If the instructions on inspection of lubricators in NR/SP/TRK/8006 had been followed, the failure of the Motspur Park lubricator would have been discovered, and the lubricator on the curve at 13 miles 75 chains could have been re-instated. That this was not done was a causal factor in the derailment. However, the standard does not specify the action to be taken to reduce the risk of derailment in the absence of effective lubrication (**Recommendation 3**).

Track maintenance history

113 The TISE had noted the steady deterioration of the gauge, top and alignment at the heel joint of points 840B, and some of this information had been entered into MIMS. Various measures had been proposed to remedy the situation (paragraph 82). The situation of this joint, on the outside of a heavily trafficked curve, and adjacent to pointwork, made it particularly prone to developing misalignment if not given regular attention.

114 Tamping of the track is unlikely to have rectified the extremely localised misalignment of the rails at the heel joint, but it might have slowed the rate at which it developed (paragraph 85). However, the top could have been improved if the tamping which was scheduled on three occasions during 2005 and 2006 had actually taken place.

115 The horizontal and vertical misalignment could have been corrected by the intervention of a maintenance team, who could have manually re-aligned the track and re-packed the ballast in the area. The Wimbledon section was understaffed at the time of the incident, and the available staff were heavily committed to the maintenance of the main lines. As a consequence, only limited time could be spared for the branches, including Raynes Park – Epsom.

116 The TRC run on 30 August had resulted in a sudden heavy workload of defect rectification, which was still in progress at the time of the derailment, but because the teams had started from Effingham Junction and were working up the line, had not reached the area of the derailment (paragraph 52).

117 The TISE noted the wide gauge (1460 mm) at the point of derailment on several occasions during the facing point inspections (paragraph 83). In April 2006 he recommended fitting tie bars to correct the gauge, pending replacement of the switches, but this was not done.

118 The absence of proper maintenance attention, to correct the faults in alignment and gauge, was a causal factor in the derailment (**Recommendation 2**).

<u>Renewal of points 840B</u>

119 The right hand set of switches of points 840B are subject to heavy loading because of their position on a sharp curve. At the time that they were installed in 1984, it was standard practice to use austenitic manganese steel (AMS) for such switches because of its high resistance to wear. The switches had been in place for 22 years by 2006 and were heavily worn and approaching the end of their life.

120 The renewal of these switches had first been planned over 4½ years before the derailment, and had been repeatedly deferred by re-prioritisation by a succession of track engineers and section managers. At the time of the derailment a replacement set of switches had been ordered and delivered to site, but not yet fitted (in fact the switches supplied were the wrong size – paragraph 88).

121 Because of the system of KPIs described in paragraph 78, managers felt under pressure to reprioritise work listed in MIMS, to reduce the number of overdue items and thus improve the KPIs by which they are judged. The extent to which this pressure may have influenced the professional judgement of the people concerned has been considered as part of the investigation. The resources available to the section manager were not adequate or in line with the establishment for the area (paragraphs 72, 132) and may have been a reason why some of the work, including the renewal of 840B points, had been reprioritised several times (**Recommendation 1**).

122 The replacement of the switches would have involved re-making and realigning the heel joint, and not doing this work was a causal factor in the derailment (**Recommendation 1**).

<u>Renewal of rail on the curve</u>

123 The down line from 13 miles 25 chains to the start of the CWR at 13 miles 68 chains was due to be renewed in weeks 10 and 11 of 2006/07 (June 2006). It was the intention to re-rail the curve from 13 miles 68 chains as far as points 840B at the same time, because of the sidewear on the high rail. The rail on the curve had previously been replaced in July 2005.

124 This re-railing did not take place because it would have involved a locomotive-hauled train running on the line, and at the time this was prevented by the problem with the weak bridge at Epsom which had also prevented runs by the track recording train (paragraph 49). If this re-railing had been carried out, it is possible that the wide gauge and misalignment at the heel joint would have been corrected.

125 The deferral of the renewal of this section of line was a contributory factor to the derailment.

<u>Facing point examinations</u>

126 The poor condition of the points had been repeatedly highlighted in the facing point inspection reports (paragraph 82). The section manager did not see these reports, and relied on the asset inspection team to contact him if they found something that required urgent action.

127 The TISE, carrying out the facing point inspections, had recommended tie bars to prevent further gauge spread (which was a symptom of the developing misalignment at the joint), but these had not been fitted. If tie bars had been fitted, or if the switches had been re-packed as recommended in each of the previous eight facing point examinations, the geometry of the joint would not have deteriorated to the extent that it did.

128 The absence of effective action to follow up the facing point examinations was a causal factor in the derailment (**Recommendation 1**).

Train operation

129 The train was travelling just below the line speed for the location, and the signalling system was functioning correctly. The driving of the train and the operation of the signalling system did not contribute to the causes of the accident.

130 The driver stopped the train as soon as he saw that it was derailed. He had previously decided to coast into the station, despite feeling the train shudder and jolt. In the past he stated that he had experienced a seized *traction motor*, which had caused the train to shudder, and he thought that this might have happened again. Not stopping at the earliest opportunity could have increased the risk to passengers if the train had struck the platform ramp, but on this occasion no adverse consequences resulted.

Train condition

131 Examination of the wheels and suspension of the train did not disclose any defects which could have caused it to behave in an abnormal manner. The condition of the train did not contribute to the causes of the derailment.

Identification of underlying causes

Resource allocation and workload

132 The Wimbledon section manager was short of staff (paragraph 72). To try to deal with the effects of this shortage, he had organised his staff into a patrolling gang and a maintenance gang. He had not succeeded in getting staff to fill the vacancies in his section, because he had not yet been permitted to recruit staff to reach the establishment that he and his manager believed was required, and had experienced difficulty in prioritising the large volume of work (paragraph 121). He had no detailed knowledge of the condition of 840B points and was not aware that tie bars were required there.

133 Resources were concentrated on the main lines because the TRC ran more frequently over those lines, and each run identified a quantity of remedial work. The TRC run over the Raynes Park – Epsom line on 30 August 2006 produced a large volume of rectification work which overwhelmed the resources available to the section manager.

134 The track maintenance engineer was not aware of problems with track quality on the Raynes Park – Epsom line. In the absence of TRC runs along the line (because of the weak bridge at Epsom (paragraph 49)) he had no information about it because NR/SP/TRK/001 specifies that reports arising from patrolling or special asset inspections are reviewed by the section manager and are not sent to the track maintenance engineer unless requested. In fact the special asset inspection reports were being filed in the track maintenance engineer's office (paragraph 84), but were not brought to his attention.

135 The shortage of staff in the area, leading to a backlog of remedial work, and the workload of the managers at all levels was an underlying cause of the derailment (**Recommendation 1**).

Severity of consequences

136 The low speed of the train and the prompt response of the driver were the main factors in the lack of serious consequences in this incident.

Conclusions

Immediate cause

137 The immediate cause of the derailment was that two wheel flanges climbed the rail head immediately beyond the heel joint of points 840B (paragraph 95).

Causal factors

138 Causal factors were:

- Poor track geometry created by a combination of lateral and vertical misalignment, local rail damage and sidewear (paragraph 107). These defects were apparent from visual inspection, and measurement by asset inspection staff and the track recording coach, and were covered by standards which required action to be taken. Because compliance with these standards would have corrected the conditions, no recommendation is made in respect of track geometry standards.
- The absence of rail lubrication at the point of derailment, following removal of the local lubricator and the failure of the remote lubricator (paragraph 112, **Recommendations 1, 3**).
- The lack of proper maintenance attention to the track at the point of derailment (paragraph 118, **Recommendation 2**).
- The non-renewal of the right hand half set of switches in points 840B, which had been planned for several years (paragraph 122). This was a result of the poor resource situation in the maintenance organisation (**Recommendation 1**).
- The lack of effective follow-up to facing point inspections which had identified various faults at points 840B over a period of two years (paragraph 128, **Recommendation 1**).

Contributory factors

139 The following factor was considered to be contributory:

- The loss of the planned re-railing of the plain line on the approach to 840B points in June 2006 (paragraph 125).

Underlying causes

140 The underlying causes were:

- the shortage of track maintenance staff in the area and the workload of staff at all levels in the maintenance organisation (paragraph 135, **Recommendation 1**);
- the failure of staff to understand the consequences of the removal of the lubricator on the curve (**Recommendations 1, 2, 3**);
- the absence of proper maintenance attention to the defective lubricator (**Recommendation 3**).

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

141 The mechanical lubricator that had been removed from the down line at 13 miles 75 chains was replaced immediately after the derailment. The electric lubricator at 9 miles 45 chains was put into order.

142 Network Rail has increased the number of lubricators on the system, and has a continuing project to install additional electric lubricators where necessary.

Recommendations

143 The following safety recommendations are made[1]:

Recommendations to address causal and contributory factors

1 Network Rail should review the resourcing of the track maintenance organisation in the Wessex area, Wimbledon section to ensure that it is adequate for its existing and planned workload. The review should consider the recruitment and retention arrangements in the area, the numbers of posts and the necessary competences, the arrangements for ensuring that all sections of line are given appropriate levels of attention, and the technical and professional support available to the inspection and maintenance staff (paragraphs 138, 140).

2 Network Rail should revise its instructions to staff to ensure that patrollers and local track managers have clear and specific instruction and guidance on the identification of and response to alignment faults and localised poor rail condition (paragraph 138).

3 Network Rail should review Company standard NR/SP/TRK/8006 to provide improved guidance on the use and siting of remote rail lubricators, and the action to be taken in the event of lubrication failure, to reduce the risk of potential derailment (paragraph 138).

[1] Responsibilities in respect of these recommendations are set out in the Railways (Accident Investigation and Reporting) Regulations 2005 and the accompanying guidance notes, which can be found on the RAIB's web site at www.raib.gov.uk.

Appendices

Glossary of abbreviations and acronyms — Appendix A

AI	Asset inspector
AMS	Austenitic manganese steel
CSR	Cab secure radio
CWR	Continuous welded rail
DTOS	Driving trailer open standard
IBJ	Insulated block joint
MIMS	Mincom Information Management System
MSP	Measured shovel packing
NR	Network Rail
OTMR	On-train monitoring recorder
RAIB	Rail Accident Investigation Branch
SWT	South West Trains
TISE	Track Inspector (Special Examiner)
TRC	Track recording coach/train
TSR	Temporary speed restriction
WAIF	Work arising instruction form

Glossary of terms

Appendix B

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

Ballast	Crushed stone, used to support track both vertically and laterally.*
Bearer	A wooden or concrete beam used to support the track. The term generally applies to long switch and crossing (S&C) timbers.*
Bogie	A metal frame equipped with two or three wheelsets and able to rotate freely in plan, used in pairs under rail vehicles to improve ride quality and better distribute forces to the track.
Cant	The design amount by which one rail of a (curved) track is raised above the other rail.*
Chain	A unit of length, being 66 feet or 22 yards (approximately 20117mm). There are 80 chains in one mile.*
Continuous welded rail	On Network Rail, a rail of length greater than 36.576m (120'), produced by welding together standard rails.*
Crossover	Two turnouts (points) connected to permit movements between parallel tracks.*
Diamond crossing	A switch and crossing unit that consists of two common crossings and two obtuse crossings, allowing two tracks to cross each other on the flat.*
Down line	A track on which the normal passage of trains is in the Down direction, away from London, or towards the highest mileage.*
Dynamic track gauge	The gauge of the track, measured as a train passes over it. It can be estimated by applying a predefined load to the gauge faces of the rails to force them apart, and measuring the resulting displacement.
Electric multiple unit	A train consisting of one or more vehicles (semi-permanently coupled together) with a driving cab at both ends, whose motive power is electricity.*
Facing points	A set of points or set of switches installed so that traffic travels from switch toe to switch heel in the normal direction of traffic.*
Fishplate	Specially cast or forged steel plates used in pairs to join two rails at a fishplated Rail Joint. Two, four or six bolts are used through the fishplates and rail ends to secure the fishplates to the rails.*
Flat-bottom rail	A rail section having a flat based rail foot or flange.*
Formation	The prepared surface of the ground, on which any filter or structural materials, the ballast and the track is laid.*
Gauge Stop	A metal plate fixed to the upper surface of a sleeper against a chair or baseplate to restrict the outward lateral movement of the rail.*
Heel	The end of the movable length of the switch rail furthest from the switch toe.*

Heel joint	The rail joint at the heel end of a switch rail or stock rail.*
Insulated block joint	A fishplated rail joint in which one rail is electrically insulated from the abutting rail for signalling or electrification purposes, normally utilising insulated fishplates.*
Island	Platform with tracks on both sides, with passenger access via a bridge, subway or level crossing.
Jointed track	Track constructed from rail shorter than 36.576m (120 feet) drilled with bolt holes and intended to be connected together using fishplated rail joints allowing the rail to freely expand.*
Lookout	A competent person whose duties are to watch for and to give an appropriate warning of approaching trains by means of whistle, horn or warning siren.*
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 stone chippings are introduced under the sleeper to achieve this lift.*
Planed length	The dimension measured along the switch rail, from the switch toe to the end of the head planing, ie the length over which the switch is machined during manufacture.*
Protected	When a train is involved in an incident and is not able to be moved, the Rule Book requires it to be protected from movements of other trains which might otherwise collide with it. This protection involves placing signals to danger and may require the use of explosive detonators, clipped to the rails, if there are no suitable signals nearby.
Rolling contact fatigue	Collective term for all rail defects directly attributable to the rolling action of a rail wheel on the rail.*
Rotation damper	Equipment for inhibiting rapid rotational motion of a vehicle bogie.
Running-off rail	At a joint between two rails, the rail on which trains travelling in the normal direction of traffic approach the joint.
Running-on rail	At a joint between two rails, the rail on which trains travelling in the normal direction of traffic leave the joint.
Sidewear, sideworn	A progressive removal of rail metal generally afflicting the high rail on curves, due to the high lateral forces produced when a train negotiates a curve with insufficient cant or high cant deficiency. Eventually the rail head assumes a profile complementary to the passing wheelsets, increasing the likelihood that wheelsets will climb the rail.*
Stock rail	The fixed rail in a switch half set.*
Super Red	A length of track (usually an eighth of a mile) for which track geometry quality is very poor, in that more than 90 % of the standard deviation values for vertical profile and alignment are outside the target values.

Switch rail	The thinner movable machined rail section that registers with the stock rail and forms part of a switch assembly.*
Switch (half) set	The assembly for one side of a switch comprising a stock rail, a switch rail, baseplates, slide baseplates, stress transfer blocks, heel blocks or switch anchors, plus all appropriate bolts, nuts, washers and rail clips.*
Tamping	The operation of lifting the track and simultaneously compacting the ballast beneath the sleepers, carried out by machine (a tamper).*
Tie bar	An adjustable metal bar normally constructed with an insulated section in the middle, fixed between running rails to restore and maintain track gauge.*
Toe	The movable end of a switch rail.*
Top	The vertical alignment of a track over a short distance, measured separately for the left and right hand rails in the normal direction of traffic.*
Track circuit block	A signalling system where the line is proved clear to the end of the overlap beyond the next signal using track circuits or axle counters.*
Track recording coach/train	A passenger coach converted to be used as a means of gathering track geometry data automatically, or the train containing such a vehicle which runs regularly over all lines on the network.*
Traction motor	The electric motor used as the means of turning the powered axles on a rail vehicle using electric traction.*
Trailing points	A set of points or switches where two routes converge in the normal direction of traffic, e.g. traffic normally travels from switch heel to switch toe.*
Twist	A rapid change in the level of the two rails relative to one another, as though the track is twisted. Twist is calculated by measuring the cross-level at two points a short distance apart, and then expressing the difference as a 1 in x gradient over the interval.
Up line	A track on which the normal direction of trains is in the Up direction, i.e. towards London, or lowest mileage.*
VAMPIRE®	A dynamic modelling system for rail vehicles which allows a virtual model of any rail vehicle to be run over real measured track geometry. Produced by Delta Rail (formerly AEA Technology).*

Key standards current at the time Appendix C

NR/SP/TRK/053	Inspection of Switches
NR/SP/TRK/001	Inspection and Maintenance of Permanent Way
NR/SP/TRK/8006	Installation and Management of Rail Mounted Lubricators

MIMS information Appendix D

MIMS information relating to the down line and S & C between 14 miles 0 chains and 14 miles 20 chains, from the walkout report dated 18 August 2006. **Note**: some of the entries in the "Track ID" column are not consistent with the down line, but it is believed that this is what is being referred to.

ELR	Track ID	Mileage from	Mileage to	Work Order Description	Extended Description	UM	Qty	RFD	Due	Work Order
RPE	1104	14m 4c	14m 15c	S & C – TAMPING	S & C tamp – design lift and line through both S&C and Plain Line (704 yds) between 13m 63c to 14m 15c. Related W/O No. 1151227 Identified by DE 31/1/06. *Re-prioritised to M3 via Track Manager Walkout Report	PE	1	26/09/2006	48	1151229
RPE	2100	14m 9c	14m 9.5c	S & C – Renew Half Set of Switches	Reported by: GC | 14m 09c change RH ½ set switches 840B pts due to sidewear on stock rail fronts***Re-prioritised to M6 via walkout report dated 4/2/05 signed by AG*****Re-prioritised to M3 via Week 22 – Patrol 10 walkout	EA	1	21/10/2006	73	1005667
RPE	1104	14m 10c	14m 10c	S & C – RENEW CROSSING	Worn obtuse crossing at 14m 10c. Identified by AH 30/9/05	XG	2	30/09/2007	417	1065592
RPE	1104	14m 10c	14m 10c	S & C – ADJUST GAUGE	Wide gauge on heels of 840B points – tie bars required at 14m 10c. Identified by AB 3/4/06.*Reprioritised to M1 via Patrol 10 Week 4 Walkout report dated 2/5/06 signed by RC*Re-prioritised to M2 via Walkout report Week 12 – 26/6/06	YD	5	26/08/2006	17	1203106

Comments associated with facing points inspection reports, 840B points, Epsom, 2005 - 2006 — Appendix E

Date	Comments
7/2/05	Wide gauge at heels 1455mm MSP throughout Poor alignment at heels Repair switch r/h RH Stock front sidewear 10
2/5/05	Wide gauge at heels 1455mm MSP throughout Poor alignment at heels Repair switch r/h RH Stock front sidewear 10
18/7/05	Wide gauge at heels 1455mm MSP throughout Poor alignment at heels RH Stock front sidewear 10
17/10/05	Wide gauge at heels 1455mm plus slue track MSP throughout Poor alignment at heels RH Stock front sidewear 14 new gauge
3/1/06	Wide gauge at heels 1455mm MSP throughout Poor alignment at heels Repair switch r/h RH Stock front sidewear 14 new gauge
4/4/06	Wide gauge on heels of switches 1460 tie bar req MSP throughout Poor alignment at heels
26/6/06	Wide gauge on heels of switches 1458 tie bar req MSP throughout Poor alignment at heels
11/9/06	Wide gauge on heels of switches 1459 tie bar req MSP throughout Poor alignment at heels Sidewear on heel of right hand stock reading 8 Front right hand stock reading 12 Dry slide chairs

In these reports, 'MSP' indicates that the points required additional ballast using the *measured shovel packing* technique to restore the top level. The figures given for sidewear are for readings on the sidewear gauge, and do not have a direct dimensional conversion.

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