Rail Accident Investigation Branch

Rail Accident Report

Train collision with material washed out from a cutting slope at Corby, Northamptonshire
13 June 2019

Report 04/2020
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This investigation was carried out in accordance with:

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

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Preface

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In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as '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 accident or incident 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 RAIB, expressed with the sole purpose of improving railway safety.

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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.

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Summary

At about 15:53 hrs on Thursday 13 June 2019, a northbound passenger train, travelling at 40 mph (64 km/h), collided with debris washed out by flood water from an adjacent cutting slope, around one mile (1.6 km) north of Corby station. After reporting the incident, the driver found the rear of the train had become trapped by further debris washed out from the cutting slope. All 191 passengers on the train were later transferred to a southbound train, which itself then became trapped by flood water to the north and south. Between 450 and 550 passengers (from both trains) were then taken off the southbound train by 23:14 hrs, and conveyed to nearby stations to continue their journey by rail. No one was reported as injured as a result of the collision or subsequent detrainments. However, conditions on the southbound train were very uncomfortable for passengers due to overcrowding. Temporary repairs were made to the cutting slope and track to allow the railway to reopen the following day with a speed restriction in place.

The investigation found that the cutting slope had failed because it was not designed to cope with a large volume of water that had accumulated at its crest. Flood water had accumulated at the crest because two adjacent flood storage ponds had overfilled with water from a nearby brook. A blockage beneath a bridge over the brook caused its level to rise so water flowed over a spillway and into the ponds, which had not been routinely pumped down for nearly four weeks. The bank of the pond closest to the railway was a low point and the excess water spilled into the field between the ponds and the crest of the cutting slope. Exceptionally heavy rainfall was not a factor in the incident.

The investigation also found three underlying causes. One was a lack of engagement and communication between various parties responsible for the flood management system at this location about the potential for it to cause flooding on the railway. A second was the absence of an effective flood management system to manage the risk to the railway line, which is a principal transport route. Thirdly, although Network Rail was aware that the cutting slope was at risk of a washout failure when the nearby ponds overfilled and had long-term plans to act, it had not taken any action to mitigate this risk in the short term. The investigation also considered why the rescue and evacuation of passengers was significantly delayed and found that a lack of equipment for transferring passengers from one train to another was a factor.

RAIB has made five recommendations. The first calls for the Environment Agency to work with Northamptonshire County Council, Anglian Water, Homes England, Corby Borough Council and Network Rail to implement an effective flood management system at this location. The second calls for Network Rail to identify similar locations prone to safety critical flooding and review how it manages flood risk at each of those places. The third relates to Network Rail providing its staff with training and guidance on how to better manage the short-term risks to earthworks while waiting for longer term planned work to take place. The fourth calls for Network Rail and the Rail Delivery Group, as part of an ongoing industry-wide programme of work to improve the management of stranded passenger train incidents, to jointly review their procedures for managing stranded trains to identify what emergency equipment is needed, and the fifth relates to Network Rail, as part of the same ongoing industry-wide programme of work, taking steps with train operating companies to make this equipment available for use.

RAIB also identified one learning point, which urges non-railway organisations responsible for managing flood risk to include the effect of flooding on railway lines, which are part of the United Kingdom's national infrastructure, in their planning.

Introduction

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 which are explained in appendix A. Sources of evidence used in the investigation are listed in appendix B.

3 Throughout this report, southbound towards London is referred to as the ‘up’ direction and northbound away from London is referred to as the ‘down’ direction.

The incident

Summary of the incident

4 At about 15:53 hrs on Thursday 13 June 2019, a northbound passenger train, travelling at 40 mph (64 km/h), collided with debris around one mile (1.6 km) north of Corby station (figure 1). The debris comprised sandy gravel and soil which had been washed onto the track from the adjacent cutting slope (figure 2) by flood water. The train did not derail. The driver brought the train to a stand and contacted the signaller to report the landslip and flooding.

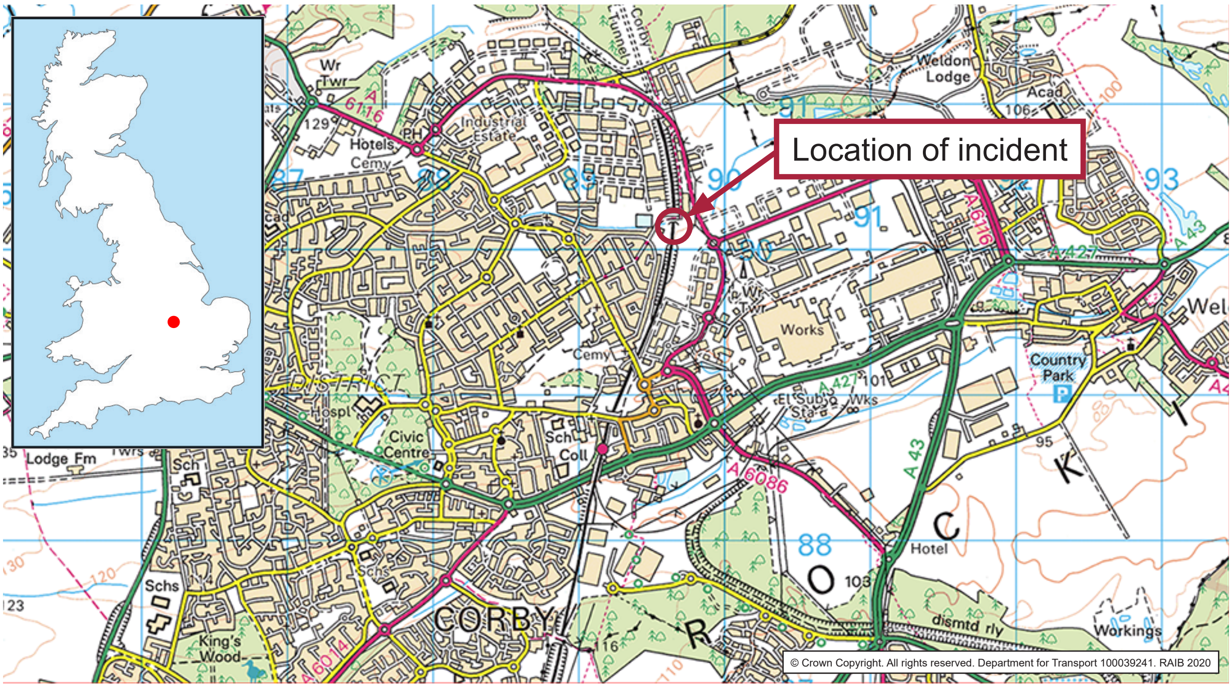

Figure 1: Extract from Ordnance Survey map showing location of the incident

5 After speaking to the signaller, the driver examined the train and found that its rear two vehicles had become trapped by further sandy gravel that flood water had washed out from the cutting slope in the time since the train had stopped (figure 3). All of the passengers were later transferred to a southbound train which subsequently itself became trapped by flood water to the north and south. Once lighting and road transport were in place, all the passengers were taken off the southbound train by 23:14 hrs. One group of passengers was taken by road to Corby station and the remainder were taken to Kettering station, to continue their journey by rail.

6 No one was reported as injured during the collision or subsequent detrainments. However, conditions on the southbound train were very uncomfortable for passengers due to overcrowding. There was some minor damage to the northbound train due to it running through flood water. The cutting slope was damaged by flood water and the track was contaminated by the washed-out sandy gravel and soil.

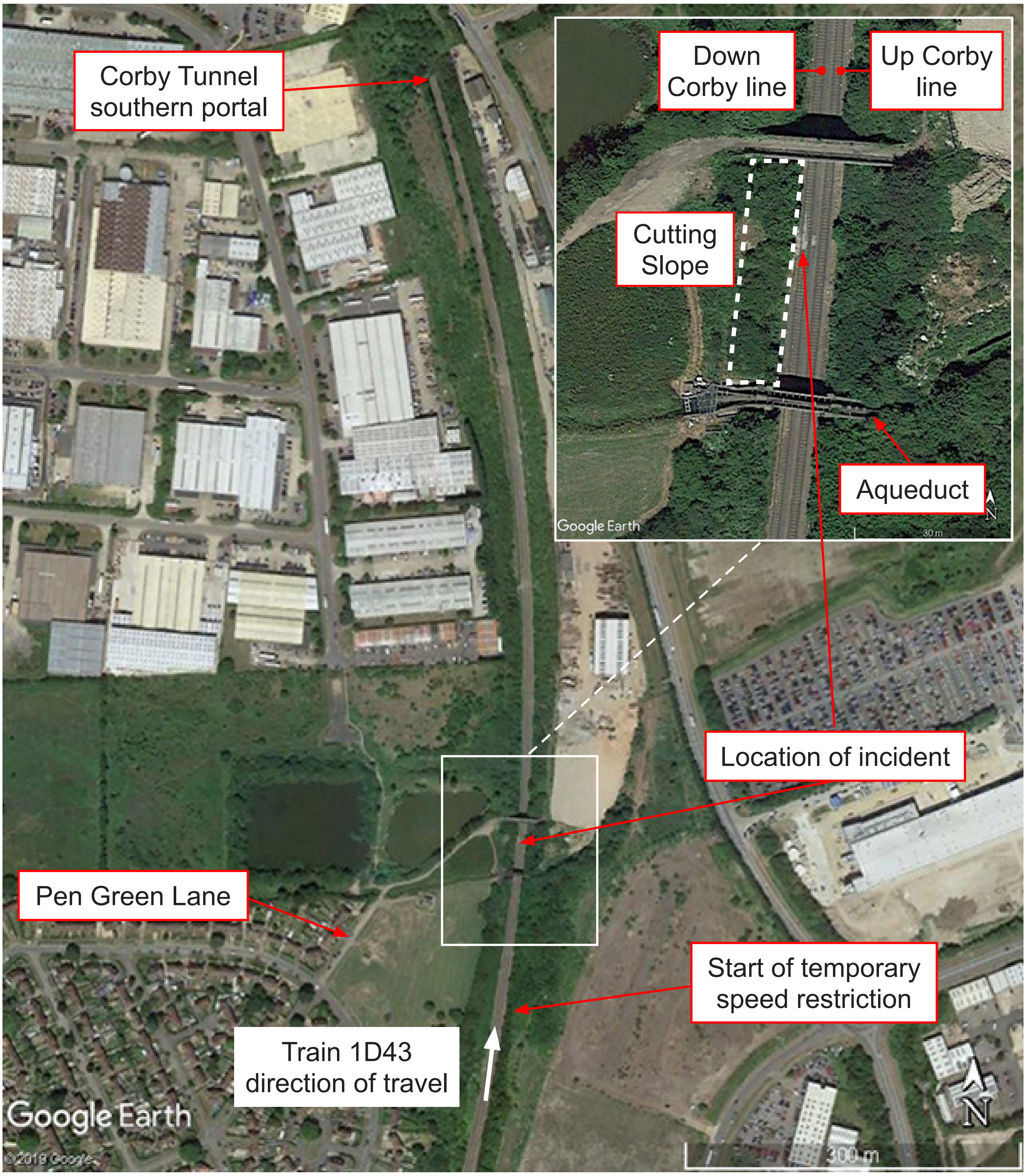

Figure 2: Google Earth image showing overview of incident site

Figure 3: The rear of the train after further sandy gravel washed-out around it (main image courtesy of Network Rail, other images courtesy of the driver of train 1C52).

Context

Location

7 The collision happened on the down Corby line (figure 2) at 80 miles 39 chains[1] (from a zero reference at London St Pancras), between Corby and Manton Junction, which is part of Network Rail's East Midlands Route[2] within its Eastern Region.[3] Here the railway passes through a cutting, on a left-hand curve (in the northbound direction of travel) with a radius of about 2000 metres (figure 2).

[1] A unit of length equal to 66 feet or 22 yards (around 20 metres).

[2] Part of Network Rail's organisation which manages, operates and maintains the railway from London St Pancras to Chesterfield and a number of routes that branch off main lines to Northamptonshire, Rutland, Leicestershire, Derbyshire, Nottinghamshire and Lincolnshire (but does not include the East Coast main line).

[3] Part of Network Rail's organisation which supports four of its routes: Anglia, East Coast, East Midlands and North & East.

8 At this location, known as the Pen Green Lane area, the two-track railway comprises the up Corby and down Corby lines. The permitted speed for trains on both lines is 60 mph (97 km/h). However, northbound trains were travelling slower than this as a temporary speed restriction of 40 mph (64 km/h) was in place on the down Corby line, starting 9 chains (181 metres) to the south. This speed restriction was due to the condition of the track in Corby Tunnel. Just south of the incident location, at 80 miles 38 chains, an aqueduct carries a watercourse called Willow Brook North, over the railway (figures 2 and 4).

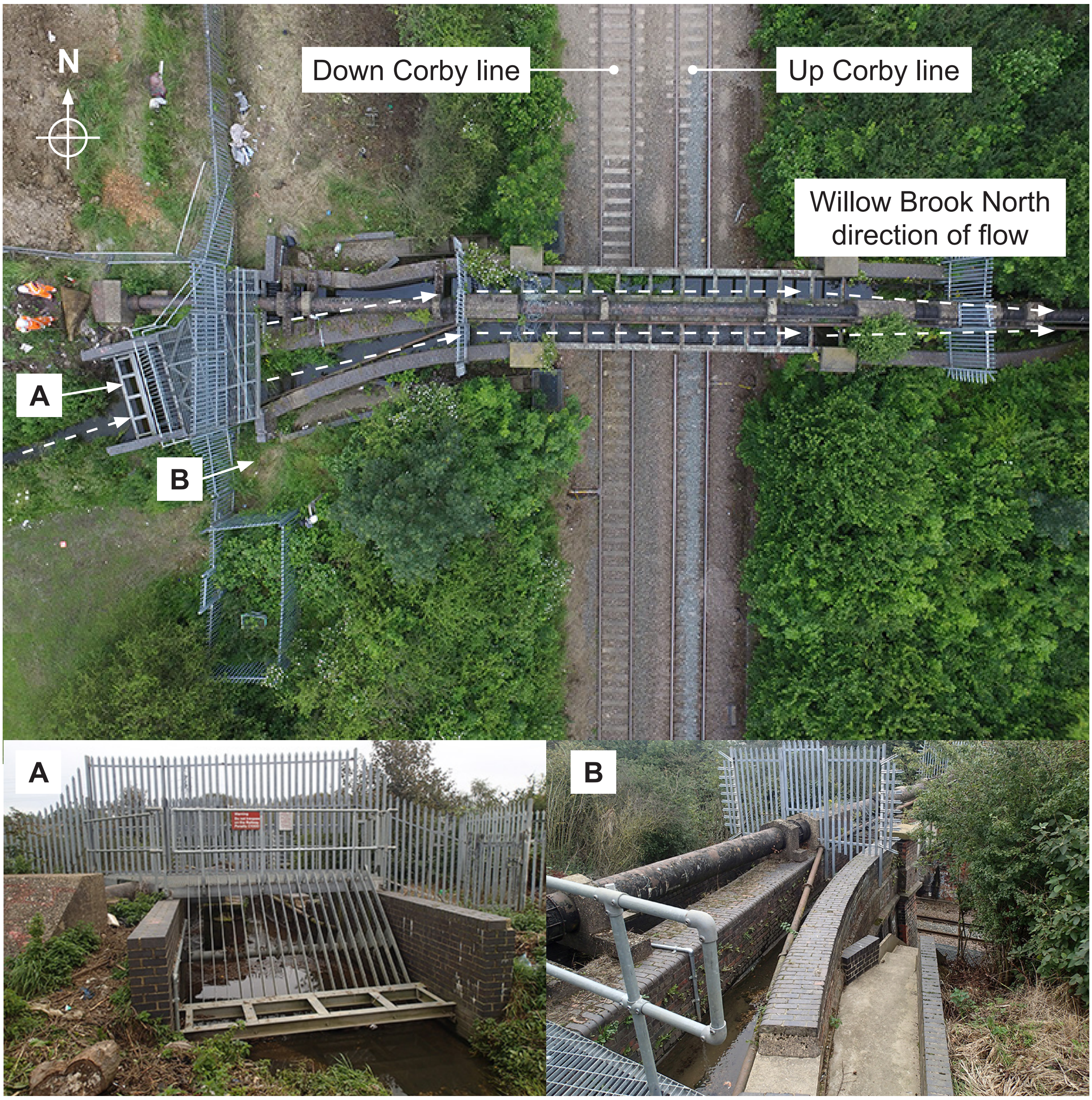

Figure 4: The aqueduct over the railway

9 Signalling in this area detects whether trains are absent or not using axle counters[4] and is controlled by a signaller in the East Midlands Control Centre (EMCC) in Derby. The railway here is not electrified.

[4] A system that detects the absence of a train by counting the individual axles of a train in at one end of a section of track and out at the other end.

Organisations involved

10 Network Rail owns, operates and maintains the railway infrastructure where the incident occurred, including the track, cutting slope and aqueduct. It also employed the signaller and some of the staff working in the control room at EMCC (see paragraph 18).

11 The two passenger trains involved were operated by East Midlands Trains, which also employed the drivers. It employed the other staff working in the control room at EMCC (see paragraph 18). The franchise held by East Midlands Trains at the time of the incident has since passed to East Midlands Railway.

12 Figure 5 shows the assets relevant to flooding in the Pen Green Lane area and the organisations responsible for them. The watercourse, Willow Brook North, is designated as a main river.[5] This means the Environment Agency has permissive powers under the Flood and Water Management Act 2010 to maintain the watercourse as necessary for flood risk management purposes. Network Rail is responsible for the aqueduct that carries Willow Brook North over the railway, and the trash screen at its entrance. Anglian Water is the owner of the Pen Green Lane flood storage reservoir (from now on referred to as pond 1) and is responsible for the structure and trash screens that connect it to Willow Brook North. Homes England is the owner of the Pen Green Lane balancing pond (from now on referred to as pond 2) and is responsible for the culvert and trash screens that connect it to pond 1. Corby Borough Council is responsible for the bridge that carries Pen Green Lane over Willow Brook North. Northamptonshire County Council is the Lead Local Flood Authority, and is responsible for preparing and maintaining a strategy for managing the risk of flooding in the Corby area.

13 All of the above organisations freely co-operated with the investigation.

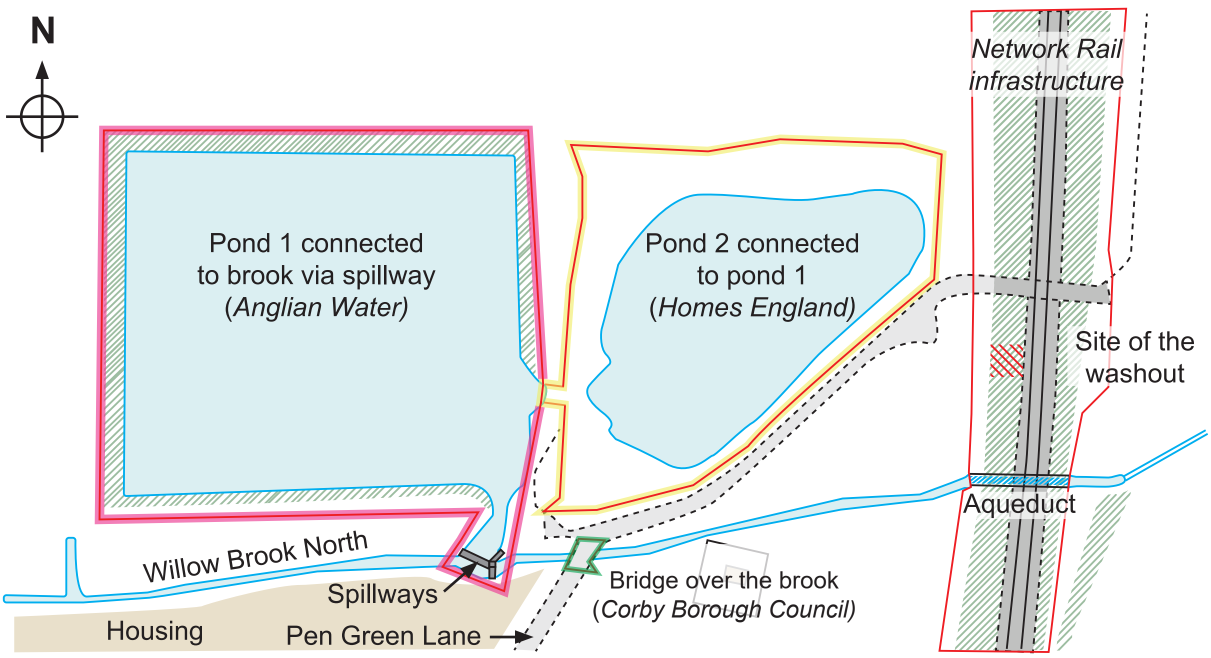

Figure 5: The assets relevant to the flooding in the Pen Green Lane area

[5] Main rivers are usually larger rivers and streams on which the Environment Agency carries out maintenance, improvement or construction work to manage flood risk. Other rivers are called 'ordinary watercourses' on which lead local flood authorities, district councils and internal drainage boards carry out flood risk management work.

Train(s) involved

14 The train which struck the debris, reporting number 1D43,[6] was the 14:34 hrs service from London St Pancras International to Nottingham. It was a High Speed Train (HST) and comprised eight passenger coaches with a class 43 diesel-electric power car at each end. It had been diverted from its timetabled route due to an incident near to Leicester (paragraph 23).

15 The southbound train used for the train-to-train transfer of passengers, reporting number 1C52, was the 13:59 hrs service from Sheffield to London St Pancras International. It was also an HST but was shorter and comprised six passenger coaches with a power car at each end. It too had been diverted due to the incident near Leicester (paragraph 23)

Staff involved

16 The driver of train 1D43 had over 16 years' experience of driving trains. He had driven a train to London earlier that day and was driving train 1D43 to Nottingham. The driver of train 1C52 had booked on for duty at Derby, where he took over this train from another driver and was driving it to London. RAIB found no evidence that the way the trains were driven contributed to the incident.

17 The signaller involved was working on the Kettering workstation[7] at EMCC. RAIB found no evidence that the actions of the signaller contributed to the incident.

18 Staff from both Network Rail and East Midlands Trains, co-located in the control room at EMCC, were responsible for managing the railway's response to the incident. Their role was to manage the train service between London and Chesterfield and included managing the stranded trains, authorising the train evacuations,[8] and sending staff to the site.

External circumstances

19 It was daylight at the time of the incident. The local weather conditions, based on rainfall radar data and closed circuit television (CCTV) footage, were cloudy with light rainfall. A local weather station, located 1.65 miles (2.65 km) away, reported that the temperature was 13°C. The influence of the rainfall which occurred before the incident is discussed at paragraphs 20 and 96.

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[6] An alphanumeric code, known as a 'train reporting number', is allocated to every train operating on Network Rail infrastructure.

[7] A desk with the signalling in the area being controlled shown on a series of monitors, and a trackerball and keyboard provided to operate the signalling functions.

[8] The procedures followed by Network Rail and train operating companies for managing stranded trains use the term evacuation to describe the process of taking passengers off a stranded train either onto a station platform, another train or onto the track. In many cases, an evacuation from a stranded train will take place in a controlled manner without the passengers being in any immediate danger.

The sequence of events

Events preceding the incident

20 In response to rainfall over the previous five days, Network Rail staff in the control room at EMCC directed a mobile operations manager, whose role is to provide first line response to incidents and accidents, to go to Pen Green Lane on the morning of the incident. This was because staff at EMCC knew the railway in that area was susceptible to flooding. The mobile operations manager was asked to check the flow of water over the aqueduct and clear any debris from its trash screen. He reported back at 09:47 hrs that he had removed debris from the aqueduct's trash screen, and that the water level in Willow Brook North was high but it was flowing freely over the aqueduct. He also reported that the nearby pond 2 was very full and close to overflowing. He suggested to control room staff that further visits should take place.

21 The last train to travel through the Pen Green Lane area before the incident passed at 12:43 hrs on the up Corby line (the up line). CCTV footage from this train showed standing water between the rails of the down Corby line (the down line), over a length of around 40 metres. This started around 60 metres to the north of where the cutting slope was later washed out. There was no sign at that time of water flowing onto the railway at either the aqueduct or the foot of the cutting slope.

22 A Network Rail track maintenance team from Kettering depot visited Pen Green Lane at 13:10 hrs. A team member called EMCC to report that the trash screen at the aqueduct was clear of debris. He also reported that the water in Willow Brook North was high but flowing freely, and that the water level in the nearby ponds was high. At 14:15 hrs, telemetry fitted at the aqueduct to monitor the water level in its channels, issued an alarm to report that a 75% threshold level had been exceeded, but this was not received by control room staff (see paragraph 117).

23 At 14:33 hrs train 1C52 departed on time from Derby and at 14:37 hrs train 1D43 departed three minutes late from London St Pancras International. Shortly afterwards, at 14:47 hrs, Network Rail received a call from the British Transport Police reporting that a person was on the parapet of a road-over-rail bridge around 0.8 miles (1.3 km) south of Leicester station, and was threatening to jump off, onto the railway below. By 14:58 hrs, trains were stopped on all lines to the south of Leicester station. At 15:07 hrs, train 1C52 arrived at Leicester station from the north and was held there.

24 At 15:15 hrs, staff in the control room at EMCC decided to implement a contingency plan to divert trains between Kettering and Leicester via Corby and Manton Junction (figure 6). Shortly after this, the signaller contacted the driver of train 1D43 to advise him that his train would be diverted and would no longer call at Market Harborough and Leicester stations, and therefore he needed to stop at Kettering station. At 15:27 hrs, train 1D43 stopped at Kettering station to allow passengers for Market Harborough and Leicester to get off.

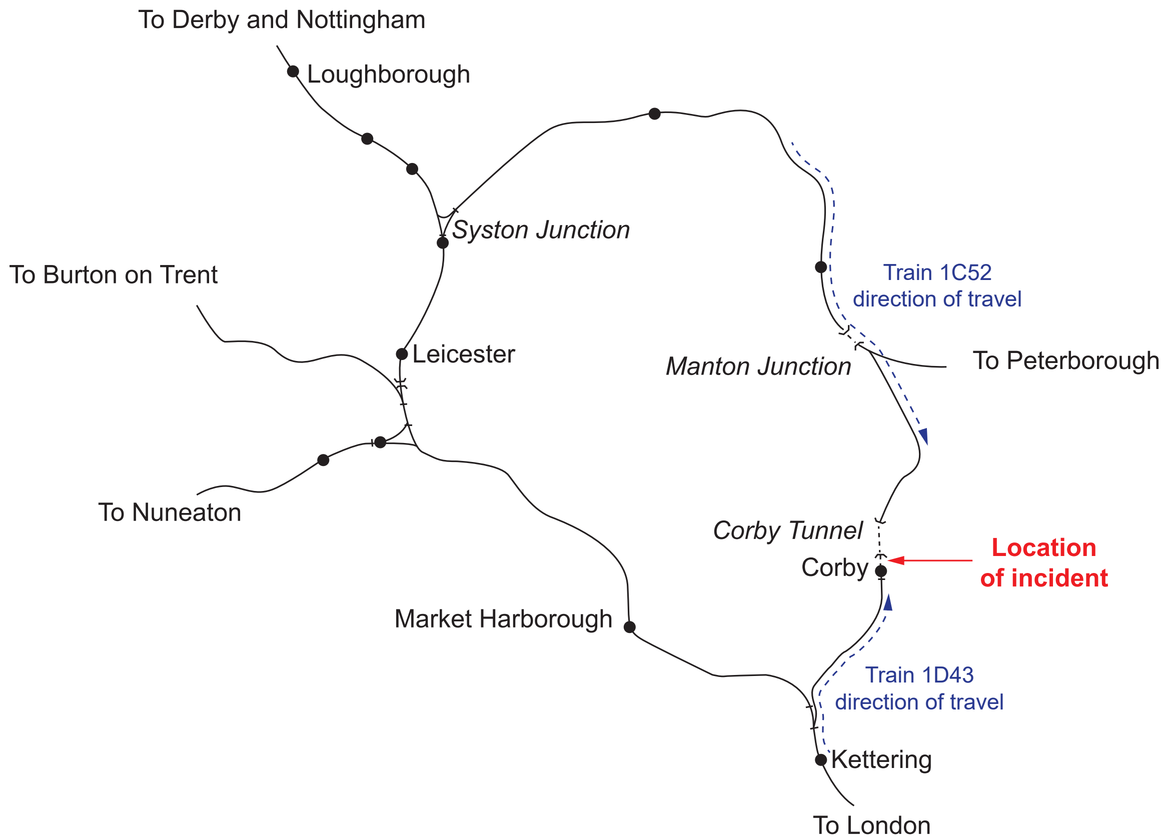


Figure 6: The planned diversionary route via Corby and Manton Junction

25 After being advised of the diversion, the driver of 1C52 changed ends and train 1C52 departed from Leicester at 15:35 hrs towards Manton Junction. At 15:40 hrs, train 1D43 departed from Kettering towards Corby.

Events during the incident

26 At 15:48 hrs, train 1D43 passed through Corby station travelling at 42 mph (68 km/h), about one mile (1.6 km) from Pen Green Lane. About one minute later, while travelling at 43 mph (69 km/h), the driver of train 1D43 began applying the train's brakes to slow it down for the start of the 40 mph (64 km/h) temporary speed restriction on the down line through Corby Tunnel.

27 As the train entered the cutting at Pen Green Lane on a left-hand curve, the driver noticed the track ahead was flooded. As the train continued around the curve, the driver also noticed debris on the track ahead (figure 7). At 15:50:20 hrs, while travelling at 40 mph (64 km/h), the driver made an emergency brake application. At about the same time, train 1D43 struck sandy gravel and soil that had been washed out from the cutting slope onto the track. Train 1D43 stopped at 15:50:40 hrs, after travelling for a further 193 metres.

Figure 7: Image from the forward facing CCTV on train 1D43 showing the flooding and debris on the down line.

Events following the incident

28 Once the train had stopped, the driver looked back from his cab to check that his train was not derailed. At 15:53 hrs, the driver called the signaller using the train's radio system to report the collision and flooding. The driver obtained permission from the signaller to leave the cab to confirm that the rear of the train had not derailed. After walking to the rear of his train, the driver found the rear coach and power car were still on the rails but could not be moved as more debris had washed underneath and around them. He reported back to the signaller that his train was stranded but the adjacent up line was still clear for the passage of trains.

29 At 15:58 hrs, normal working resumed through Leicester station after the person (paragraph 23) had climbed down from the bridge parapet. Train 1C52 was now approaching Corby from the north. The signaller stopped train 1C52 at the signal before Corby Tunnel and explained to the driver that train 1D43 was stranded after striking a landslip. The signaller then authorised the driver of train 1C52 to proceed forward at extreme caution and report back. Train 1C52 set off into Corby Tunnel at 16:15 hrs.

30 After exiting the southern portal of Corby Tunnel, the driver of train 1C52 noticed flood water on the adjacent down line which was starting to spread across to the up line. Flood water was covering the sleepers but was still below the top of the rails. He continued at 5 mph (8 km/h) before stopping about 20 metres from the front of train 1D43. At around 16:30 hrs, the driver of train 1C52 obtained permission from the signaller to leave his cab and went to speak to the driver of train 1D43. Both drivers spoke to the signaller who told them that three trains had been diverted south via Corby. The signaller advised that staff based in the control room at EMCC were planning to evacuate the passengers from the stranded train 1D43 onto the third of these trains. The driver of train 1C52 was asked to proceed south at extreme caution.

31 Just after setting off, the driver of train 1C52 stopped towards the rear of train 1D43 as flood water now covered the up line and had washed debris onto the track, blocking it. At 16:45 hrs the driver of 1C52 reported this to the signaller, who in turn reported this to staff in the control room at EMCC. Consequently, staff in control changed their plan, and decided to evacuate the passengers from train 1D43 onto train 1C52 instead. Train 1C52 would then return north via Manton Junction to Leicester.

32 From about 17:00 hrs, Network Rail staff and officers from the British Transport Police began arriving on site to help transfer the passengers from one train to another. At 19:11 hrs the transfer of passengers from train 1D43 was complete. At 19:32 hrs, train 1C52 headed back northwards but encountered more flooding on the up line just to the north of Corby Tunnel, with flood water above the height of the rails. The driver of train 1C52 spoke to the signaller and was instructed by the signaller to return south through the tunnel. Train 1C52 headed back south, arriving back at train 1D43 at 20:25 hrs. The driver of train 1C52 made this movement at a very slow speed as he had noticed flood water was now flowing above the sleepers in many places throughout the tunnel. When asked to return north in train 1C52, accompanied by Network Rail staff who would assess the flooding, both drivers refused as they considered it unsafe to take the train into the tunnel again.

33 At 20:53 hrs the British Transport Police declared a major incident. This led to the fire and rescue service attending to assist with taking the passengers off train 1C52 and onto the track. The evacuation started at 21:42 hrs after Network Rail staff and its contractors on site had cleared, and provided lighting along, the pathway from a railway access point near to the trains to the buses now waiting on a nearby road. The first bus took passengers to Corby station, while the remaining buses took passengers to Kettering station. The last of the passengers were taken off the train at 23:14 hrs, with the passengers who went to Kettering station transferred onto additional trains provided by East Midlands Trains to take them to London or Derby.

Background information

History of flooding at Pen Green Lane

34 The aqueduct at Pen Green Lane was built by the Midland Railway in 1878 to carry Willow Brook North over the then new railway line it was constructing to provide an alternative route from Kettering to Nottingham. A map dated 1885 shows the brook was an open watercourse, running through a rural area each side of the aqueduct (figure 8).

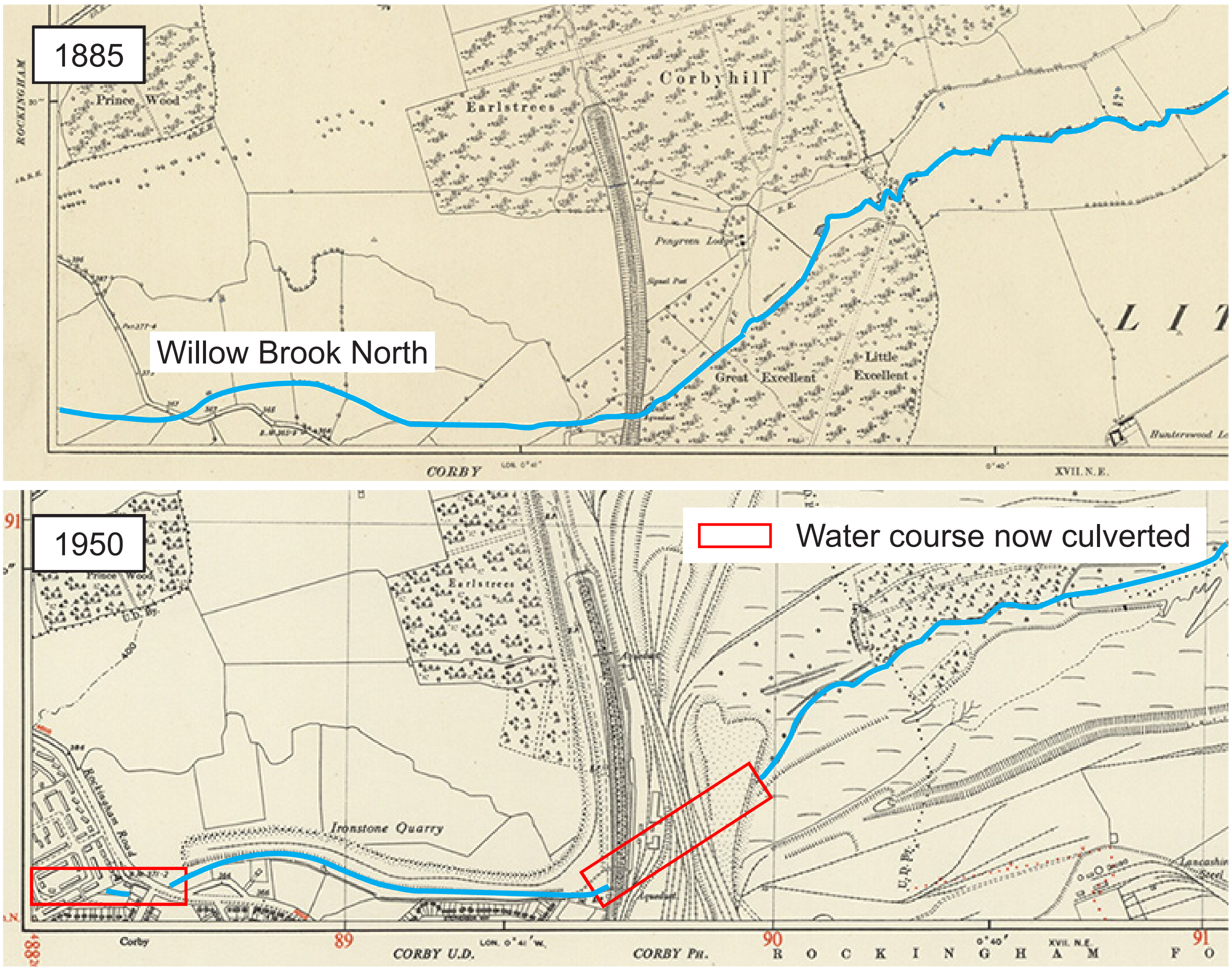


Figure 8: Map dated 1885 showing the brook passing through a rural area and a map dated 1950 showing the significant changes to the area due to industrialisation (extracts taken from the National Library of Scotland on Wikimedia Commons. Used under Creative Commons licence.)

35 A later map dated 1899 shows the first signs of industrialisation in this area, with quarries appearing to the north east of the railway, but the brook was still an open watercourse. During the 1930s the industrialisation of this area accelerated alongside the construction and opening of the nearby steelworks in 1933. A map dated 1938 shows newly built houses nearby. This map also shows the brook was now culverted in two places to the east of the railway. A map dated 1950 shows significant industrial development had taken place to the east of the railway, and there were ironstone quarry workings to the north of the brook (figure 8). Since 1950 there has been further extensive change in the area, with widespread residential and commercial development (figures 1 and 2).

36 The earliest records found by Network Rail which describe flooding on the railway at Pen Green Lane date back to 1968. British Rail, the then owner of the railway, asked Corby Urban District Council (which later became Corby Borough Council) whether it could install a trash screen at the entrance to the aqueduct. The council stated that it had no objections to this.

37 Further British Rail correspondence dated 1969 noted that prior to 1965, flooding had only happened on the railway following exceptional rainfall. However, since 1965 it noted there had been a major flooding event every three to six months when rainfall was high but not exceptional. British Rail engineers had identified four new outfall pipes from recent factory developments that were discharging surface drainage water into the brook. Additionally, pumps at the ironstone quarry workings were also pumping considerable amounts of water into the brook. During the flood events, water had overtopped the aqueduct channels on occasions, but more often it overtopped the wing walls at the entrance to the aqueduct and flowed down the cutting slope onto the railway. The flowing flood water was also noted as eroding the aqueduct's abutment.

38 Records from 1969 show that British Rail, Stewarts and Lloyds Ltd (the owners of the steelworks) and Corby Urban District Council met to discuss the flooding at the aqueduct. These meetings identified that flooding was also being caused by water backing up on the eastern side of the railway at a syphon drainage pipe. This was because the aqueduct's capacity to carry water was greater than the capacity of the syphon drainage pipe to take it away downstream. When the water backed up from the syphon drainage pipe, it overtopped the aqueduct.

39 British Rail correspondence from 1973 noted that further flooding had occurred on the railway as no action had been taken since the previous flooding events. In 1974, British Rail and Corby Urban District Council agreed plans to build a flood storage reservoir. This led to the construction of pond 1 in 1976. In 1977, British Rail modified the entrance to the aqueduct. This change was to better manage the water when it reached too high a level on the aqueduct, by directing it into the track drainage.

40 Further letters between British Rail and Corby Urban District Council, from 1980 and 1981, refer to flooding happening again on the railway. These letters described problems with debris blocking various trash screens and silt building up in pond 1 which had reduced its capacity. This correspondence also noted that the downstream restriction at the syphon drainage pipe was still present.

41 Further flooding of the railway occurred in 1982, which also damaged the cutting slope next to the aqueduct. At the request of British Rail, Corby Urban District Council replaced the syphon drainage pipe during 1982 with a larger culvert (as it was now responsible for this land after the steelworks closed in 1980). At the same time, Anglian Water agreed to remove silt from pond 1, to restore its capacity to store water.

42 In 1989, the Commission for the New Towns (which became English Partnerships and later Homes England) submitted plans to Corby Urban District Council for a new balancing pond (pond 2) alongside pond 1 to accommodate further developments that were taking place on the Earlstrees industrial estate to the north-west of Pen Green Lane. The plans included a culvert to connect the ponds and showed the capacity of pond 2 would be 4000 cubic metres. Pond 2 was constructed at some time between 1990 (when planning permission for pond 2 was granted) and 1997 (when pond 2 is first shown on an ordnance survey map) but Homes England does not hold any records that give an exact date.

43 In May 1999, the railway flooded and a landslip occurred at 80 miles 40 chains, which is next to the aqueduct. At the time, Railtrack, the then owner of the railway, questioned whether Anglian Water had reduced the water level in the ponds before a period of intense rainfall. In 2001, when the railway flooded again, Railtrack claimed that Corby Urban District Council was not maintaining the trash screens and that Anglian Water had allowed the ponds to silt up.

44 In October 2006, Network Rail visited the site in response to further reports of flooding on the railway that was affecting the track. The site visit report stated that flood water was washing debris from the cutting slope onto the tracks which was contaminating the ballast and adversely affecting track quality. Further flooding occurred in 2008, with Network Rail staff reporting that water was overflowing at the entrance to the aqueduct.

45 In October 2009, Network Rail completed work on the aqueduct to better manage the water at its entrance. This work extended the wing walls at the entrance, modified the trash screen and provided a stepped flume to take any overflowing water down the bank, and into the drainage system running alongside the track. At the same time, Network Rail repaired the cutting slope following its failure in 1999. However, just one month later, the railway flooded again due to water overflowing around the aqueduct entrance as the trash screen was blocked. Network Rail identified that the trash screen required further modification and this work took place in 2011.

46 In August 2013, the railway was flooded again. Network Rail reported that the cause was debris in the trash screen which was diverting water onto the track. A follow-up site visit by Network Rail confirmed that blockages or restrictions in the channel by the aqueduct's entrance had allowed water to create a third pond in the field above the cutting slope. After that flooding event, Network Rail commissioned the fitment of telemetry to the aqueduct to monitor the water level flowing over it.

47 In October 2015, Network Rail held discussions with the Environment Agency about the repeated flooding of the railway at Pen Green Lane. Sometime in 2016, Network Rail installed a second trash screen in the brook, upstream of the aqueduct's entrance. However, this was soon removed at the request of the Environment Agency because it considered the installation had not been fully agreed and there were issues with its design. The trash screen had the potential to become blocked and cause water in the brook to back up, which then risked flooding nearby residential properties.

48 In June 2016, the railway flooded again and the cutting slope was washed-out in places. Network Rail reported that the flood water was coming over the crest of the cutting slope and washing debris onto the track. In May 2017, when the cutting slope was examined as part of its routine examination regime, the examiner saw evidence of previous washouts, and so he noted the cutting slope as being at a high risk of washout.

49 In February 2019, a senior asset engineer from the Route Asset Manager (RAM) Geotechnical team[9] visited the site. This was to determine the scope of the repair work needed to the cutting slope following the previous washouts. The senior asset engineer reported that the washouts were due to water coming from pond 2 and pooling in the field next to the crest of the cutting slope. In April 2019, Network Rail devised a scope of work to repair the cutting slope and planned to carry this work out within 16 weeks. The incident occurred before this work had taken place.

Cutting slope examination regime

50 The RAM Geotechnical team manages all the earthworks[10] on the East Midlands Route. The railway is divided into sections that are 5 chains (100.6 metres) long, and any section with an earthwork in it will count as one asset. The team manages the examination of each earthwork asset in accordance with Network Rail company standard NR/L3/CIV/065, 'Examination of Earthworks', and uses contracted examiners to do the routine examination work. The team then evaluates the examination findings. RAIB found that the earthwork asset which included the cutting slope that failed was being examined at the intervals specified in NR/L3/CIV/065. It was last examined in 2017 (paragraph 48) and this resulted in it being given the Network Rail 'marginal' classification. Soil cutting slopes with this classification are subject to examination every three years, so its next examination was due in 2020.

Weather management processes

51 Network Rail has developed processes to take special measures when extreme weather is forecast. These include special inspections of earthworks which are listed on an 'at risk' register, when particularly heavy rainfall and other adverse weather conditions are forecast. Network Rail has a structured approach to identify which earthworks are to be included on the 'at risk' register, that considers both the likelihood of an earthwork failure and the potential consequence. Network Rail assesses the likelihood of failure by taking account of historic instability and indicators suggesting possible future instability. These indicators include earthwork category recorded during the examination process (paragraph 50). The assessment of likelihood also takes account of any water concentration features identified by Network Rail's 'washout and earthflow risk mapping' process. This process identified areas where ground topography concentrates surface water flows at particular locations along the railway.

[9] The Route Asset Manager (RAM) Geotechnical is responsible for the earthwork assets on the route. A team working for the RAM is responsible for managing the safety of these earthworks by applying Network Rail's processes for managing earthworks and delivering the associated work to achieve this.

[10] Network Rail defines an earthwork as a cutting, embankment or natural slope, lying within the Network Rail boundary, that is equal to or greater than 3 metres high or, if less than 3 metres high, its failure could pose an unacceptable risk to the safe operation of trains or the performance of the railway infrastructure.

52 The cutting slope where the incident happened was included on Network Rail's register of 'at risk' earthworks so a special inspection was required whenever an extreme amount of rain was forecast. However, Network Rail did not receive any forecasts of extreme rainfall on the day of the incident, nor in the seven days before it, so none of these processes to take special measures, including a special inspection of the cutting slope, applied.

Analysis

Identification of the immediate cause

53 **Train 1D43 did not stop before colliding with sandy gravel and soil that flood water had washed onto the track from the adjacent cutting slope.**

54 The driver of train 1D43 reported seeing debris and flood water ahead as he rounded the left-hand curve approaching the washed out debris. The forward facing CCTV footage from train 1D43 showed a pile of debris on the down line at the foot of the cutting slope, close to where it had failed (figure 7).

55 Once the train had stopped, flood water continued to flow onto the railway, at the aqueduct and where the cutting slope had failed. It washed a large volume of sandy gravel and soil from the cutting slope onto the track, which flowed underneath and around the rear of train 1D43 (figure 3).

Identification of causal factors

56 The incident occurred due to a combination of the following causal factors:

a. the adjacent flood storage ponds overfilled, causing excess water to pool in the field between the ponds and the crest of the cutting slope (paragraph 57);

b. the cutting slope failed as it was not designed to cope with a large volume of water accumulating in the field above it (paragraph 78); and

c. the train driver did not have sufficient sighting of the debris to be able to stop the train in time (paragraph 88).

Each of these factors is now considered in turn.

Pooling of water in the adjacent field

57 **The adjacent flood storage ponds overfilled, causing excess water to pool in the field between the ponds and the crest of the cutting slope.**

58 Contractors called to the site by Network Rail after the incident found a large volume of water had pooled in the field above the cutting slope. This water was coming from pond 2, pooling in the field, and then flowing onto the railway where the cutting slope had failed, and also at the northern side of the aqueduct (figure 9).

59 This causal factor arose due to a combination of the following:

a. the flow of water in Willow Brook North was restricted at the entrance to the bridge carrying Pen Green Lane over the brook (paragraph 60);

b. the eastern bank of pond 2 was the lowest point on the perimeter of the two ponds and was lower than the emergency spillway between pond 1 and the brook (paragraph 64); and

c. the pump to reduce the water level in the ponds was last operated on 17 May 2019 (paragraph 70).

Each of these factors is now considered in turn.

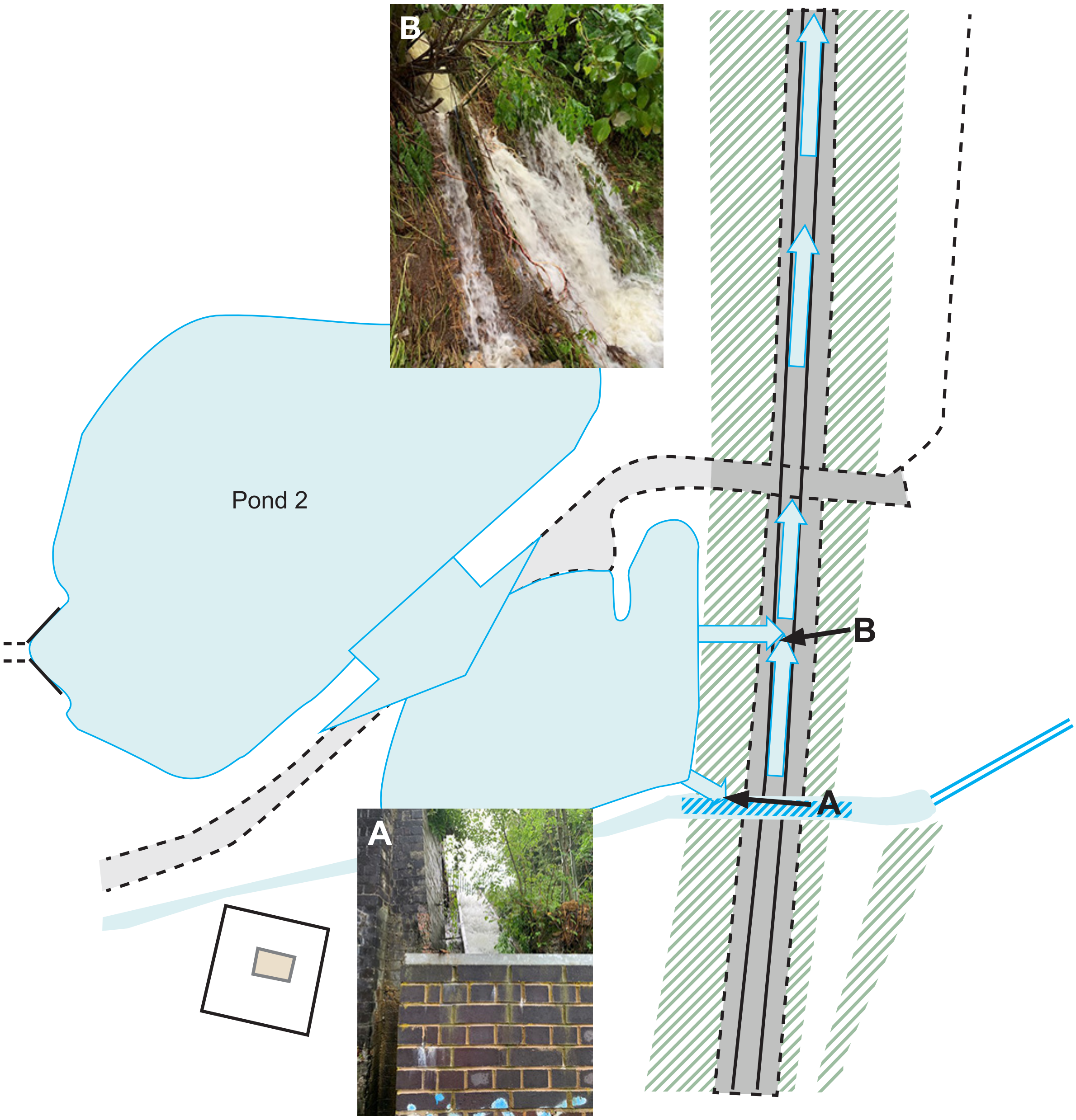


Figure 9: The flow of water from pond 2, through the field and onto the railway. Inset image A shows flood water flowing down the stepped flume on the northern side of the aqueduct. Inset image B shows flood water flowing onto the railway at the foot of the cutting slope.

Restriction under the bridge

60 The water flowing in Willow Brook North was restricted by debris that had collected at the entrance to the bridge carrying Pen Green Lane over it (figure 5). This caused water in the brook to back up to the spillways located about 25 metres upstream of the bridge (figure 5). The spillways control the flow of water between Willow Brook North and the flood storage ponds as described in figure 10. When the water backed up, it raised the water level in the brook, which in turn diverted more water over the service spillway and into the ponds.

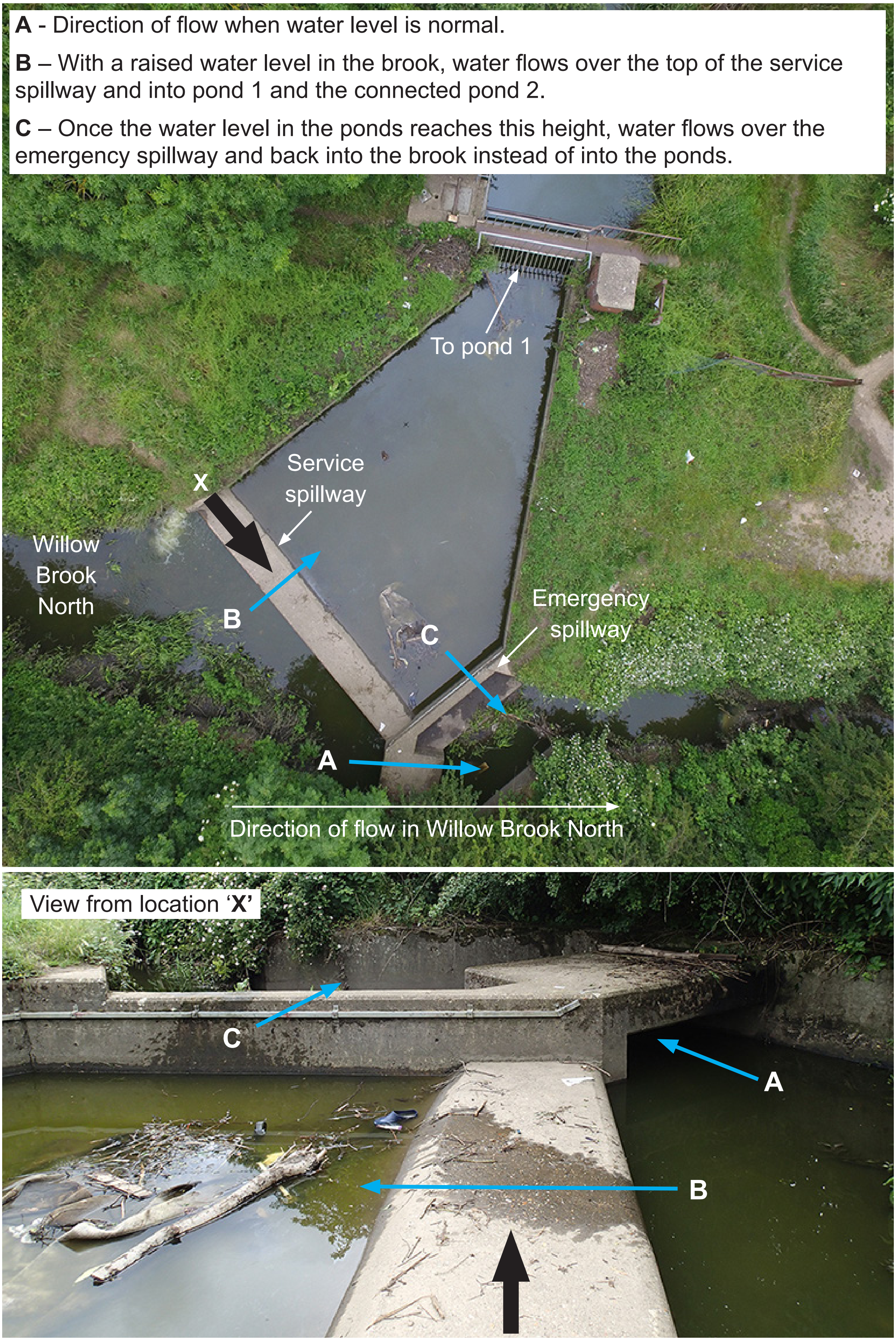


Figure 10: The spillways connecting the brook and pond 1

61 There is a clearance of around 0.4 metres between the bridge carrying Pen Green Lane over the brook and the typical water level in the brook when there has been no rainfall for several days (figure 11). Following rainfall, the water level in the brook quickly rises, reducing this clearance and increasing the likelihood of debris becoming trapped at the water's entrance to the bridge.

Figure 11: Typical clearance between the underneath of the bridge and the brook when there has been no rainfall for several days

62 The contract staff called to site by Network Rail after the incident found a large amount of debris, mostly vegetation and large pieces of wood, trapped at the entrance to the bridge (figure 12). They removed the debris, which allowed the brook to flow freely through to the aqueduct. To reduce the likelihood of further flooding downstream, they also removed debris that had collected on the trash screen at the entrance to the aqueduct.

63 With the brook now flowing freely from the spillways to, and over, the aqueduct, the contract staff reported that the water level in the ponds soon began to fall as this allowed water to flow back out of the ponds, over the service spillway, and into the brook instead. This was evidenced by the water level in the ponds falling so that water no longer covered the path adjacent to the eastern bank of pond 2 (figure 5), which had been flooded when the contract staff had first arrived on site (figure 13). It also meant the water level in the ponds could continue to fall back to the level of the service spillway, which was the approximate water level in the ponds noted later by RAIB when on site at 21:00 hrs.

Figure 12: Left image: The contractors called to the site by Network Rail removing debris from the watercourse under and before the bridge (image courtesy of CML). Right image: The debris removed from the watercourse.

Figure 13: The drop in the water level on the path. Left image shows the path next to pond 2 before blockages were cleared and right image (looking in opposite direction) shows the path after the blockages were cleared (images courtesy of CML).

Level of the eastern bank of pond 2

64 After the incident, Network Rail commissioned a level survey which recorded the height of various points in the area relative to each other and the ordnance survey datum (mean sea level). RAIB also carried out its own survey of the area using aerial images taken by its drone which were processed using photogrammetry software to produce a 3D model of the area and a contour map.

65 Both surveys showed that the eastern bank of pond 2, which runs alongside Pen Green Lane, was the lowest point on the perimeter of the two ponds (figure 14). Along a 40 metre long section of this bank, the lowest level was recorded as 104.40 metres above ordnance datum (AOD), with typical levels over this section measured between 104.43 and 104.48 metres AOD.

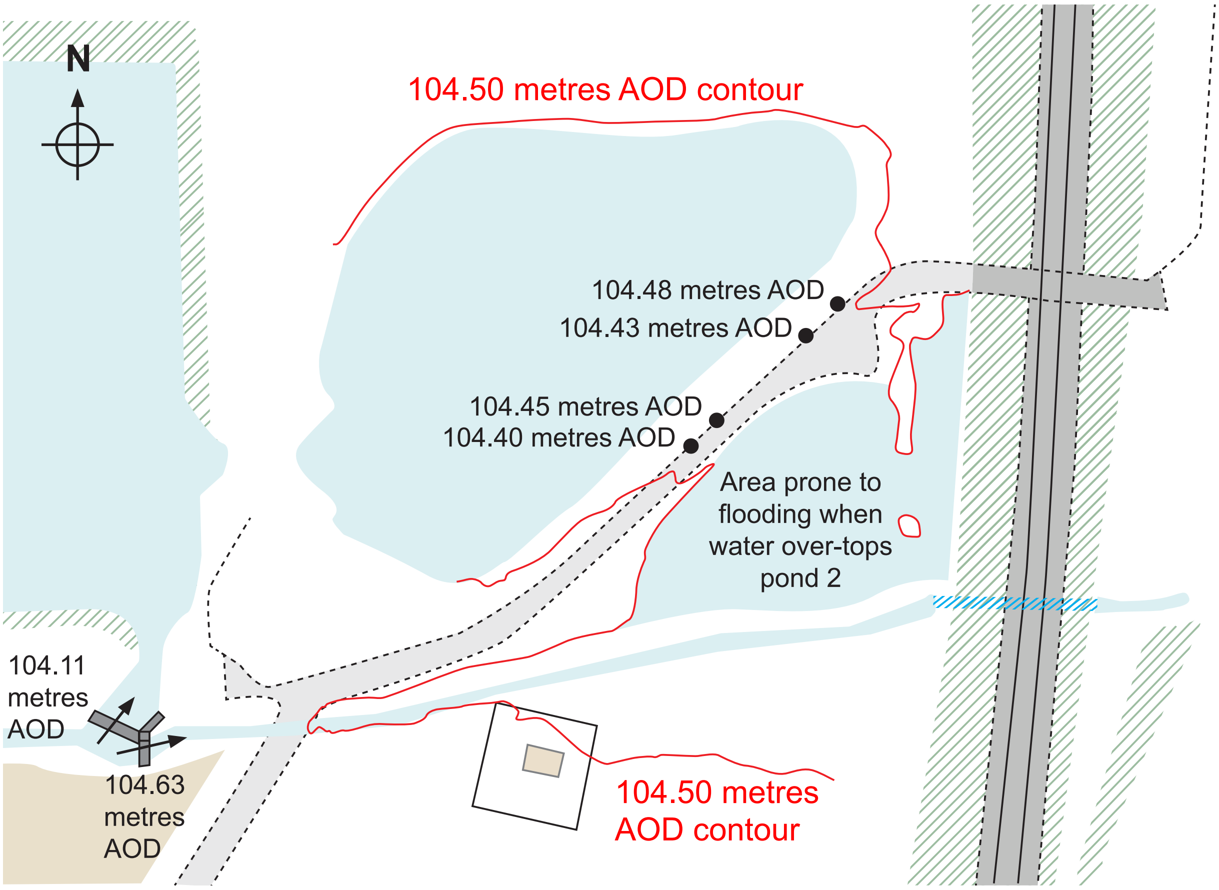


Figure 14: The levels as recorded by the surveys for the spillways and ground showing the low point on the eastern bank of pond 2

66 The level survey, supported by RAIB's measurements of the spillways and drawings provided by Anglian Water, recorded a level of 104.11 metres AOD as the height of the service spillway. This is the level at which water flows from the brook into the ponds.

67 The emergency spillway (figure 10), which should control the maximum water level in the ponds by allowing water back into the brook, was recorded by the level survey, measurements and drawings as having a level of 104.63 metres AOD. This is 0.14 to 0.23 metres higher than the 40 metre-long section of pond 2's eastern bank. This resulted in water flowing from the brook and into the ponds until it over-topped the eastern bank of pond 2, instead of flowing back into the brook via the emergency spillway.

68 RAIB obtained copies of the planning application submitted to Corby Borough Council in 1989 to gain permission for the construction of pond 2. The application included a plan which showed the maximum water level for pond 2 was expected to be 104.15 metres AOD (figure 15) which is about the same level as the service spillway.

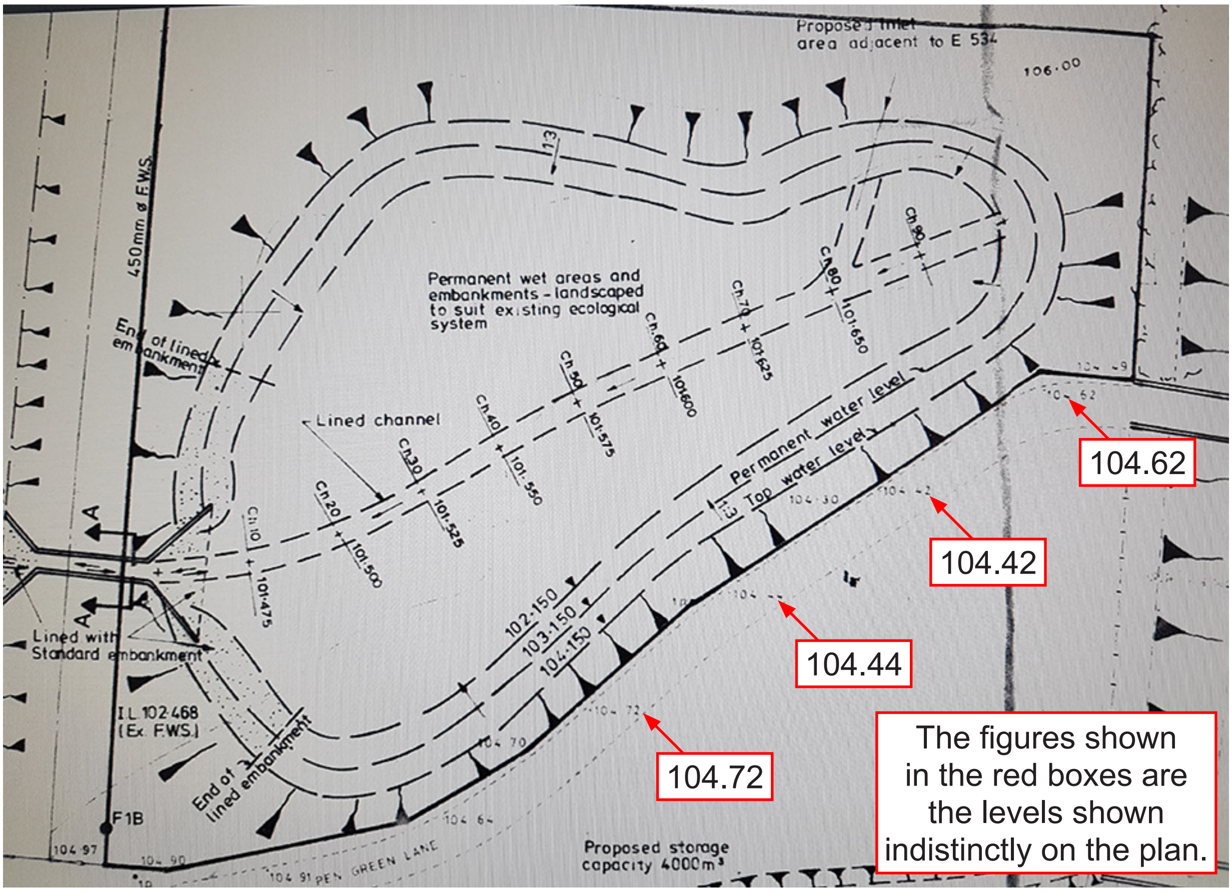


Figure 15: The plan from the planning application for pond 2

69 The plan also showed levels of 104.42 and 104.44 metres AOD recorded for the eastern bank of pond 2, indicating this bank was designed to be lower than the level of the emergency spillway. This made the emergency spillway ineffective in controlling the maximum water level in the ponds. Instead, the maximum water level in the ponds was controlled by water over-topping the eastern bank and flowing into the adjacent field at the crest of the cutting slope. Anglian Water staff with over 15 years' experience of this location reported to RAIB that they had never seen the water level in the ponds reach the point where water had passed over the emergency spillway.

Operation of the pond discharge pump

70 While the service spillway allows water to flow into the ponds when the water level in the brook is high, there is no outfall allowing water to flow from the ponds by gravity to reduce their level. The water level in the ponds needs to be reduced so that the ponds have capacity to store water when the next rainfall event occurs. An electric pump is used to pump water from the ponds back into Willow Brook North once the water level in the brook has fallen.

71 The pump is installed next to the trash screen by the entrance to pond 1, with its outlet into the brook located just before the service spillway (figure 16). Anglian Water is responsible for the pump and its operation. When pond 1 was constructed a pump system was installed and its operation was automated, with sensors that measured the water levels in the brook and pond 1 to determine when the pump should run. However, the system was frequently vandalised and so Anglian Water moved the controls for the pump to its nearby sewage pumping station (figure 16). This change resulted in the pump becoming manually controlled. RAIB has not been able to establish the exact date of this change. However, documentation related to flood management in the area that was issued in 2006, refers to the pump being manually controlled.

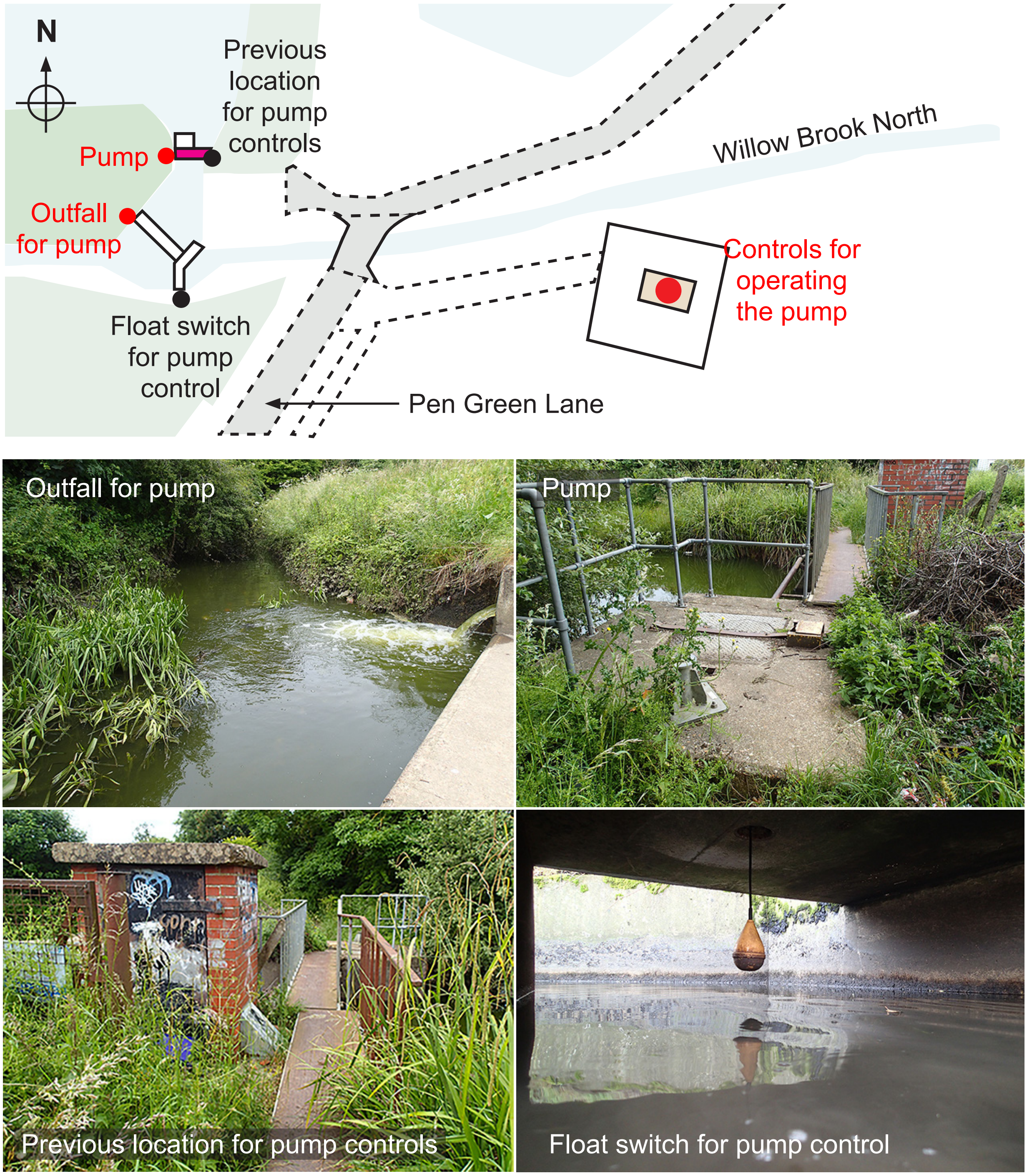


Figure 16: The pumping system at the spillways

72 Anglian Water has reported to RAIB that it does not have any formal arrangements in place for the manual operation of the pump, such as when it should be used or what the water level in the ponds should be reduced to. Instead, the pump is manually operated by a field maintenance technician employed by Anglian Water who uses his experience to decide when to run the pump.

73 Typically, after a period of rainfall, the field maintenance technician will go to Pen Green Lane at the start of his day shift, between 08:00 and 08:30 hrs. He will run the pump if the water level in the ponds is high enough and the water level in the brook is below the height of the service spillway. If the field maintenance technician does run the pump, he will return before the end of his shift, at about 15:00 to 15:30 hrs, to turn it off, as the pump is only operated during the day. Anglian Water does not permit the field maintenance technician to operate the pump at night due to complaints from neighbours about the noise the water makes at the outfall as it discharges into Willow Brook North.

74 The field maintenance technician will normally reduce the water level in the ponds to about 0.3 metres below the end of the spillway apron at the entrance to pond 1 at the trash screen. The recorded level at the end of the spillway apron is 103.76 metres AOD so this equates to reducing the water level in the ponds to a level of about 103.46 metres AOD. This is 0.65 metres below the top of the service spillway. The field maintenance technician estimated that running the pump for 7 to 8 hours in a day will reduce the water level in the ponds by about 0.12 to 0.15 metres. When the ponds were full, the technician reported that he would expect to run the pump during the daytime for four days to reduce the water level by the required amount.

75 If the field maintenance technician is off work, Anglian Water can arrange for another technician to attend but there is no formal process in place to guarantee this happens. This cover is usually provided by another field maintenance technician who works nearby. He has attended at this location often enough to know what to do and is able to judge whether to run the pump.

76 Anglian Water does not record the operation of the pump. The field maintenance technician maintains his own notes of when he attends the site, including when he switches the pump on and off. Prior to the flooding on 13 June, the field maintenance technician had last operated the pump from 14 to 17 May. The effect of the operation of the pump can be seen in the data recorded by the telemetry at the aqueduct (paragraph 46) on these dates so is consistent with the field maintenance technician's notes. Consequently, no water had been pumped out of the ponds for about one month before the incident. During this intervening period, there was rainfall on 27 May, 4 June, 7 June, 8 June, and 10 to 12 June. The telemetry data showed each of these rainfall events raised the level in Willow Brook North sufficiently to allow water to flow over the service spillway and into the ponds. This meant the ponds had reduced capacity to store water from the persistent rainfall in the four days prior to the incident, and made it likely that the ponds would become overfilled.

77 After the last period of pump operation (14-17 May), the field maintenance technician reported that he visited Pen Green Lane on 28 May, 31 May, 3 June and 12 June. He explained that these visits were in response to rainfall or forecasts of rainfall, but each time he had visited he had deemed the water level in the brook to be too high for him to switch the pump on. If the water level in the brook is higher than the service spillway, operating the pump only circulates the water (as the outfall is upstream of the service spillway, water that is pumped into the brook simply passes back over the service spillway and back into the ponds). The pump's outfall is positioned upstream of the service spillway so that the control of the water level provided by the service spillway cannot be bypassed by operating the pump.

Cutting slope design

78 **The cutting slope failed as it was not designed to cope with a large volume of water accumulating in the field above it.**

79 The repair to the cutting slope that was undertaken in 2009 (paragraph 45) was not appropriate for the flood water scenario that occurred in this incident. It was not designed to cope with large volumes of water accumulating at the crest of the cutting slope. Instead the 2009 repair was designed alongside some other changes aimed at minimising the accumulation of water at the cutting crest by better management of flooding at and around the entrance to the aqueduct.

80 The geology of the cutting slope comprises a sandstone rock base with layers of sand and clay above it (figure 17). The cutting slope was damaged by flood water in 1999 (paragraph 43). At the time, the earthwork engineer who attended reported that the failure was due to material washing off the cutting slope onto the track, but the earthwork itself was stable. This allowed the railway to reopen within four hours of the landslip first being reported. Photographs taken by Network Rail in 2004, during an earthwork examination, show material from the cutting slope was partially filling the cess and contaminating the track ballast. No records can be found to indicate that any work took place on the cutting slope after the landslip in 1999, until it was repaired in 2009 (paragraph 45).

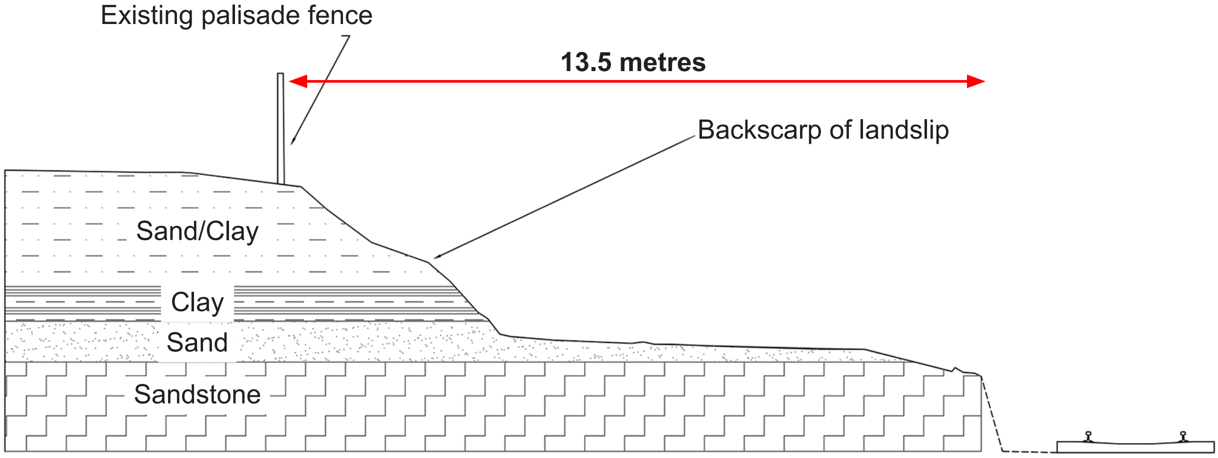


Figure 17: The geology of the failed cutting slope

81 A site visit by Network Rail staff in 2006 (paragraph 44) took place in response to reports of flood water washing material from the earthwork onto the track. This material was adversely affecting track quality. The Network Rail staff found that the material was from the landslip in 1999. The visit report noted that a track renewal was planned which included digging out the material in the cess. It identified that this work would destabilise the cutting slope at its toe and further failures would occur. Therefore, the cutting slope needed to be repaired before the track renewal work proceeded.

82 The 2006 site visit report formed the basis for the subsequent work to repair the cutting slope in 2009. The repair was designed during 2008 and signed off in December 2008. The cutting slope was repaired in September 2009. The repair included the installation of a barrier material at the crest of the cutting slope to provide some protection from small amounts of water draining through the crest. However, this protection was ineffective against a large volume of water accumulating at the crest of the cutting slope, as occurred immediately prior to this incident.

83 The 2006 site visit report had also identified the source of the water for the washout failure as coming from the entrance to the aqueduct when it became blocked. Water from the brook then flooded the land surrounding the entrance and flowed to a low spot at the top of the cutting slope, where the washout in 1999 had occurred. To better manage flooding at the entrance to the aqueduct, Network Rail scoped, designed, obtained planning permission and made changes at the aqueduct's entrance between 2007 and 2009. This included modifications to the inlet of the aqueduct, installation of a new trash screen with a platform for clearing debris, replacement of the flumes either side of the aqueduct with stepped flumes to better manage any overflow, and modifications to the cess drain chambers to receive the overflow water (figure 18). Network Rail also installed an emergency drain pipe, with its inlet at the boundary fence line of the adjacent field. Its outlet discharged into the flume on the northern side of the aqueduct.

84 Network Rail completed these changes to the aqueduct's entrance in 2009, at the same time that the earthwork was repaired. It believed that these changes would protect the adjacent cutting slope from flood water, so the repair to the cutting slope did not include any specific measures to deal with a large volume of water at the crest. This meant that when water from pond 2 flooded the field at the crest of the cutting slope prior to this incident, the cutting suffered a washout failure.

85 The as-built drawings for the repair to the cutting slope show that a series of steps, called benched excavations, were cut into the cutting slope. The void was then filled using 'MOT class 1 granular fill' and covered with a layer of soil (figure 19). This fill material was a sandy gravel and was very susceptible to washout if significant amounts of water seeped through it from the pond that formed in the adjacent field at the cutting slope's crest.

Figure 18: The changes made at the aqueduct's entrance, 2007-2009 (images courtesy of Network Rail)

Figure 19: The repaired cutting slope in 2009 (image courtesy of Network Rail)

86 Once the sandy gravel was washed out from the cutting slope during this incident, it flowed underneath and through the gaps in the underframes of the vehicles at the rear of train 1D43 (figure 3). Afterwards, the void left in the cutting slope revealed the benched excavations made when the 2009 repair was carried out (figure 20), showing that the flood water had only washed away the fill material.

Figure 20: The void left in the cutting slope showing the benched excavations from the 2009 repair, viewed from the top of the cutting slope looking towards the railway

87 The sandy gravel chosen for the repair in 2009 was suitable for the volume of water that Network Rail expected the cutting slope would be exposed to. The expectation was that the water would be limited to surface water from rain falling onto the cutting slope and the field between the cutting slope and pond 2. As discussed in paragraphs 82 to 84, the repair was not designed to cope with a large volume of water seeping through the cutting slope from water ponding at its crest.

Sighting distance

88 **The train driver did not have sufficient sighting of the debris to be able to stop the train in time.**

89 The driver of train 1D43 reported seeing the washed-out debris and flood water (figure 7) ahead of his train (paragraph 27) as he rounded the left-hand curve, while travelling at 40 mph (64 km/h). From this speed, the distance the train took to stop after application of the emergency brake was 193 metres.[11] This was greater than the available sighting distance for the debris, which the CCTV footage from train 1D43 suggests was around 100 metres. There was therefore nothing the driver could have done to stop the train before running through the debris on the track.

Identification of underlying factors

Engagement and communication between parties

90 **The different parties involved did not engage and communicate effectively about the potential risk of their assets causing flooding of the railway.**

91 Copies of correspondence between British Rail (and later Railtrack), Corby Urban District Council (later Corby Borough Council) and the steelworks' owners, dating from the 1960s through to the early 2000s, indicate that previous engagement between the involved parties was often adversarial, seeking to apportion blame and recover costs.

92 However, more recent correspondence indicates signs of cooperation between Network Rail and Corby Borough Council. For example, in 2009 Corby Borough Council gave planning permission to extend the walls at the aqueduct's entrance beyond Network Rail's boundary (paragraph 83). This included a discussion over who would be responsible for clearing the trash screen which would now be located on land owned by the council. Additionally, Network Rail held meetings with the Environment Agency in 2015 to discuss the flooding on the railway (paragraph 47). However, these meetings did not result in any actions to address the flooding problem.

[11] RAIB's investigation into a near miss at Didcot North Junction on 22 August 2007 (RAIB report 23/2008) found that the HST involved achieved an average mean retardation of 9.05%g following an emergency brake application. Train 1D43 achieved an average mean retardation of 8.44%g which is compliant with Appendix C in the latest issue of Railway Group Standard, GK/RT0075, Requirements for Minimum Signalling Braking and Deceleration Distance.

93 At the time of the incident, there were no clear lines of communication between the various owners of the assets that form the flood management system at Pen Green Lane to pass on information about the state of each other's assets. Consequently, each of the asset owners was focused on their own assets in isolation:

a) Network Rail was primarily concerned with keeping the trash screen at the aqueduct clear of debris, monitoring the water levels over the aqueduct, managing the water at the entrance to the aqueduct, examining its cutting slope, and taking action to protect the cutting slope from flood water.

b) Anglian Water managed the water level in the ponds by maintaining and operating the pump and kept the spillway apron and trash screen at the entrance to pond 1 clear of debris.

c) The Environment Agency did not own any of the flood management assets at this location, but as Willow Brook North was designated a main river, it was solely exercising its permissive powers to manage the flood risk from Willow Brook North, which in this instance consisted of localised vegetation management.

d) Homes England was solely focused on inspecting and maintaining pond 2.

e) Corby Borough Council inspected and maintained the pathway, Pen Green Lane, and the bridge that carried it over Willow Brook North.

94 If staff from one organisation noted an issue with an asset belonging to another party, there were no clear lines of communication to pass on this information. There was also a reluctance within the various organisations to intervene and take action that might affect another organisation's asset. For the flood management system to function and be effective, it needed all of these organisations to work together rather than in isolation. As a result, the long-standing problem of flooding to the railway in the vicinity of Pen Green Lane was not addressed in a holistic way.

Flood management system

95 **The parties involved did not have an effective flood management system in place, given the presence of nearby national infrastructure in the form of the railway line which is a principal transport route.**

96 Flooding has been happening on the railway at Pen Green Lane for a long time (paragraphs 36 to 49). Rainfall radar data for the Willow Brook North surface water catchment area (figure 21) recorded between 9 June and 13 June 2019 indicated the rainfall was not exceptional. It was less than a 1 in 1 year[12] rainfall event over the five-day period, in terms of both intensity and volume. Figure 21 also shows that the size of the water catchment area is not large, covering about two square miles (five square kilometres). However, the flood management system at this location could not cope with the volume of surface water that was discharged into the brook during that period. This was primarily due to three factors:

a) the system lacks capacity to cope with the increased surface water drainage from the housing and commercial developments that have taken place within the brook's catchment area over the years

[12] A 1 in 1 year event has a 100% probability of occurring in any given year.

b) the effectiveness of the system was further reduced by a lack of maintenance and susceptibility to blockages due to debris in the brook

c) vandalism and anti-social behaviour leading to damage to the original automated pumping system and the dumping of significant amounts of rubbish into the channels of Willow Brook North.

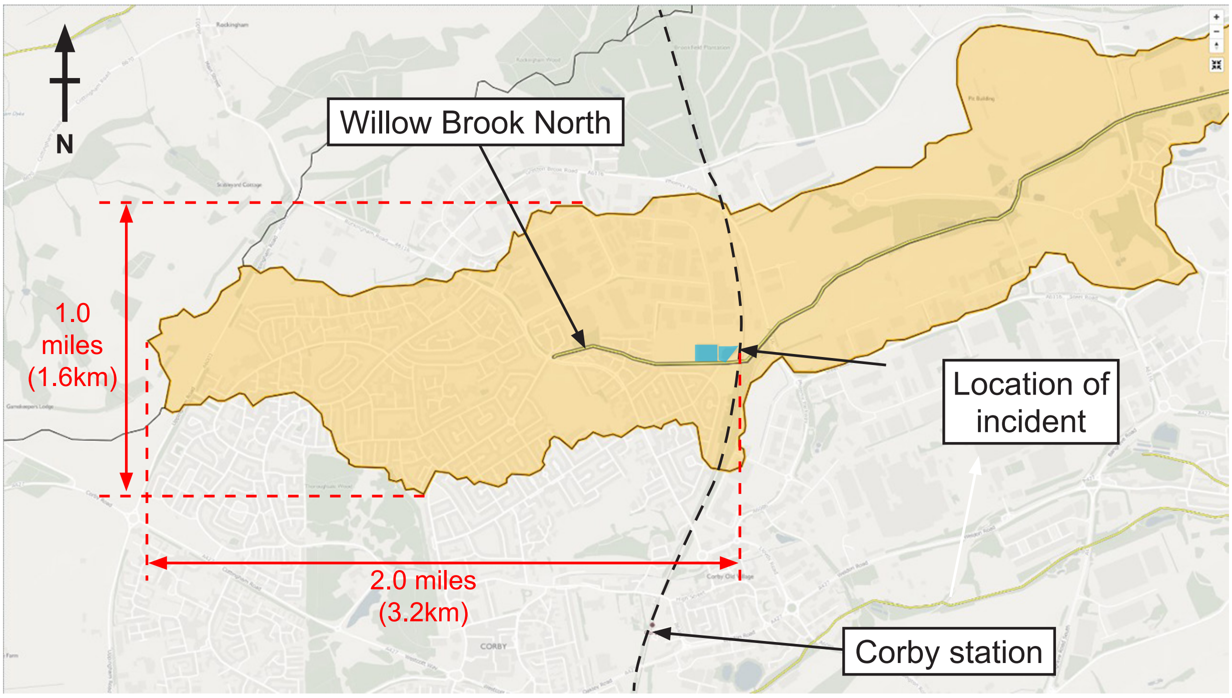
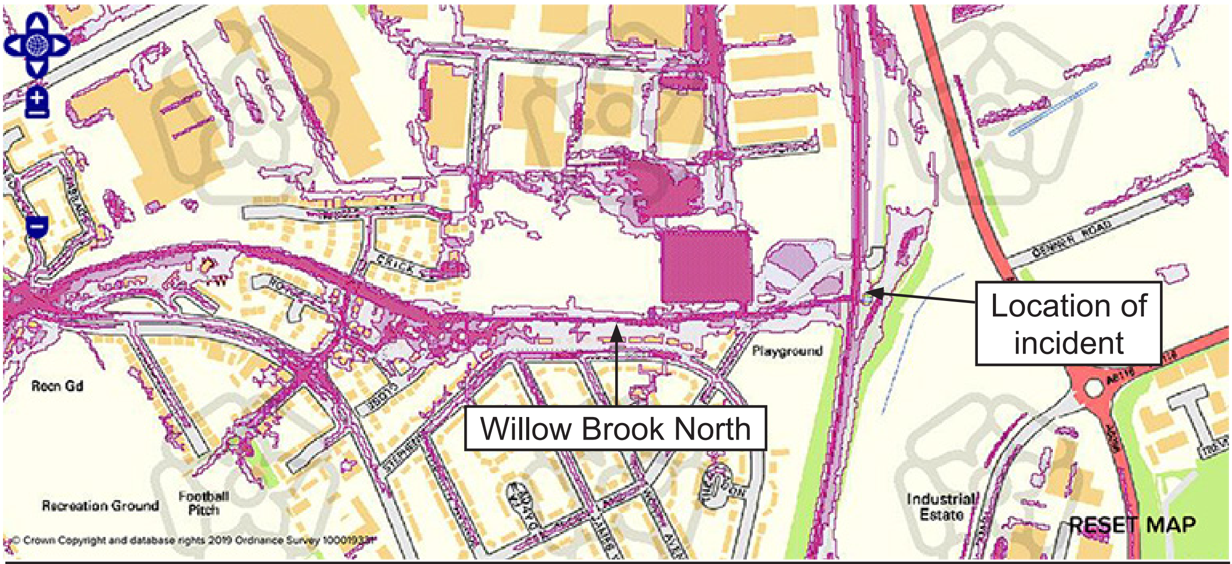


Figure 21: The catchment area for Willow Brook North as defined by the Environment Agency (image courtesy of the Environment Agency, see https://environment.data.gov.uk/catchment-planning/WaterBody/GB105032045590)

97 Northamptonshire County Council is the Lead Local Flood Authority for this location. In accordance with the Flood and Water Management Act 2010, Northamptonshire County Council assessed the railway to be critical national infrastructure. Critical national infrastructure is defined as 'those infrastructure assets (physical or electronic) that are vital to the continued delivery and integrity of essential national services, the loss or compromise of which would lead to severe economic or social consequences, or to loss of life'. Section 19 of the Act requires Lead Local Flood Authorities to investigate flooding events affecting such infrastructure. Northamptonshire County Council has drafted a section 19 report for this flooding event, but had not issued it at the time of publication of this report.

98 As the Lead Local Flood Authority, Northamptonshire County Council also provided a publicly available web-based toolkit to understand the risk of flooding at locations within its area of responsibility. The toolkit showed the Pen Green Lane area as being at risk from surface water flooding (figure 22). Northamptonshire County Council had no plans to carry out any flood mitigation work at this location as it considered fluvial flooding[13] to be the greatest risk at Pen Green Lane, so under the Flood and Water Management Act 2010, it believed that management of this risk rested with the Environment Agency.

[13] A fluvial flood occurs when the water level in a river, lake or stream rises and overflows onto the surrounding land.



- Area with high chance of flooding from surface water, with chance of flooding greater than 1 in 30
- Area with medium chance of flooding from surface water, with chance of flooding between 1 in 100 and 1 in 30
- Area with low chance of flooding from surface water, with chance of flooding between 1 in 1000 and 1 in 100

Figure 22: Northamptonshire County Council flood risk toolkit results for risk of surface water flooding in the Pen Green Lane area

99 The Environment Agency has a duty, under the Flood and Water Management Act 2010, to ‘exercise a general supervision over all matters relating to flood defence’. In 2004 Willow Brook North (from Rockingham Road, Corby, through to where it joins the River Nene near Elton) was designated as a main river under sections 193 and 194 of the Water Resources Act (WRA) 1991. This designation did not place any additional duties on the Environment Agency but gave it permissive powers to carry out maintenance and improvement works. The Environment Agency does not own any of the land the brook passes through or the structures it passes under or over, so the basic common law obligations and statutory responsibilities for the brook remain with its landowners. Under its permissive powers, the Environment Agency does carry out some basic routine maintenance on the brook, such as clearing vegetation from it twice a year, and monthly inspections from October to March, which include removing debris from the brook’s channels. The Environment Agency has not used its permissive powers to carry out any improvements on the brook. Traditionally, any action taken by the Environment Agency was focused on reducing the risk of flooding to adjacent properties and businesses, but the flooding at this location has only tended to affect the railway. The Environment Agency has no plans to take any action to reduce the risk of flooding at this location.

100 The need for housing development in the Corby area, driven by government plans in 2003 to address housing shortfalls across the south of England, resulted in Corby Borough Council commissioning studies between 2003 and 2006 which looked at its water infrastructure. A strategy document issued in 2006 detailed the water infrastructure that was required to facilitate this growth in Corby, and included high level specifications for a number of flood risk mitigation measures. A flood risk assessment study, also issued in 2006, identified areas of flood risk over the whole of the borough. It included detailed flood risk assessments for several potential development areas, one of which was very close to Pen Green Lane. The study also included an assessment of the effect that large scale urban development in the Willow Brook North catchment area would have on flood risk in Corby.

101 Both documents recognised that the flood storage ponds at Pen Green Lane had insufficient capacity for the level of urban development that had taken place in the Willow Brook North catchment area. They reported the combined water storage capacity of the ponds was 19,500 cubic metres. The flood risk assessment study noted that while pond 1 had an estimated capacity of 15,500 cubic metres, at the time it was constructed it was calculated that it needed a capacity of 28,000 cubic metres for a 1 in 10 year[14] rainfall event. While the construction of pond 2 provided some additional capacity, it was still not adequate for a 1 in 10 year rainfall event. The strategy document noted that Willow Brook North had a low standard of protection upstream of the aqueduct over the railway line, with the aqueduct spilling at a 1 in 10 year standard of protection (in its simplistic form, this means that over time, the protection will be insufficient once every ten years). It also noted that the two ponds at Pen Green Lane were not in a good state of repair, were heavily silted and full of debris, and so spilled at between a 1 in 2 year and 1 in 5 year rainfall event. It also noted that the trash screen at the aqueduct needed replacing and its failure would flood the railway line.

102 In February 2019 Corby Borough Council issued a new version of the flood risk assessment document, which it had updated in response to legislative changes. This latest document noted that the Pen Green Lane area was a flood hotspot, due to inadequate flood storage capacity, and was susceptible to a high risk of surface water flooding. The document showed that no improvements to reduce the risk of flooding had been made in the 13 years since the 2006 report. Meanwhile, there had been further commercial and housing developments in the catchment area during this time. Although the rate at which surface water can run off these developments was restricted by more recent planning legislation, overall these developments have probably increased the amount of surface water run-off into the brook.

[14] A 1 in 10 year event has a 10% probability of occurring in any given year, a 1 in 5 year event has a 20% probability of occurring in any given year, and a 1 in 2 year event has a 50% probability of occurring in any given year.

103 The effectiveness of the flood management system was also affected by a lack of long-term maintenance that impacted on the system's limited capacity. Since 2004 when Willow Brook North was designated as a main river, the Environment Agency had not carried out any work on the brook to reduce its risk of flooding, such as removing silt from its channels. After flooding in 1982, British Rail identified that pond 1 was silting up and Anglian Water removed silt to reinstate its capacity. No evidence has been found that any further work has taken place since that time to remove silt from either pond. Anglian Water reported that both ponds were now contaminated with heavy metals, making it more difficult and expensive to remove the silt.

104 Anglian Water and Network Rail reported that the effectiveness of the flood management system at Pen Green Lane was also affected by high levels of antisocial behaviour. The automated pumping system stopped working due to frequent vandalism. The location also suffers from significant amounts of rubbish and items being thrown into the channels of Willow Brook North, causing blockages in the channels which reduce the flow of water. Debris also collects to form blockages at restrictions, such as under bridges or at trash screens, which also affects the flow of water in the brook. During checks on 13 June, the Network Rail mobile operations manager found and removed debris from the aqueduct's trash screen in the morning. It was still clear when checked again in the early afternoon (paragraphs 20 and 22) but after the incident, Network Rail's contractors found more debris had collected at the trash screen and was affecting the flow of water onto the aqueduct (figure 23).

Figure 23: Debris in the aqueduct's trash screen after the incident (image courtesy of CML)

Short-term mitigation

105 **Network Rail had not implemented any short-term mitigations while longer term actions to repair the cutting slope were being planned, even though it was aware that the cutting slope was at risk of washout due to water overtopping pond 2.**

106 After the 2009 cutting slope repair and changes to the aqueduct's entrance (paragraphs 82 to 83), flooding events continued to occur. There were two notable flooding events in 2013. In July 2013, Network Rail reported water on the railway was due to flooding at the aqueduct's entrance. Later, in September 2013, water was recorded as ponding in the field above the cutting slope, and was identified by Network Rail as coming from Willow Brook North due to blockages in the brook's channel.

107 The next significant flood event occurred in 2016. Network Rail staff and an earthwork examiner attended a reported landslip. They found a washout had occurred with water ponding in the field above the cutting slope. They reported that the water had come from the flood storage pond which had overtopped, as well as from the entrance to the aqueduct. They also noted that the emergency drain pipe that should allow water to drain from the field at the cutting slope's crest was blocked (figure 18).

108 During 2017, two earthwork examinations noted washout failures in five separate places along the cutting slope and recorded the cutting slope as being at high risk of washout and scour. Network Rail identified that the earthwork was stable but gave it an overall risk rating of 'high' due to its high risk of washout failure. The examination findings, along with the known history of flooding events at this location, triggered a visit by a senior asset engineer from the RAM Geotechnical team in February 2019.

109 In response to the findings of the site visit, in April 2019 the RAM Geotechnical team prepared a remit for work to be carried out on the cutting slope. The remit noted that as well as debris in the brook's channels and at the aqueduct's trash screen, the recent flooding was also due to water overtopping the ponds. The field adjacent to the crest of the cutting was acting as a further flood storage pond, with water then seeping through the crest and washing away sections of the cutting slope. Consequently, the remit called for work to prevent water passing through the crest and into the slope when the adjacent land flooded. It proposed installing an impermeable layer on the boundary side of the crest, keyed about one metre below the natural ground level to prevent water passing through it. The remit was signed off by the RAM Geotechnical on 23 April 2019, with a required response time of 16 weeks in which to complete the work. This work had not started prior to the flooding on 13 June.

110 Although the RAM Geotechnical team was aware of the high risk of washout due to water accumulating in the field above the cutting slope, it did not consider implementing any short-term mitigations to manage this risk. Network Rail company standard NR/L2/CIV/086 ‘Management of Earthworks Manual’, and its twelve supporting modules, outline the controls that Network Rail can use to mitigate the risks of earthwork failures that can affect the operation of trains. Four broad types of mitigation are defined in NR/L2/CIV/086:

a) ‘operational restrictions’: a restriction imposed on normal operations that would reduce the impact of an earthwork failure should one occur (for example, a temporary speed restriction or a line closure)

b) ‘monitoring’: using instrumentation to identify pre-failure indicators (for example, early slope movements detected by equipment such as inclinometers or surface-mounted tiltmeters)

c) ‘alarms/alerts’: using instruments to identify an earthwork failure with a linked response to control normal operations (for example, using a link to the signalling system)

d) ‘temporary restraints’: installing a physical barrier between the hazardous slope and the railway line to protect the line from material falling onto the track (for example, sand bags or water filled barriers).

111 Modules 5 and 6 of NR/L2/CIV/086 define the types of mitigation, their selection and their implementation. All the mitigations described in these modules are solely focused on using geotechnical instrumentation to monitor slopes. Implementing geotechnical instrumentation in accordance with the modules requires a significant amount of associated work, which points to a long-term use of the instrumentation to provide a monitoring or alarm/alert system. However, the repair work on the cutting slope was planned to take place within 16 weeks, so Network Rail needed to find a way of mitigating the cutting slope’s risk of failure due to washout in the time before this work took place.

112 The cutting slope’s risk of failure due to washout could have been mitigated in the short term by monitoring the water level in the adjacent ponds. In practical terms, this would have required the RAM Geotechnical team to liaise with staff working within other functions in Network Rail (such as its drainage and operations functions), Anglian Water for any work related to pond 1, and Homes England for pond 2. The need for liaison with other parties is briefly mentioned in module 1 of NR/L2/CIV/086, which covers earthwork evaluations, as it refers to liaising with other asset owners as a possible outcome of an evaluation. However, there is no reference to liaison with others in either module 5 or 6 when choosing a mitigation.

113 As the RAM Geotechnical team had not communicated the high risk of washout at this cutting slope to other functions within Network Rail, the staff working in the control room at EMCC were unaware of this risk. However, these staff were aware of the risk of the railway flooding at this location. Whenever rainfall was forecast (not just adverse or extreme rainfall), staff in the control room at EMCC would direct other Network Rail staff to go to the site to check for flooding (paragraph 20). The date and time of the last visit was recorded on a status board in the control room.

114 As it had been raining in the five days before, and more rain was forecast on 13 June, staff in the control room arranged visits to Pen Green Lane in the morning (paragraph 20) and early afternoon (paragraph 22). Both visits reported back that the ponds were close to overtopping. None of the staff who visited the site or the staff in the EMCC control room were aware of the risk of washout to the cutting slope if the ponds overtopped and flooded the adjacent field.

115 The RAM Drainage team had installed remote monitoring telemetry at the aqueduct to measure the water levels (paragraph 46). The RAM Drainage team had provided the EMCC with access to the data output by the telemetry via a website, along with instructions on what actions to take when extreme rainfall was forecast. Actions to take included monitoring the live data from the site and sending staff to the site if high water levels were observed. However, EMCC staff working in control at the time were not aware of these instructions.

116 The telemetry fitted to the aqueduct was set to issue alarms as text messages when the water level reached specified thresholds of 50% and 75% of the capacity of the aqueduct. Consequently, the telemetry issued an alarm at 12:45 hrs when the water level exceeded the 50% threshold, and at 14:15 hrs when it exceeded the 75% threshold (paragraph 22). The telemetry measured the water level at the aqueduct, so it would not have detected the upstream blockage in Willow Brook North (paragraph 60). It is likely that the water level exceeded the 75% threshold when water which had overtopped pond 2 found its way back into the brook's channel before the aqueduct's entrance, via the flooded field above the cutting slope.

117 At the time of the incident, no one in the control room at EMCC was set up to receive these text message alarms so no action was taken in response to them. Although staff in the control room had arranged two site visits earlier in the day (paragraphs 20 and 22), it is likely that a third visit, in response to the 75% threshold alarm, would have found flooding in the field above the cutting slope and on the railway. However, it is uncertain whether this would have resulted in recognition that the cutting slope was at risk of failing, for which immediate mitigation was required.

Factor affecting the severity of consequences

118 **The rescue and evacuation of passengers was significantly delayed, taking over seven hours from when train 1D43 became stranded.**

119 Soon after coming to a stop, sandy gravel washed out from the cutting slope and surrounded the rear vehicles of train 1D43 (figure 3), preventing it from moving. Once the driver had informed staff in the control room at EMCC that train 1D43 was stranded, they began planning an evacuation of the passengers onto another train. However, these plans ran into various problems resulting in the need to carry out two evacuations, the first from train 1D43 to a rescue train and then a second evacuation, from the rescue train which also became stranded, to the track and onward road transport.

120 Control room staff had decided to divert three southbound trains via Manton Junction and Corby due to the ongoing incident to the south of Leicester (paragraph 23) and planned to use the last of these to collect passengers from the stranded train, since it was lightly loaded. However, when the first southbound train, train 1C52, arrived at the incident site, its driver found that the up line was now obstructed by flood water and sandy gravel washed out from the cutting slope (figure 24). Once the driver of train 1C52 had reported this back to control staff, they had no option but to use that train for collecting the stranded passengers.

Figure 24: Flood water and sandy gravel blocking the up line (image courtesy of Network Rail)

121 Train 1C52 was also an HST but it had two coaches fewer than train 1D43 (paragraph 15), and a total of about 380 seats. Train 1C52 was the first train that had departed from Leicester towards London during the disruption (paragraph 25). It was announced at Leicester station as the first train to London, so many passengers boarded it, although there were two further trains to London waiting just north of Leicester station. East Midlands Trains control had estimated that train 1C52 was loaded with between 250 to 350 passengers, and it needed to accommodate a further 191 passengers from train 1D43. This meant there were 60 to 160 more passengers than seats available on train 1C52.

Transfer of passengers from train 1D43 to train 1C52

122 Network Rail company standard NR/L3/OPS/045 'National Operating Procedures', is followed by staff working in control rooms. Procedure 4.15 applies to 'Managing Stranded Trains and Train Evacuation'. Section 8.3 of the procedure states that '*evacuation onto the track shall be used as a last resort due to the inherent risks associated*'. Therefore, staff in the EMCC decided to evacuate the passengers from train 1D43 by a side-to-side transfer onto train 1C52, rather than evacuating passengers onto the track first.

123 However, side-to-side transfer between trains 1D43 and 1C52, both of which were HSTs, was made more difficult by the type of passenger doors and the curvature of the track, which prevented passenger doors being fully opened because they were fouled by the adjacent train. This meant a side-to-side transfer between the trains was only possible via the sliding doors on the HST power cars. Therefore, the drivers lined up the sliding doors on the front power cars of both trains for a side-to-side transfer.

124 To facilitate a side-to-side transfer from one train to another, a train evacuation bridge is needed. This bridge provides a platform between two adjacent trains, via doors that are opposite each other. Passengers can then walk across the bridge from one train to another without the need to set foot on the track. However, neither train 1D43 nor 1C52 carried this item as it was not included in the emergency equipment carried by the HSTs operated by East Midlands Trains. Instead both HSTs carried ladders for getting passengers off the train and down onto the track.

125 Section 5.1 of Railway Group standard GM/RT2130 'Vehicle Fire, Safety and Evacuation', states the mandatory requirements for the emergency and safety equipment that must be carried on trains. In part d), which lists the equipment which must be made available to both traincrew and passengers, it lists 'one ladder or step ladder made from non-conducting material'. There is no requirement within GM/RT2130 for a train to carry a train evacuation bridge.

126 The drivers attempted to overcome this issue by constructing a temporary bridge between the trains using the ladders and a large fibreglass panel, which was the cover for the emergency equipment cubicle, which they secured using rope. The drivers tested its robustness and deemed it suitable for passengers to use for the side-to-side transfer. However, staff in the control room at EMCC did not approve its use on the grounds of safety and so instead Network Rail arranged with British Transport Police for officers to bring a platform-train access ramp to the site from Corby station. This caused further delay.

127 Once the platform-train access ramp was in place, along with rope handrails between the two trains, the side-to-side train transfer began. All 191 passengers from train 1D43 had to make their way to the front of the train, cross over the ramp with the assistance of Network Rail and East Midlands Trains staff at the door of each train, and then find a space on train 1C52. This took about an hour to complete (paragraph 32).

128 After being given permission by the signaller, at 19:32 hrs, train 1C52 began moving very slowly north in an authorised wrong direction movement along the up line. This was about three and a half hours after train 1D43 had stopped, and by this time, a significant volume of flood water had flowed north through the track drainage and along the track, to an outfall just to the north of Corby Tunnel. The outfall was overwhelmed which caused the up line to flood. When train 1C52 came out of Corby Tunnel, the driver stopped the train as he could see flood water above the height of the rails on the line ahead of him.

129 The driver of train 1C52 reported the flooding to the signaller as required by Rule Book Module M3, GE/RT8000/M3 ‘Managing incidents, floods and snow’. In turn, the signaller reported this flooding to control at EMCC. As train 1C52 was now blocked by flood water to both the north and south, staff in the control room decided to send train 1C52 back to the incident site to pick up Network Rail operations staff, who were still at the site. They planned that these staff could then travel with the train back north to assess the flooding.

130 Train 1C52 travelled back to the incident site, through Corby Tunnel, at a very slow speed because its driver had noticed that the flood water was flowing quickly along the tracks through the tunnel and its level was still rising. After arriving back at the incident site (paragraph 32), the drivers told the Network Rail operations staff that they were not willing to take train 1C52 into Corby Tunnel again as they thought it was unsafe due to the amount of flood water now flowing through it. Train 1C52 was now also trapped at the incident site.

Evacuation from train 1C52 onto road transport

131 The only option then available to the staff at EMCC was to take the passengers off the train. To do this, the staff in the control room needed time to arrange road transport to take the passengers to either Corby or Kettering stations. There was an access point at the incident site which was suitable for the passengers to use, but it did require the passengers to walk about 400 metres along a path to the road transport (figure 25). This path had been flooded earlier so Network Rail, along with its contractors that were on site, needed time to clear it to make sure it was safe. Network Rail also needed to set up lighting along the path as it would become dark during the evacuation.

132 While Network Rail was making these arrangements, the drivers, traincrew and passengers on the train were not given any information about what was happening. During this time conditions on the train were uncomfortable and deteriorating. East Midlands Trains control noted that the train’s lights and toilet systems were still functioning, but the air conditioning was struggling to cool the coaches and it was becoming very hot on board. The catering car had also run out of drinks. Some of the passengers became agitated while waiting and threatened to detrain themselves. Consequently, the British Transport Police declared a major incident (paragraph 33) which activated the local fire and rescue service and ambulance service to attend. The ambulance service treated one person on the train who had fainted, and the fire and rescue service assisted with getting the passengers down from the train and off the railway.

Figure 25: The access point and pathway (left image courtesy of CML)

133 Train 1C52 was moved so that the sliding door on its front power car was close to the ramp for the access point (figure 25) and the evacuation began (paragraph 33), one passenger at a time. As this was taking a long time, staff from East Midlands Trains, Network Rail and the fire and rescue service began assisting able-bodied passengers down onto the track from a second door towards the rear of the train. These passengers needed to be able-bodied as they were required to walk a short distance along the track to the access point. Just over seven hours after train 1D43 had stopped, the transfer of about 450 to 550 passengers off the railway was completed without any further incidents or injuries being reported.

Previous occurrences of a similar character

134 In June 2012, a passenger train scheduled to operate between Belfast and Portrush ran onto a section of washed-out embankment near Knockmore on the Antrim branch line in Northern Ireland (RAIB report 14/2013). The investigation found there had been heavy rainfall in the area during the previous evening, and a system of culverts at and downstream of the washout could not cope with the water flows generated by the rainfall, causing localised flooding which led to the washout. In a similar way to the incident at Corby, the investigation found that there was no engagement between the infrastructure operator and the organisations responsible for flood management about the potential for flooding at the location.

135 In June 2016, three passenger trains passed over a section of the single line at Baildon, West Yorkshire (RAIB report 03/2017), where part of the supporting embankment had been washed away by flood water, leaving one of the rails unsupported. Of relevance to the incident at Corby, that investigation found that the drainage system running under the track could not cope with the quantity of water following a short period of intense rainfall, and a repair made to the embankment following a previous flood event could not withstand the flow of flood water. Planned work to make the embankment resilient to flood water had not taken place. The investigation also found that the RAM Geotechnical team had identified that the location had a history of flooding, and was working to introduce an extreme weather warning system that would issue alerts. Local on-call staff would then respond to these alerts to inspect or monitor the site. The system predicted the heavy rainfall, but staff working in control did not get this alert because the system was still in its trial stage.

Summary of conclusions

Immediate cause

136 Train 1D43 did not stop before colliding with sandy gravel and soil that flood water had washed onto the track from the adjacent cutting slope (paragraph 53).

Causal factors

137 The causal factors were:

a) The adjacent flood storage ponds overfilled causing excess water to pool in the field between the ponds and the crest of the cutting slope (paragraph 70). This causal factor arose due to a combination of the following:

   i. The flow of water in Willow Brook North was restricted at the entrance to the bridge carrying Pen Green Lane over the brook (paragraph 60, **Recommendation 1**)

   ii. The eastern bank of pond 2 was the lowest point on the perimeter of the two ponds and was lower than the emergency spillway between pond 1 and the brook (paragraph 64, **Recommendation 1**)

   iii. The pump to reduce the water level in the ponds was last operated on 17 May 2019 (paragraph 70, **Recommendation 1**)

b) The cutting slope failed as it was not designed to cope with a large volume of water accumulating in the field above it (paragraph 78, **Recommendation 2**)

c) The train driver did not have sufficient sighting of the debris to be able to stop the train in time (paragraph 88, no recommendation).

Underlying factors

138 The underlying factors were:

a) The different parties involved did not engage and communicate effectively about the potential risk of their assets causing flooding of the railway (paragraph 90, **Recommendation 1 and Learning point 1**)

b) The parties involved did not have an effective flood management system in place, given the presence of nearby national infrastructure in the form of the railway line which is a principal transport route (paragraph 95, **Recommendation 1 and Learning point 1**)

c) Network Rail had not implemented any short-term mitigations while longer term actions to repair the cutting slope were being planned, even though it was aware that the cutting slope was at risk of washout due to water overtopping pond 2 (paragraph 105, **Recommendation 3**).

Factor affecting the severity of consequences

139 The rescue and evacuation of passengers was significantly delayed, taking over seven hours from when train 1D43 became stranded (paragraph 118, **Recommendations 4 and 5**).

Previous RAIB recommendations relevant to this investigation

Class investigation into landslips affecting Network Rail infrastructure between June 2012 and February 2013, RAIB report 08/2014, Recommendation 1

140 In response to six landslips which occurred on Network Rail infrastructure between June 2012 and February 2013, RAIB carried out a class investigation into earthwork issues related to land neighbouring the railway and to risk management during adverse weather. The landslips were caused by factors including heavy rain, absent or ineffective drainage, and activities undertaken, or not undertaken, on neighbouring land. In several instances, trains were being operated without any precautions in place when there was a significant risk of encountering a landslip. The following recommendation made by RAIB in that class investigation has some relevance to this investigation.

Recommendation 1

Network Rail should review and improve its processes for managing earthworks related risk arising from neighbouring land, including associated drainage issues. This should provide a documented process which takes account of the extent to which it is practical and proportionate for Network Rail to review and/or rely on land management activities undertaken by neighbours.

The new process should, where reasonably practicable:

- *obtain relevant information from other sources where it cannot be collected by earthwork examiners (eg where examiners are unable to view areas due to access constraints, fences, etc);*
- *take advantage of opportunities offered by current technology to assess areas at risk from ground movement and areas where ground movements are occurring;*
- *provide a robust process for identifying, and responding appropriately, to activities on neighbouring land which have the potential to significantly increase risk to the railway between routine earthwork examinations; and*
- *take advantage of opportunities offered by real-time rainfall monitoring to issue alerts identifying heavy rainfall when this has not been forecast.*

141 In its last report to RAIB in October 2019, the Office of Rail and Road (ORR) reported that after reviewing the information provided to it by Network Rail, it concluded that Network Rail had taken the recommendation into consideration, and had taken action to implement it.

142 In implementing this recommendation, Network Rail developed a nationwide hazard rating system for natural slopes in collaboration with the British Geological Survey. It also developed topographical catchments from digital terrain models to identify which mapped hazards might affect the railway and used this information to understand the relative consequence of a natural slope failure at a particular location on the railway network. This work then formed the basis for a process to assess the hazards arising from natural slopes and the consequences of natural slope failure, which Network Rail documented in module 3 of NR/L2/CIV/086. The process defined in module 3 takes place when the earthwork evaluation process defined in module 1 of the same standard triggers a desk-based review of the earthwork, which in turn can lead to a site-based review, and ultimately a landslide hazard assessment as documented in module 3. The assessment process in module 3 is primarily focused on outside party natural slopes. However, it does consider the effects of water, with specific reference to the site-based reviews looking for evidence of restrictions and/or debris accumulating in streams, and the presence of water concentration features above the slope.

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

143 Network Rail has procured a number of train evacuation bridges for use by East Midlands Trains (now East Midlands Railway) for side-to-side transfers between trains. These bridges are placed at stations along the routes it operates between London and Sheffield, and at Lincoln. A procedure issued by East Midlands Railway describes the method of work for its staff to follow when using a train evacuation bridge. It also states that a train evacuation bridge will be taken to site by either the chosen rescue train or by a Network Rail employee in a road vehicle. The provision of this equipment allows Network Rail and train operating companies to carry out side-to-side transfers between trains in line with Network Rail's national operating procedures.

144 The route control manager based in the control room at EMCC now receives the text message alarms issued by the telemetry that measures the water levels at the aqueduct near Pen Green Lane. At the same time, Network Rail issued an instruction that when the route control manager receives a 50% or a 75% level alarm from the telemetry, staff in control will instruct the signaller to caution any train passing the site. This instruction to caution trains will remain in place until someone has attended the site to check for flooding, observed the flow of water over the aqueduct, cleared the trash screen if required, and checked the water level in the nearby ponds.

Other reported actions

145 In July 2019 Network Rail completed repairs to the cutting slope. The repair that Network Rail had planned back in April 2019 was modified to include steel sheet piles to protect the slope from water pooling in the adjacent field at its crest (figure 26). These piles were installed to a depth of about 4.5 metres along the crest of the cutting slope, from the aqueduct through to the bridge to the north of it. The sheet piling was then capped with concrete (figure 27). The void left in the slope by the washout was infilled with pieces of stone (figure 27).

146 The effectiveness of the repair was demonstrated on 28 July when there was further flooding at Pen Green Lane after heavy rainfall. This time the cutting slope between the aqueduct and the bridge was protected by the piling. However, the new barrier diverted much of the flood water to the southern side of the aqueduct. Here, the flood water washed out material from the cutting slope and onto the track in three different places (figure 28). Although Network Rail had protected its infrastructure in one place, lack of capacity in the local flood management system resulted in the problem being moved to another location. This showed that Network Rail cannot solve the problem of flooding on the railway at Pen Green Lane on its own, and that it needs to work with the other organisations to improve the effectiveness of the flood management system at Pen Green Lane. The 28 July flooding event also demonstrated the need for effective liaison between Network Rail geotechnical staff and drainage staff when developing geotechnical solutions to problems involving drainage issues.

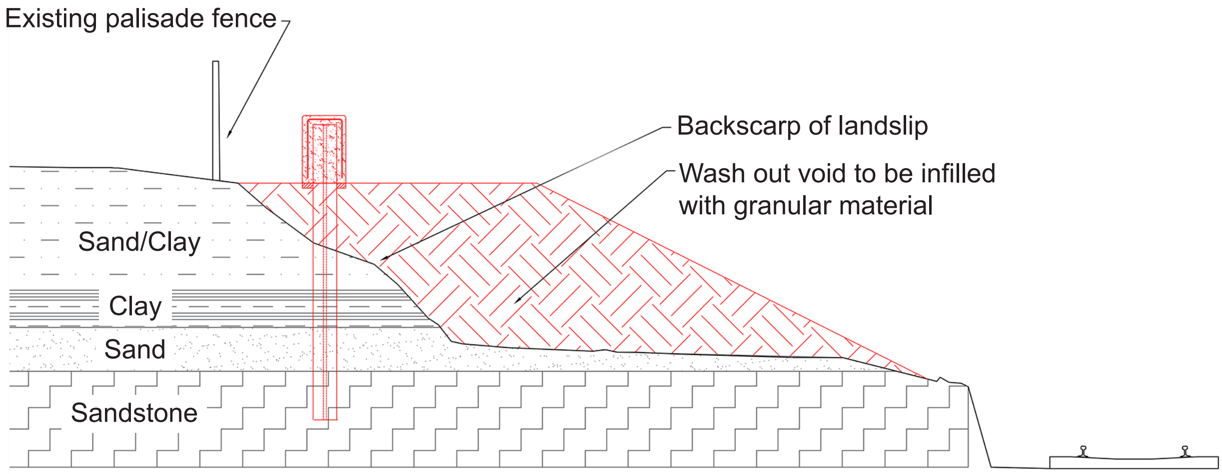


Figure 26: Drawing of Network Rail's repair to the cutting slope

Figure 27: The repaired cutting slope

Figure 28: Images of the flooding on 28 July (courtesy of Network Rail)

147 Anglian Water was planning to modify the outfall for the pump that takes water out of the ponds and puts it back into the brook. This modification will reduce the noise that the operation of the pump makes so that Anglian Water can leave the pump running overnight. This will reduce the time it takes Anglian Water to restore the ponds' capacity to store water after a rainfall event. Anglian Water is also considering options to reinstate an automated system to run the pump, removing the need for its staff to visit the site to turn the pump on and off. Separate to the operation of the pump, Anglian Water is assessing options for how it can monitor the water level in pond 1 and provide remote access to this data.

148 In March 2020 Anglian Water removed silt and vegetation that had built up on parts of the concrete structure that connects the brook to pond 1 via the service spillway. This work has improved the flow of the brook as it passes the structure.

149 Corby Borough Council now visits the site when requested by Network Rail or Anglian Water to take away any rubbish that has been removed from the trash screens or the brook's channels. Staff clearing the trash screens are not always able to remove rubbish from the site so it is sometimes left on the banks and, in the past, it was often found thrown back into the brook.

150 Homes England has appointed a consultant to look at what improvements it can make to the management of pond 2. Network Rail had approached Homes England about raising the level of the eastern bank of pond 2 to prevent it from over-topping. However, both Homes England and the Environment Agency would not agree to this work until its consequences were understood and, if necessary, appropriate mitigation proposed, as it was likely to move the flood risk elsewhere. The Environment Agency has provided Network Rail with its river model for Willow Brook North so that Network Rail can get it updated and then use it to better understand the consequence of any planned work that could affect flood risk.

151 In response to requirements set by the ORR, Network Rail is leading an ongoing industry-wide effort to improve the management of stranded passenger train incidents. The work is focussing on three areas: the first covers the training and competencies of staff, the second is looking at sharing knowledge and adopting good practices, and the third is covering refinements to guidance, operating procedures and reporting requirements for stranded passenger trains. To date the work has completed a survey of all industry stakeholders to validate its scope of work and identify the next steps to take. Work on drafting guidance has also commenced.

152 One of the intended outcomes for this work is for stranded train incidents to be managed in a consistent way across the industry by embedding good practice and knowledge sharing. Another intended outcome is to improve the rail industry's response to stranded trains through improvements to requirements and guidance notes. To achieve these outcomes, one of the future priorities for this work is to share knowledge of good practice, procedures and equipment. Another priority is to understand the existing evacuation practices and the key equipment that is used. These future work priorities, both of which are related to equipment needs, have the potential to address the issues encountered during this incident when transferring the passengers from the stranded train to the rescue train.

Recommendations and learning point

Recommendations

153 The following recommendations are made:[15]

1 *The intent of this recommendation is that the owners of the surface water drainage assets that form the flood management system at Pen Green Lane, Corby, cooperate to reduce the risk of flooding on the railway in that area, both in the short and long term.*

The Environment Agency should, in conjunction with Northamptonshire County Council, Anglian Water, Homes England, Corby Borough Council and Network Rail, lead the production of a timebound plan to implement and maintain an effective flood management system at Pen Green Lane, Corby. The plan should take into consideration short and long-term actions to address the system's susceptibility to blockages and the limitations of the ponds to store water (paragraphs 137a(i), 137a(ii), 137a(iii), 138a and 138b).

2 *The intent of this recommendation is to manage the risk of washouts or landslips on railway infrastructure at specific locations that could endanger trains due to the flooding of adjacent land, following rainfall which falls below the threshold of Network Rail's adverse/extreme weather plans.*

Network Rail should:

a) compile a list of locations on or around its infrastructure where it is known that surface water flooding with the potential to affect railway safety occurs during normal levels of rainfall (that is, during rainfall events that are not classified by its weather management processes as adverse/extreme weather)

b) review the adequacy of the flood management arrangements in place at the locations listed in (a)

c) identify the organisations responsible for each of the assets that form part of a relevant flood management system or could affect flood related risk to the railway at the locations listed in (a)

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[15] 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, recommendation 1 is addressed to the Environment Agency and recommendations 2, 3, 4 and 5 to the Office of Rail and Road, to enable them to carry out their duties under regulation 12(2) to:

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

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

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website www.gov.uk/raib.

d) take steps to establish lines of communication with the organisations identified in (c) to set up joint studies to establish how the risk due to surface water flooding can be reduced at these locations (paragraph 137b).

3 *The intent of this recommendation is to enable more effective management of the short-term risk to earthworks while waiting for planned work to take place in the longer term, when mitigations using geotechnical instrumentation are not viable options.*

Network Rail should review, and amend as necessary, its processes for the management of earthworks, so that its staff responsible for earthworks are trained and have clear guidance on when and how to trigger appropriate monitoring and/or other short-term mitigations. This is particularly relevant when mitigations using geotechnical instrumentation are not viable options and actions that involve other functions within Network Rail or external organisations are needed instead (paragraph 138c).

4 *The intent of this recommendation is to better enable the safe and effective detrainment of passengers by understanding what equipment needs to be available for train evacuations.*

As part of the ongoing industry-wide programme of work to improve the management of stranded passenger train incidents, Network Rail and the Rail Delivery Group should carry out a joint review of existing procedures and codes of practice for managing stranded trains and carrying out train evacuations, to identify what equipment is needed to deliver the requirements in these procedures for each method of train evacuation. They should then provide this information about what equipment is needed to those responsible for the implementation of recommendation 5 (paragraph 139).

5 *The intent of this recommendation is to better enable the safe and effective detrainment of passengers by making equipment available for train evacuations.*

Upon completion of recommendation 4, as part of the ongoing industry-wide programme of work to improve the management of stranded passenger train incidents, Network Rail should:

a) take steps, in cooperation with the train operating companies, so that the equipment identified as required for managing stranded trains and train evacuations is available for use when needed (such as on specific types of train or placed at strategic locations along each route)

b) brief and/or train its staff involved in managing or responding to stranded trains and train detrainments on how to get the equipment made available in (a) to the site of a stranded train and how to use it correctly once it is there

c) work with each train operating company to prepare rolling stock specific guidance so that each train operating company can brief and/or train its staff involved in managing or responding to stranded trains and train detrainments on what to expect when this equipment is to be used to evacuate passengers from its trains (paragraph 139).

Learning point

154 RAIB has identified the following important learning point:[16]

1 Organisations* responsible for managing the risk of flooding, in accordance with the Flood and Water Management Act 2010 (in England and Wales) and the Flood Risk Management (Scotland) Act 2009, are urged to consider the effect of flooding on railway lines when delivering their flood risk management responsibilities. The need to do so is reinforced by Cabinet Office guidance for developing plans to reduce the vulnerability of national infrastructure to flooding (which identifies the rail network as part of the United Kingdom's national infrastructure) (paragraph 138b).

* The National Flood Forum identifies these organisations as:

a) The Environment Agency (in England) and National Resources Wales (in Wales) – the equivalent organisation in Scotland is the Scottish Environment Protection Agency and in Northern Ireland is the Department for Infrastructure

b) Lead Local Flood Authorities

c) Local Authorities

d) Planning Authorities

e) Internal Drainage Boards

f) Highways Authorities

g) Water and sewerage companies

h) Riparian owners.

Household and business owners are also identified as they are responsible for looking after their own property, including reducing the risks of water entering it and causing damage. Network Rail holds this responsibility for its infrastructure.

Appendices

Appendix A - Glossary of abbreviations and acronyms

AOD	Above Ordnance Datum
CCTV	Closed Circuit Television
EMCC	East Midlands Control Centre
HST	High Speed Train
ORR	Office of Rail and Road
RAM	Route Asset Manager

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

a) information provided by witnesses
b) information provided during meetings with the organisations responsible for the assets that form the flood management system
c) drawings and plans for the flood management system assets
d) flood management documents and legislation
e) information taken from train 1D43's on-train data recorder
f) closed circuit television (CCTV) recordings taken from trains
g) site photographs and measurements
h) site surveys by Network Rail and RAIB
i) weather data, reports and observations at the site
j) data from the telemetry fitted to the aqueduct
k) records for the examination, evaluation and repair of the earthwork
l) copies of historic correspondence held by Network Rail
m) a review of previous RAIB investigations that had relevance to this incident.

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