Rail Accident Investigation Branch

Rail Accident Report

Derailment of a freight train at Barrow upon Soar, Leicestershire
27 December 2012

Report 22/2013
December 2013

This investigation was carried out in accordance with:

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

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* Cover photograph courtesy of Network Rail

Derailment of a freight train at Barrow upon Soar, Leicestershire, 27 December 2012

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Summary

At about 04:50 hrs on 27 December 2012, a freight train derailed about 1 mile (1.6 km) north of Barrow upon Soar station, Leicestershire. One of the rails of the line on which the train was travelling, dipped due to the failure of the supporting embankment. The locomotive and first ten wagons remained on the track, the eleventh and twelfth wagons derailed, the thirteenth remained on the track and the rear seven, which separated from the rest of the train, derailed and tipped over. No one was hurt but the track, the embankment and some of the wagons were damaged.

The investigation found the embankment failed under the weight of the passing train because water within the embankment had reduced its stability and none of Network Rail's processes had identified this. It is possible that an evaluation of the embankment could have identified the reduced stability, but the circumstances for triggering an evaluation were unclear, and there was no defined process for reporting trigger events. The investigation also observed that the evaluation process did not make use of rainfall data, or data that showed how the geometry of the track on top of the embankment was changing over time. An additional inspection during flooding could possibly have identified the embankment's reduced stability. However, none was required at this location as Network Rail did not consider how the embankment was constructed when assessing the risk of an earthwork failure due to water. It is also possible that the embankment's reduced stability could have been identified by a routine examination, but none was due. A basic visual track inspection had been planned for three days before the accident but it was not completed. It is possible that this planned inspection would have found a track defect which could have led to the discovery of the embankment's reduced stability.

The report makes three recommendations, all to Network Rail, which cover:

- the provision of information to trigger an earthwork evaluation;
- using track geometry and rainfall data to improve the earthwork evaluation process; and
- improving the process used to decide if an earthwork should be inspected when a flood warning is issued.

Introduction

Preface

1 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.

2 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.

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

Key definitions

4 All dimensions in this report are given in metric units, except speeds and locations which are given in imperial units, in accordance with normal railway practice. Where appropriate the equivalent metric value is also given.

5 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.

The accident

Summary of the accident

6 At about 04:50 hrs on 27 December 2012, a freight train derailed about 1 mile (1.6 km) north of Barrow upon Soar station, Leicestershire (figure 1). One of the rails of the *up slow* line, on which it was travelling, dipped due to the failure of the supporting embankment.

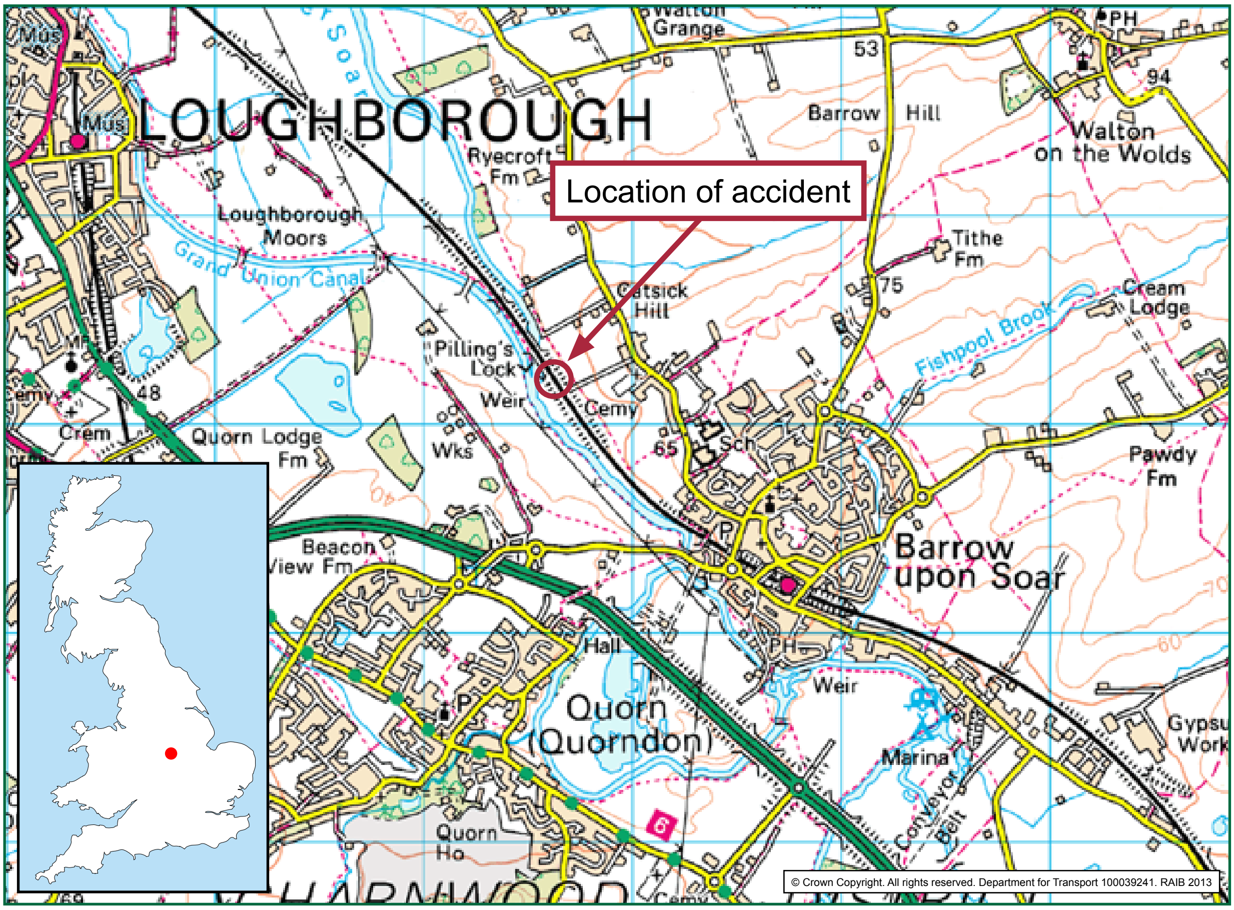


Figure 1: Extract from Ordnance Survey map showing location of accident

7 The locomotive and first ten wagons remained on the track; the eleventh and twelfth wagons derailed by their leading *bogies* only; the thirteenth remained on the track; and the rear seven, which separated from the rest of the train, derailed and tipped over (figure 2).

8 No one was hurt in the accident and there were no other trains in the vicinity at the time. The slow lines remained closed for twelve days for recovery of the wagons and repairs to the embankment and track.

Figure 2: Aerial view of the accident site (photograph courtesy of Network Rail)

Context

Location

9 The derailment occurred on the up slow line between Loughborough and Barrow upon Soar, at 109 miles and 51 *chains* (from a zero reference at London St Pancras station), which is part of Network Rail's *East Midlands Route*. Just before the point of derailment, the railway crosses a bridge (referred to as bridge 64) over the River Soar.

10 At this location, the four track railway comprises the up and *down slow* lines and the up and down *fast* lines (figure 3). The permitted speed for trains on both slow lines is 65 mph (105 km/h) and 110 mph (177 km/h) on both fast lines. The slow lines are mainly used by local passenger services that stop at stations between Loughborough and Leicester, and by freight trains.

11 The track on the up slow line consists of *continuous welded rail* on steel *sleepers*. Signalling in the area is by the *track circuit block* system with *four aspect colour light signals*, and is controlled from the East Midlands Control Centre in Derby.

Organisations involved

12 Network Rail owns, operates and maintains the infrastructure, including the track and the embankment where the derailment occurred. The freight train was operated by DB Schenker Rail (UK) Ltd, who also employed the driver. Both Network Rail and DB Schenker freely co-operated with the investigation.

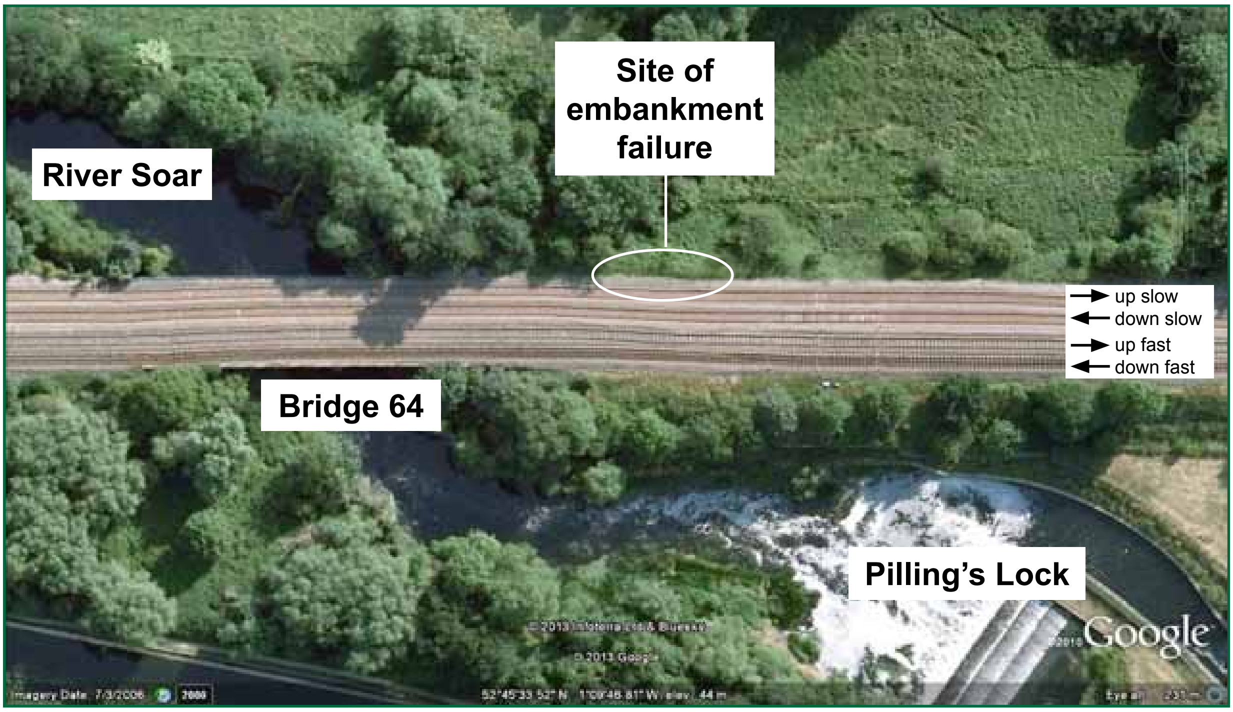


Figure 3: Location of the accident site

Trains involved

13 The freight train that derailed was train 6L73, the 02:15 hrs service from Peak Forest, near Buxton, to Ely. It consisted of a class 66 diesel-electric locomotive hauling 20 bogie *hopper wagons* which were a mixture of types IIA, HOA and JGA (figure 4). All the wagons were loaded with stone giving a total train weight of 2036 tonnes: the locomotive weighed 126 tonnes, and when laden, the IIA and HOA wagons each weighed up to 102 tonnes and the JGA wagons each weighed up to 90 tonnes.

14 The previous train that had passed over the up slow line before train 6L73 was train 6L82. This was the 02:27 hrs service from Barrow Hill to Middleton Towers, operated by Freightliner Heavy Haul, which passed this location at about 03:00 hrs. It consisted of a class 66 locomotive hauling 25 empty wagons, type MJA, which weighed 23 tonnes each. Because of the Christmas holiday period, this was the first train to pass over this line since the evening of 24 December.

Staff involved

15 The driver of train 6L73 had signed on for duty at Peterborough depot at 20:10 hrs on 26 December. As part of his shift, he went to Toton Yard, near Nottingham, where he took over train 6L73 from another driver and was due to drive this train as far as Peterborough. The RAIB has found no evidence that the driving of the train contributed to the accident.

16 The signaller was working on the Leicester *workstation* at the East Midlands Control Centre. The RAIB has found no evidence that the actions of the signaller contributed to the accident.

17 Staff based at Network Rail's Leicester maintenance depot were responsible for maintaining the track where the accident happened. Staff working for the Route Asset Manager (Geotechnical) were responsible for managing all of the *earthworks* on the East Midlands Route.

Figure 4: Class 66 locomotive (above left); IIA, HOA and JGA wagons (above right); and Train 6L73 (below - photograph courtesy of Network Rail)

External circumstances

18 It was dark at the time of the accident. The local weather conditions were dry with a temperature of about 5°C. It had last rained during the afternoon of the previous day. The influence of rainfall on this accident is discussed in paragraphs 42 to 46.

19 Data from an Environment Agency river level monitoring station at Pilling's Lock (figure 3) on the River Soar, which is less than 200 metres from where the river passes under the railway, recorded a river level of 1.32 metres at the time of the accident. The Environment Agency considers that flooding is possible at this location when the river level is higher than 1.14 metres. When not in flood, the level of the River Soar is normally in the range of 0.94 to 1.14 metres. The effect of the river level on this accident is discussed in paragraphs 47 to 52.

Events preceding the accident

20 The last train before the Christmas holiday period to pass over this part of the up slow line was a local passenger train at about 20:00 hrs on 24 December. The level of the nearby River Soar was rising at this time and peaked at 1.87 metres between 17:00 hrs and 18:00 hrs on 25 December, before it began to fall slowly.

21 The river level continued to fall throughout 26 December and was recorded at 1.33 metres when train 6L82 passed over the up slow line at about 03:00 hrs on 27 December. The driver of that train did not report a track irregularity at any point during his journey.

22 Train 6L73 had departed from Peak Forest on time at 02:15 hrs. The train ran via Dore and Chesterfield to Toton, where it arrived 26 minutes early and stopped for a planned change of drivers. Train 6L73 departed Toton at 04:26 hrs, joined the up slow line at Trent South Junction at 04:33 hrs, and passed through Loughborough at 04:46 hrs. The journey up to that point had been uneventful.

Events during the accident

23 After slowing for a 20 mph (32 km/h) speed restriction through Loughborough station which applied to train 6L73 due to its weight, the driver slowly accelerated. At about 04:50 hrs, the train crossed bridge 64 over the River Soar while travelling at 36 mph (58 km/h).

24 About 51 metres further on, while travelling at 37 mph (60 km/h), the driver felt the locomotive lurch sharply to the left. As the train continued on, a short length of the embankment progressively slipped underneath it, causing the rail on the *cess* side to drop. The locomotive and first ten wagons passed over the embankment slip before it worsened sufficiently under the train to cause the leading bogies of the eleventh and twelfth wagons (both type IIA) to derail to the right (figure 5). The thirteenth wagon (type HOA) did not derail.

Figure 5: Derailed eleventh and twelfth wagons

25 The embankment slip continued to worsen under the train and caused all of the wheels on the remaining seven wagons to derail to the left towards the cess and these wagons then overturned. This caused the coupling between the thirteenth and fourteenth wagons to break, which in turn ruptured the train's *brake pipe*. This caused the train's brakes to apply and the front of the locomotive came to a stop 436 metres beyond the start of the embankment slip. The two portions of the train came to rest 112 metres apart (figure 6).

Figure 6: Where the two portions of train 6L73 came to rest (photograph courtesy of Network Rail)

Events following the accident

26 At 04:55 hrs, after coming to a stop, the driver contacted the signaller. The driver told the signaller what had happened and that he thought his train may have divided. The signaller placed signals to "stop" to prevent trains from approaching the area on any of the four tracks so the driver could examine his train. The driver walked back and found the two derailed wagons. He reported to the signaller that his train was derailed to the right and was affecting the adjacent down slow line. He then explained he was going to walk back further to locate the rest of the train. The driver continued walking back and soon found the remaining wagons on their sides. He reported this to the signaller and told the signaller that the accident appeared to be the result of a embankment slip.

27 The signaller and driver discussed whether the fast lines were affected. The driver explained that because it was very dark, he could not be certain, so the signaller decided to use a train to examine the fast lines in accordance with the Rule Book (Railway Group Standard GE/RT8000). Train 1C05 was waiting at a signal to the north on the up fast line so the signaller asked its driver to examine the fast lines. The driver of train 1C05 did this and reported back to the signaller that the fast lines were unaffected. At 05:38 hrs, trains began running at their permitted speed on both of the fast lines while the signaller kept both slow lines shut so that investigation and recovery activities could commence.

28 Later that day, the eleventh and twelfth wagons were re-railed and on 28 December the locomotive and first thirteen wagons were moved to Humberstone Road sidings, Leicester. The seven overturned wagons were recovered between 30 December and 6 January 2013. The embankment was repaired from 3 to 5 January and the track repaired from 6 to 8 January. Both slow lines were handed back for traffic at 06:12 hrs on 8 January.

The investigation

Sources of evidence

29 The following sources of evidence were used:

- witness statements;
- data recorded by the train's on-train data recorder (OTDR);
- site photographs and measurements;
- a geotechnical report commissioned by Network Rail;
- Network Rail documents for earthwork examinations, track inspections and track maintenance activities;
- data recorded by Network Rail's *track geometry recording trains*;
- weather reports and observations from nearby weather stations;
- river level data for the River Soar;
- information about train movements recorded by Network Rail's systems;
- Network Rail's control logs;
- voice recordings of telephone calls to and from the signaller at the East Midlands Control Centre;
- mobile phone records;
- closed circuit television (CCTV) recordings taken from trains operated by East Midlands Trains;
- CCTV recordings from Loughborough station;
- Network Rail company standards and Railway Group standards; and
- a review of previous RAIB investigations that had relevance to this accident.

Key facts and analysis

Identification of the immediate cause[1]

30 **The immediate cause of the accident was that the support under the cess side rail of the up slow line failed as train 6L73 was passing over it.**

31 A dip in the cess rail had formed due to material in the embankment underneath it slipping, causing the driver of train 6L73 to feel a lurch to the left when the locomotive passed over it. As the train continued to pass over the dip, the amount of slippage in the embankment worsened, which caused the dip to become larger. The eleventh and twelfth wagons, which were type IIA, were unable to negotiate the dip and their leading bogies derailed to the right. The thirteenth wagon, which was a type HOA, did not derail on the dip, probably because its frame was less stiff than that of an IIA wagon.

32 The fourteenth and following six wagons all derailed towards the cess and tipped onto their sides (figure 7). These wagons almost certainly derailed due to the embankment slip worsening as the fourteenth wagon passed over it, resulting in a greater vertical deflection of the cess rail and complete loss of support under it as shown in figure 7.

Figure 7: The rearmost wagon and loss of support under the cess rail of the Up Slow line

33 A section along the top of the embankment, over a length of about 25 metres, had dropped down by about 0.5 metres. This extended inwards from the cess towards the centre of the up slow line, removing all support under the cess rail. Scars within the embankment showed the extent of the movement (figure 8).

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

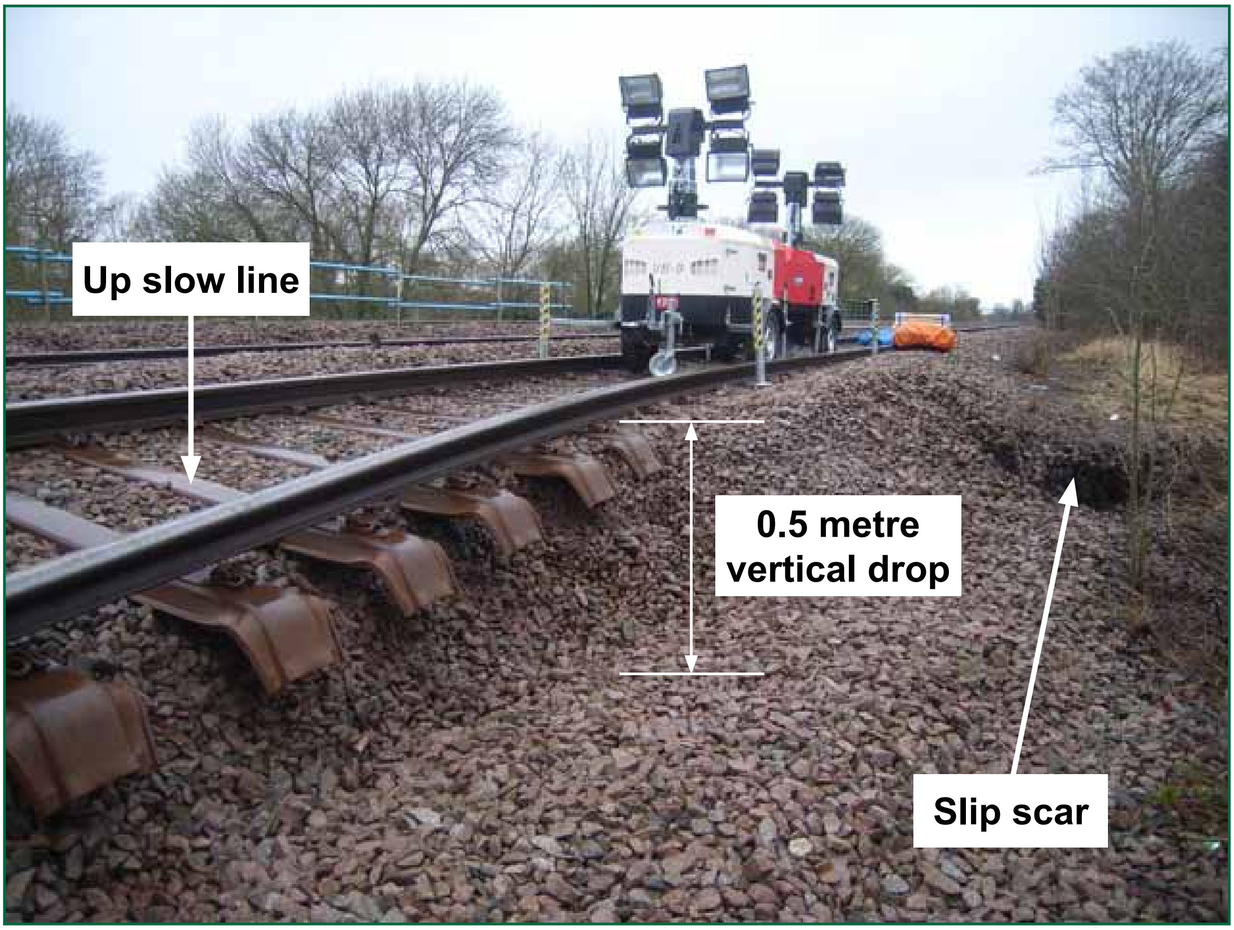


Figure 8: Scars showing embankment slip

34 The RAIB measured the profile of the embankment and found a small bulge in the horizontal plane towards the bottom of the slope (figure 9). Network Rail also surveyed the bottom of the embankment and found that the drainage ditch running along the foot narrowed where the slip had occurred, suggesting that the foot of the embankment had moved outwards. Network Rail took samples from the embankment to identify the materials within it and carried out tests to determine the strength of these materials. As part of the remedial works to repair the embankment, Network Rail employed a contractor to dig a trial trench to establish the extent of the failure within the embankment and the failure mechanism. This work identified that a single *rotational failure* (figure 10) had occurred within the embankment, where a layer of clay met a layer of ash material[2]. The cause of this failure is discussed later in the report (paragraph 41).

35 The RAIB surveyed the track from bridge 64 to the point of derailment and found no evidence of any faults with the track before the embankment slip.

[2] The Network Rail contractor found that the ash material comprised a mix of black ash, gravel and used ballast.

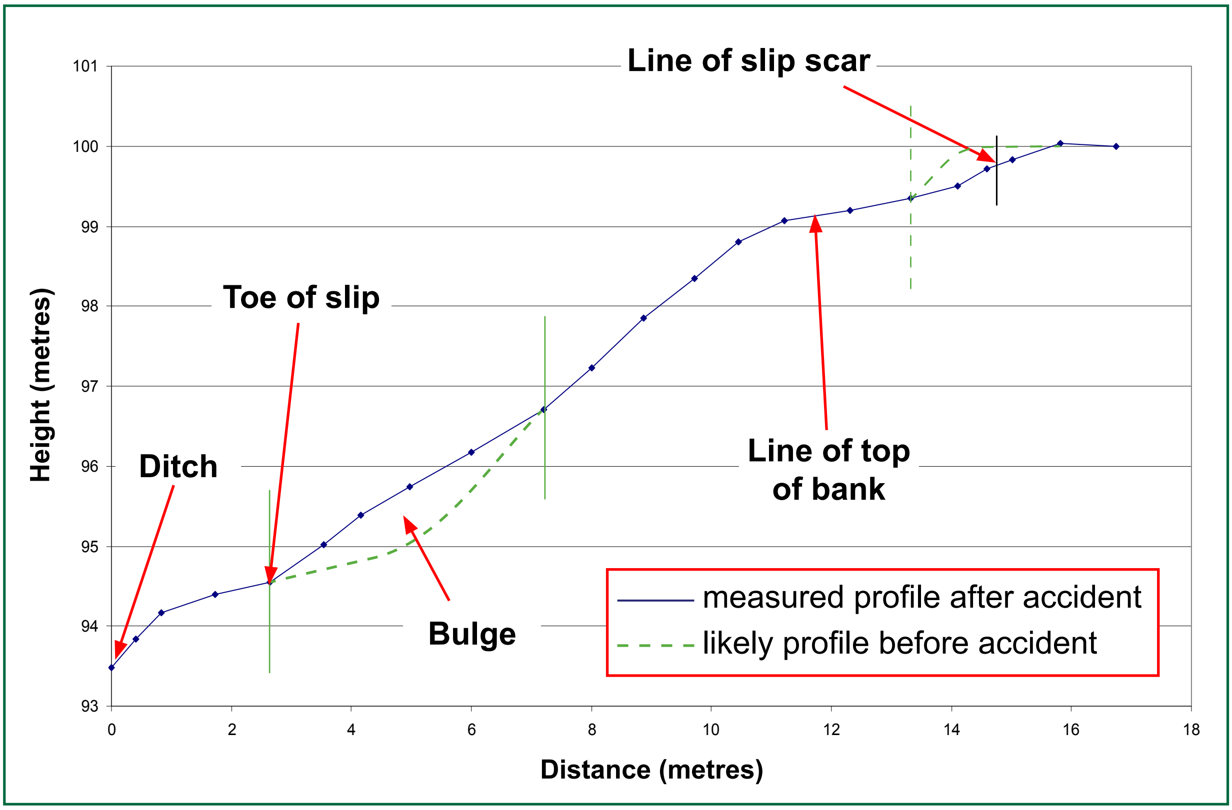


Figure 9: The embankment profile after the failure

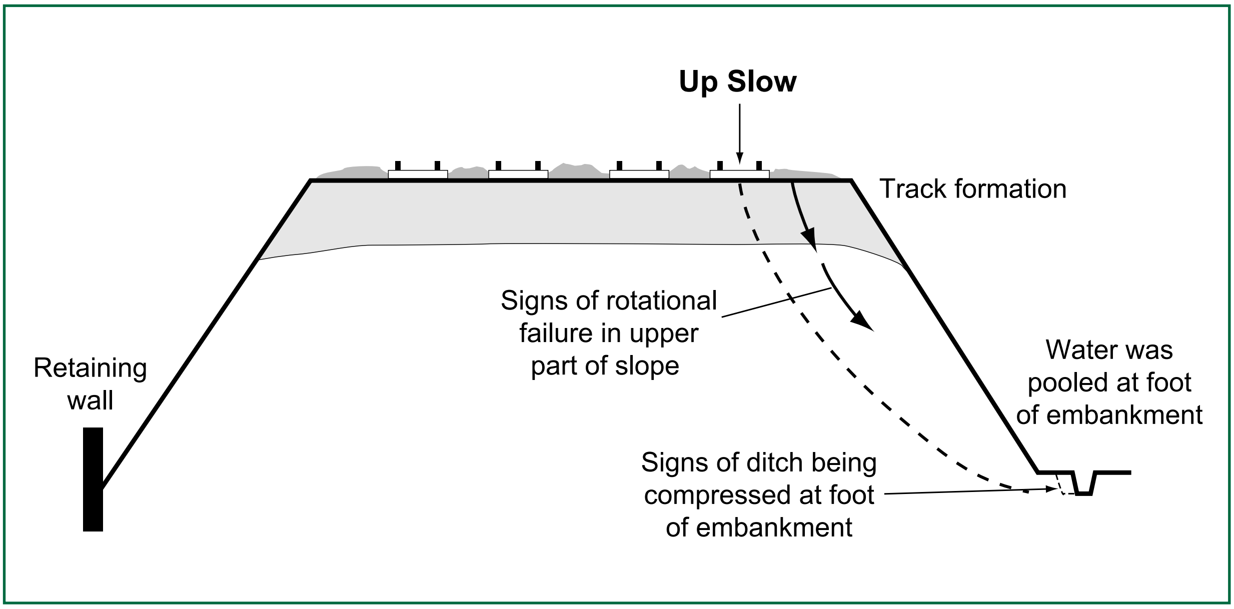


Figure 10: The rotational failure within the embankment

Identification of causal factors[3]

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

- The weight of the train on top of the embankment (paragraph 37).
- Water within the embankment had reduced its stability (paragraph 41).
- None of Network Rail's processes identified that the embankment's stability was reduced and that it was at risk of failing under a passing train, particularly in the three months before it did (paragraph 56).

Each of these causal factors is now considered in turn.

The weight of the train

37 **The weight of the train initiated an embankment slip as the train passed over the top of the embankment. Ordinarily the embankment would have been capable of supporting this weight. This is a causal factor.**

38 Over time water had reduced the stability of the embankment (paragraph 41) which increased the risk that it would slip. The previous train (paragraph 14) had passed over the embankment without incident, although its wagons were empty so each had a *wheelset* weight of about 5.8 tonnes. It is possible that the passage of the previous train caused the slip to worsen, as the driver of train 6L73 felt a sharp lurch as his locomotive passed over the embankment (paragraph 24). That the locomotive and front wagons of train 6L73 did not derail, while nine out of the ten trailing wagons derailed, indicates that the amount of slippage in the embankment increased as the train passed.

39 All of train 6L73's wagons were laden with stone. After the train left Peak Forest, it passed over Network Rail's *WheelChex* site at Grindleford in Derbyshire which measured wheelset weights of 19.6 to 22.7 tonnes for the JGA wagons, and 23.1 to 25.5 tonnes for the HOA and IIA wagons. These weights were at or below the permitted levels for the respective wagons except for the rear wheelset on the fifteenth wagon, an HOA wagon, which measured 25.5 tonnes. It was 0.1 tonnes heavier than the wheelset weight limit of 25.4 tonnes set by Network Rail for its infrastructure. WheelChex is configured to give a warning for wheelset weights greater than 28 tonnes. This wagon's overall weight was 99.8 tonnes (compared to a limit of 101.6 tonnes) and being the fifteenth wagon, the embankment had already slipped by the time this wagon reached it. The RAIB concluded that the weight of this train was normal for the embankment to support.

40 WheelChex measures the impact loads from a train's wheels to monitor whether any of the wheels have flat spots. None of the wheels on train 6L73 had impact loads that approached the warning level set on WheelChex, indicating that impact loads from the train's wheels were not a factor in this accident.

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

Water within the embankment

41 **Water in the embankment had reduced its stability. This arose due to a combination of the following causal factors:**

- **water draining from the track into the embankment affected its stability at its upper levels (paragraph 42); and**
- **water pooling at the foot of the embankment affected its stability at its lower levels (paragraph 47).**

Each of these factors is now considered in turn.

Water draining from the track into the embankment

42 The up slow line was located above a layer of clay with a layer of ash material built up on top of the slope of the original embankment side (figure 11). This ash layer was added by the Midland Railway Company in the 1870s when the railway was widened at this location from three to four tracks. This was a common construction method at the time as ash material was freely available.

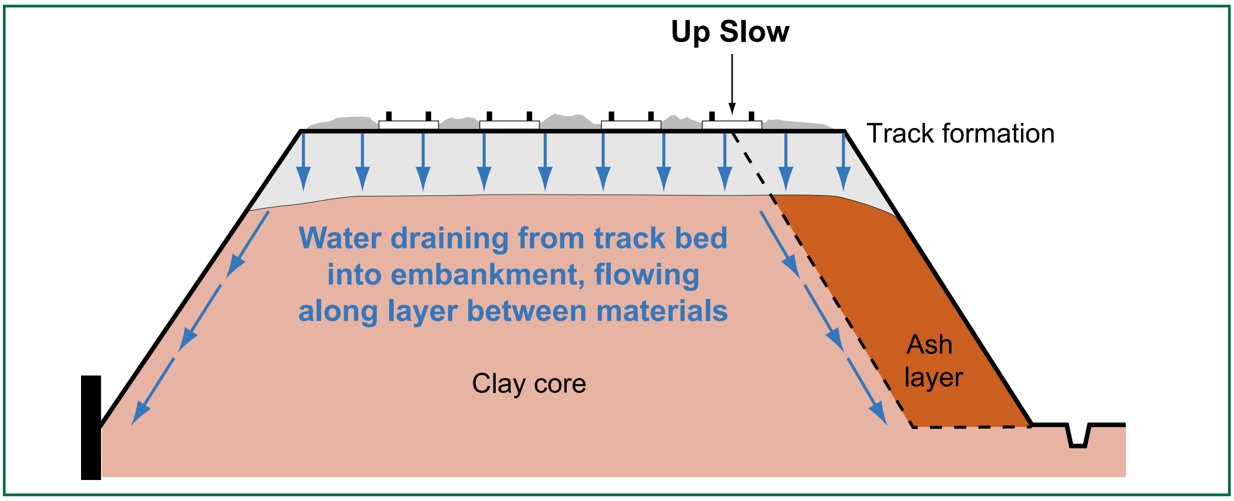


Figure 11: The layers within the embankment

43 Over time, the material within the embankment, where the clay and ash layers met, had weakened due to water flowing along a path between the layers. When Network Rail's contractors cleared the vegetation and dug out the embankment after the accident to investigate the cause of the slip and undertake repairs, they found that water had saturated the ash material. The water had also softened the first 300 to 400 mm of clay where it met the ash layer (figure 11), reducing the strength of this clay material. The contractors found the slip had occurred along the plane where the clay and ash layers met, over a length of about 25 metres (figure 12).

44 It is a normal condition for water to drain from the track, through its *formation* and into the embankment beneath. If water does not drain away from the track, the track quality will be poor. During November and December 2012 there was persistent rainfall in the area. Extreme rainfall events were only recorded once in each month, at two of the three weather stations located within 3 miles (4.8 km) of the accident site. Network Rail company standards define an extreme rainfall event as more than 25 mm of rainfall in a day. The nearest weather station (in the southern outskirts of Loughborough) recorded 140 mm of rainfall in December, with 113 mm (81%) of this falling before the accident.

Figure 12: The embankment after being dug out (photograph courtesy of Network Rail)

45 The monthly rainfall level recorded at the Met Office site at Sutton Bonington (which is about 6 miles (10 km) away) during November 2012 was 90 mm, compared to a November monthly average at this location for the past 50 years of 54 mm. In December 2012, the rainfall was almost double the December monthly average, with 107 mm of rainfall recorded against a monthly average of 56 mm.

46 The persistent rainfall meant water was flowing into the embankment from above and draining along a path between the material layers. The water softened the clay and ash materials and reduced their strength. This weakened the plane between the layers, which reduced the embankment's stability and made the embankment susceptible to failing at this point.

Water pooled at the embankment's foot

47 The material at the foot of an embankment is a key factor in governing an embankment's stability as it supports the rest of the embankment. The foot of this embankment is naturally wet as it is the water catchment area for the nearby fields that slope down towards the railway. Maps dating back to 1884 show this location as a marshy area. The water that flows into this area is collected in a drainage ditch that runs along the foot of embankment, with an outfall into the nearby River Soar (figure 13).

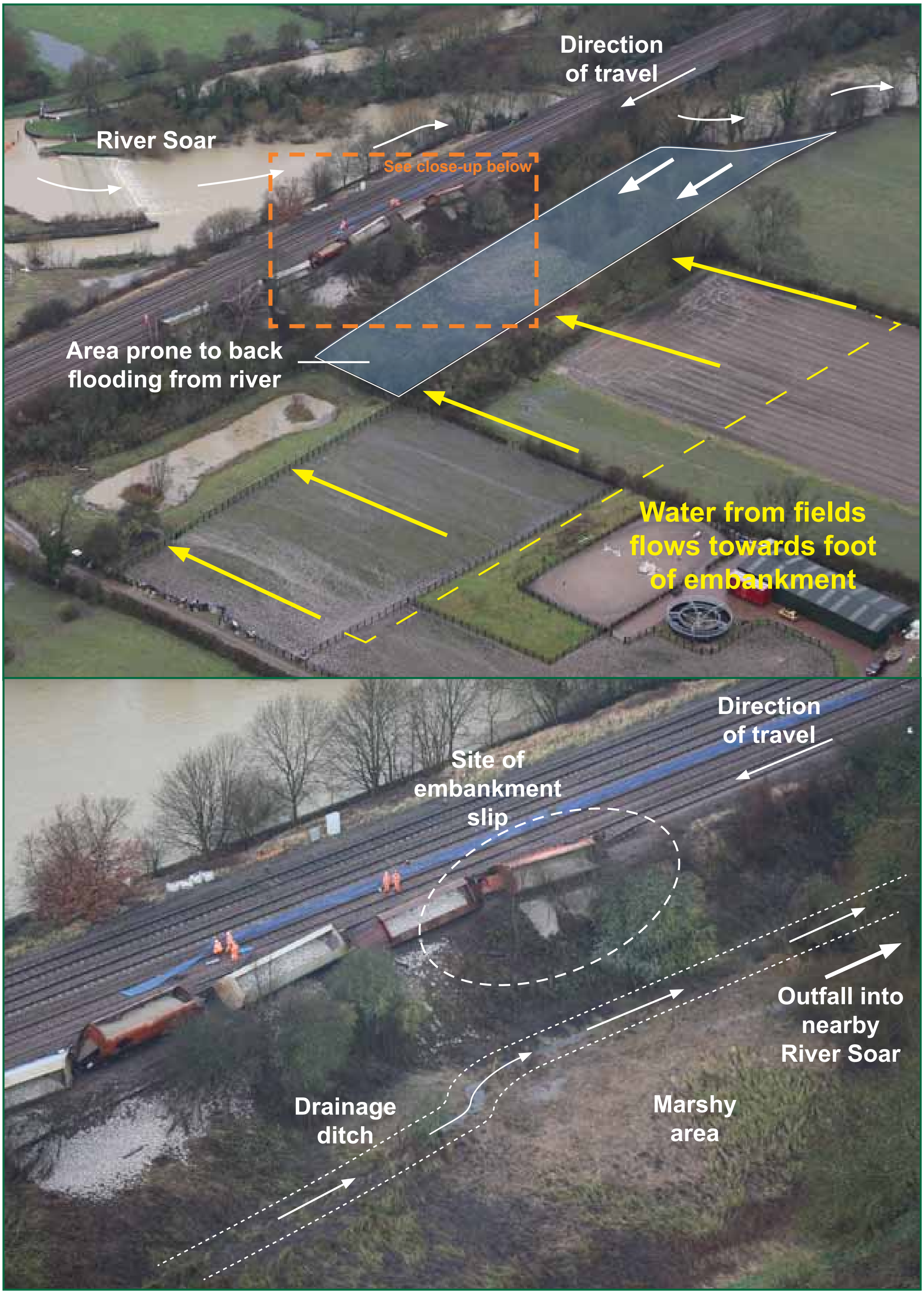


Figure 13: Drainage from the foot of the embankment to the River Soar (photographs courtesy of Network Rail)

48 There was persistent rainfall in this area throughout November and December (paragraph 44) which caused the River Soar to flood. The water from the river then back flooded along the ditch and pooled at the foot of the embankment (figure 13). The highest river level recorded at Pilling's Lock in 2012 was 2.1 metres which was on 26 November (figure 14). The river level then remained higher than normal for most of December (paragraph 19).

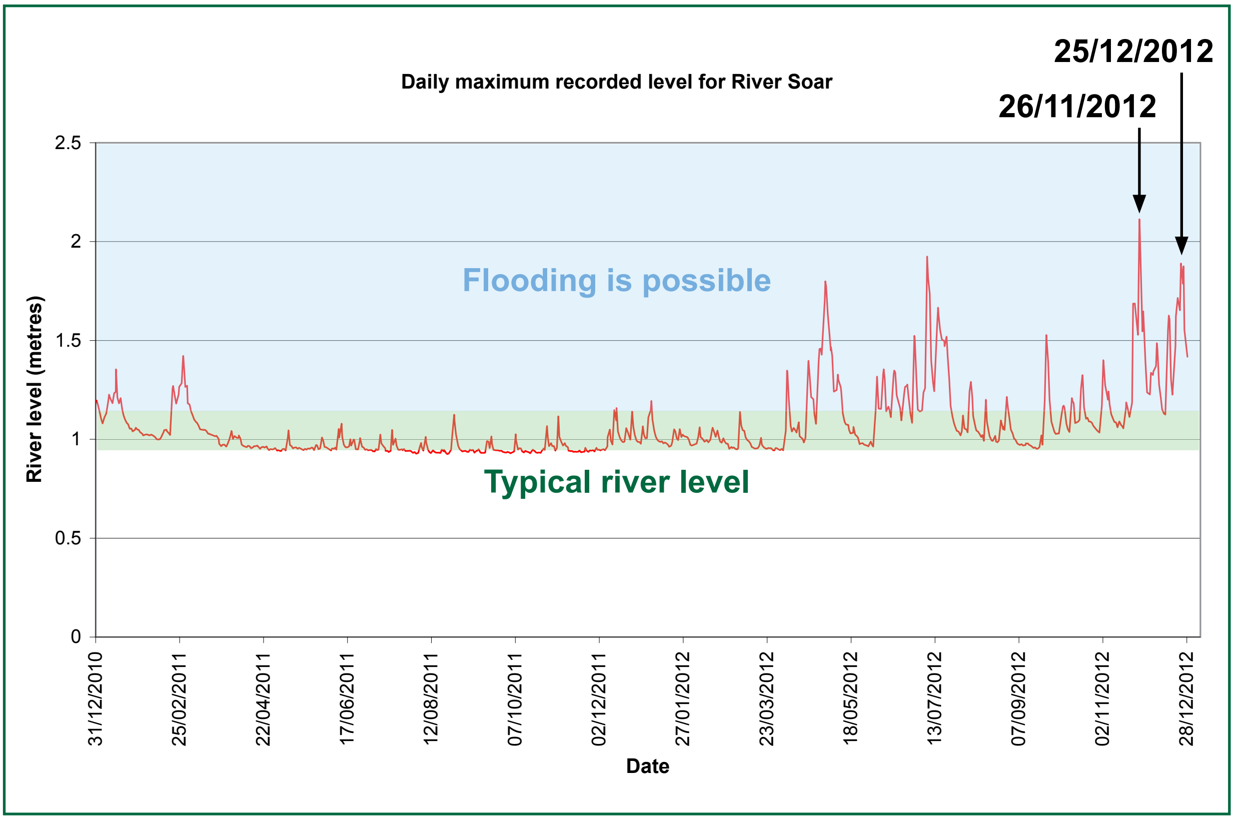


Figure 14: Graph showing level of River Soar recorded at Pilling's Lock for 2011 and 2012

49 Network Rail maintenance staff were at this location on 8 December (paragraph 62). There was no flooding at the foot of the embankment but they described the ground as saturated. An assistant track maintenance engineer carried out a track inspection on 21 December and saw water pooled at the foot of the up slow line embankment.

50 There were peaks in the river level of 1.72 metres at 20:00 hrs on 21 December, 1.89 metres at 23:00 hrs on 23 December and 1.87 metres at 17:00 hrs on 25 December (figure 14). By the time of the accident, the water level had dropped by 0.5 metres to 1.32 metres (this level was still high enough for the Environment Agency to consider that flooding was possible (paragraph 19)).

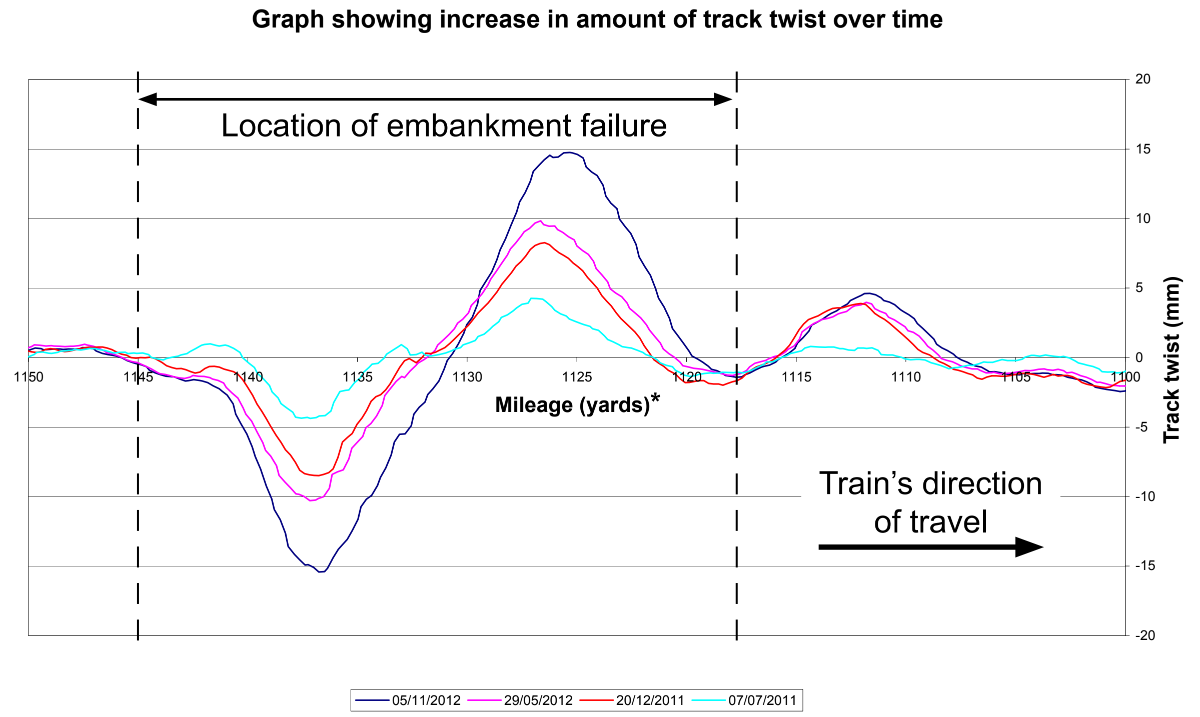
51 The water pooled at the foot of the embankment would have restricted the flow of water draining out of the embankment. The water that remained in the lower part of the embankment, because it could not drain away, saturated the clay and ash material, reducing the strength of the clay and ash material at the foot of the embankment. The reduction in the strength of the clay and ash at the foot increased the likelihood of the embankment failing, which it did when train 6L73 passed over it.

52 Site investigations after the accident found a bulge which narrowed the drainage ditch running along the foot (figures 10 and 13). This restriction in the drainage probably happened as a result of the slip. If it had been present before the accident, it would not have caused the levels of flooding seen at the foot of the embankment beforehand; all of the drainage was overwhelmed by surface water from the adjoining land and flood water backing up from the nearby River Soar.

Time taken for water to affect the embankment's stability

53 The first sign of a problem with the embankment's stability showed itself as a dip in the cess rail on the up slow line, causing a *track twist*. Track twist is the variation in cant over a given distance, where cant is a measure of the height that one rail of a track is above the other. The amount of track twist is usually expressed as the rate of change of cant, or gradient, over this given distance and expressed as a value of 1 in x. Network Rail company standards and the processes for track inspection and maintenance call for track twist to be measured over a base distance of 3 metres, and all limits for track twist are based on this. For example, a track twist limit of 1 in 200 would represent a difference of 15 mm between two cant readings taken 3 metres apart. Ideally, the cant is measured when the track is under load from a train, so the *dynamic track twist* can be determined.

54 The RAIB analysed the track geometry data recorded by a track geometry recording train, to identify how the dynamic track twist had grown over the previous two years. The data shows that the twist fault developed over an 18 month period, with very little track twist in July 2011 increasing to over 15 mm of track twist in November 2012 (figure 15). The period when the track twist grew the most coincided with the high levels of rainfall and flooding during the second half of 2012.



* Note: Location of embankment failure as shown relates to mileage as recorded by the track geometry recording train on 05/11/2012

Figure 15: Track twist at the point where the embankment failed

55 It is not possible to be certain about how much the water draining into the embankment from above, or the water pooling at its foot, each contributed to the eventual embankment failure. However, the reduced stability of the embankment was a result of a combination of both factors, with water being a common feature.

Identification of the embankment's reduced stability

56 A causal factor was that none of Network Rail's processes identified that the embankment's stability was reduced and that it was at risk of failing under a passing train. It is possible the embankment's reduced stability could have been identified by:

- **a report to the Network Rail geotechnical team responsible for the East Midlands Route to trigger it to carry out an earthwork evaluation, but none was received (paragraph 57);**
- **a routine earthwork examination, but none was due (paragraph 72);**
- **an additional inspection of the embankment during flooding, but the extreme weather plan for the East Midlands Route did not require Network Rail's maintenance organisation to do this (paragraph 77); or**
- **a *basic visual track inspection* on 24 December, but the up slow line over the embankment was not inspected as planned (paragraph 86).**

Each of these is now considered in turn.

No earthwork evaluation

57 Network Rail company standard NR/L2/CIV/086, 'Management of Earthworks', includes a process for carrying out an earthwork evaluation. Network Rail defines an evaluation as '*an appraisal of all relevant information regarding the stability, condition and use of an Earthwork, to determine the actions required to maintain acceptable levels of safety and performance*'. Network Rail will carry out an earthwork evaluation as and when required, usually after receiving information that raises concern about the stability of an earthwork.

58 NR/L2/CIV/086 defines the circumstances under which an evaluation must be considered. One such circumstance is when '*there are exceptional changes in the alignment of a track, which are not attributable to the quality of the track or the maintenance or renewal of the track support system*'. However, there is no clear definition of what is meant by an exceptional change in track alignment. In the months before the accident, the local Network Rail maintenance team were finding changes in the vertical track geometry on the up slow line where the embankment later failed, but these were small changes and unlikely to be classified as exceptional.

59 On 2 October, during a basic visual track inspection, a *patroller* found a dip in the cess rail. The patroller marked the location of the dip by writing on the foot of the cess rail (figure 16). The dip was not large enough to warrant any immediate action, but the patroller made a note of it and reported it to his supervisor after completing the inspection. The supervisor arranged for an entry to be created on Ellipse (Network Rail's system for managing the maintenance of its infrastructure) and gave it a priority of M4, meaning the dip needed to be repaired within four months.

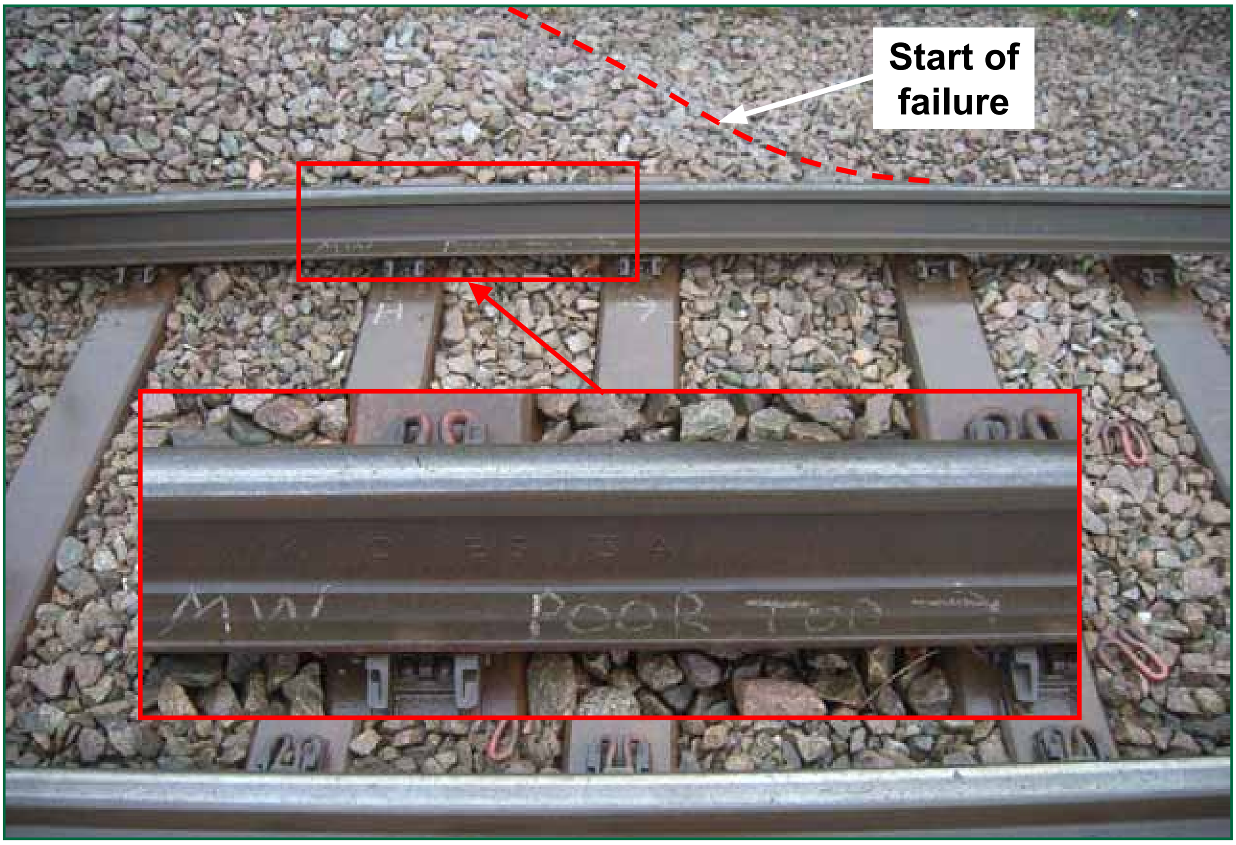


Figure 16: Marking on rail on up slow line

60 On 5 November, one of Network Rail's track geometry recording trains ran over the up slow line. When it measured the track geometry where the embankment failed, it recorded a 3 metre track twist of 15.4 mm (1 in 195). This was just greater than the fault threshold of 15 mm, at which trains can continue to run over the track, but the maintenance organisation is required to repair it within 14 days. The track twist was included on the last page of a six page report that was generated following the train's run from Toton to Wigston, just south of Leicester. The report was emailed to Network Rail maintenance staff, including the planner at Leicester depot. The planner looked at the first five pages and noted they were only applicable to Trent depot. However, the planner missed the sixth page, so the faults that Leicester depot needed to repair within 14 days were not entered into Ellipse and not repaired. Network Rail only noticed this omission, which only applied to 14 day faults[4], after the accident.

61 At 17:12 hrs on 5 December, a passenger train driver reported to the signaller that they had felt a jolt as they passed over the up slow line. The driver reported the location as in the vicinity of 109 miles 40 chains, just after an underbridge with an X on it. This description matches bridge 64 over the River Soar. However, the driver reported it 'was just after bridge 66' which is about 20 chains (0.4 km) to the north. The driver of the next train over the down slow line was asked to examine the adjacent line but did not see anything amiss between Barrow upon Soar and Loughborough. Network Rail maintenance staff also responded and went to the area. They inspected the track on the up slow line between bridges 63 and 66, albeit in darkness, and did not find any defects.

[4] Track geometry faults that require immediate action or repair within 36 hours cannot be missed in this way, as staff working on the train log these faults directly with Network Rail's fault control, who in turn mobilise the local maintenance team.

62 At 06:15 hrs on 8 December, a passenger train driver reported a possible rail break as their "train shook violently" while travelling on the up slow line. The driver reported the location as being between 109 miles 60 chains and 109 miles 0 chains. The driver of the next train over the up slow line was asked to examine the line and reported feeling a jolt about 20 to 50 yards after a bridge. Network Rail maintenance staff arrived on site at about 08:30 hrs and found a noticeable dip in the cess rail about 50 yards south of bridge 64. This was the same location where the patroller had previously found the dip (paragraph 59), as the maintenance staff noticed his writing on the foot of the cess rail. After further staff and equipment were brought to the site, the track was lifted over a length of 25 sleepers and the *ballast* was packed using *reciprocating hammers* to repair the dip. The repairs were completed and trains began running again at 12:00 hrs.

63 On 10 December, the track section manager for the Leicester area asked one of his supervisors to go to the site where the rough ride had occurred. He wanted the supervisor to inspect the repair work and check for any signs of an underlying problem with the embankment. The supervisor went to site and noted that the repair had successfully removed the dip. The supervisor also looked at the embankment but saw no signs of a problem – there were no obvious visible signs of trees leaning, surface cracks or deformation (such as bulges in the slope), although most of the embankment was hidden by vegetation.

64 On 11 December, the track maintenance engineer for this area rode over the up slow line in the rear cab of a train to specifically feel any movement by the train as it passed over the repair site. The track maintenance engineer felt nothing and was content that the track repair was effective.

65 However, the dip in the cess rail formed again. On 21 December, the assistant track maintenance engineer noted a dip in the cess rail at this location when he was carrying out a supervisor's inspection of the up slow line. He measured the dip and found a track twist of less than 10 mm which meant no immediate action was necessary. The assistant track maintenance engineer was aware of the recent repair and thought the dip was due to settlement after this work. He noted the dip and extended the mileage for some existing repair work, which was planned to happen within the next three months, to include this location.

66 In the twelve months before the accident, the embankment supporting the up slow line was becoming unstable, albeit very slowly. This slow change in its stability was showing itself as a dip in the cess rail of the up slow line (paragraphs 53 to 54). These changes were being recorded by runs every six months over the line by Network Rail's track geometry recording trains. Although track geometry faults at this location were unusual, the fault that developed was relatively minor so no one from Network Rail maintenance thought there might be an underlying problem with the embankment's stability, and there were no obvious signs that the earthwork was starting to fail. Consequently, there was no report from the maintenance organisation to the Route's geotechnical team to trigger them to carry out an earthwork evaluation.

67 An earthwork evaluation can also be triggered in response to water-related problems. NR/L2/CIV/086 states that an evaluation shall be considered '*where flooding, high fluvial flow etc. has damaged the Earthwork, or associated or adjacent infrastructure; for example, by overtopping or Scour*' and also when there is '*a change in the drainage system in and around the Earthwork - such as the re-alignment of a Watercourse, an increase in surface run-off due to construction works, and reports of blocked drains and the ponding of water*'.

68 The Route geotechnical team has a database for managing earthwork assets, which includes the location of each earthwork on the Route and the location of flood plains. The embankment that failed was identified as being at risk from flooding but not from scour. This was because although there was a ditch at its foot, the embankment was not next to fast flowing water that could wash material away and damage it. Therefore it was very unlikely that an evaluation would be triggered by damage to the embankment.

69 The embankment was, however, at risk of blocked drainage and ponding of water at its foot. As described in paragraph 48, the drainage ditch running along the foot of the embankment was prone to back flooding when the River Soar was in flood and water was seen pooled at its foot on 21 December.

70 The embankment is located on a flood plain that is estimated by the Environment Agency to flood at least once every five years. River levels recorded at the nearby Pilling's Lock and witness evidence indicated it would not have been unusual for Network Rail maintenance staff to see localised flooding at this particular location. Consequently, no one from Network Rail maintenance reported the ponding water at the foot of this embankment to the Route geotechnical team, so there was no trigger for an evaluation to be considered.

71 It is not possible to determine if an evaluation by the Route geotechnical team would have identified that the embankment was becoming unstable. In the three months before the embankment failed, the only visible sign of instability was a dip in the cess rail. Any other signs of instability that may have been present were likely to have been hidden by vegetation. Since the vegetation may not have been removed before the evaluation, and the process did not require consideration of the track geometry data, it is possible that an evaluation might not have led to any immediate action being taken by the Route geotechnical team which would have prevented this accident.

No routine earthwork examination due

72 The Route geotechnical team that manages all of the earthworks on the East Midlands Route also manages all of the earthworks on the London North East Route. On each Route, the railway is divided into sections that are five chains (100.6 metres) long, and any section with an earthwork in it will count as one asset. The team is responsible for managing the examination of each of these assets in accordance with Network Rail company standard NR/L3/CIV/065, 'Examination of Earthworks'. Network Rail staff do not carry out the routine examination work but instead Network Rail has a contract with Amey to supply the examiners.

73 The five chain length that included the embankment that failed was last examined in November 2011. At this examination, the Amey examiner classified the asset's condition as marginal, and gave it a risk category of average. In his report, the examiner noted some soil creep movements and local slumping in the upper and mid-slope in places which he attributed to burrowing by rabbits. The examiner did not find any problems that were significant enough to trigger a change in the earthwork's classification from marginal to poor, which would have triggered an evaluation by the geotechnical team.

74 The track geometry data recorded about one month later showed the track twist above the embankment had increased to 8 mm by this time (figure 15). Although this indicates that the embankment's stability was starting to reduce, it is unlikely that this small amount of movement in the embankment would have caused any signs of a problem that would have been visible to the examiner. It was reasonable that the examiner did not find the problem at this time.

75 NR/L3/CIV/065 requires an earthwork with a poor classification to be examined every year but those with a marginal classification are only examined every five years. Therefore the next examination for this earthwork was not due until 2016.

76 It is not possible to determine if an earthwork examiner would have identified that the embankment was becoming unstable in the three months before it failed. Apart from the dip in the cess rail, any other signs of instability that might have been present were likely to have been hidden by vegetation. Therefore it is possible that an examination might not have led to any immediate action being taken which would have prevented this accident.

Extreme weather plan for flooding

77 Network Rail has extreme weather plans which list the structures, including bridges, viaducts, retaining walls, culverts and earthworks that need to be inspected during periods of extreme weather. The list of structures at risk due to flooding in each plan is based on information held in a flood warning database.

78 The flood warning database is a controlled database that is available to all Network Rail staff and its contractors. When a flood warning is received from the Environment Agency, the database is used to provide an indication of which structures will be affected by the flood event. It creates a list of the structures which are at risk, including all associated structures that are likely to be affected by the flooding. It can be used to create a report, which identifies those structures that Network Rail staff will need to respond to straight away.

79 The extreme weather plan for the London North East and East Midlands Routes included a list of 45 earthworks that must be inspected by the maintenance organisation in accordance with Network Rail company standard NR/L3/TRK/1010, 'Management of response to extreme weather conditions at structures, earthworks and other key locations'. An inspection at one of these earthworks is triggered when an Environment Agency flood warning is received for the area in which it is located. All 45 earthworks were listed because Network Rail had identified that they were at risk of scour from the flood water and their condition was classified as poor. Although the earthwork that failed on the up slow line was at risk of ponding at its foot, it was not at risk of scour and its condition was not poor. Consequently, it was not on the list so there was no requirement to inspect it in response to an Environment Agency flood warning.

80 The extreme weather plan also included a list of 2,931 earthworks that were identified as being at risk from flooding. This list was created using the Route geotechnical team's earthwork database (paragraph 68). Although the earthwork that failed on the up slow line was included in this list, the plan did not require any action to be taken at any of these earthworks when a flood warning was received.

81 The plan does state that studies are underway to look at what action should be taken at these earthworks in response to a flood warning. The actions that are being considered include:

- instrumentation to be installed at earthworks (which could be remotely monitored, or monitored on site during flood events);
- proactive physical works to be undertaken to mitigate the risk of scour; and
- flood markers to be installed and monitored in a similar way to bridges so trains can be stopped when the water reaches a defined level.

82 This work to improve the management of flood risk to earthworks was ongoing within Network Rail at the time of the accident. In response to earthwork failures due to very heavy rainfall, Network Rail had developed a system, known as WERM (Washout and Earthflow Risk Mapping), to identify the water catchment area and water concentration features in the vicinity of the railway. Its output was then used on Network Rail's Scotland Route.

83 Network Rail used the output from WERM, along with a new rainfall alert system, to assess how likely it was that structures would be flooded by extreme rainfall. Other factors such as earthwork condition, number of tracks, permitted line speed, proximity to structures, etc, were used to assess the consequence of a failure. From this, Network Rail determined the risk of a structure failing due to flooding. Once the risk from an extreme rainfall event was understood, Network Rail decided what actions must be taken to mitigate it. Actions that Network Rail might elect to take include:

- an inspection by Network Rail operations or maintenance staff on foot;
- running trains at a reduced speed; or
- using a train to examine the line.

84 Network Rail's new process for managing flood risk from extreme rainfall events has been in place on Scotland Route since 2012. It was not being used on the East Midlands Route at the time of this accident although Network Rail is currently rolling out this process to include the structures and earthworks on its other Routes.

85 There were no extreme rainfall events in the six days before this accident but there was persistent rain over many days. This led to flood warnings for the River Soar being issued by the Environment Agency, and flooding was seen at the foot of the embankment in the days before the accident (paragraph 49). Network Rail knew the earthwork supporting the up slow line was at risk from flooding, as it was listed as such in the extreme weather plan, but because it was not listed in the flood warning database, there was no requirement for anyone to take any action. However, it is not possible to determine if a response to a flood warning would have identified that the embankment was becoming unstable before it failed, so there is no certainty that immediate action would have been taken which could have prevented this accident.

Last track inspection

86 After the supervisor's inspection on 21 December (paragraph 65), the next inspection that was due over the up slow line was a basic visual track inspection on 24 December. This was the last track inspection planned over the top of the embankment before the accident. It was reported as completed, but did not actually take place.

87 Network Rail's company standard NR/L2/TRK/001/mod02, 'Track Inspection', required a basic visual track inspection to take place every fortnight on the slow lines where the embankment failure happened. To do this inspection, maintenance staff were required to walk along either the up slow or down slow line while looking for defects on both slow lines. Basic visual track inspections are carried out to identify defects which, if uncorrected, could affect the safety or reliable operation of the railway before the next inspection. In practice this means that any defect requiring action within four weeks must be reported. The staff who do these inspections are known as 'patrollers' and must be assessed by Network Rail as competent.

88 During inspections, patrollers based at Leicester maintenance depot may come across other railway infrastructure defects, including problems with structures or earthworks. Unless the defect makes it unsafe for trains to run, in which case a patroller must apply a speed restriction or block the line, the patrollers are not required by Network Rail's standards to report any of these other defects. However, at their discretion, they can note information about a defect on their paperwork. This information is then passed to the section manager at Leicester depot for review, who will use his experience when deciding whether to pass this information to the responsible engineer (although there is no requirement in Network Rail's standards for him to do this).

89 On 24 December, three Network Rail maintenance staff based at Leicester maintenance depot were allocated to carry out a basic visual track inspection of the slow lines. One person was to be the patroller, another to be a *lookout* and a third to drive their vehicle and be a lookout as required. The inspection plan that day required the patroller to start at Barrow upon Soar station and walk along the up slow line to Normanton on Soar (just to the north of Loughborough). After returning to Leicester depot later that day, the patroller signed off two records for this inspection to show that it had been completed and no defects had been found that required action to be taken within four weeks.

90 During this investigation, the RAIB established from the evidence it gathered (which included witness statements, voice recordings of conversations between the patroller and a signaller, CCTV footage and mobile phone records) that most, if not all, of this inspection was not undertaken and the patroller did not walk along the up slow line where the embankment failed. Evidence also shows that the Network Rail maintenance staff took steps to make it appear that the inspection had taken place.

91 The RAIB has been unable to establish the reasons why this inspection was not carried out. Although the weather was poor (wet with a temperature of about 6°C) this should not have prevented the inspection from taking place. There were sufficient staff available to do the inspection that day and the patroller was granted access to the up slow line by the signaller when it was requested. There was enough time for the inspection to be done that morning despite these staff being told that they needed to go to Wigston that afternoon to repair a track defect.

92 CCTV footage from trains that ran over the up slow line on 24 December shows the trains sway as they pass over a dip on the up slow line, just at the point where the embankment later failed. However, none of the drivers reported a problem with the track to the signaller, probably because it was not sufficiently severe to cause concern. On 24 December, it is likely that the dip in the cess rail would have been visible to the patroller had the inspection been undertaken. However, it is not possible to determine if the dip would have been severe enough to have caused the patroller to take immediate action.

93 The RAIB has no evidence through other investigations it has undertaken that there is a current widespread problem with inspections not being done on the national network. The actions taken by Network Rail in response to the missed inspection on 24 December are described in paragraphs 119 and 120.

Identification of underlying factors[5]

Assessing the risk of earthwork failure associated with water

94 **The risk of earthwork failures associated with water was assessed against factors such as signs of scour and a history of problems, while other factors related to water flowing through the earthwork were not considered.**

95 The Route geotechnical team assesses the risk of an earthwork failing due to flooding by considering its condition along with other factors such as the history of scour, signs of scour seen during examinations, and previous problems or repair work at that location.

96 The earthwork that failed near Barrow upon Soar had no history of scour and no signs of scour were reported during previous examinations. Network Rail had no record of it ever failing and being repaired, although there is a *berm* from a previous embankment repair located about 120 metres south of the failure. Trees growing out of this berm indicated it had been there for a long time and this was confirmed by a map dating back to 1921 (figure 17). Based on its knowledge of the earthwork, the Route geotechnical team had no concerns about it failing from the effects of water.

97 To manage the effects of water on its infrastructure, Network Rail's company standards focus on flooding and extreme levels of rainfall. Network Rail receives flood warnings from the Environment Agency and warnings of extreme rainfall events from its weather forecaster. However, as discussed earlier (paragraphs 77 to 85), Network Rail had no plans to take any action at the earthwork at Barrow upon Soar for either flooding or extreme rainfall events. None of these standards considers the possibility of an earthwork failing due to the cumulative effect of rainfall directly onto it over a longer period.

98 In the two months before the earthwork failed, the River Soar was flooded on several occasions, during periods of persistent wet weather (paragraphs 48 to 50). The persistent rainfall onto the top of the earthwork, and the way its construction allowed rainwater to flow through it, increased the probability that the earthwork would fail (paragraphs 42 to 46).

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

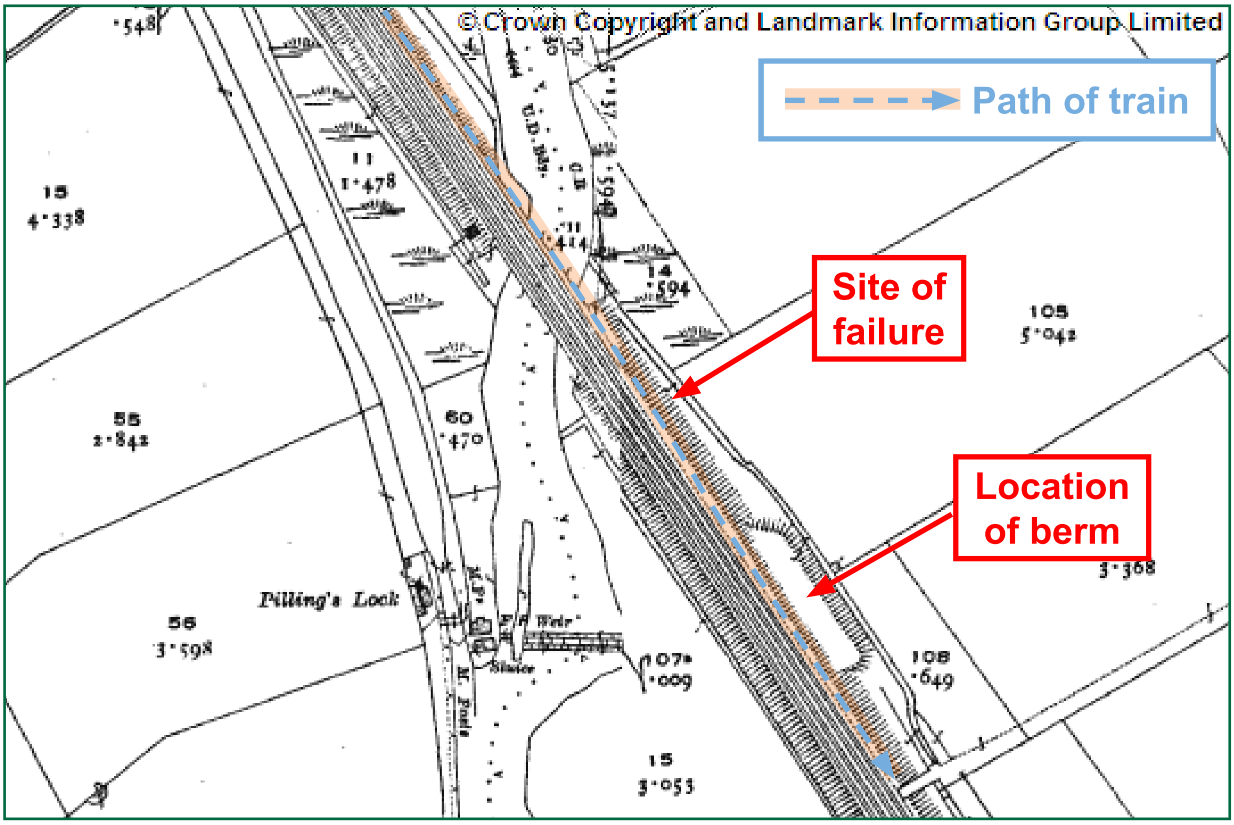


Figure 17: Map from 1921

99 In accordance with NR/L2/CIV/086, the Route geotechnical team maintains a register of earthworks that are adjacent to flowing water or at risk of a loss of functionality from flooding or water action. For each earthwork on the register, the Route geotechnical team carry out an initial assessment of its susceptibility to flooding or water action, which may be reviewed upon receipt of reports of flooding or water related issues (eg changes to water courses or drainage). This process is described in NR/L2/CIV/086 and includes a list of factors that need to be considered. However, this list does not include consideration of how the construction of the earthwork might make it susceptible to failing due to water flowing within it. Therefore the Route geotechnical team did not need to consider the way in which the embankment was constructed.

Network Rail company standards

100 **Network Rail company standard, NR/L2/CIV/086 'The Management of Earthworks', does not clearly define the circumstances when the Route geotechnical team must consider the need to carry out an evaluation, and does not define who is responsible for submitting reports to the Route geotechnical team when these circumstances arise and how they should be reported.**

101 Network Rail company standard NR/L2/CIV/086 explains the circumstances when the Route geotechnical team must consider the need to undertake an earthwork evaluation. There is considerable reliance on other parts of Network Rail's organisation telling the Route geotechnical team about circumstances that could affect the safety of an earthwork.

102 The examination regime for this earthwork (paragraphs 72 to 76) meant the Route geotechnical team only received information about its condition once every five years. In between examinations, the Route geotechnical team relied on Network Rail maintenance staff from the Leicester maintenance depot to report possible problems with this earthwork, as they saw it every two weeks while walking over it to carry out a visual inspection of the track.

103 As explained in paragraph 58, one of the circumstances defined in NR/L2/CIV/086 for an evaluation to be considered is when there are exceptional changes in the alignment of a track which are not attributed to the track quality or the track support system. NR/L2/CIV/086 does not define what is considered to be an exceptional change, ie whether it is a change in track alignment that is greater than would be expected for normal deterioration rates or whether it is a change in track alignment that is unusual for that location. For the track at Barrow upon Soar, the change in its alignment required maintenance intervention but was not unusually large. However, it was very unusual for a track defect to be found at the accident location.

104 Even if Network Rail maintenance staff had decided that the change in the track's alignment was exceptional, NR/L2/CIV/086 does not define who is responsible for reporting this to the Route geotechnical team, or define what the mechanism for making a report would be. Similarly, as explained in paragraph 67, another circumstance relates to reports of blocked drains and the ponding of water. Again NR/L2/CIV/086 does not define who is responsible for submitting these reports to the Route geotechnical team and how they would do it.

105 Section 2 of NR/L2/CIV/086, which defines its scope, states that '*this standard does not define the organisational or commercial responsibilities for delivering the requirement of this standard*'. The briefing note for NR/L2/CIV/086 shows that it is briefed out to staff in Network Rail's Asset Management and Investment Projects functions. Therefore the Network Rail maintenance staff, who are the most likely to report the two circumstances explained above, would not be aware of NR/L2/CIV/086 and its requirements.

106 The RAIB did not find any corresponding requirements in Network Rail's company standards and instructions for track maintenance, such as NR/L2/TRK/001 'Inspection and Maintenance of Permanent Way'. There is a general statement in NR/L2/TRK/001 that problems with earthworks and structures are reported to the responsible engineer. Witness evidence indicates that when Network Rail maintenance staff based at the Leicester depot find an obvious problem with an earthwork, it is escalated via their section manager to the track maintenance engineer who will report it to the Route geotechnical team. Witness evidence also indicates that Network Rail maintenance staff on the East Midlands Route are not reporting exceptional changes in the alignment of a track (which are not attributed to the track quality or the track support system) to the Route geotechnical team as required by NR/L2/CIV/086.

Observations[6]

107 The earthwork evaluation process as described in NR/L2/CIV/086 does not take into account how the geometry of the track on top of the embankment has changed over time.

108 NR/L2/CIV/086 lists the factors that should be taken into account when carrying out an earthwork evaluation. Although an evaluation can be triggered by a change in the track's geometry (paragraph 58), the evaluation process does not include looking at how the track geometry, particularly cant and track twist, has changed over time. For the embankment at Barrow upon Soar, the RAIB identified that the track geometry changed over a period of 18 months as the amount of instability increased (paragraph 54).

109 The earthwork evaluation process as described in NR/L2/CIV/086 does not take into account the amount of rain that has fallen onto the top of an embankment.

110 The RAIB identified that persistent rainfall onto the top of the embankment was one of the factors that caused the embankment at Barrow upon Soar to fail (paragraphs 42 to 46). NR/L2/CIV/086 lists the factors to be considered when assessing the susceptibility of an earthwork to flooding and water action. However, while factors related to flood water levels and drainage are included, the amount of rainfall, and therefore the amount of water draining into the embankment from the track, is not.

Previous occurrences of a similar character

111 Earthwork failures on Network Rail infrastructure are not uncommon and their failure often involves water from either flooding or very heavy rainfall. A number of earthwork failures have been the subject of RAIB investigations. However, the failures investigated by the RAIB have generally been instances where an earthwork had failed and deposited debris onto the track, which was then struck by a train causing it to derail. None were instances where an embankment slipped and caused the track support to fail under a passing train.

112 The RAIB investigated an embankment failure at Cricklewood curve on 31 January 2006 (reference RAIB report 02/2007) that caused the track support to fail and derail a train. However, in that case the embankment's stability had been reduced by engineering work that was taking place. That failure was not due to water ingress.

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

Summary of conclusions

Immediate cause

113 The immediate cause of the accident was that the support under the cess side rail of the up slow line failed as train 6L73 was passing over it (**paragraph 30**).

Causal factors

114 The causal factors were:

a. The weight of the train initiated an embankment slip as the train passed over the top of the embankment. Ordinarily the embankment would have been capable of supporting this weight (**paragraph 37, no recommendation**).

b. Water draining from the track into the embankment affected its stability at its upper levels (**paragraph 42, Recommendation 1**).

c. Water pooling at the foot of the embankment affected its stability at its lower levels (**paragraph 47, Recommendation 1**).

d. None of Network Rail's processes identified that the embankment's stability was reduced and that it was at risk of failing under a passing train. It is possible the embankment's reduced stability could have been identified by:

   i. a report to the Network Rail geotechnical team responsible for the East Midlands Route to trigger it to carry out an earthwork evaluation, but none was received (**paragraph 57, Recommendation 1**);

   ii. a routine earthwork examination, but none was due (**paragraph 72, Recommendation 1**);

   iii. an additional inspection of the embankment during flooding, but the extreme weather plan for the East Midlands Route did not require Network Rail's maintenance organisation to do this (**paragraph 77, Recommendation 1**); and

   iv. a basic visual track inspection on 24 December, but the up slow line over the embankment was not inspected as planned (**paragraph 86, no recommendation**).

Underlying factors

115 The underlying factors were:

a. The risk of the earthwork failures associated with water was assessed against factors such as signs of scour and a history of problems, while other factors related to water flowing through the earthwork were not considered (**paragraph 94, Recommendation 2**).

b. Network Rail company standard, NR/L2/CIV/086 'The Management of Earthworks', does not clearly define the circumstances when the Route geotechnical team must consider the need to carry out an evaluation, and does not define who is responsible for submitting reports to the Route geotechnical team when these circumstances arise and how they should be reported (**paragraph 100, Recommendation 1**).

Additional observations

116 Although not linked to the accident on 27 December 2012, the RAIB observes that:

a. The earthwork evaluation process as described in NR/L2/CIV/086 does not take into account how the geometry of the track on top of the embankment has changed over time (**paragraph 107, Recommendation 3**).

b. The earthwork evaluation process as described in NR/L2/CIV/086 does not take into account the amount of rain that has fallen onto the top of an embankment (**paragraph 109, Recommendation 3**).

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

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

117 Network Rail investigated the cause of the embankment failure to understand what had happened and to identify how it could be repaired. Network Rail repaired the embankment by removing the ash material where it had slipped and cutting steps into the clay (figure 12). The embankment was then rebuilt using stone. Network Rail also installed new drainage at the foot of the embankment.

118 The Route geotechnical team within Network Rail's East Midlands Route is continuing its work using WERM to identify those earthworks that are likely to be flooded and then assess the risk to each of these earthworks from flooding. The output from this work will be used to populate the flood warning database for the East Midlands Route. Once these earthworks are included in the database, Network Rail can take some form of action to check them upon receipt of a flood warning that affects the East Midlands Route.

119 The Network Rail management team responsible for track inspection and maintenance in the Leicester maintenance depot area carried out a series of checks during February 2013. These aimed to identify if there were other instances of staff signing off paperwork to show a basic visual inspection as complete when some or all of it had not been done. The checks included track walks, reviewing the paperwork completed for inspections, analysing voice recordings and reviewing CCTV footage from passing trains. No instances of inspections not being done were found. As a final check, senior managers carried out spot checks over a two week period and in each case found staff carrying out their track inspection activities where they should be.

120 Network Rail has since undertaken further verification work and self assurance checks. It is satisfied that the track inspection regime for the Leicester area is compliant and has not found any evidence of a widespread problem with missed inspections at Leicester maintenance depot.

Other reported actions

121 Network Rail issued a Safety Bulletin on 29 December 2012 about the actions to be taken by maintenance staff after flooding at an embankment. The bulletin called for maintenance staff to request that the Route geotechnical team carry out a special examination of an embankment if it has been flooded or recently flooded and one or more of the following circumstances has occurred:

- a rough ride has been reported;
- a loss of ballast from the track has been identified; or
- a track geometry fault has been found.

122 Once Network Rail became aware that some of the track faults found by the track geometry recording run on 5 November 2012 had been missed (paragraph 60), it checked that there were no other such instances. Staff in the route asset management team responsible for track on the East Midlands Route checked that all the track faults found by the last track geometry recording runs over every line on the East Midlands Route had been signed off as repaired. No other instances of track faults being missed were found. The section manager at Leicester maintenance depot has since introduced local checks to prevent a recurrence.

Recommendations

123 The following recommendations are made[7]:

1 *The intent of this recommendation is to reduce the risk of an embankment failure due to flooding by providing the Route geotechnical team with information that will trigger an earthwork evaluation.*

Network Rail should amend its company standards so that track maintenance staff are required to notify the Route geotechnical team if the foot of an embankment is saturated, flooded or has recently been flooded, and a track geometry defect or loss of ballast is found on top of the embankment (paragraphs 114b, 114c, 114d.i, 114d.ii, 114d.iii and 115b).

2 *The intent of this recommendation is to reduce the risk of an embankment failure by improving the process used by the Route geotechnical team to determine if an earthwork should be included in the flood warning database.*

Network Rail should amend its processes so that when assessing whether an embankment should be included in the flood warning database, the assessment should include additional factors which are relevant to its stability such as how the embankment was constructed (as far as can reasonably be determined) to understand the effect of water on any planes between different types of materials, and the history of flooding or ponding at the foot of the embankment (paragraph 115a).

continued

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

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable 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.raib.gov.uk.

3 *The intent of this recommendation is to reduce the risk of an embankment failure by improving the quality of the earthwork evaluation process used by the Route geotechnical team.*

Network Rail should amend its company standards so that when an earthwork evaluation is carried out on an embankment, the evaluation should consider how the geometry of the track on top of an embankment has changed over time, using data recorded by Network Rail's track geometry recording trains. If the evaluation has been triggered by a change in track quality, flooding or the ponding of water, and includes an assessment of the embankment's susceptibility to flooding or water action, the levels of recent rainfall onto the top of the embankment should be considered as part of the assessment (paragraphs 116a and 116b).

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed Circuit Television
OTDR	On-Train Data Recorder
RAIB	Rail Accident Investigation Branch
WERM	Washout and Earthflow Risk Mapping

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	The stone material on which the sleepers are laid.
Basic visual track inspection	A visual inspection of the track, carried out on foot, which aims to identify any immediate or short term actions that are required. Often referred to as a track patrol.
Berm	A mound or bank of earth, that is built up against the side an earthwork to increase its stability.
Bogie	An assembly of two wheelsets in a frame which is pivoted at the end of a long vehicle to enable the vehicle to go round curves.
Brake pipe	A pipe running the length of a train that controls, and sometimes supplies, the train's air brakes. A reduction in brake pipe air pressure applies the brakes.
Cess	The part of the track bed outside the ballast at the ends of the sleepers that should be maintained lower than the sleeper bottom.*
Chain	A unit of length equal to 66 feet or 22 yards (20.1168 m). There are 80 chains in one standard mile.
Continuous welded rail	A rail of length greater than 36.576 m (120'), or 54.864 m (180') in certain tunnels, produced by welding together standard rails or track constructed from such rails.*
Down slow	The name generally given to the nominally less important of the two down lines in a four track railway (on which trains travel in a direction away from London or towards the highest mileage). It may or may not be slower than the other down line, normally called the down fast.*
Dynamic track twist	The change of cant along a track measured over a specific distance, while the track is under load from a train. The static twist is the measure when the track is not loaded.
Earthwork	A collective term for cuttings, embankments and natural slopes.
East Midlands Route	A name for the railway from London St Pancras to Sheffield including Leicester, Derby and Nottingham stations plus a number of secondary routes that branch off the main line.
Fast (line)	On a route with four or more tracks, the more important pair will often be titled the up fast and down fast. These may not be any faster than the up slow and down slow lines.*
Formation	The prepared surface of the ground, on which any filter or structural materials, the ballast and the track is laid.*

Four aspect colour light signals	A railway signal which uses coloured lights to indicate whether the driver has to stop, needs to be prepared to stop or can proceed without restriction. The lights may show: ● Green - proceed, the next signal may be displaying green or yellow; ● Double Yellow - caution, there are two signal sections to the stop signal, the next signal may be displaying a single yellow; ● Yellow - caution, be prepared to stop at the next signal as it may be displaying a stop signal when you reach it; and ● Red – stop.
Hopper wagon	A wagon which discharges its load through doors in the bottom area of the wagon.
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 lookout operated warning system.*
Patroller	A competent person whose duties are to carry out a basic visual track inspection.
Reciprocating hammer	A hand-held machine for compacting ballast, consisting of a vibrating blade drive by a power source which may be petrol, electric or pneumatic.
Rotational failure	A catastrophic failure of a cutting slope or embankment resulting in a mass of material rotating about a virtual centre point. This type of failure is aggravated by poor drainage of the slope and overloading of the top of the slope. It is colloquially known as a bank slip or slip.*
Route	One of ten strategic parts of Network Rail's infrastructure, which functions as a separate unit with its own management for operating, maintaining and renewing the infrastructure within in. The ten Routes are Anglia, East Midlands, Kent, London North Eastern, London North Western, Scotland, Sussex, Wales, Wessex and Western.
Sleeper	A beam made of wood, pre- or post-tensioned 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 distance is maintained between the rails.*
Track circuit block	A signalling system where the line beyond each signal is automatically proved clear to the next signal, and sometimes beyond it, using track circuits. Track circuit block can also be implemented using any automatic train absence detector system.*

Track geometry recording train	A specially equipped train that automatically measures and stores track geometry information for the lines that it runs over.
Track twist	The change of cant along a track measured over a specific distance (normally 3 metres on Network Rail's infrastructure). It can be recorded as the difference in cant, in mm, between the two points (eg 15 mm). It can also be recorded as a gradient or rate of change of cant between the two points (eg a difference in cant of 15 mm between two points that are 3 metres apart would be recorded as 1 in 200).
Up slow	The name generally given to the nominally less important of the two up lines in a four track railway (on which trains travel in a direction towards London or the lower mileage). It may or may not be slower than the other up line, normally called the up fast.*
WheelChex	A track-mounted monitoring system designed to measure the vertical wheel loads of passing trains and identify those with the potential to cause excessive damage to the infrastructure.
Wheelset	Two rail wheels mounted on their joining axle.
Workstation	A development of the signal box panel, the signaller is provided with a display of the signal box diagram on a series of VDUs, and a trackball and keyboard to operate the signalling functions.*

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