RAIB

Rail Accident Investigation Branch

Rail Accident Report

Collision at Knockmore Junction, Northern Ireland
4 February 2016

Report 20/2016
October 2016

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.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Email: enquiries@raib.gov.uk
Telephone: 01332 253300
Fax: 01332 253301
Website: www.gov.uk/raib

This report is published by the Rail Accident Investigation Branch, Department for Transport.

Preface

The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where the RAIB has described a factor as being linked to cause and the term is unqualified, this means that the RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident. However, where the RAIB is less confident about the existence of a factor, or its role in the causation of the accident, the RAIB will qualify its findings by use of the words 'probable' or 'possible', as appropriate. Where there is more than one potential explanation the RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, the words 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the event being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of the RAIB, expressed with the sole purpose of improving railway safety.

The RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of any inquest or fatal accident inquiry, and all other investigations, including those carried out by the safety authority, police or railway industry.

This page is intentionally left blank

Collision at Knockmore Junction, Northern Ireland, 4 February 2016

Contents

Summary

At around 06:53 hrs on Thursday 4 February 2016, the 06:25 hrs passenger train from Belfast Great Victoria Street to Portadown collided with an excavator bucket. This had been left on the track near Knockmore Junction, about 1.25 miles (2 km) from Lisburn Station. The train hit the bucket at a speed of 57 mph (92 km/h) and then travelled 330 metres in an upright position before stopping. There were no significant injuries to the people on the train, but the leading vehicle was badly damaged and the track required repair.

The bucket had been detached from an excavator machine undertaking track maintenance work during the previous night when regular train services were not running. The machine driver had forgotten about the bucket. The track safety co-ordinator had not remained near the machine, as required by the rule book, and so was unaware that the bucket had been detached. Other members of the work group had not noticed that it remained on the track as they removed other equipment in darkness. There was no effective process for checking that the track was clear of obstructions before the line was reopened to regular services.

The work group was working within a worksite to which access was being controlled by an engineering supervisor. Although not a factor in the accident, the track safety co-ordinator and engineering supervisor had arranged this access using an informal method that did not meet the rule book requirements.

The RAIB has made two recommendations addressed to Northern Ireland Railways. The first seeks a formalised process for checking that lines are safe after engineering work is complete and before the line is reopened to regular traffic. The second seeks a review and possible modifications to the formalised communication arrangements used by engineering supervisors controlling access to the railway. The RAIB has also identified three learning points relating to track safety co-ordinators always remaining with their work groups, minimising risks due to objects capable of endangering trains being placed on the line and compliance with formalised arrangements for controlling access to worksites.

Introduction

Key definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.

2 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B. Sources of evidence used in the investigation are listed in appendix C.

The accident

Summary of the accident

3 At around 06:53 hrs on Thursday 4 February 2016, train reporting number B301, the 06:25 hrs Belfast Great Victoria Street to Portadown service, struck an excavator bucket on the track near Knockmore Junction, in Lisburn, County Antrim (figure 1).

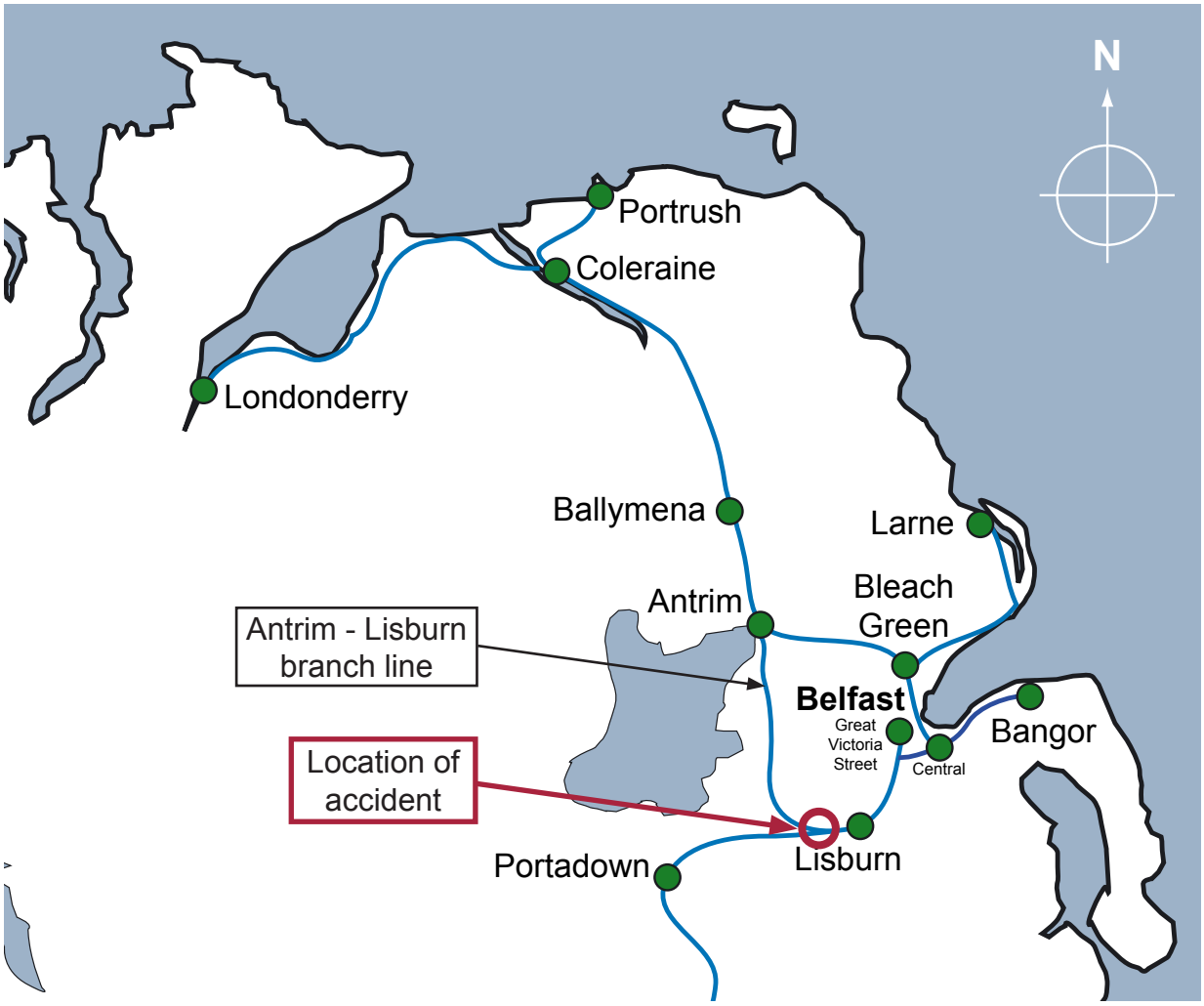

Figure 1: Location of the accident

4 The front of the train was lifted by the impact and the wheels of the leading *bogie* briefly lost contact with the rails. The train travelled for approximately 330 metres, pushing the bucket beneath the leading vehicle. The train remained upright and stopped in line with the rails and with the front portion of the leading vehicle resting on top of the bucket. The bucket had been left on the track following engineering work carried out during the previous night.

5 There were no significant injuries to the eight passengers and three members of train crew on board the train. However, the leading vehicle was badly damaged, with distortion to the vehicle body. The track was damaged for the distance the train travelled after the impact and required repair before the line could be reopened for service the following morning.

Context

Location

6 The accident occurred approximately 2 km from Lisburn station on the *up main* line between Belfast and Dublin. The impact occurred close to a site compound created adjacent to the railway near the Knockmore Road overbridge, approximately 103.75 miles (167 km) from Dublin[1].

7 At this location, the railway consisted of three tracks in the area of the former Knockmore Junction. These were the up and *down main* lines and an adjacent single line between Lisburn and Antrim known as the Antrim branch. The maximum permitted speed on the up and down main lines was 60 mph (97 km/h). The Antrim branch was under a permanent *possession* after being closed to regular rail traffic in 2001.

8 The Knockmore Road site compound was one of several created along the railway corridor to facilitate engineering work undertaken as part of the Belfast to Lurgan track rehabilitation works. A temporary *road/rail access point* (RRAP) had been constructed on the railway adjacent to the site compound entrance. This RRAP consisted of railway *ballast* placed up to rail level (figure 2).

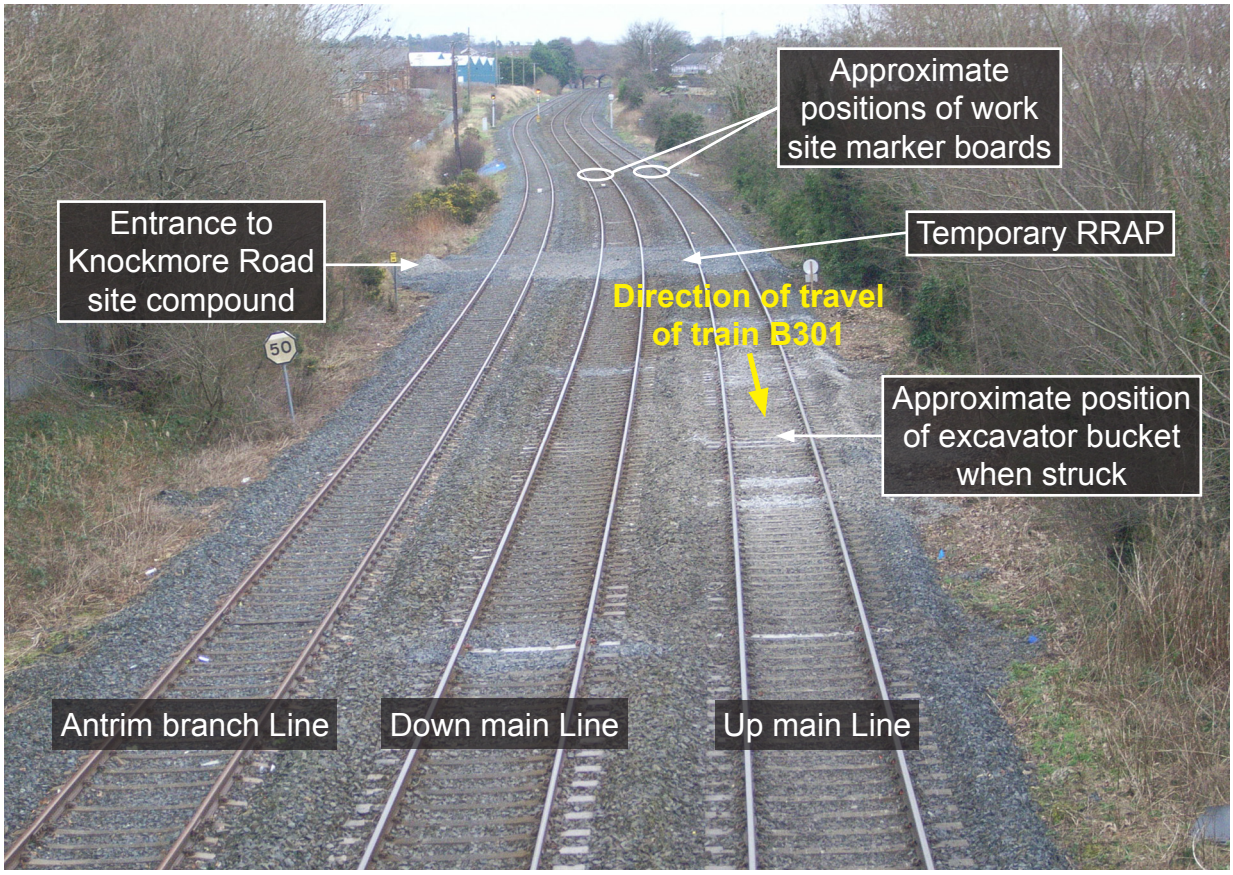

Figure 2: RRAP and worksite marker board location near Knockmore Road site compound

[1] Mileages on the Dublin to Belfast line are measured from Connolly station in Dublin.

9 During the night before the accident a work group was replacing *sleepers* between Lissue and Maze level crossings, respectively 1.2 km and 1.7 km west of the RRAP. This work was done in a *worksite* extending from about 50 metres east of the RRAP to Dagger Road underbridge, about 0.6 km west of Maze level crossing (figure 3). The total length of the worksite was about 2.3 km. It was within a possession extending from Lisburn to Portadown, a distance of approximately 28 km.

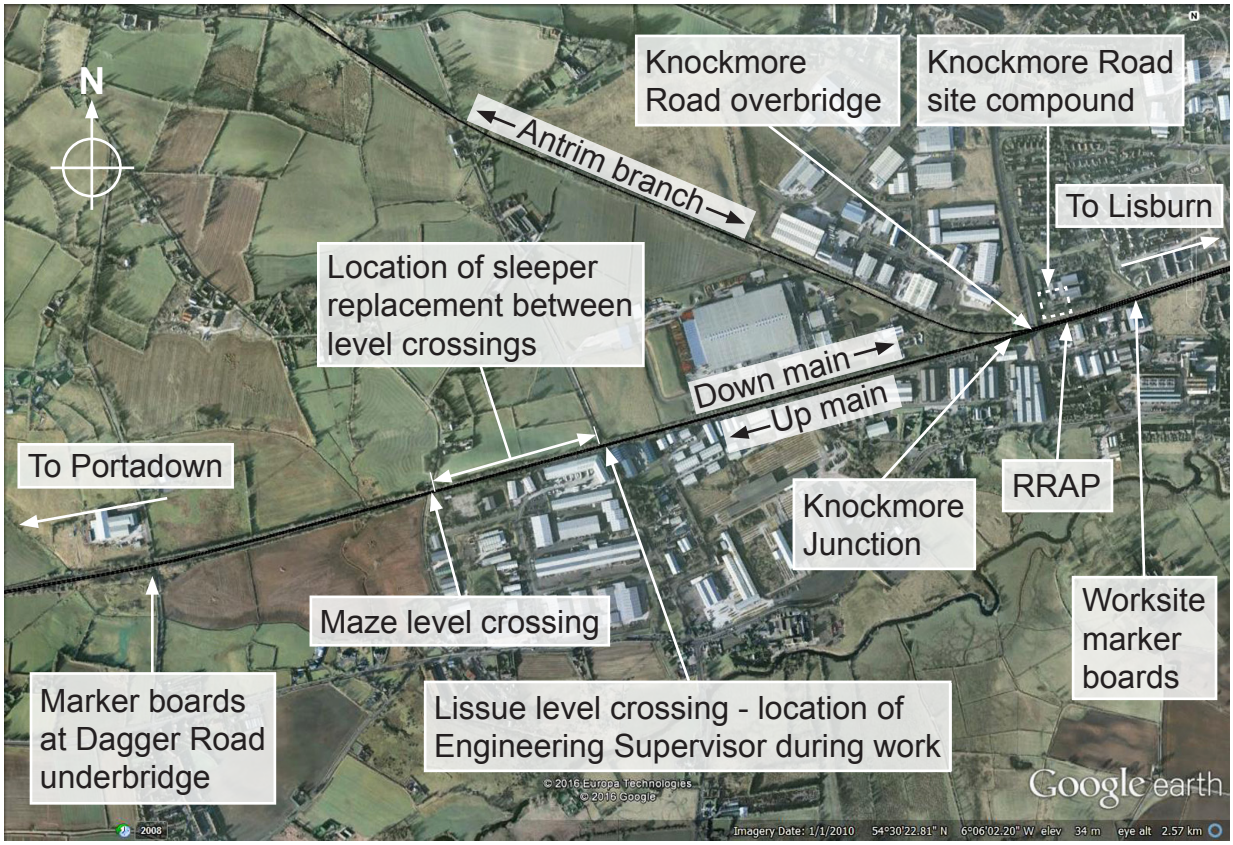

Figure 3: Google Earth image showing a plan of the site

Organisations involved

10 Northern Ireland Railways (NIR) owns and maintains the track and signalling which forms the Northern Irish rail network. It also operated the train which struck the excavator bucket, and employed the train driver.

11 Mott MacDonald Ltd (Mott MacDonald) was the lead consultant for the Belfast to Lurgan track rehabilitation works and undertook the role of project manager and contract administrator, and provided a site supervisor for this project (under the NEC3 Professional Services Contract[2]).

12 FP McCann Ltd (FP McCann) was appointed by NIR as the principal contractor for the Belfast to Lurgan track rehabilitation works. FP McCann also planned, managed and provided design services as required for the project.

[2] NEC3, formally known as the New Engineering Contract, is a standardised contract framework devised by Institution of Civil Engineers, the purpose of which includes defining the responsibilities and duties of employers and contractors.

13 NE Rail, a trading name for Northern Excavators Ltd, was a sub-contractor to FP McCann. NE Rail supplied the machinery and work group members involved in the accident as well as the Person in charge of the Possession (PICOP), the Engineering Supervisor and Track Safety Co-ordinator (TSC).

14 All parties freely co-operated with the investigation.

Train involved

15 The train was formed of two three-car class 3000 *diesel multiple units* coupled together. The RAIB has found no evidence that the condition of the train, or the way it was driven, contributed to the accident.

Equipment involved

16 Two *road/rail machines* were being used by the work group. These were 20 tonne, 360-degree hydraulic excavators equipped with both road and rail wheels. The bucket involved was attached to one of the machines by a *quick-coupler* (also known as a quick-hitch), a device on the end of the machine arm which allows the driver to quickly change buckets without intervention from other workers. Driver-only coupling to a detached bucket could be achieved only if the bucket was left with its attachment point correctly oriented to the coupling point on the approaching machine arm. It was also possible to use the machine to lift loads by manually attaching *lifting chains* to the arm in place of the bucket.

17 The work group also used a five metre *flatbed* trailer with a large open box container, known as a ballast box, to transport ballast to site. This was attached to the road/rail machine on the up main line. A road/rail machine and trailer with ballast box, similar to those being used by the work group on the night before the accident, are shown in figure 4.

Figure 4: Example of a road/rail machine (left) and trailer and ballast box combination (circled right) similar to that used by the work group but not involved with the incident.

18 The excavator bucket was manufactured specifically for NE Rail and weighed approximately 670 kg; it was 1330 mm wide (figure 5). The bucket was this width to maximise digging efficiency when working between rails fixed at the 1600 mm track gauge used throughout Ireland.

Figure 5: The excavator bucket after the accident

Staff involved

19 The engineering supervisor had been employed by NE Rail since 2007 and had been qualified to perform this role since 2008.

20 The TSC had been employed by NE Rail for 8 years and came to the business with 3 years' previous experience in that role.

21 Machine driver A was operating the road/rail machine from which the bucket was detached and left on the track. He had operated rail mounted machinery on the railway since 2000.

22 Machine driver B was operating a different road/rail machine. He had been an operator of excavators and similar machines for many years before joining the railway in 2003.

23 All staff involved held the competence certification needed to undertake their roles as described in this report. Testing undertaken in accordance with routine rail industry post-accident processes showed that these staff also met industry requirements concerning drugs and alcohol.

External circumstances

24 The weather was cold and damp during the night, but this did not influence the events leading to the accident during the night shift. The collision occurred as dawn was breaking, at which time the weather had turned to light rain and drizzle.

The sequence of events

Events preceding the accident

25 The signaller at Portadown signal box granted the possession to the PICOP at 00:10 hrs on Thursday 4 February. At around the same time, the TSC at Knockmore Road site compound was briefing his work group on the sleeper replacement work to be undertaken that night.

26 The PICOP's responsibilities included controlling access to the possession so, at around 00:15 hrs, he telephoned the engineering supervisor and gave him permission to set up his worksite between Dagger Road underbridge and Knockmore Junction, including the RRAP. The engineering supervisor then placed a worksite marker board on each of the two tracks at Dagger Road underbridge.

27 The engineering supervisor then drove to Lissue level crossing to switch the crossing into manual operation, part of performing his second duty that evening as an emergency level crossing operator. It was necessary to switch the crossing from automatic to manual operation to prevent the rail mounted machines working nearby triggering a road closure sequence when this was not required.

28 The TSC stated that, at around 00:30 hrs, he received a telephone call from the engineering supervisor requesting him to place two worksite marker boards on the main lines to mark the Lisburn end of the worksite. The TSC placed the worksite marker boards on the up and down main lines about 50 metres east of the RRAP at the Knockmore Road site compound entrance.

29 The duties of an engineering supervisor include controlling access to their worksite, so during this telephone call, the engineering supervisor also gave the TSC permission to access the worksite. The TSC then instructed the machine drivers to start *on-tracking* their machines, one on each line.

30 Machine driver B positioned his machine on the down main line and machine driver A positioned a rail mounted trailer and ballast box on the up main line. Machine driver A then loaded the trailer with ballast before on-tracking his machine and driving along the up main line towards the location of the work with the trailer attached at the rear.

31 The TSC stated that the two machines travelled unaccompanied towards the location of the sleeper replacement work while another member of the work group drove him to Lissue level crossing by car. The car was left at the crossing, and he walked from there to the location of the work with the rest of the work group and the two road/rail machines.

32 The work group undertook their work, digging out and replacing sleepers using the machine on the down main line. They used the up main line machine to take ballast from the trailer to fill in the area around the new sleepers. At about 04:00 hrs, the TSC informed the work group that they should not start any further sleepers and should finish the current replacement. When this was complete, the TSC instructed the work group and machine drivers to travel back towards the Knockmore Road site compound.

33 The TSC accompanied the machines to Lissue level crossing. Between Lissue level crossing and the Knockmore Road site compound the machine drivers travelled unaccompanied, while the TSC and remaining work group members returned to the site compound by road.

34 During the time that the TSC was travelling from Lissue level crossing to the RRAP, machine driver A had stopped near the RRAP and detached the excavator bucket from his machine, positioning the bucket between the rails of the up main line at the rear (Portadown side) of his machine. The bucket had been removed to allow the ballast box and trailer to be lifted from the up line into the *cess*. The bucket then remained in this position while the two machines were taken off track, the work group left the railway and the site compound entrance to the railway was secured shut (paragraphs 48 to 69).

35 At around 04:40 hrs, the TSC made a telephone call to the engineering supervisor. He stated that the Lisburn end worksite marker boards had been removed from the track and that the machines and work group were clear of the line.

36 The engineering supervisor switched Lissue level crossing into automatic mode and drove to Dagger Road underbridge to remove the Portadown end marker boards. He then telephoned the PICOP and gave up his worksite at 04:45 hrs. The PICOP returned control of the line to the signaller, and recorded this on his paperwork as being at 05:02 hrs.

37 The scheduled train service began with a down direction train passing the site of the excavator bucket at approximately 06:22 hrs. The driver of this train did not report seeing the bucket on the adjacent up main line. It is probable that he could not see the bucket because it was dark with light rain falling at the time (figure 6).

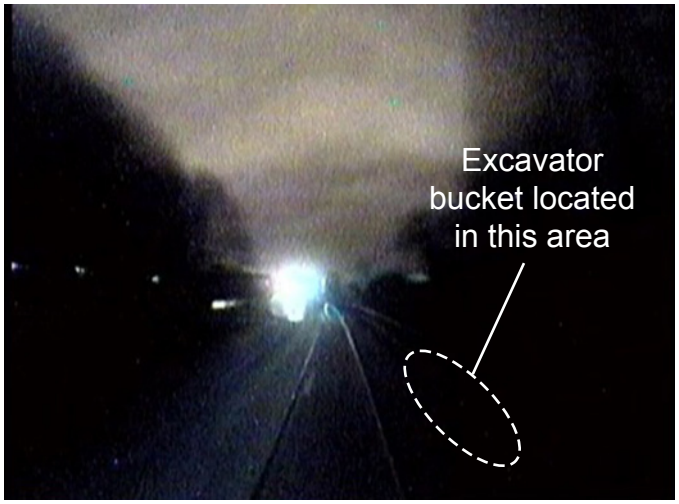

Figure 6: Forward facing CCTV image from the first down service as it passed the detached bucket at approximately 06:22 hrs

38 A second down direction train passed the site of the excavator bucket about the time that train B301 struck the bucket. It has not been possible to determine the exact time this down train passed the site or view the forward facing closed circuit television (CCTV) images from this train. These images were not available due to a fault with the CCTV equipment (paragraph 89).

Events during the accident

39 At around 06:49 hrs, train B301 departed from Lisburn station heading in the up direction towards Knockmore Junction. It was the first train of the day in that direction. The on-train data recorder (OTDR) shows the driver accelerated his train to 59 mph (95 km/h) after leaving Lisburn station and was travelling at this speed until, on the approach to Knockmore Junction, the driver saw a dark object on the track ahead of him and applied the emergency brake. The OTDR records the emergency brake application occurring about 3 seconds before the train hit the excavator bucket while travelling at 57 mph (92 Km/h). This happened at around 06:53 hrs.

40 The train pushed the bucket along the track, damaging rail fixings and sleepers as it passed. As it did so, the leading vehicle was lifted vertically as the train's obstacle deflector rode over the top of the bucket which then passed between the train's *lifeguards,* devices intended to deflect objects from the path of the leading wheels (figures 7 and 8). As the leading vehicle continued to ride further over the bucket, the leading bogie to vehicle body fastening was badly damaged and the battery box was dislodged (figure 9).

Figure 7: The front of train B301 after the accident

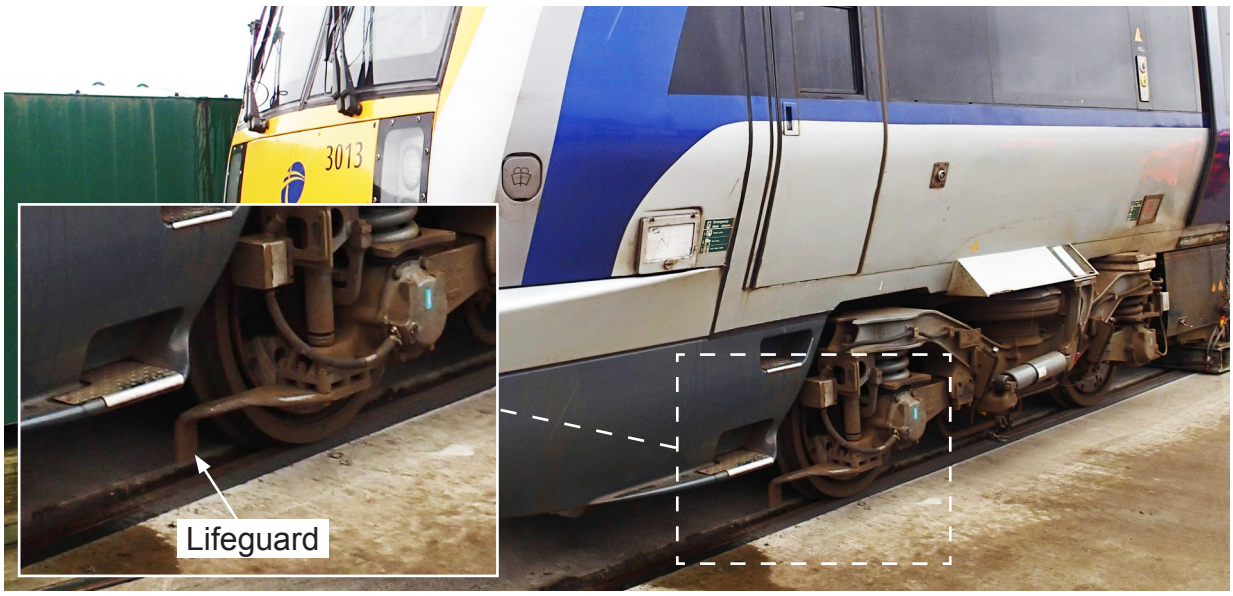

Figure 8: Side view of train B301 after the accident showing the left side lifeguard ahead of the leading bogie

41 The leading vehicle remained in line with the track. This was possibly because the bucket remained in contact with the vehicle underside and was prevented from moving sideways. It was constrained by the rails either side of it, which provided some guidance.

42 The train stopped 330 metres from the point of initial impact, with the fuel tank of the leading vehicle balanced on top of the bucket. The diesel fuel tank had been punctured during the accident and its contents emptied into the bucket (figure 9).

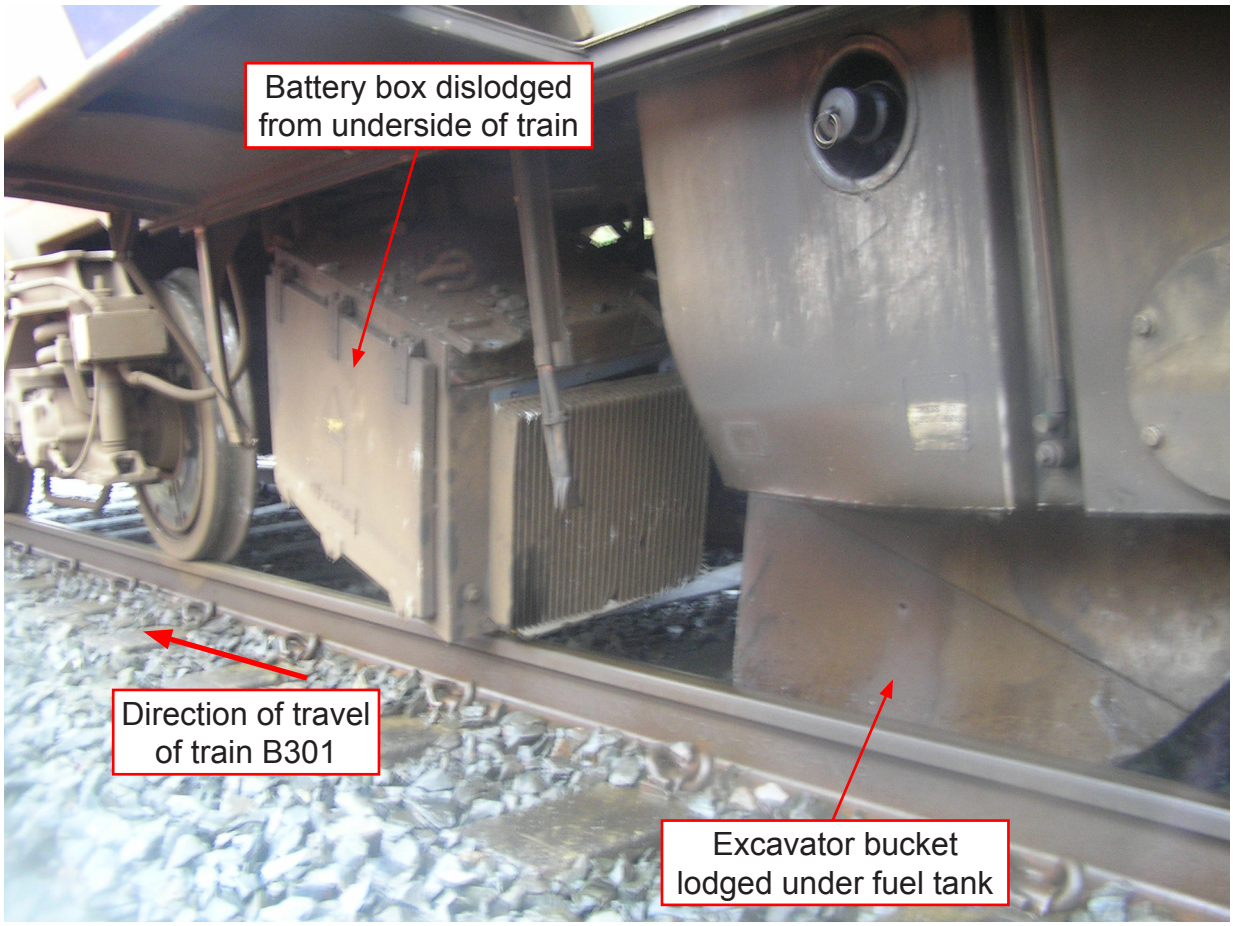

Figure 9: Vehicle damage and excavator bucket under train B301

Events following the accident

43 The driver stated that, when the train came to a rest, the passenger saloon of the leading vehicle was in darkness. This had been caused by the engines shutting down, and damage to the battery power equipment located under the floor of the vehicle body. The driver reported the accident to the signaller by mobile telephone and requested trains on the adjacent track to be stopped. He also asked for the attendance of the emergency services.

44 The passengers were evacuated from the train and taken along the track about 500 metres to Lissue level crossing. The train could not be moved, and remained in position until it could be recovered by crane. The track was repaired in time for the scheduled service to start the following morning.

Key facts and analysis

Identification of the immediate cause

45 The up main line was reopened to rail traffic when it was unsafe to do so.

46 The PICOP gave up the Lisburn to Portadown possession at 05:02 hrs, returning control of the line to the signaller. He had received confirmation from the engineering supervisor that the sleeper replacement work had been completed. He had also received confirmation from other engineering supervisors that work was complete at three other worksites within the possession. The engineering supervisor and PICOP were both unaware that the up main line was obstructed by the excavator bucket near Knockmore Junction.

Identification of causal factors

47 The accident occurred due to a combination of the following causal factors:

a. Machine driver A detached the excavator bucket from his machine between the rails of the up main line (paragraph 48).

b. Machine driver A forgot to collect the bucket when he left site after lifting the trailer and ballast box into the cess, leaving the bucket obstructing the up main line (paragraph 54).

c. The TSC and other members of the work group were unaware that the excavator bucket was causing an obstruction and so action was not taken to remove it (paragraph 57).

d. The worksite was handed back to the PICOP when the line was not safe for the passage of trains (paragraph 67).

Each of these factors is now considered in turn.

Placement of the bucket

48 Machine driver A detached the excavator bucket from his machine between the rails of the up main line.

49 When the sleeper replacement work was complete and both machine drivers had returned to the RRAP at the Knockmore Road site compound, machine driver B suggested to machine driver A that the trailer and ballast box could be left outside the site compound in the up main line cess. This would be a change from the work group's previous practice of taking the trailer and ballast box into the site compound. The use of the cess to store materials and items of machinery is not uncommon on NIR infrastructure and had been done previously by the work group on a different part of the route.

50 Machine driver B made the suggestion because he considered it preferable to crossing two tracks with the trailer slung from the arm of a machine on the uneven surface of the temporary RRAP. It would also avoid the need to manhandle the trailer and ballast box through the site compound entrance, a gap too narrow to take the trailer 'lengthways' and requiring track workers on foot to provide assistance (the size and location of this entrance had been determined by NIR's desire to minimise damage to trees already established on the railway boundary line).

51 Machine driver A agreed with this suggestion and detached his bucket to the rear of his machine. It was necessary to detach the bucket from the arm of the machine to fit the lifting chains needed to move the trailer and ballast box into the cess. Machine driver A stated that he detached the bucket between the rails because he believed it might become difficult to retrieve the bucket if it slid or rolled down the slope which existed in the cess at this location. It had been his intention to collect the bucket and take it to the site compound after placing the trailer and ballast box in the cess.

52 Both machine drivers were aware of the need to avoid leaving attachments where they could be in, or could possibly fall into, a dangerous position. However, neither could recall receiving formal instruction or training regarding specific locations where buckets (or other machine attachments) should be changed.

53 NIR does not prohibit the changing of machine attachments where they could cause an obstruction if left behind after a possession, as it is not always possible to avoid using these locations. NIR also considered such temporary obstructions would be no different to work which might affect the safety of the line during engineering possessions. However, when being stored out of use, NIR does require equipment to be left in a position which does not endanger trains. Both NIR, and the contractors undertaking the work, considered that a bucket remains 'in-use' when temporarily detached during engineering activities.

Equipment left behind

54 **Machine driver A forgot to collect the bucket when he left site after lifting the trailer and ballast box into the cess, leaving the bucket obstructing the up main line.**

55 Machine driver A stated that he had forgotten about the excavator bucket after lifting the trailer and ballast box into the cess. He off-tracked his machine at the RRAP and shut it down in the site compound, unaware that the bucket was still on the up main line. It has not been possible to establish exactly why the driver forgot about the bucket. It was likely to have been a consequence of one, or a combination, of the factors described in the following paragraphs:

a. Distraction

After detaching the bucket from his machine, machine driver A has stated that he became focused on lifting the trailer and ballast box into the cess. In particular he was keen to ensure both were clear of passing trains on the up main line. These thoughts could have taken his attention away from the bucket behind him.

b. Change in work pattern

The work group had been using the Knockmore Road site compound for the three previous weeks. On the previous nights, machine driver A had off-tracked his machine and detached the bucket in the site compound. He had then returned to the RRAP to take the trailer and ballast box to the site compound in turn. This previous method of working could have prompted the machine driver to believe his work was complete when the trailer and ballast box were clear of the line and his machine stowed in the site compound.

c. Fatigue

Machine driver A generally worked permanent night shifts, but had worked two day shifts followed by two night shifts before the shift in which he forgot about the bucket. He stated he was not feeling tired while detaching the bucket and moving equipment into the site compound. When assessed using the HSE fatigue and risk index[3], this working pattern was within the limits accepted by the rail industry[4]. However, the RAIB has previously reported that this methodology does not fully reflect fatigue risk[5] and so fatigue cannot be entirely discounted as contributing to the events. This is partly because there is a naturally occurring dip in human alertness in the early hours of the morning.

56 Time pressures have been discounted as contributing to the events on the 4 February 2016 because there is no evidence that the work group believed it was necessary to rush the removal of the machines from site. The work group had stopped the sleeper replacement work and returned to the site compound with sufficient time to remove all their equipment from the track without needing to hurry to avoid delaying the start of scheduled train services.

Obstruction overlooked

57 **The TSC and other members of the work group were unaware that the excavator bucket was causing an obstruction, and so no action was taken to remove it.**

58 The excavator bucket was placed on the up main line just after the machines had arrived back at the RRAP and before the TSC had reached the RRAP (paragraphs 33 and 34). Two other members of the work group had attached the lifting chains to the machine arm and ballast box before the TSC had returned to site. When the TSC arrived at the RRAP, these two people went into the site compound and had no further involvement with activities at the RRAP. The only people at the RRAP were then the two machine drivers and the TSC.

59 While the TSC and machine driver A were preparing to lift the trailer and ballast box, machine driver B was manoeuvring his machine to a position on the RRAP astride the main lines (figure 10). He was intending to drive his machine into the site compound after observing the lift of the trailer and ballast box into the cess.

---

[3] HSE Research Report 446, 'The development of a fatigue/risk index for shiftworkers' (2006).

[4] 'Managing Rail Staff Fatigue', available at http://orr.gov.uk/__data/assets/pdf_file/0005/2867/managing_rail_fatigue.pdf.

[5] RAIB report 15/2011, 'Uncontrolled freight train run-back between Shap and Tebay, Cumbria, 17 August 2010' and RAIB report 18/2016 'Two signal passed at danger incidents, at Reading Westbury Line Junction, 28 March 2015, and Ruscombe Junction, 3 November 2015'.

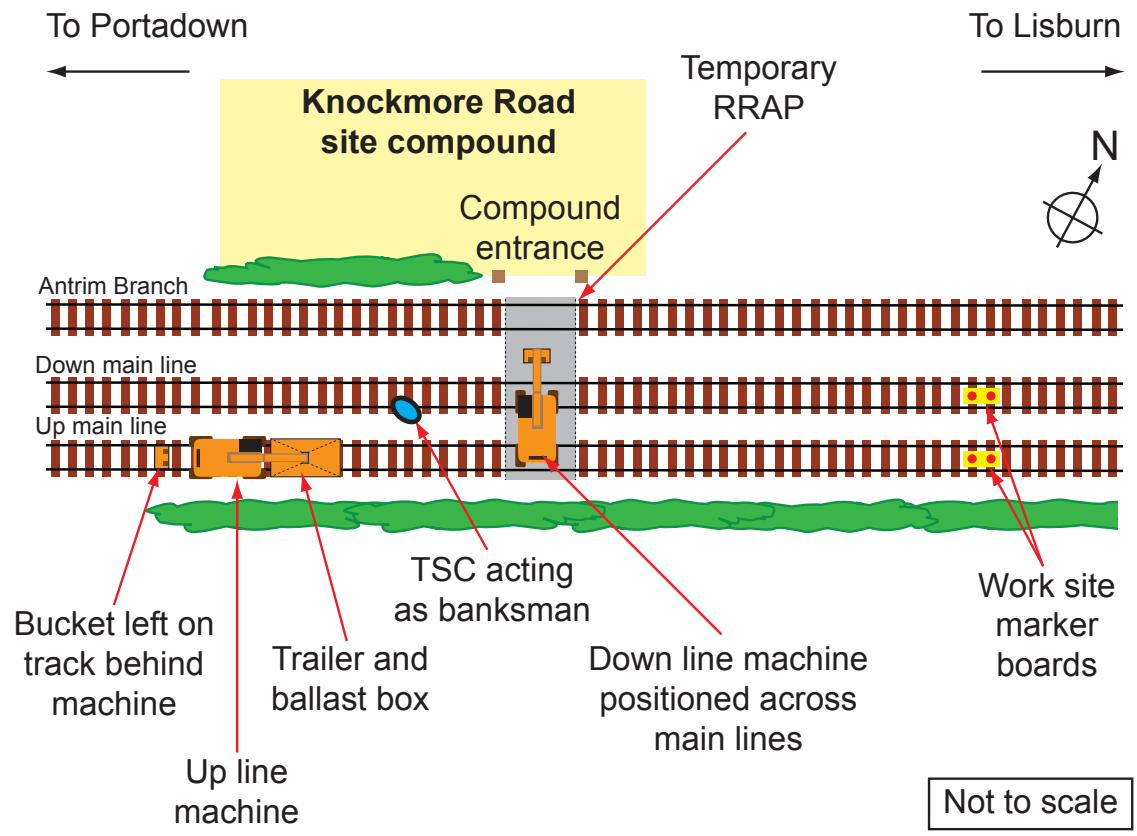

Figure 10: Location of the equipment and the TSC immediately before lifting the trailer and ballast box into the cess

60 During the lift, the TSC and machine driver B could not see the excavator bucket as their view was obscured by the machine performing the lift. The TSC stated that he had realised the bucket was no longer on the machine when he reached the RRAP because the lifting chains had already been attached in its place. However, the TSC did not consider where the bucket might have been detached. Machine driver B took his machine into the site compound, before machine driver A had off-tracked. This then meant that the only person remaining at the RRAP who had been aware of the bucket was machine driver A.

61 After machine driver A had off-tracked his machine, the TSC walked from the RRAP towards Lisburn to collect the worksite marker boards, then walked back into the site compound and secured the entrance from the site compound onto the railway. This meant he did not walk back beyond the RRAP towards Portadown and into the area where the bucket had been detached. He stated that he did not inspect this area.

62 Site lighting had not been provided at the RRAP so the work group were reliant on torches and the forward facing lighting of the machines. Had additional lighting been provided to assist on and off-tracking, it would have been focused on the RRAP, and so unlikely to illuminate the area containing the bucket. The provision of RRAP lighting was at the discretion of the contractor undertaking the work because NIR did not require temporary RRAPs to be illuminated.

63 Without additional lighting, it is likely that a dark coloured excavator bucket would only be visible if caught in the TSC's torch light, or that of another member of the work group, if passing close by. However, no member of the work group had a defined role to inspect the track, nor did they have any other reason to be in the vicinity of the detached bucket. From the time the trailer and ballast box were placed in the cess to when the site compound was secured, the bucket was not seen by the work group and so it remained on site.

64 The TSC would have been present when the bucket was detached if he had accompanied the two machines from Lissue level crossing to Knockmore Road site compound. He was required to do this by the rule book[6] which states:

'stay with your group until the work is completed and everyone is clear of the line or until you are relieved by another TSC'

65 It is unlikely that the bucket would have been left on the track if the TSC had complied with this requirement, since both he and machine driver A would have been aware that the detached bucket needed to be removed from the track.

66 NIR does not require every road/rail machine to be accompanied by a second person[7], but does require a 'Person in Charge' to be responsible for ensuring appropriate railway safety arrangements are in place for each road/rail machine. This can be the machine operator or, as in this case, the TSC.

67 **The worksite was handed back to the PICOP when the line was not safe for the passage of trains.**

68 After the road/rail machines had been stored in the site compound, the engineering supervisor was advised by the TSC at about 04:40 hrs that the work group and machines were now clear of the line (paragraph 35). The engineering supervisor, unaware that the bucket remained on the track and believing the line to be safe, then gave up the worksite to the PICOP at about 04:45 hrs. The engineering supervisor stated that:

a. he understood the rulebook placed a requirement on him to ensure the line was clear, but at the time he had not thought through how this duty could be discharged;

b. during the shift, he had been required to act as an emergency operator at Lissue level crossing and, as a consequence of this duty, could not leave the crossing to walk through the worksite in person checking for obstructions;

c. from his position at Lissue level crossing, he could see the lights of the machines at the RRAP as they moved off track, so reinforcing his belief that the line was clear; and

d. he trusted the TSC, and the machine operators where they travelled alone, to ensure the line was clear before the TSC gave up the worksite protection.

[6] NIR Rule Book section B part two, Additional Instructions to Persons with Specific Responsibilities, paragraph 6.3.

[7] A second person, known as a machine controller, is normally required on Network Rail infrastructure.

69 The TSC stated that he understood he was confirming the work was complete and the line was safe and clear when giving up the worksite. When doing this, the TSC believed that the line was safe because:

a. he had ensured the work was complete at the location of the sleeper replacement and walked back with the machines as far as Lissue level crossing;

b. although he had left the machines to travel unaccompanied between Lissue level crossing and Knockmore Road site compound, he believed there was no risk to the railway as the machines were travelling and not undertaking work;

c. he had been *banksman* when the trailer and ballast box were lifted into the cess, and, believing the biggest risk to the safety of the railway would come from these items being foul of the line, he had fully satisfied himself that this risk had been controlled; and

d. when the machines were back in the site compound, he spoke with machine driver A who indicated that his work was complete, and he was not aware of any reason to prevent trains running.

70 There is no evidence that the actions of the TSC had been influenced by fatigue. His working pattern, when assessed using the HSE fatigue and risk index, was within limits accepted by the rail industry. However, the possibility of fatigue cannot be entirely discounted.

Possible underlying factor

71 **NIR and its contractors had not defined how the areas of work should be inspected to ensure they were clear of obstructions.**

72 The intended method of working relied upon the engineering supervisor to determine how to comply with the rule book requirement to ensure that the line is clear. Neither NIR nor its contractors had given instructions to the engineering supervisor as to how this should be achieved when it was impractical for him to inspect the worksite in person.

73 The engineering supervisor was unable to inspect the line because he was performing the role of emergency operator which prevented him from leaving Lissue level crossing, an arrangement permitted by NIR. However, the engineering supervisor was content to accept the line was clear when the TSC said the worksite was no longer required.

74 NIR stated that the TSC is expected to know the line is safe and clear before telling the engineering supervisor that the worksite protection is no longer required. NIR believed that the TSC would achieve this by:

a. being with the work group at all times, including with travelling machines, and in doing so would identify and deal with obstructions if and when they occurred;

b. remaining vigilant and leaving the worksite only after establishing the work is complete using either their own knowledge for minor work, or that of a site engineer for more complex tasks; and

c. ensuring all members of the work group and road/rail machines are clear of the line at the end of the working shift.

75 NIR stated that it expects the engineering supervisor to meet the requirement to check the line is clear by whatever method is appropriate to the work which had been undertaken. Before the Knockmore Junction accident, in the case of simple tasks such as sleeper replacement work, NIR expected the engineering supervisor to determine an appropriate method for themselves. For complex work, NIR would expect the method of handback to be documented in a task method statement supplied to, and reviewed by, NIR or its nominated representative.

76 As sub-contractor for the track rehabilitation works project, NE Rail prepared the task specific method statements relating to the sleeper replacement work. This included the identification and mitigation of risks arising from the site activities including those relating to the use of road/rail machines. These documents did not require anyone to carry out an inspection intended to find any equipment left on the line.

77 NE Rail had not explicitly identified the possibility that large plant items could be left behind by the work group and remain on the track after the process of handback to the PICOP and re-opening the line. NE Rail had identified the risk from waste materials remaining on the track after engineering work and had specified the following mitigation:

> *'All operatives to inspect their immediate work area at the end of the shift and remove any waste materials or debris. As part of the track handover the ES/TSC will inspect the complete worksite and remove and [sic] waste materials'.*

78 On the night of 3/4 February, the engineering supervisor was prevented from leaving Lissue level crossing and inspecting the worksite. The TSC did not believe it was necessary to inspect the full length of the worksite from Dagger Road underbridge to Knockmore Road site compound including the area west of Maze level crossing not reached by his work group. He did inspect the location of the sleeper replacement work. He did not inspect the track between Lissue level crossing and the Knockmore Road site compound after the road/rail machines used this part of the worksite because he travelled from Lissue level crossing to the site compound by car (paragraph 33). He did not carry out a comprehensive inspection of the area around the site compound after the machines had left the railway. However, the activities undertaken in the areas he did not inspect would not generate waste material.

79 FP McCann was responsible for preparing the project risk assessments and method statements. These higher level assessments identified risks due to working with plant on an operational railway. It had identified a medium risk from equipment being struck by trains. The control measures for this included the statement that:

> *'no equipment to be left on track, or line side at any time. All equipment when not in use to be securely positioned in the cess'.*

80 FP McCann states that this control was also intended to apply during possessions, and therefore applied to the work group on 3/4 February 2016. The method statement does not define whether machine attachments which are being exchanged are considered to be 'not in use' (paragraph 53).

81 FP McCann did not produce the method statements or task specific risk assessments for removing plant and machinery from the railway, nor did it assess the worksite handback process. FP McCann considered that the handback process, including the apportioning of responsibilities to individuals, should be managed by NE Rail.

82 FP McCann was supplied with all method statements produced by NE Rail for these works. As principal contractor for the track rehabilitation work, FP McCann was responsible for health and safety on the project, a role which included reviewing NE Rail's method statements. FP McCann did not query the absence of a defined worksite handback procedure, including the absence of a check for equipment left on the line, in the NE Rail documentation.

83 Although NIR requires contractors to assess and manage hazards from their own work activities, NIR also reviews contractors' method statements. For the track rehabilitation project, NIR had appointed Mott MacDonald to accept the supplied method statements on its behalf.

84 Mott MacDonald has stated that it expected the method of worksite handback to be determined by the individual engineering supervisor (in accordance with the rule book) and not to be documented in a method statement. Therefore the absence of a worksite handback process, including the absence of a check for obstructions on the line, was not queried.

85 The RAIB acknowledges that the TSC believed it was safe to return the line to service (paragraph 69), and so a documented process for checking the safety of the line might not have influenced his actions. However, if a process for checking that no obstructions had been left on the line around the RRAP had existed, the TSC might have felt obliged to undertake a rigorous inspection of the area around the RRAP. If he had conducted such an inspection, before reporting that his work group no longer required worksite protection, it is probable that the bucket would have been found and the accident prevented.

Observations

86 **The engineering supervisor and TSC had adopted an informal method of signing-in and signing-out of the worksite.**

87 The engineering supervisor controls access to the worksite for engineering trains and work groups led by a TSC. In accordance with the rule book[8], the engineering supervisor must record details of the worksite on an 'engineering supervisor's certificate'. The same certificate is used to record the details of the TSCs requiring access to the worksite. The rule book requires each TSC to sign the engineering supervisor's certificate when granted access to the worksite, and to sign the certificate again when informing the engineering supervisor that the worksite protection is no longer required.

[8] NIR Rule Book section T part three, 'Arrangements for absolute possessions of the line', paragraph 10.4.

88 There is conflicting evidence about exactly when the TSC signed the engineering supervisor's certificate, but all evidence indicates that this did not happen either when the TSC was granted access to the worksite or when he gave it up. Both these actions were carried out over the telephone while the TSC was at the Knockmore Road site compound and the engineering supervisor was at Lissue level crossing. It is uncertain whether the TSC's signatures were added to the engineering supervisor's certificate before or after these telephone calls. The use of a telephone, rather than signed agreement in person, to arrange the commencement and termination of the worksite protection, was contrary to the requirements of the rule book[9]. The RAIB believes that this practice may be common on NIR.

89 **It was not possible to download the forward facing CCTV from the second down direction train as the system was faulty.**

90 The failure of the forward facing CCTV system on the second down direction train did not cause a significant problem for this investigation. However, images from this train would have allowed the RAIB to establish the position of this train at the time of the accident and the potential for it to have been affected by the accident. The images would not have changed the causal factors identified by the investigation.

91 In different circumstances, CCTV systems can provide critical evidence. For example, the RAIB was only able to establish the sequence of events during a near miss at Hest Bank (RAIB report 08/2015) with the aid of CCTV images taken from the incident train.

92 The RAIB acknowledges that accident damage, rather than a pre-accident failure of the equipment, prevented viewing of the CCTV images from train B301. This was because the damage sustained caused the last minutes of recording to be lost.

93 The lack of functioning CCTV has been identified in previous RAIB investigations and was raised in a letter sent by the RAIB's Chief Inspector to all UK train and freight operating companies on 27 May 2015. The letter drew operators' attention to the need for effective maintenance of CCTV cameras and associated equipment. It also requested that they should give consideration to the installation of appropriate cameras on all passenger trains and locomotives in regular service.

Previous occurrences of a similar character

94 Two previous events investigated by the RAIB involved engineering supervisors giving up their worksites when they incorrectly believed it was safe to do so. Both of these events occurred on Network Rail infrastructure. They are similar to the Knockmore Junction accident because the engineering supervisor was expected to be at a location where it was not possible to check the safety of the line in person. In both accidents, the engineering supervisor incorrectly believed that other people had carried out the checks needed to confirm it was safe to reopen the line.

[9] NIR Rule Book section T part three, 'Arrangements for absolute possessions of the line', paragraph 10.6.

Watford Tunnel, 26 October 2014

95 At around 07:19 hrs on 26 October 2014, a train struck an open door of a lineside equipment cabinet while travelling through Watford Tunnel in Hertfordshire. The RAIB's investigation (RAIB report 12/2015) found that the cabinet door had opened under aerodynamic forces as the train passed, probably because the door had been left closed, but unsecured, after work undertaken on equipment in the cabinet during the previous night.

96 The RAIB's investigation found that no-one had been allocated the responsibility for checking that cabinet doors were closed and secured at the end of the work. The engineering supervisor was unaware that this had not been done when he returned the worksite to the PICOP. The RAIB recommendation addressing this issue is discussed at paragraph 105.

Somerleyton, Suffolk, 18 June 2015

97 At about 05:50 hrs on 18 June 2015, a train struck a wooden sleeper lying across the track just after passing through Somerleyton station in Suffolk. The obstruction had been left on the track following engineering work the night before.

98 Bundles of scrap wooden sleepers had been collected and transported along the railway using a road/rail vehicle with front and rear trailers. Three sleepers fell onto the railway from the rear trailer and the staff undertaking this work were not aware of this when they informed the engineering supervisor that they no longer required worksite protection. The engineering supervisor was unaware that the method of working did not include a check that the line was not obstructed.

99 The Watford Tunnel recommendation (paragraph 105) had been published shortly before the RAIB Bulletin describing events at Somerleyton (RAIB bulletin 03/2015). The bulletin noted that the need to inspect the track after work was already addressed by the Watford Tunnel recommendation and so no further recommendation was made on this issue.

Summary of conclusions

Immediate cause

100 The up main line was reopened to rail traffic when it was unsafe to do so (paragraph 45).

Causal factors

101 The causal factors were:

a. Machine driver A detached the excavator bucket from his machine between the rails of the up main line (paragraph 48, **Learning point 2**).

b. Machine driver A forgot to collect the bucket when he left site after lifting the trailer and ballast box into the cess, leaving the bucket obstructing the up main line (paragraph 54, **Learning point 2**).

c. The TSC and other members of the work group were unaware that the excavator bucket was causing an obstruction and so action was not taken to remove it (paragraph 57, **Learning point 1**).

d. The worksite was handed back to the PICOP when the line was not safe for the passage of trains (paragraph 67, **Recommendation 1**).

Possible underlying factor

102 NIR and its contractors had not defined how the areas of work should be inspected to ensure they were clear of obstructions (paragraph 71, **Recommendation 1**).

Observations

103 Although not linked to the accident on 4 February 2016, the RAIB observes that the engineering supervisor and TSC had adopted an informal method of signing-in and signing-out of the worksite, contrary to the requirements of the rule book (paragraph 86, **Recommendation 2, Learning point 3**).

104 The availability of CCTV evidence was not crucial to the conclusion of this investigation, but in different circumstances, CCTV systems can provide critical evidence (paragraph 89).

Previous RAIB recommendations relevant to this investigation

Accident at Watford Tunnel, 26 October 2014, Recommendation 2

105 The above recommendation relates to the need for an effective process to ensure that the line is safe before reopening to traffic. This was a factor in the Knockmore Junction accident (paragraph 67) and so the recommendation is reproduced below:

Recommendation 2

Network Rail should implement a means to meet the rule book requirement for the designated person (Engineering Supervisor or Safe Work Leader) to confirm to the PICOP that the railway is safe and clear for the passage of trains when that designated person is not present on site.

106 This recommendation was made to Network Rail and not NIR. It is expected that, as part of their safety related duties, all infrastructure owners (including NIR) would consider whether this recommendation applied to their operations. A similar recommendation is now made directly to NIR (paragraph 110).

107 The Office of Rail and Road (the safety authority for Network Rail) has not yet reported to RAIB on the status of the Watford Tunnel recommendation. This report would relate only to the extent of implementation by Network Rail.

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

108 NIR, in conjunction with FP McCann and NE Rail, has introduced an infrastructure safety instruction (I/CIV/INS/1601) requiring site staff to formally record plant items when taken onto the railway. This requirement applies to those items which can present a danger to the operational railway, such as lifting chains and excavator buckets. When the work is complete, an independent person verifies that equipment has been accounted for at the end of the shift. NIR also requires such equipment to have large areas painted in bright colours to increase its conspicuity when viewed from a distance.

Other reported actions

109 NIR is reviewing its training material to establish whether it:

a. makes engineering supervisors fully aware of their duty to ensure the line is safe when returned to traffic; and

b. provides engineering supervisors with guidance on how to discharge this duty.

Recommendations and learning points

Recommendations

110 The following recommendations are made[10]:

1 *The intent of this recommendation is to ensure that, before engineering supervisors permit lines to be returned to service after engineering activities, the safety of the line is checked by a method (or methods) appropriate to the activities undertaken. The checks must be pre-planned and may be carried out by the engineering supervisor or by others who report their findings to the engineering supervisor.*

Northern Ireland Railways should introduce a process to ensure that the engineering supervisor or other designated individual(s) are assigned responsibility for carrying out a visual inspection (or implementing equivalent checks) to confirm that track within a worksite is in a safe condition after engineering activities are completed and before the worksite is given up. The assignment of responsibility should be pre-planned (where possible before work commences), documented and practical. It should cover all areas where engineering work is undertaken, all access/egress points and all sections of track used for travelling between these locations (paragraph 101d).

2 *The intent of this recommendation is to ensure that a robust document process, compliant with Northern Ireland Railways' requirements, is always used when staff sign in and sign out of worksites.*

Northern Ireland Railways should review the methods used by staff, such as track safety co-ordinators, when signing-in and signing-out of worksites. The review should include how and when briefings are provided by engineering supervisors, methods used to ensure staff comply with formalised procedures and possible modifications to existing processes such as introducing formalised systems for signing-in and signing-out by telephone (paragraph 103).

[10] 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 Department for Infrastructure to enable it to carry out its 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 200 to 203) can be found on RAIB's website www.gov.uk/raib.

Learning points

111 The RAIB has identified the following key learning points[11]:

1 It is important for track safety co-ordinators to closely monitor the activities of their work group at all times. This is essential for them to discharge their responsibility for the work group and to ensure that the line is returned to traffic in a safe condition. A similar learning point was identified for Controllers of Site Safety and Safe Work Leaders responsible for work groups on Network Rail infrastructure following the investigation into dangerous events at Heathrow Tunnel Junction, 27 and 28 December 2014 (RAIB report 20/2015).

2 Workers should, where possible, avoid placing objects capable of endangering trains in locations where such equipment could present a threat to railway safety were they to be forgotten. This includes locations used when changing attachments for road/rail machines. Where this is not possible, the track safety co-ordinators should be informed of the obstruction and the equipment should be moved to a safe position as soon as possible.

3 It is essential that staff completing engineering supervisor's certificates do so in accordance with rule book requirements. Varying from these requirements, for example using telephones in a system designed for face to face communication, increases the risk of errors leading to serious accidents.

[11] 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed Circuit Television
ES	Engineering Supervisor
NIR	Northern Ireland Railways
ORR	Office of Rail and Road
OTDR	On Train Data Recorder
PICOP	Person in Charge of the Possession
RAIB	Rail Accident Investigation Branch
RRAP	Road rail access point
TSC	Track Safety Co-ordinator

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.

Ballast (track)	Crushed stone, nominally 48mm in size and of a prescribed angularity, used to support sleepers both vertically and laterally.*
Banksman	A person appointed to assist the driver in the safe movement or operation of a vehicle or construction equipment.
Bogie (on class 3000 trains)	An assembly of two pairs of two wheelsets (two wheels mounted on a joining axle) in a frame which is pivoted at the end of a long vehicle to enable the vehicle to go round curves.
Cess	The area of railway between the nearest rail and the boundary line.
Diesel multiple unit	A diesel powered train consisting of one or more coaches, including at least one powered vehicle, with driving cabs at each end, which can be coupled to other units and operated as a single train.
Down main (at this location)	A line on which the normal direction of travel is towards Belfast.
Flatbed (rail trailer)	General purpose trailer with a level loading deck and without load retaining sides.
Lifeguard	Heavy metal brackets fitted vertically immediately in front of the leading end wheels of a rail vehicle, one over each rail. Their purpose is to deflect small objects away from the path of the wheels.*
Lifting chains	Length of chain links used to sling heavy loads from lifting equipment.
Off-tracking	Removing a road/rail machine from the rails and driving it away from the track.
On-tracking	Driving a road/rail machine onto the track and placing it in to rail mode.
Possession	A formal temporary closure of a line to trains for safety reasons or to allow engineering work to take place.*
Quick-coupler / quick-hitch (excavator machine)	The mechanical device mounted on the outer end of an excavator arm and allowing the machine driver to couple buckets and other attachments from the driving position and without requiring outside assistance from others.
Road/rail access point (RRAP)	Located on the railway, a roadway built up to and across the track, and laid at right angles to and level with the top of the rail. This allows a road/rail vehicle to be driven onto the RRAP to change between road mode and rail modes.

Road/rail machine	An item of machinery normally operated on roadways that has been adapted to make it capable of running on railway track as well as on the road.
Sleeper	A beam made of wood, pre-stressed reinforced concrete or steel placed at regular intervals at right angles to and under the rails. Their purpose is to support the rails and to ensure that the correct spacing is maintained between the rails.*
Up main (at this location)	A line on which the normal direction of travel is towards Dublin.
Worksite (engineering)	The area within a possession that is managed by an engineering supervisor. A worksite is delimited by marker boards and by used by one or more work groups, each controlled by a track safety co-ordinator (TSC).

Appendix C - Investigation details

The RAIB used the following sources of evidence in this investigation:

- information provided by witnesses;
- information taken from the train's on-train data recorder (OTDR);
- closed circuit television (CCTV) recordings taken from the first down train;
- site photographs and measurements;
- weather reports and observations at the site;
- personnel records of those involved;
- site records and possession paperwork; and
- a review of previous RAIB investigations that had relevance to this accident.

This report is published by the Rail Accident Investigation Branch,
Department for Transport.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Telephone: 01332 253300
Fax: 01332 253301
Email: enquiries@raib.gov.uk
Website: www.gov.uk/raib