RAIB

Rail Accident Investigation Branch

Rail Accident Report

Derailment of a passenger train at Grange-over-Sands, Cumbria
22 March 2024

Report 02/2025
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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

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

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

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

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident 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.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

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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Derailment of a passenger train at Grange-over-Sands, Cumbria, 22 March 2024

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Summary

At around 06:05 on 22 March 2024, a passenger train travelling at 56 mph (90 km/h) derailed on the approach to Grange-over-Sands station. The derailment occurred because a void had opened in the embankment on which the train was travelling, leading to the rails under the train losing support. The train was carrying four train crew and four passengers when it derailed. Nobody was injured, but significant damage was caused to both the train and the railway infrastructure.

RAIB's investigation found that the void had been created because water had dislodged embankment material and carried it away. The water came from a pipe partially buried beneath the railway, which had been damaged during routine maintenance around 2 days before the derailment.

The damage to the pipe had been reported immediately to the railway control room by the maintenance staff involved. However, as a result of ineffective communications, no action was taken to stop the consequent leak. The pipe had been installed by Network Rail in 2016 as a temporary measure to assist in managing flood water in the surrounding areas, but on-call engineering staff were unaware that it was in use and carrying water at the time it was damaged.

Underlying factors to the accident were that those responsible for managing flood water at this location had not done so effectively, leading to the prolonged need to rely on temporary pumping arrangements. RAIB also identified that staffing levels at Network Rail's Carnforth maintenance delivery unit did not provide sufficient resilience and had allowed non-compliance with the standards relating to the management of tamping to become normalised. In addition, Network Rail had allowed a temporary pumping arrangement to become permanent without applying the relevant asset management procedures.

As a result of its investigation, RAIB has made five recommendations. The first three recommendations are made to Network Rail. The first of these aims to reduce the risk associated with temporary drainage solutions which remain in place for longer than anticipated. The second asks Network Rail to review how it can improve the ability of tamper operators to detect buried services. The third aims to reduce the likelihood that buried services are struck during maintenance by ensuring staffing levels are adequate to comply with Network Rail's own procedures. The fourth recommendation is made to the Environment Agency, and other local stakeholders, and aims to encourage timely decision-making in relation to the future of this area so that the management of flood water does not manifest in another risk to the railway. The final recommendation is addressed to Eversholt Rail Leasing Limited, the owner of the train involved, and aims to reduce the risk of a derailed train being struck by a train on the adjacent line due to a failure of communications and warning systems.

Additionally, RAIB has identified three learning points. The first of these reminds track workers of the importance of completing required site visits ahead of planned work to mark up obstructions. The second reminds staff of the importance of being readily contactable when on call, and the final learning point encourages railway controllers to escalate issues where the first line on-call staff are not available.

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

The accident

Summary of the accident

3 At around 06:05 on 22 March 2024, a passenger train derailed on the approach to Grange-over-Sands station on the railway line between Carnforth and Barrow-in-Furness. The train was traveling at 56 mph (90 km/h) when a section of the embankment it was travelling on collapsed, leaving the rails unsupported and causing the derailment. The leading three vehicles of the 6-car train derailed in the accident, and the train came to a stand with its front cab approximately 184 metres beyond the point of derailment with the rear of the third carriage foul of the adjacent line. A large void in the embankment was found after the passage of the train at the location of the derailment.

4 Nobody was injured in the accident. Damage was caused to lineside infrastructure including broken sleepers, masonry knocked from the parapet wall which runs alongside the railway, and damage to mechanical signalling equipment. The train also suffered significant damage after striking the parapet wall. The derailment and damage cut power to the train's control and communication systems including the Global System for Mobile Communications Railway (GSM-R) radio. The consequences of the derailment could have been more serious had the train not been restrained by the parapet wall, which sits at the top of an embankment leading to a beach below.

5 The embankment collapsed because a partially buried pipe, which was fed by a pump used for moving water from the landward side of the railway into Morecambe Bay, was damaged during routine railway maintenance on 20 March 2024. The damage to the pipe was reported by maintenance staff on site to the relevant railway control room, but subsequent communication of the damage to the on-call engineer was ineffective. As a result, the pump was not stopped, and water was discharged into the embankment for around 2 days, causing material to be washed away and a hidden void to be formed.

Context

Location

6 The accident occurred on the approach to Grange-over-Sands station (figure 1). At this location the railway comprises two lines. The line to the north is the Up Main line, heading towards Carnforth, and the line to the south, on which the train derailed, is the Down Main line, heading towards Barrow-in-Furness. The maximum permitted speed on both lines is 60 mph (97 km/h).

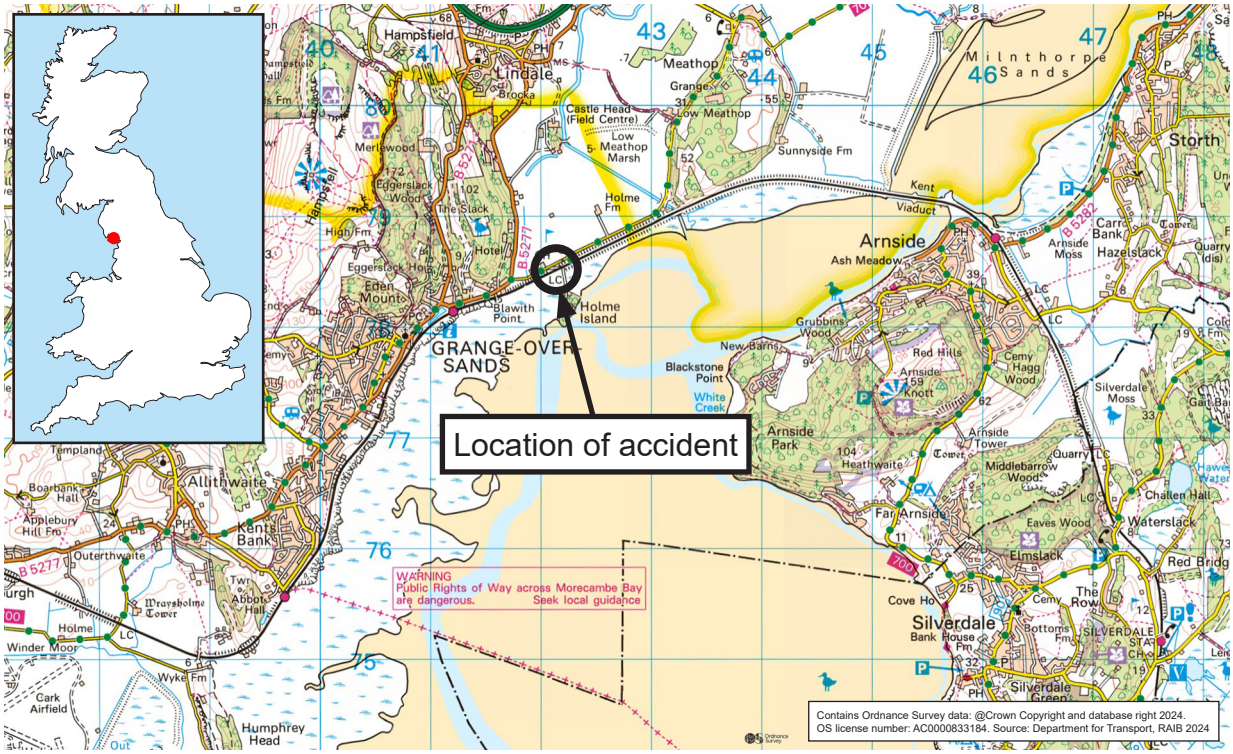

Figure 1: Extract from Ordnance Survey map showing location of the accident at Grange-over-Sands.

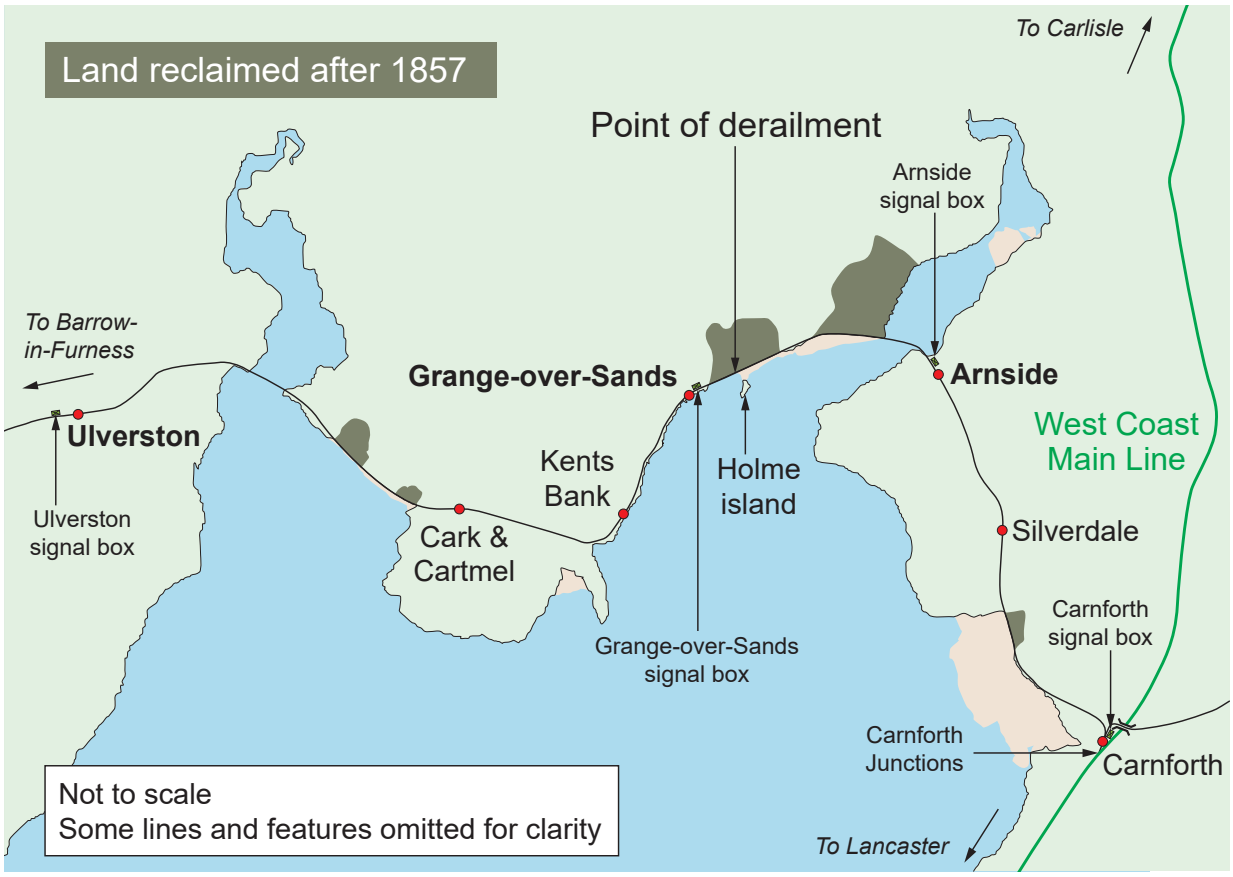

Figure 2: Main features of the railway line between Carnforth and Ulverston.

7 There are two railway signals around 120 metres west of the point of derailment. Signal GS7 on the Down Main line controls the movement of trains heading west towards Grange-over-Sands. Signal GS13 on the Up Main line controls the movement of trains heading east towards Arnside. Both signals are semaphore signals, controlled by mechanical signal wires running from Grange-over-Sands signal box. When commanded by the signaller, these wires, with the assistance of a series of pulleys, raise the signal arm to indicate to a driver that they have permission to proceed. If these mechanical signalling wires fail the relevant signal arm should fall back down, to indicate to a train driver that they must stop their train.

8 Grange-over-Sands signal box is around 550 metres west of the point of derailment and it is possible to see the accident location from a window in the signal box. The signal box is capable of being 'switched out'. This is a common operating practice in areas controlled by semaphore signals, and creates a larger signal section, allowing trains to be signalled between Arnside and Ulverston signal boxes without input from a signaller at Grange-over-Sands (figure 2). This is achieved by, among other things, setting all the semaphore signals controlled by Grange-over-Sands signal box along the through route to proceed. Switching out a signal box reduces a line's capacity for trains due the increase in the length of the signal section but reduces the staffing requirement, as a signaller at Grange-over-Sands signal box is not needed. Only designated signal boxes can be switched out.

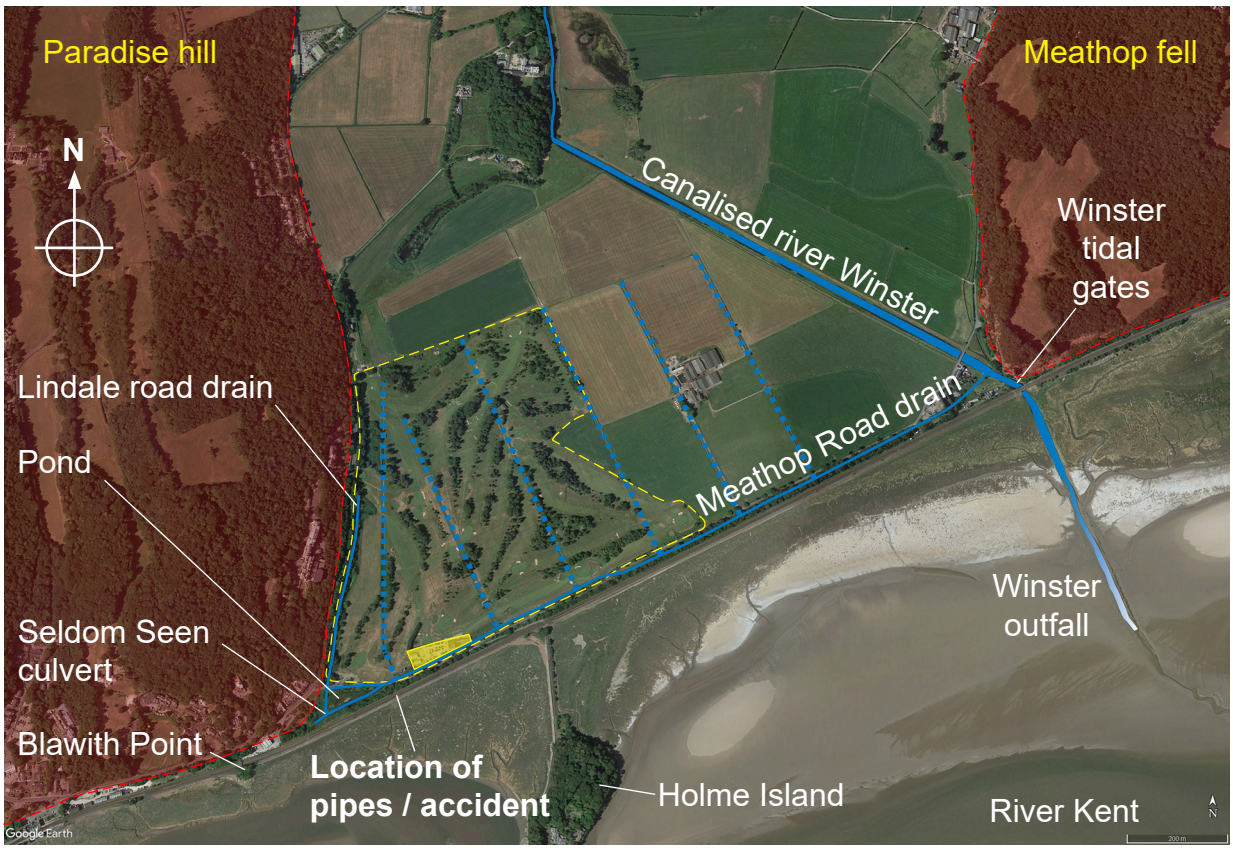

Figure 3: Main features at point of derailment. The golf club is highlighted in yellow, with the club house and car park indicated by a yellow box. The main watercourses are depicted as solid blue lines, with minor water courses shown as dotted blue lines.

9 A golf club and several farms are located on land to the north of the railway. The land, bounded by Meathop fell to the east and Paradise hill to the west (figure 3), was reclaimed from the sea as part of the railway's construction in the 1850s (see paragraph 32). Consequently, the land has several drainage features intended to keep it clear of water:

- The golf club and the farms include drainage channels which transport water from the land and discharge it into Meathop Road drain.
- Meathop Road drain runs parallel to the railway at the foot of the landward side of the embankment. Water entering the drain east of the golf club discharges into the River Winster close to Meathop fell. Water entering the drain west of a peak in the drain bed, close to the golf club's car park, runs west to a pond.
- The River Winster runs from north-west to south-east crossing the railway at Bridge 16, close to Meathop fell. The railway bridge is fitted with tidal gates to allow water to flow out of the River Winster, and to prevent the tide from flowing back up the channel and flooding the land.
- Once past the railway, the River Winster runs through a channel on the sand and across the bay, until it reaches the River Kent. This channel is guided by rock armour walls, consisting of large boulders bounding the channel, and is referred to as the Winster outfall.
- Lindale Road drain runs from north to south at the foot of Paradise hill. This drain also discharges into the pond.
- The pond is located at the foot of the landward side of the railway embankment. Water entering the pond can discharge to the west as far as Seldom Seen culvert.
- Seldom Seen culvert is intended to take water from the landward side of the railway out into the River Kent. The culvert's outlet is fitted with a non-return tidal flap to prevent sea water coming back through the culvert. The outlet is currently buried under sand, holding the flap closed. The culvert is named after a limestone outcrop located close to the culvert's historical discharge point.

10 To the south of the railway is Morecambe Bay. Morecambe Bay is an important environmental site and carries the following environmental designations:

- Site of special scientific interest (SSSI): this designation is awarded to sites that are of particular interest to science due to the rare species they contain.
- Special area for conservation (SAC): this designation protects one or more habitats and/or species.
- Special protection area (SPA): this designation protects habitats for birds.
- Ramsar site: this designation protects wetland habitats of international importance under the 1971 Ramsar convention.
- Area of outstanding natural beauty (AONB): this designation protects areas of the countryside due to their significant landscape value.

11 The River Kent runs into Morecambe Bay at its north-east limit. This river is important in controlling the migration of the sand in the north-east portion of the bay. Historically, the position of the River Kent moved from north to south, and back again. This washed away the sand and salt marsh on the side of the bay which encountered the river and allowed for the build-up of sand and salt marsh on the other side of the bay. Since the 1850s, engineered modifications to the landscape around the bay have impacted this natural process of accretion and attrition, and the River Kent has been running in its current position (on the south side of the estuary) since the 1950s.

Organisations involved

12 Network Rail owns, maintains, and operates the railway infrastructure in the Grange-over-Sands area, which is on its North West route. This route is part of Network Rail's North West and Central region. Network Rail also employs the track maintenance workers, engineers, controllers, and signallers involved in the accident.

13 Northern Trains Ltd, which trades as Northern, operated the train and employs the drivers and guards involved in the accident.

14 Colas owns and operated the tamper (see paragraph 22) involved and employs its crew.

15 Grange-over-Sands golf club operates an 18-hole parkland course overlooking Morecambe Bay. The golf course has experienced extensive flooding for decades and the club is heavily involved in trying to seek resolution to the management of flood water at this location. The golf club also operates pumps to manage flooding at this location (see paragraph 61).

16 The Lynster Farmers' Group (LFG) is a limited company formed in July 2023 by local landowners which is seeking to prevent flooding in the Lyth and Winster catchment areas.

17 Westmorland and Furness council is a unitary authority, holding the responsibility of both a county council and a district/borough council (since the creation of the railway there have been a number of councils with responsibility for this area, so the report will refer to the relevant council of the time as 'the council'). The council, as the lead local flood authority (LLFA) has discretionary powers to manage flood risk from ordinary watercourses (all those not designated main rivers) and from surface water. Land and property owners, however, have the main responsibility for safeguarding their land and property against flooding. The council is also the landowner for the foreshore adjacent to the railway, meaning that it has a legal duty to safeguard its land against flooding. This includes accepting water from land upstream which, in this case, is the water that reaches Seldom Seen culvert. The council is also the designated highways authority responsible for Meathop Road.

18 The Environment Agency (EA) is an executive non-departmental public body, sponsored by the Department for Environment, Food & Rural Affairs (DEFRA). EA is responsible for managing flood risk from all designated main rivers and the sea. In the same way as for the LLFAs, EA's powers to manage flood risk are discretionary. EA also issues permits that are required to undertake any work to main rivers which may impact on flood risk. At this location, the River Kent, River Winster, Meathop Road drain, Lindale Road drain and the channel from the pond to Seldom Seen culvert and into the bay are designated by EA as main rivers.

19 The Marine Management Organisation (MMO) is an executive non-departmental public body, sponsored by DEFRA. MMO is responsible for, among other things, permitting activities in protected marine areas up to the mean high-water springs (MHWS) line (the average throughout the year of two successive high waters in a 24-hour period when the tidal range is at its greatest (spring) tide). The UK government's MAGIC (Multi Agency Geographic Information for the Countryside) map, used for environmental planning, shows that, on this basis MMO's jurisdiction extends to a point 10 metres from the outlet for Seldom Seen culvert. Any excavation aiming to maintain a channel to the River Kent from this outlet would therefore require MMO permits.

20 Natural England is an executive non-departmental public body, sponsored by DEFRA. Natural England is the government's adviser for the natural environment in England. Its main purpose is to ensure that the environment is protected and to support the delivery of the government's 25-year plan to improve the environment.[1] Natural England has statutory duties and general responsibilities in relation to SSSIs and stated that it is required to assess whether activities would have an adverse effect on the integrity of such sites. Natural England is a statutory consultee to any permitting activities undertaken by EA or MMO at this location.

Train involved

21 The train which derailed in the accident (figure 4), reporting number 2C37, was the 05:18 passenger service from Preston to Barrow-in-Furness. The train was the first service to pass through the area of the embankment damage (on either line) on the morning of the derailment. Train 2C37 was made up of two 3-car class 195 units coupled together, making a total of six vehicles. Class 195 trains are a type of diesel multiple unit from the Civity family. It was manufactured by CAF and is owned by Eversholt Rail Leasing Ltd. The train was fitted with an on-train data recorder (OTDR) and forward-facing, rear-facing, and bodyside mounted closed-circuit television (CCTV) systems.

Rail equipment involved

Tamper

22 A tamper is a type of on-track machine (OTM) which restores the vertical (height) level and horizontal (lateral) alignment of the railway track. When undertaking routine maintenance tamping, the machine first passes over the work site and measures the track to calculate what adjustments need to be made; this is known as a measurement run.

23 The tamper then returns to its starting position and repeats its movement through the work site on a treatment run. During a treatment run, it uses large forks called tines to pack the ballast under the railway sleepers to adjust the level and alignment of the track (figure 5).

[1] https://assets.publishing.service.gov.uk/media/5ab3a67840f0b65bb584297e/25-year-environment-plan.pdf.

Figure 4: Train 2C37 following the derailment.

Figure 5: Tamper tines (circled) on the tamper involved in the accident.

24 The tamper which struck the pipe, train reporting number 6J87, was being used for routine track maintenance (figure 6). This tamper requires a three-person crew to operate it, comprising of one supervisor and two operatives. The OTM supervisor sits in the cab of the machine looking in the direction of travel. The operatives sit in the middle of the machine facing backwards and operate its tines. This tamper is also fitted with a welfare area, for staff not directly involved in the tamping operation and for the crew to take breaks.

Figure 6: Tamper 6J87 which struck the pipe.

25 In addition to the crew of the machine, a tamping operation requires a track quality supervisor (TQS). A TQS is Network Rail's representative during the work. They set the required objective which the machine operators should achieve and retain responsibility for the track, including ensuring it re-enters service in a safe condition.

Radio systems

26 On the mainline railway network in Great Britain, train drivers communicate with signallers using GSM-R radios fitted to their trains. A feature of the GSM-R radio is the ability to send a railway emergency call (REC). When a REC is sent, by pressing a distinctive button on the radio terminal, an alarm is sounded on all nearby radios and in the relevant railway control room and signal boxes. This alarm instructs drivers to stop their train and await further instructions from the signaller.

Staff involved

27 There were two drivers in the leading cab of train 2C37 during the accident, a trainee and an instructor. The trainee driver was at the controls of the train during the derailment. The trainee driver starting driving trains in November 2023 and had previously completed trips over this route with a different instructor. The instructor driver had 5 years' experience driving trains, always with Northern, and had qualified as an instructor shortly before the accident. The way in which the train was driven had no bearing on the accident.

28 There were two TQSs involved in the working of the tamper on different nights in the area of the derailment. TQS 1 worked full-time in the TQS role, was based at Carnforth maintenance delivery unit and had around 37 years' experience working in track management in this area. TQS 2 was based at Preston maintenance delivery unit and had around 11 years' experience working in track management. Although fully qualified to carry out the role of a TQS, TQS 2 normally carried out other duties relating to the management of track. TQS 2 had not previously worked in the Grange-over-Sands area and was unfamiliar with the track layout and infrastructure at this location.

29 The incident controller (IC) involved in the management of the report of a damaged pipe was based at Manchester rail operating centre (ROC). The IC had 20 years' experience in this role and before that had worked as a signaller for 15 years. The IC is supported in their duties by an incident support controller (ISC).

30 The senior asset engineer (SAE) involved in the management of the report of the damaged pipe was based at a Network Rail office in Manchester and had 12 years' experience in managing structures in Cumbria. It is part of the SAE's normal duties to be on an on-call roster to provide technical assistance to controllers managing faults and incidents outside of office hours.

External circumstances

31 Sunrise on the morning of 22 March 2024 was at 06:05. This is also the approximate time at which train 2C37 derailed and CCTV footage shows that it was light at the time of the accident. The nearest Met Office station, at Silverdale, around 6.3 km from the accident site, recorded at 06:45 that it was 7 degrees Celsius with a 6.5 km/h wind blowing from the west. The weather station also recorded some light rain at the time. There is no evidence that external circumstances played any part at the time of the accident.

Background information

Historical management of flood water at this location

32 Before the construction of the railway in the 1850s, the land to the north (now comprising the golf course, cottages, and farmland) formed part of the bed of Morecambe Bay or was marshland. The reclamation of this land formed part of the plan to fund the railway's construction.

33 The Ulverstone[2] and Lancaster Railway Act was passed in July 1851 and provided the legal framework for the building of the railway. The Act made several specifications on what was to be constructed as part of the railway. One such specification states:

> *'the said Company shall form in the Embankment or Viaduct for carrying the said Railway across the Winster Bay not less than Four Openings, of Twenty Feet wide each, for the free Ingress and Egress and Scour of the Tides and Flood Water, with a clear Head-way under each of the said Openings of not less than Ten Feet each, between High-water Mark of ordinary Spring Tides and the Soffit of the said Embankment or Viaduct.'*

34 The construction was split into 10 sections, with section 4 including Meathop embankment (running from Blawith Point to Arnside viaduct). Preparation works for the construction of the embankment started in May 1852. These works diverted the River Winster from its previous bed, with an outfall between Holme Island and Blawith Point, to a straight canal which now passes through tidal flap gates below the railway at the base of Meathop fell (figure 7).

35 Construction of the Meathop embankment, as the embankment involved is known, was completed by March 1855. However, the railway, as constructed, does not have the openings as specified in the Act. There is one culvert at the western end of the bay (Seldom Seen culvert) and a larger river outlet at the eastern end (River Winster viaduct) which is around 14 metres (45 ft) across. In March 1857, the Admiralty sent an investigator to Cumbria to call public meetings and hear complaints from local residents about the construction of the railway impacting the tide and sands in the bay. Records suggest that, although residents raised issues with the railway at Arnside and Ulverston, there was no complaint regarding the impact of the section across the Winster bay. The railway opened to passengers in August 1857.

36 By May 1874, the railway had to make significant modifications to the constructed drainage arrangements near the embankment by signing agreements to construct a boulder wall to route the River Winster's outfall over the sand to join with the River Kent. This probably indicates that the installed drainage was not wholly effective at this time.

[2] Previous spelling of Ulverston retained here as this remains the name of the Act.

Figure 7: Tidal gates on the River Winster.

37 By August 1899, the railway was entering into further legal agreements to change how drainage should be managed on the landward side of the railway. An agreement was reached that the railway would no longer have to maintain Seldom Seen culvert. In exchange for this, the railway would take responsibility for maintaining Meathop Road drain from where it crosses Meathop Road (approximately 340 metres east of the golf club) to where it joins the canalised River Winster. In February 1902, the council bought the foreshore from the Duchy of Lancaster, including the outfall for Seldom Seen culvert.

38 The golf club opened in its current location in 1919. The club made attempts to reopen Seldom Seen culvert's outlet in the 1950s and 1960s in response to regular flooding of the course in winter months. This outlet was excavated on at least three occasions, possibly more, but on each occasion quickly silted up. In April 1970, British Rail (at that time the owner and maintainer of the railway) wrote to the golf club stating that it was not the railway's responsibility to maintain the outlet of the culvert, as this responsibility would be assigned to the owner of the foreshore, but at that time the owner of the foreshore was considered to be unknown.

39 During the 1950s, the River Winster developed a preferential path along the seaward side of the embankment, joining the River Kent near Holme Island. In 1964/65, the boulder wall was extended to push the River Winster out to join the River Kent opposite where it exited the tidal gates. This extension was apparently not wholly effective as it was further extended in 1973/74. There is evidence of serious flooding to the land north of the railway around this time.

40 In June 1971, the golf club entered into an agreement with the railway to install a permanent pipe through the embankment and create a sump adjacent to the foot of the embankment on the landward side. This was a metal pipe, buried deep in the embankment and surrounded by concrete armour. The associated pumping station, operated by the golf club, became fully operational in early 1972 and golf club records show that this arrangement was, at that time, effective in removing water from the course.

41 In the 1990s, the boulder wall for the River Winster was partially removed on the western side. RAIB has been unable to determine with any certainty who did this or why. By May 2021, the river breached the eastern side of the boulder wall and created a weir. This weir slowed the flow of the water which favoured further deposition of sediment in the main channel. A study by Nottingham Trent University in May 2023 found that the main channel was now blocked by a rising bank of silt in the river located about 400 metres from the railway embankment on the beach.

42 By April 2015, the permanent pipe was no longer effective in controlling the increasing amount of flood water (see paragraph 138). As a result, the first of a series of monthly local flood response meetings took place, organised and chaired by the golf club. Attendees to these meetings included Network Rail, EA, local residents and the National Farmers Union.

43 In July 2015, the local MP wrote to the chief executive of Network Rail requesting a timely resolution to the flooding problems in this area, giving particular consideration to dredging the River Winster and replacing the tidal gates. The Network Rail route managing director for North West route responded and explained that Network Rail was seeking to understand the cause of the flooding and had gone out to tender for a consultant to carry out a full investigation. The reply noted that any resolution would be complicated by the environmental protections afforded to Morecambe Bay and would require support from various other parties to secure the permits required for any works.

44 In July 2015, Network Rail reported to the monthly flood response meeting that it would be prepared to fund a one-off dredge of the River Winster, but only if it could be demonstrated to be a sustainable solution. Network Rail was also able to report that it had commissioned contractors to find the outlet for Seldom Seen culvert but that the contractors had been unable to do so. At this meeting, Network Rail agreed to contribute towards the golf club's pumping costs until the report it had commissioned regarding the cause of the flooding was delivered.

45 In August 2015, the local MP again wrote to the chief executive of Network Rail stating that the tidal gates were defective and were allowing the tide to come up the Winster channel and flood the land. Network Rail replied to say that it had investigated and found the tidal gates to be working correctly, but that it was aware of the flooding at this location and was having monthly meetings with local stakeholders to seek a resolution (paragraph 42).

46 Also in August 2015, Network Rail reported to the monthly flood response meeting that it had obtained a quote for dredging the River Winster but, due to its belief that this would not deliver long-term benefit, dredging would not be pursued and that it would wait for the consultant's report. Network Rail explained that it could not take the lead resolving the wider flooding problems due to a lack of expertise in this area. By the time of the December flood response meeting, Network Rail reported that the remit had been issued for the consultant's study and a report was due by July 2016. During the meetings in 2016, there was increasing discussion that more pumps needed to be installed.

47 In May 2016, a Network Rail drainage engineer wrote to Network Rail's legal team to advise that they ought to make provision for a second pipe across the embankment at this location. Network Rail's legal team advised that they would be happy to allow this additional pipe to be installed, at no cost to the golf club.

48 On 20 June 2016, the Network Rail drainage engineer recorded that Network Rail could install pipes between the sleepers to increase pumping capacity for moving water over the embankment. On 23 June, the drainage engineer met with Network Rail's works delivery team to discuss installation and by 24 June the temporary pipe, which was later struck in the accident, was installed. At an unknown date, but before November 2016, a second temporary pipe was also installed.

49 The consultant's report commissioned by Network Rail was delivered in November 2016. This report found that:

- Sediment in the River Winster on the seaward side of the railway was preventing water from freely discharging and was generating increased river levels on the landward side of the railway.
- The hydraulic gradient of Meathop Road drain is generally very low and the level of the bed of the drain inhibits the western end of the Meathop catchment from draining (under gravity) towards the River Winster.
- Elevated levels of the River Winster above the outlet of Meathop Road drain prevent the drain from discharging at all.
- Limited storage capacity in Meathop Road drain and the problems with flow cause regular flooding.

Modelling completed as part of this report also identified that both the River Winster and Meathop Road drain would be expected to flood in all rainfall events greater than a 1 in 5 year return period.

50 The report identified that this would not be a simple problem to solve. With regards to managing the River Winster outfall, the report noted that tidal waters would always impact the river's ability to discharge at high tide, so opportunities for the river to discharge at low tide should be maximised. The report identified that any permanent engineering solutions, such as pumping or a long pipe out to the River Kent, would likely be overwhelmed by an influx of sand at some point and are unlikely to be viable in the long term. The report considered maintenance-based solutions, such as dredging the River Winster's channel, but concluded that this was also unlikely to be sustainable in the long term as it would be expected to refill with sand within a relatively short timescale.

51 The report looked at possible solutions to the flooding occurring from Meathop Road drain. It concluded that even if the level of the River Winster was lowered the drain would not be able to fully discharge into the river under gravity alone, and although the flooding would be reduced, it would not be eliminated. The report concluded that the flooding associated with Meathop Road drain could be reduced by increasing the pumping capacity near the golf club. Reopening Seldom Seen culvert was considered, but it concluded that the level of maintenance required to keep both the culvert and its outlet free of sand would likely be cost-prohibitive.

52 Due to damage to one of the tidal gate's hinges, and in an attempt to resolve the issue with flooding, Network Rail replaced the River Winster gates in 2017/18. The gates were replaced with a modern top hung design, as opposed to the previous 'barn door' style gates.

53 In 2020, the golf club funded an excavation of the outlet at Seldom Seen culvert under a licence issued by the council. A 70-metre channel was created from the outlet and the culvert was cleared of sediment by golf club contractors. The golf club contractors also fitted a new non-return valve to the seaward side of the culvert, and a metal grill on the landward side to protect the culvert from becoming blocked again. This excavation was effective in discharging water over the summer months, but by autumn/winter 2020 the channel had blocked up again (figure 8). This was similar to the experience of those trying to maintain the channel in the 1950s/60s (paragraph 38).

Figure 8: The outfall to Seldom Seen culvert pictured 3 to 4 months apart around May to September 2020 (courtesy of Westmorland and Furness Council).

54 In November 2021, the golf club approached EA and Natural England for consent to try to clear the channel for Seldom Seen culvert a second time. A multi-agency meeting was convened. During the meeting, Natural England explained that it would not support another clearance of the channel because, during the previous clearance, the excavated sand and silt had been left adjacent to the channel and damaged the salt marsh habitat. Although Natural England does not have permitting powers, it is a statutory consultee to MMO and EA both of which do have permitting powers, and hence securing Natural England's support is an important step in obtaining a permit. At the November 2021 meeting, MMO stated that it believed the planned works would be above the MHWS line (which can move over time) and therefore it had no jurisdiction over the channel. However, MMO stated that it is up to the applicant to decide if a marine licence is required or not.

55 In February 2022, the golf club made an application to EA for a permit to excavate the channel. This was granted with restrictions that the excavation must not exceed 30 metres in length or 8 metres in width. The permit also required that the excavated material should be transported to the deep-water channel to allow it to be naturally dispersed. The excavation started in April 2022, but it quickly became apparent that this work would not be successful, as the tracked dump truck could not safely reach the main channel to dispose of the spoil, so work was stopped.

56 In June 2022, the golf club made a third attempt to reopen Seldom Seen culvert. In November 2022, a consultant acting on its behalf made a variation request to EA for an extension to the existing permit and to allow a 73-metre channel to be excavated. A permit variation was granted in February 2023, but only to 50 metres from the outlet. This is because EA would no longer classify the channel as a main river beyond that distance. EA advised the golf club that an MMO permit would be required for the last 23-metre section of channel proposed to be excavated. The golf club already held a self-service MMO licence allowing it to remove up to 500 m^3 of material from the bay. The golf club considered this adequate to manage the excavation of the last 23 metres of channel. However, MMO informed the golf club that a self-service licence does not allow for dredging and disposal, so the golf club would be required to apply for a band-3 marine licence. A band-3 marine licence cannot be obtained through the self-service portal and is for activities which require a more in-depth consideration by MMO before approval.

57 After a meeting chaired by the local MP, MMO advised that, although it believed that the scope of the project required a band-3 marine licence, it was the applicant's responsibility to decide what type of licence was required. The golf club satisfied itself that a self-service licence was in fact sufficient and the works started without the band-3 marine licence in place.

58 On 28 March 2023, excavation of the channel began. Although the culvert outlet was located and water did drain out, the golf club's consultant assessed that the water in the excavated channel settled higher than the water on the landward side of the culvert. The consultant's conclusion mirrored that of the earlier Network Rail report. This was that, due to a rise of ground level on the seaward side of the railway, a gravity-powered drainage system for Seldom Seen culvert was not a reasonably practical solution to install and maintain.

59 Following this conclusion, and in the light of the peak in the bed of Meathop Road drain (paragraph 49), the only way to get water away from the western side of the catchment was to pump it through the pipes installed in and on the railway embankment.

60 In June 2023, the council relocated one of its flood response pumps to the golf club and agreed to fund the fuel for this pump. The council decided on 2 January 2024 to withdraw this support at the end of the financial year due to the significant costs involved. The pump supplied by the council was in addition to a pump which Network Rail had been supplying intermittently to the golf course on request. This had been supplied on at least six occasions since 2017. Although the pump supplied by Network Rail was capable of operation at the time of the accident, and had previously been connected to one of the temporary pipes, it had not been used for pumping water since before 6 March 2024 (more than 2 weeks before the accident).

61 There are no specific records about what pipe was connected to which pump at any given time (see paragraph 116) and golf club staff generally used the pipes and pumps in the way they thought best to protect the land north of the railway. However, RAIB has established that the arrangement of the pumps and pipes at the time of the accident was as follows (figure 9):

- A diesel pump owned by the golf club which was unserviceable and stored in the car park (the red pump in figure 9). RAIB has not been able to determine with certainty when this pump arrived at the golf course or how long it was in use for.
- A pair of electric pumps in a pump house which had not been used since around 2020 due to the rising cost of electricity. RAIB has not determined when these pumps were installed, but they were not connected to any of the pipes and therefore not directly relevant to this accident.
- A diesel pump rented by Network Rail on behalf of the golf club (paragraph 60) which was physically connected to the permanent pipe installed by British Rail (paragraph 40). This pump was not in operation when the accident occurred (paragraph 60).
- A diesel pump provided by the council (paragraph 60) which was connected to the first temporary pipe installed by Network Rail. This was the pipe that was damaged by the railway maintenance activity (paragraph 5). The consequent leak created the void that led to the accident (see paragraph 115).

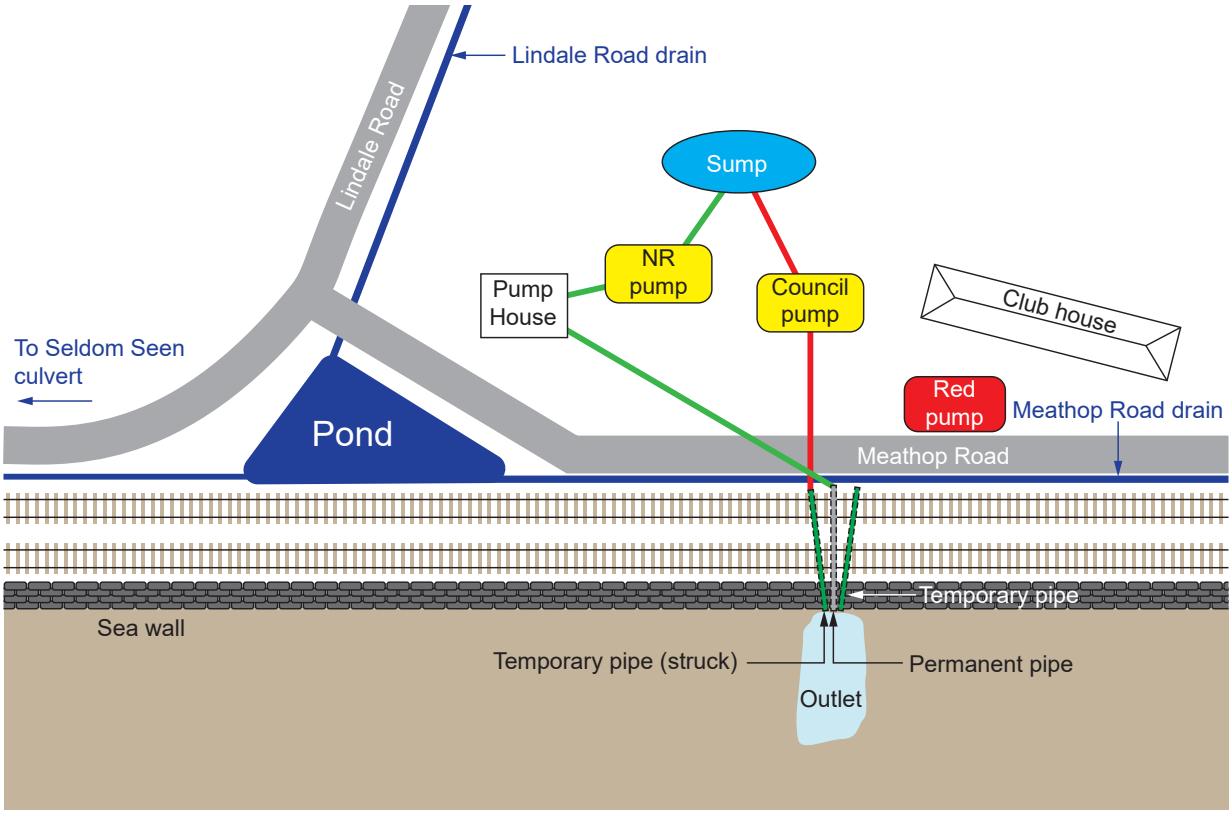

Figure 9: The pipe and pump arrangements at the golf club as discovered immediately after the accident.

The sequence of events

Events preceding the accident

62 On 6 March 2024, a representative from the golf club emailed the SAE to advise Network Rail that the golf club no longer needed the pump that had been provided by Network Rail to control the flood water levels, as the pump that the council had provided would be sufficient. The following day, the SAE contacted the Network Rail contractor from which the pump was rented to arrange for the pump to be collected. Unbeknown to the SAE, although the pump was off-hired, it remained in place at the golf club as the contractor had not collected it by the time of the accident.

63 On the night between 18 and 19 March, TQS 1 completed a routine maintenance tamp on the Up Main line during an engineering possession.[3] This tamp overlapped the location of the planned tamp on the down line for the following night. After the accident, TQS 1 stated that, while marking obstructions with spray paint ahead of the tamping of the Up Main line, they also marked the pipe, all the way across the Down Main line where it was subsequently struck during tamping in the early hours of 20 March.

64 Late in the morning of Tuesday 19 March, TQS 1 reported to the assistant track maintenance engineer (ATME) in Carnforth that they were unable to attend duty that night due to sickness. The ATME attempted to find a replacement TQS by contacting other ATMEs on the route. The ATME at Preston delivery unit was able to offer TQS 2 for that evening. Because TQS 2 had not worked in the Grange-over-Sands area before, the ATME from Carnforth arranged for a member of the track team to join the tamping team for the work and carry out the role of controller of site safety (COSS). This is because a person is required to be familiar with the location when carrying out the role of COSS, but not the role of TQS. In most circumstances, the roles of COSS and TQS are carried out by the same person. The COSS was also listed as the person in charge (PIC) on the safe system of work pack. A PIC holds overall responsibility for the safety and performance of a task group, including handing back the railway line in a condition to accommodate rail traffic.

65 At around 22:30 that evening, TQS 2 arrived at the car park at Grange-over-Sands station and met the group who would undertake the tamping work. This included an apprentice, the COSS, and the tamper crew. The group received a safety brief from the COSS at around 22:40 and then started working with the tamper. The team first conducted a measurement run with the tamper, from west to east, on the Down Main line. During this run, the tamper crew, who had worked with TQS 1 the previous night, told TQS 2 that there were some pipes in the area to look out for during the treatment run.

[3] During an engineering possession the railway line is closed to normal rail traffic to allow for maintenance and renewal activities to safely take place.

66 Once the measurement run had been completed, the tamper returned to the west end of the work site and then started the treatment run from west to east. TQS 2 walked ahead of the machine with the apprentice to look for the pipes that they had been warned about. However, they did not find them. At around 01:30 on Wednesday 20 March, the COSS, who had been sitting in the welfare area of the tamper, called TQS 2 to say the tamper had struck a pipe.

67 TQS 2 reported this to the operations delivery manager (ODM), a Network Rail employee who manages engineering possessions. The ODM in turn called Manchester ROC at 01:46 to let the IC know to expect a call from site because the tamper had struck a pipe. During this call, the ODM twice told the IC that someone needed to be sent to site to assess the asset because, although the site team was reporting a "trickle" of water escaping from the pipe, this was a subjective assessment.

68 Between 01:50 and 02:15, over a series of phone calls, TQS 2 reported to the IC that they had hit a pressurised water pipe. During the conversation, the IC sought confirmation that the track was not flooded, and water was not dislodging ballast. TQS 2 provided a photo of the struck pipe by email and in return was given a fault reference number (see paragraph 122).

69 At 02:22, the IC phoned the on-call manager, who happened to be the SAE with responsibility for this asset, to seek technical assistance on how to resolve this issue. There was no answer, so they left a voicemail. This was followed up by an email from the IC to the SAE.

70 The tamping work was scheduled to be completed by 04:50 and the railway line was handed back on time. As part of the handback process, the PIC confirmed that the line was safe to accept rail traffic, via an engineering supervisor, to the person in charge of the possession (PICOP) who ultimately passed on this declaration to the relevant signaller. As the staff involved in hitting the pipe did not believe that the volume of water being discharged presented a risk to the railway, and they had reported the water discharge to the ROC, they did not stop the railway from reopening.

71 At 05:27, the SAE called Manchester ROC back and spoke with the ISC, explaining that they had mistakenly left their phone on silent. The ISC had not previously been dealing with the incident, but the SAE explained that they were aware of the pipe and that it was not connected to a pump. The SAE said that they would arrange a repair of the damaged pipe.

72 The following day, Thursday 21 March, at 07:18 the SAE made an internal request to instruct contractors to replace and relay the pipe at a greater depth to prevent it from being struck again.

Events during the accident

73 At 05:18 on Friday 22 March 2024, train 2C37 left Preston on time heading towards Barrow-in-Furness.

74 At 05:52, the signaller at Grange-over-Sands signal box arrived for a duty scheduled to start at 06:00. Grange-over-Sands signal box is normally switched out overnight, so the signaller spoke to the signaller at Ulverston at 05:54 to request permission to switch in. The Grange-over-Sands signaller was told that as signalling permissions had already been granted for trains to move on both lines between Ulverston and Arnside signal boxes, the Grange-over-Sands signaller would need to wait for the trains to clear the signalling section before switching in.

75 At 06:05, CCTV images from a nearby builders' merchant show the leading three vehicles of train 2C37 derailing to the left close to the location of the temporary pipes. As the train ran derailed, it damaged mechanical signal wires associated with Grange-over-Sands signal box. This caused signals GS7 on the Down Main line and GS13 on the adjacent Up Main line to change from a proceed indication to a danger (stop) indication. The leading vehicles ran derailed for approximately 184 metres before coming to a stand with the trailing end of at least one vehicle ending up foul of the adjacent Up Main line.

76 During the derailment, the train sideswiped the parapet wall on the seaward side of the embankment, knocking masonry down onto the beach and causing significant damage to the train. During this collision, the train lost power to its leading cab. This affected safety systems such as the GSM-R radio and the headlights, which immediately went out.

77 Witnesses from the golf club reported that during the accident they saw an "explosion" of water erupt from the railway embankment and drain into the pond adjacent to the golf club.

Events following the accident

78 Immediately following the accident, the two drivers attempted to contact the signaller using the GSM-R radio in the front cab to protect the line and ensure that no trains passed on the adjacent track. Because of the loss of power in the leading vehicle, the drivers were unable to contact the signaller.

79 After unsuccessfully attempting to turn the leading cab back on, the drivers decided to go back through the train to attempt to use a GSM-R radio in one of the other cabs. Internal CCTV from train 2C37 shows them arriving in the rear cab of the first unit at around 06:07. Recorded voice communications indicate that the driver instructor made a REC to the Arnside signaller shortly after arriving in the rear cab. This REC was also broadcast at Manchester ROC, allowing controllers to start the incident response and call the emergency services.

80 The signaller at Grange-over-Sands signal box had witnessed the accident but was unable to take action because the box was switched out. The Grange-over-Sands signaller therefore contacted the signaller at Ulverston signal box to hold the next train on the up line (train 1Y91, which was due to pass the accident site shortly after 06:24).

81 After the derailment, but before 06:30, golf club staff stopped the pump which was supplying water to the pipe.

82 By 06:35, Cumbria fire and rescue service had arrived on site and had removed the four passengers travelling on the train, all of whom were uninjured.

83 RAIB was notified of the accident at 06:50 and immediately deployed a team of inspectors who arrived on site at 11:20.

84 Following extensive repair work, the line was reopened on 22 April 2024, around 1 month after the accident.

Analysis

Identification of the immediate cause

85 Train 2C37 derailed because it ran over a length of unsupported track.

86 Following the derailment of train 2C37, a large void was discovered behind the train. The void at its largest dimensions was approximately 14.5 metres long, 4.2 metres wide and 2.5 metres deep (figure 10).

87 Footage from train 2C37's forward-facing CCTV system shows that, as the train approached the point of derailment, the track appeared to be intact and there was no visual clue that a void existed beneath it.

88 After the accident, no marks were found on the track leading up to the site of the derailment which suggest that the train was running derailed before the void was reached. CCTV footage from a nearby builders' merchant also shows the derailment occurring in the vicinity of the void and witnesses onboard the train reported that they felt the void open under the train before it derailed. There was also no indication on the CCTV footage or OTDR data downloaded from the train of any derailed running before the site of the void. RAIB has therefore concluded that the derailment occurred because track support was lost when the train passed over an unseen void in the embankment.

Figure 10: Void which opened under the track as train 2C37 passed (courtesy of Network Rail, with RAIB annotations).

Identification of causal factors

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

a. Embankment material had been washed away following the continuous discharge of water from a partially buried pipe that had been damaged during tamping (paragraph 90).

b. The void in the embankment was not identified before train 2C37 passed over it (paragraph 131).

Each of these factors is now considered in turn.

The void

90 Embankment material had been washed away following the continuous discharge of water from a partially buried pipe that had been damaged during tamping.

91 The void was created because water had been pumped into the embankment from a damaged pipe for around 52.5 hours before the derailment. The pump's rated capacity shows it could have moved more than 14,000 m^3 of water in this period (approaching the capacity of six Olympic-sized swimming pools). An inspection of the damaged pipe after the accident showed that it had a diameter of 175 mm and that it was damaged by two holes along its length. These had maximum dimensions of 32 x 97 mm and 23 x 91 mm.

92 The size and position of these holes were such that a significant proportion of the water carried by the pipe would have been discharged through them into the embankment. During RAIB's examination of the site of the derailment, the pump was temporarily turned back on for investigative purposes, and a significant quantity of water was observed being forced under pressure out of these holes (figure 11).

Figure 11: Water being sprayed from the damaged pipe during a site test.

93 As was normal at the time of construction, the railway embankment was built from materials which were readily available in the vicinity of the work site. The bulk of the embankment was therefore constructed from beach sand. Sand cannot significantly resist the action of flowing water. This means that the choice of compacted sand as a construction material for the embankment made it inherently vulnerable to being washed away, if enough water was present. In coastal environments, it is foreseeable that a railway embankment may encounter large volumes of water, particularly when the embankment may form part of the sea defences (see paragraph 144).

94 Because of this, three additional layers were applied to the beach sand embankment on its seaward side. From inside to outside, these were respectively puddled clay, quarry spoil (gravel), and a finish of limestone cobbles. The landward side was not waterproofed. The waterproofing of only the seaward side of the railway embankment may have assisted in directing the water towards the landward side and the pond.

95 The water leaking from the pipe generated a failure mechanism within the embankment known as soil piping. Soil piping is a hydraulic process which results in the development of large voids in the subsurface which can eventually lead to ground movement (figure 12).

96 As the water moved through the beach sand that the embankment was constructed from, it began to transport smaller particles through the gaps between the larger particles. As paths developed, the water was able to carry larger and larger particles through these naturally constructed channels, causing them to expand. This resulted in voids forming where the material had been removed by the water, removing support from the track bed. An estimated 80 m^3 (around the same amount as would fill 2.5 x ISO 20’ shipping containers) of material was piped away from the embankment, much of which was deposited in the pond adjacent to the railway.

97 RAIB considered the possibility that the material missing from the embankment had fallen into a naturally occurring fissure in the limestone bedrock, particularly as this had been identified by Network Rail as the cause of a previous void discovered near Grange-over-Sands signal box in 2019. The investigation report commissioned at the time by Network Rail determined that the void had been caused by dissolution of soluble rock and migration of overlying cover soils, with the embankment material being lost into naturally occurring fissures within the limestone. However, following the derailment, the bulk of missing material from the embankment could be found in the pond, and borehole samples showed that the bedrock at this location was 29 metres below ground level. There is therefore no evidence that the material missing from the embankment had fallen into a naturally occurring fissure.

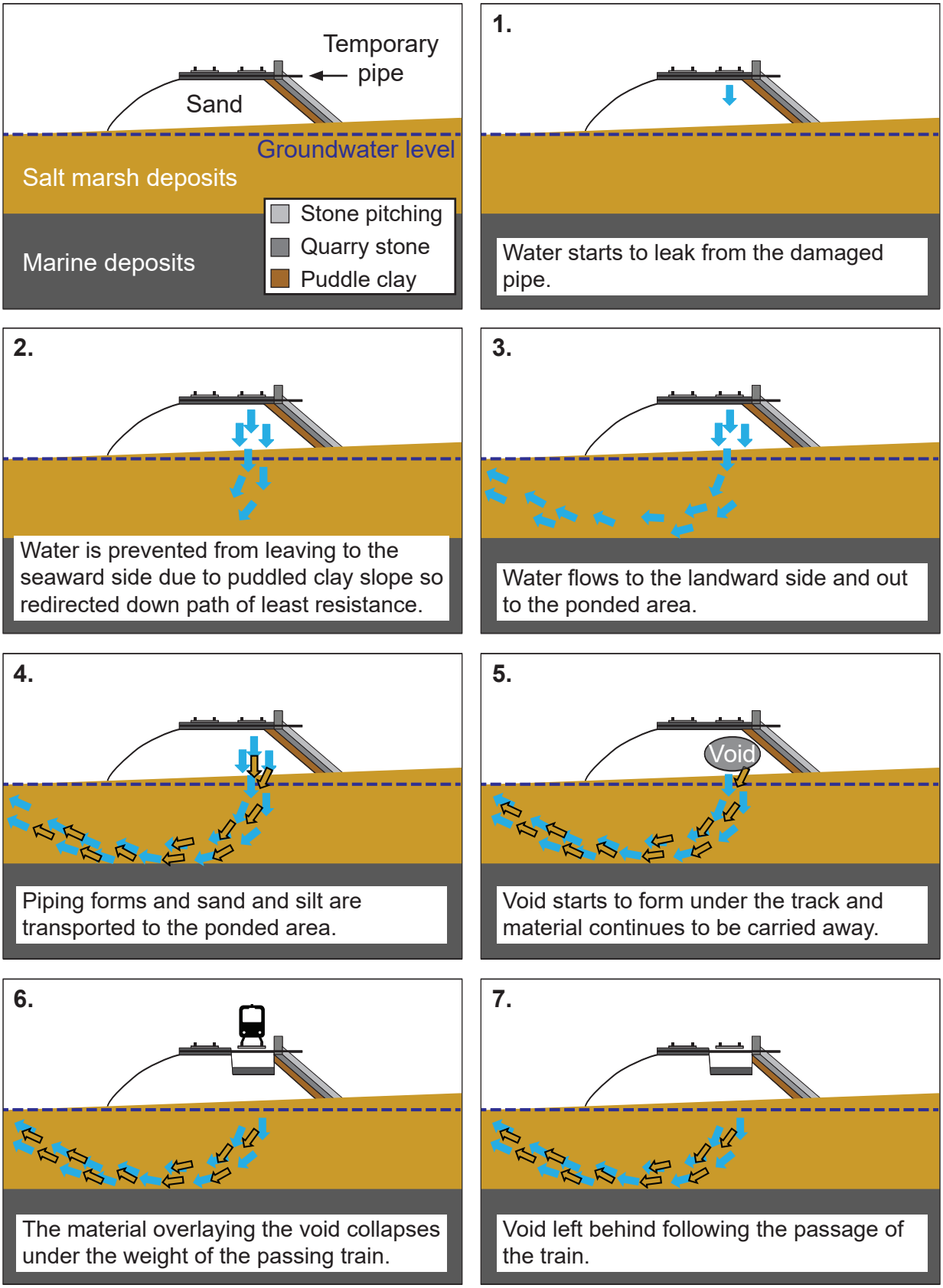

Figure 12: How soil piping affected the embankment.

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

a. The pipe had only been partially buried and this made it more likely to be struck and damaged (paragraph 99).

b. The tamping team was unable to detect the location of the pipe before the tamping tines struck it (paragraph 109).

c. No action was taken to stop the leak once the pipe had been damaged (paragraph 115).

Each of these factors is now considered in turn.

Pipe installation

99 The pipe had only been partially buried and this made it more likely to be struck and damaged.

100 The area 500 mm outwards from the end of each sleeper to a depth of 225 mm beneath the base of the sleeper is known as the 'ballast box'. Network Rail standard NR/L2/INI/CP1030, 'Working safely in the vicinity of buried services', issue 1 dated 1 December 2008, states that, in theory, the ballast box will be free of buried services to allow for track maintenance activities to take place.

101 Network Rail installed the pipe which was struck by the tamper on 24 June 2016 as a temporary measure to reduce the impact of flooding until a permanent solution could be found (paragraph 48). Photographic evidence of the pipe being laid showed that it was installed only partially buried (figure 13) and that it therefore lay within the ballast box. Other images confirm this was still the case at the time of the accident (figure 15).

102 The Network Rail standard carries a warning that there might be exceptions to the ballast box being free of services, and that care is necessary. However, the general assumption during tamping operations is that services will be buried deep enough that the tamper's tines cannot reach them, or that services will be laid on the surface and be brightly coloured to aid identification by a TQS. The exception to this is areas which should not be tamped due to shallow ballast, such as some bridge decks. Areas which should not be tamped should be fitted with a sign to warn the machine operators not to do so.

103 The partial burying of the dark coloured pipe, without any fixtures warning of its existence, contributed to the tamping team not detecting the pipe (see paragraph 109).There was no sign found in the vicinity of the pipes involved in this accident warning that the area should not be tamped, nor any evidence that one had ever been installed.

104 Network Rail has processes for installing both temporary works and permanent works to the rail network which should ensure that standards are complied with. There is only limited evidence available to RAIB which details the installation of the temporary pipes at Grange-over-Sands, with Network Rail being unable to supply a remit, design drawings, risk assessments or a firm date that the pipes were installed.

105 RAIB was, however, able to obtain photographs taken during the installation of the first temporary pipe in June 2016 from a witness (figure 13). This first pipe is believed to be the one which was struck because the joint between the two sections of pipe is located in the four-foot (the space between the running rails) of the Down Main line, whereas the second pipe's section joint is outside of the four-foot.

106 Network Rail engineers initially told RAIB that the first pipe was installed by a Network Rail minor works contractor in November 2016, and provided a remit and photographs to evidence this. However, the remit only asks for provision of a pump and does not mention installing any pipes. RAIB has spoken with this contractor which checked its records, and confirmed it was never instructed, nor paid, to install any temporary pipes at this location. Notably, the photographs taken during the delivery of the pump in November 2016 show two temporary pipes already in place, so the second pipe must have been installed by this time. Based on the available evidence, RAIB believes that the pipes were most likely installed by Network Rail's works delivery team.

107 Witness evidence suggests that the relevant Network Rail standards were probably not applied to the installation of the pipes due to this being deemed as a temporary measure. In addition, there was pressure to deliver rapid improvements following correspondence between the local MP and Network Rail senior leaders in July and August 2015 (paragraphs 43 to 45), along with the monthly meetings with local stakeholders.

108 Following the installation of the pipes, Network Rail recorded them in a local asset management system. This system provides data to a wider Network Rail system called geo-rail infrastructure network model (geo-RINM) and the existence of the pipes was recorded on that system. However, the temporary pipes were not recorded in the hazard directory as required by the relevant standard (see paragraph 113).

Figure 13: Installation of the pipe which was struck by the tamper (courtesy of Network Rail).

Non-detection of the pipe

109 The tamping team was unable to detect the location of the pipe before the tamping tines struck it.

Advance walkouts not completed

110 Network Rail standard NR/L3/TRK/3240, 'Preparation for use of on track machines', issue 2 dated 26 August 2008, gives instruction that a TQS should ensure the work site is marked up no later than 10 days before the planned tamping work during a site visit. Network Rail standard NR/L3/TRK/3241, 'Marking of track for tamping machines', issue 3 dated 7 December 2019, defines the requirements for site marking before tamping operation is to take place. This standard requires obstructions to be marked with a 3-2-1 countdown on approaching sleepers and then 'MISS' marked on the sleeper which cannot be tamped due to the obstruction.

111 An advance walkout did not take place before the tamping operation undertaken on the night of 19 to 20 March 2024. This was because TQS 1 had adopted a practice of undertaking these visits remotely using Automated Intelligent Video Review (AIVR) footage to view the planned work site, supplemented with cab rides where required. Witness evidence was that TQS 1 used this method of work perceiving that they could not get sufficient track access to fully comply with Network Rail's standards due to staff shortages (see paragraph 149). Evidently, it is not possible to spray-mark obstructions while carrying out desk-based site visits or completing the visits from the cab of a passing train. Although members of the management team at Carnforth delivery unit knew that TQS 1 was working in this way, no action had been taken to ensure compliance with Network Rail standards (see paragraph 154).

112 TQS 1 reported spraying a line all the way across the railway marking the location of the pipe during the overnight shift at the same location on the night of 18 to 19 March (paragraph 63). However, CCTV images from a train which passed the area on the Down Main line at 15:25 on 19 March only show the Up Main line as being marked by spray paint. TQS 1 suggested that the paint does not stick well in rain, and that this may explain why the markings were missing from the Down Main line. However, given that the paint remained in place on the Up Main line following the accident, RAIB considers that it is unlikely to have disappeared from the Down Main line only, and that it was probably not applied. The markings that TQS 1 reported spraying on the Down Main line would also not have been compliant with NR/L3/TRK/3241, although the Up Main line was appropriately marked with a countdown on the adjacent sleepers (figure 14).

Pipe not marked on drawings

113 Due to not being familiar with the local area, TQS 2 did not know the location of the pipes before the shift. After the warning by the tamper crew of the presence of pipes during the measurement run (paragraph 65), TQS 2 consulted Network Rail's hazard directory to try to locate the pipes but found that they were not listed. Network Rail standard NR/L2/INI/CP1030 requires that where a buried service is found, installed, or moved it should be added to the hazard directory.

Figure 14: Overview of the site captured by a drone showing the adjacent line marked with a 3-2-1 countdown (courtesy of Network Rail).

Pipe not seen during tamping run

114 The pipe which was punctured was not seen by the tamper team before it was struck by the tamping tines. TQS 2 and an apprentice walked over the pipe and were aware of its existence in the area but did not see it. The OTM supervisor and operative also did not see the pipe as the tamper was passing over it. This was probably because the pipe was dark in colour (paragraph 103), partially buried and had not been marked up in line with the relevant standard (paragraph 112) during an advanced walkout. It was also dark at the time.

Response to the damaged pipe

115 No action was taken to stop the leak once the pipe had been damaged.

116 The golf club did not require any specific permissions from Network Rail to use the pipes and pumps, nor to reconfigure the pumping arrangement. These were used by the golf club as its staff thought best to minimise flooding of the course (paragraph 61).

117 The golf club greenkeepers had been briefed by their managers to keep the pump provided by the council running constantly and it was part of their daily checks to ensure that this pump always had enough fuel in the tank to keep it running overnight.

118 The golf club had not been made aware that the pipe had been damaged by Network Rail, so had no reason to instruct the greenkeepers to stop the pump. The pump was therefore left running until after the derailment, when it was turned off by the golf club staff (paragraph 81).

Ineffective communication

119 The ODM called Manchester ROC at 01:46 on 20 March 2024 and asked if there had been a report from anyone working at Grange-over-Sands (paragraph 67). The IC responded that the TQS had been trying to call the ROC but kept getting cut off. The ODM said that the TQS had reported to them that the tamper had struck and damaged a pipe which was buried under the ballast and not marked on any diagrams. The ODM then suggested that someone needed to be sent to assess the pipe which was "pouring water out into the sea". The IC questioned whether the pipe was flooding the track, but the ODM said that the TQS had reported this as a "trickle". The ODM suggested that a specialist needed to be sent to assess the pipe as a trickle is not a standardised flow amount.

120 By 01:50, TQS 2 had managed to obtain better mobile phone signal and called the IC. TQS 2 reported a "water suction pipe" taking water from one side of the railway to the other. The IC asked how much water was escaping from the pipe, but the question went unanswered, despite the IC having responsibility to lead the conversation effectively and obtain the best information they could from TQS 2. The call ended with the IC asking TQS 2 to provide some general details about the work.

121 At 01:56, TQS 2 called the IC back with the requested details. During the call TQS 2 reported that water was "shooting out from one side to the other", and a "minimal amount of water" was coming out onto the track. TQS 2 then told the IC that it was pressurised water. The IC asked if someone needed to be sent to look at the pipe and TQS 2 said that they did. The IC asked if this could be done in daylight, and TQS 2 said it could as he didn't think it was an urgent fault.

122 At 02:07, the IC called TQS 2 back and requested a photograph of the damage. TQS 2 took a photograph (figure 15) and sent it to the IC. The tamper crew also took a video, which was not sent to Network Rail control, but was later supplied to Colas managers as part of their company report. Although it is not clear that water is being pumped out of the pipe in the photograph, it is clearly visible in the video. During the call at 02:07, the IC asked if it was worth sending someone out immediately, to which TQS 2 responded that the IC should do so. The IC then said if the discharge of water was not flooding the track or dislodging ballast it might not be worth it, and TQS 2 agreed it was not doing either of those things. On reviewing the pictures, the IC remarked that what was happening beneath the ballast was unknown.

123 At 02:12, TQS 2 called the control room but this time the call was answered by the ISC. TQS 2 asked for a fault reference number for their report, which was provided.

124 The IC then attempted to phone the first line on-call manager for this asset group (the SAE in this instance) at 02:22 but was unable to reach them because the engineer's phone had been left on silent mode (paragraph 69). The IC left a voicemail requesting a callback and sent a follow-up email to the SAE explaining that a pipe had been damaged during the tamping operation. However, no mention was made that the staff on site had reported that the water was pressurised, and this information was not included in the railway's control centre incident log.

Figure 15: The pipe after it had been struck by the tamper. This is the image that was provided to the IC at Manchester ROC (courtesy of Network Rail).

125 The ROC's inability to contact the first line on-call manager was not escalated to the second line on-call manager. This was due to the IC believing that the second line on-call manager would not be receptive to being disturbed overnight due to the first line engineer being unavailable, a belief shared by others in the control room.

126 When the SAE woke up for work, they called control back at 05:27. During this call, they spoke with the ISC. The ISC had not handled the initial reports and did not mention to the SAE that the water was pressurised. It is possible that the ISC was not aware of this, particularly as it was not included in the control room log.

Belief that the pipes were not connected to a pump

127 The SAE believed that there was no pump on site when the report of a struck pipe was passed to them from control. This is evidenced by their response to control's early hours email. At 06:38, the SAE responded by email to say that the pipe only ever carries water when it is connected to a pump '*which it isn't at the moment as far as I am aware'*.

128 This belief that the pipe was not in use was due to the fact the golf club had told the SAE on 6 March 2024 that they no longer needed the Network Rail pump (paragraph 62). However, the golf club did make it clear to the SAE in its correspondence that they had another pump in use when they reported that they no longer needed the pump provided by Network Rail.

129 Since the SAE believed that the pipe was not in use, they raised a remit for the pipe to be replaced and re-laid at a greater depth to prevent a reoccurrence but did not arrange any inspection. It is probable that if an inspection of the pipes had been carried out by an individual competent in drainage, then the actual status of the pipe and pump would have been discovered.

130 It is likely that, had the SAE been informed that pressurised water was escaping from the pipe, they would have realised that water was being pumped, and that this could present a risk to the infrastructure. The lack of verbal contact between the IC and one of the on-call managers potentially increased the chances of this information not being fully communicated.

The void remained undiscovered before the derailment

131 The void in the embankment was not identified before train 2C37 passed over it.

132 RAIB analysis of forward-facing CCTV images from train 2C37 and witness accounts show that, as train 2C37 approached the location of the damaged pipe, there were no visual indications available to the drivers that there may be a problem with the track ahead. This was due to the nature of the failure mechanism (paragraph 95).

133 Rail industry data, such as control room logs and signal box train registers, shows that, in the time between the pipe being struck and train 2C37 derailing, there were no reports from drivers of issues with track quality in the area of the derailment. This indicates that the track quality was not being affected to the degree that a driver would notice as their train passed over the site of the later derailment.

134 Train 2C50, the 19:58 Northern service from Workington to Preston, was the last train to pass through the area before the accident on the adjacent Up Main line on 21 March. This train arrived at Grange-over-Sands station at 22:21. Train 1C61, the 19:29 Northern service from Manchester Airport to Barrow-in-Furness, was the last train to pass through the area on the affected Down Main line on 21 March. This train arrived at Grange-over-Sands station at 21:14. Neither train's driver reported any degradation of track quality.

135 Network Rail advised RAIB that at this location basic visual inspections carried out by a patroller on foot have been replaced by inspections carried out by the plain line pattern recognition (PLPR) train. The last time the track was inspected by Network Rail's PLPR train was on 13 February 2024. This train carries specialised onboard equipment to detect track faults, including faults which may occur following movement to the railway embankment. The next scheduled inspection of the track would have been on 13 March, but this train was cancelled due to structural issues with a bridge at Workington, so the inspection was rescheduled to 9 April. The inspection regime for this area allows a maximum of 13 weeks between inspections. Missing one inspection was compliant with standards and would not in any case have detected any relevant issues with the track given that the pipe was not damaged until 20 March. No other track inspections took place between the time the pipe was struck and the derailment.

Identification of underlying factors

Flood risk management

136 The parties involved had not managed flood water in the Winster catchment area effectively, leading to the prolonged need to rely on a temporary pumping arrangement.

137 The management of flood water on the land which was once the Winster bay has been problematic since the early days of the railway (paragraphs 32 to 61). The difficulties associated with large scale changes involving multiple parties with different objectives, without a clear guiding mind, meant that an effective strategy to permanently resolve the issue had not been found before the accident occurred.

138 Although there had been numerous schemes which achieved short-term benefits, it is likely that these schemes were rendered ineffective in the long term, due to an increase in both rainfall volume and intensity since the 1850s, coupled with a change in land management. These issues mean that following rainfall, a larger total volume of water reaches the land side of the railway. This water arrives at the embankment quicker, which means that there is a steeper peak in the water levels than would have occurred in the 1850s.

139 Many areas with pervasive flooding issues manage this through an internal drainage board (IDB) which acts as a guiding mind. There used to be several IDBs in the north-west of England, including one covering the Grange-over-Sands area. However, in the 1970s many north-west IDBs petitioned the regional land drainage committee of North West Water to be abolished and integrated into the main river network managed by the committee. This was largely adopted by North West Water with the last of the IDBs in this region being absorbed in the 1980s. In 1995, North West Water merged with North Western Electricity Board (NORWEB) to form United Utilities. At some point around 2012, EA published a feasibility study for the reintroduction of a drainage board to cover this area which drew some conclusions on where the boundaries of such a scheme should fall. RAIB found no evidence of further action to progress this scheme.

140 EA is responsible for managing flood risk from main rivers (paragraph 18). Its policy is to prioritise funding for flood alleviation schemes based on risk to life and homes. At this location, there are very few homes affected by flooding and the majority of homes that could be affected, a hamlet of cottages close to the River Winster, have already been protected by a scheme implemented in 2018. This scheme introduced sheet piling to protect the Winster embankment due to the risk of catastrophic failure, which may have presented a risk-to-life event.

141 EA stated that, while it provided Network Rail with information regarding the severity and frequency of flooding, it is not responsible for the protection of Network Rail's assets. EA also stated that the drainage of flood water from the golf course was unlikely to meet its prioritisation criteria and that its view was that it had fulfilled its statutory duties regarding the management of flood water in the area.

142 The coast of England and Wales is covered by 20 shoreline management plans (SMPs) produced by coastal groups. Although SMPs are advisory, rather than statutory documents, they set out an agreed 100-year strategy for coastal management, and are based on agreed objectives and technical, economic and environmental assessments. These plans set out one of four high-level options for each section of coastline:

- hold the line – maintain or improve the current standard of protection
- advance the line – move defence alignments seawards
- managed realignment – allow the shoreline to move backwards or forwards, but through a managed approach
- no active intervention – no investment in defences, lets nature take its course.

143 In the case of Grange-over-Sands, the relevant coastal group is the North West North Wales Coastal Group. This comprises local authorities, EA, and other organisations which manage the coastline from Great Orme's Head in Wales to the England/Scotland border on the Solway Firth. The documented strategy for the section of coastline alongside the Meathop embankment, published in February 2023, but covering the period of 100 years from 2010, is to 'hold the line'. In this strategy there is an assumption that the railway embankment will form the sea defence.

144 The assumption that the railway embankment would effectively perform the function of a sea wall holding back the bay is likely to be flawed based on the report provided by Network Rail's consultants in 2016 (paragraph 49). This report notes that the existing embankment and wall constructed along the top were not originally designed as a flood defence, and it is unknown whether the structure could withstand a major tidal event. The report also noted that, based on modelled rising sea levels, the protection afforded by the railway embankment could be reduced so that it could only be expected to protect against a 1 in 25-year coastal surge event by the year 2050.

Management of temporary solutions

145 Network Rail allowed a temporary arrangement to become permanent without applying its relevant processes to manage the asset.

146 Network Rail, facing pressure to increase the pumping capacity, installed the first temporary pipe in June 2016 and the second by November 2016 (paragraphs 48 and 101). At this time, it was envisaged by members of the local group assembled to manage flood water that longer-term solutions would stem from the consultancy report which was delivered in November 2016 (paragraph 49).

147 However, once the report delivered its findings that a permanent solution to the flooding would be very difficult and would require long-term funding for engineered solutions and ongoing maintenance, Network Rail did not proceed further. The available evidence suggests that this was because Network Rail decided it was not the correct organisation to lead the resolution of the wider flooding problems in this area. The temporary pipes remained in place and Network Rail continued to hire a pump on behalf of the golf club on an as-required basis.

148 Network Rail, therefore, had responsibility for around 7 years before the accident for an asset which had not been installed in compliance with standards for either permanent or temporary works (paragraph 107), and was not recorded in the hazard directory (paragraph 113).

Resourcing at Carnforth delivery unit

149 Staffing levels at Carnforth delivery unit did not provide sufficient resilience to cover foreseeable staff absences and allowed a non-compliance with Network Rail standards to become normalised.

150 Before the accident, there had been a vacancy for a second TQS based at Carnforth delivery unit for around 3 years. This was part of the reason that TQS 1 developed the non-standard method of work regarding advanced walkouts (paragraph 111). Following a fatal accident involving track workers at Margam, South Wales, in 2019 (RAIB report 11/2020), Network Rail made changes to how track workers are allowed to access the railway. Before the accident in South Wales, TQS 1 would access the railway with survey teams using protection methods which have since been restricted (such as the use of lookouts). Since this restriction on using lookouts was introduced, survey teams are now protecting themselves from moving trains using other methods such as working 'separated' from trains.

151 As the survey team consists of two people, they can work separated without a site warden. However, if more than two people are working separated then a site warden must be appointed. Because there wasn't a fourth person available to act as a site warden, TQS 1 was no longer able to go out with these teams. Had there been a second TQS in post at Carnforth then they could have acted as a site warden or completed separated site visits with the other TQS as a team of two. As there was only one TQS available at Carnforth delivery unit, there was no resilience in the position, in the event of unavailability. Had there been two TQSs in post, this might have meant that a TQS with local knowledge could have supported the tamping work on 19 to 20 March 2024 (paragraph 113).

152 TQS 2 had volunteered to come from Preston delivery unit to cover TQS 1's shift due to sickness (paragraph 64). A TQS with local knowledge might have been aware of the presence of the temporary pipes, even though they were not listed in the hazard directory.

153 Compounding the resource constraints at the operational level, there had been significant turnover in the management of Carnforth delivery unit in the decade before the accident. Witnesses told RAIB that there have been four track maintenance engineers (TMEs) at the delivery unit during that period. As well as being the line manager for track engineering staff, the responsibilities of a TME include the planning and delivery of work activities and inspection regimes related to the track asset, undertaking technical inspections and monitoring of the track, and undertaking compliance activities in line with Network Rail's assurance procedures. The TME in post at Carnforth when the accident occurred had been in that role for around 12 months and was not aware of TQS 1's divergence from the requirements of the Network Rail standard regarding advanced walkouts.

154 However, the ATME at Carnforth delivery unit was aware that TQS 1 was not conducting advance walkouts. The ATME knew that this method of work was not in line with the required standard but did not challenge TQS 1 about this. Witness evidence is that this was because the method of work being used by TQS 1 was already in place when the ATME arrived on secondment (to cover the incumbent ATME, who was on secondment covering a TME vacancy elsewhere) and the ATME believed it had been authorised by a previous TME.

Observations

Design of class 195 trains

155 The design of the train meant that power was lost to some safety systems within the train's cab following the accident.

156 The derailment sequence led to a loss of power to safety systems in the train's leading cab, including the driver's desk and the GSM-R radio (paragraph 76). Recordings from nearby CCTV show the train's headlights going off as the train encountered the parapet during the derailment, indicating that this was probably the point when power was lost (paragraph 76). Although no trains were approaching the site of the derailment (paragraph 80), this loss of power delayed the drivers in sending a warning message to the signaller to stop trains on the adjacent line by around 2 minutes (paragraph 79). It also prevented the driver from applying some of the protections required by the relevant rulebook module such as displaying a hazard warning indication with the train's headlamps (Rule Book Module M1 GERT8000-M1, 'Dealing with a train accident or train evacuation', issue 7 dated September 2023).

157 There are two sources of electrical power available to the leading driving cab on a class 195 unit. The first is electrical power from the batteries from the middle and trailing vehicles, which are supplied through a cable between the leading and middle vehicle. The second is the leading vehicle's battery. This meant that the leading cab of train 2C37 lost power for two reasons.

158 The first of these was a loss of power continuity between the leading and middle vehicles. As the vehicles derailed to the left, the lateral displacement exceeded design tolerances and caused the power cable to be stretched beyond its limit. The stretching of the power cable caused damage to the internal plastic fittings of the cable, cutting off electrical power from this source (figure 16).

159 This initial damage left the unit entirely reliant upon the battery from the leading vehicle. When the front of the train encountered the parapet, the battery isolation switch for the leading vehicle was knocked to the isolated position (figure 17). At this point, electrical power to the driver's cab was entirely cut off.

Figure 16: The power transfer cable stretched taut following the derailment (main). Damage to the internal fittings of the power cable discovered post derailment (inset).

Figure 17: Damage caused to the battery isolation switch as it was knocked to the isolated position during the derailment.

Summary of conclusions

Immediate cause

160 Train 2C37 derailed because it ran over a length of unsupported track (paragraph 85).

Causal factors

161 The causal factors were:

a. Embankment material had been washed away following the continuous discharge of water from a partially buried pipe that had been damaged during tamping (paragraph 90). This causal factor arose due to a combination of the following:

   i. The pipe had only been partially buried and this made it more likely to be struck and damaged (paragraph 99, **Recommendation 1**).

   ii. The tamping team was unable to detect the location of the pipe before the tamping tines struck it (paragraph 109, **Recommendations 1 and 2, Learning point 1**).

   iii. No action was taken to stop the leak once the pipe had been damaged (paragraph 115, **Learning points 2 and 3**).

b. The void in the embankment was not identified before train 2C37 passed over it (paragraph 131, **no recommendation**).

Underlying factors

162 The underlying factors were:

a. The parties involved had not managed flood water in the Winster catchment area effectively, leading to the prolonged need to rely on a temporary pumping arrangement (paragraph 136, **Recommendation 4**).

b. Network Rail allowed a temporary arrangement to become permanent without applying its relevant processes to manage the asset (paragraph 145, **Recommendation 1**).

c. Staffing levels at Carnforth delivery unit did not provide sufficient resilience to cover foreseeable staff absences and allowed a non-compliance with Network Rail standards to become normalised. (paragraph 149, **Recommendation 3**).

Additional observations

163 Although not affecting the accident on 22 March, RAIB observes that the design of the train meant that power was lost to some safety systems within the train's cab following the accident (paragraph 155, **Recommendation 5**).

Previous RAIB recommendations relevant to this investigation

164 The following recommendations, which were made by RAIB as a result of its previous investigations, have relevance to this investigation.

Recommendations that are currently being implemented

Accident at Haddiscoe, 30 Jan 2022, RAIB report 07/2023, Recommendation 4

165 On 30 January 2022, a passenger train ran onto a washed-out section of track at Haddiscoe, Norfolk. The track support had been washed away due to the overtopping of flood defences. This recommendation addressed one of the factors identified in this investigation (paragraph 136). To avoid duplication, it is not remade in this report. However, shown below is a recap of its wording and an account of its current status.

166 Recommendation 4 in the report reads as follows:

The intent of this recommendation is to improve interaction between Network Rail and organisations responsible for tidal flood defences where the operation of these defences affects railway safety. This includes consideration of railway-specific risk such as localised flooding leading to washout of material supporting the track resulting in a serious accident.

Network Rail, the Environment Agency and Natural Resources Wales should work together to identify any railway-related risks arising from the overtopping and/or failure of tidal flood defences where this could adversely affect the safety of Network Rail infrastructure. Where such locations are identified, Network Rail, the Environment Agency and Natural Resources Wales should undertake the following:

- *agree a shared understanding of roles and responsibilities in the management of flood defences, including where railway infrastructure (such as embankments) forms an integral part of the flood defence*
- *ensure processes are provided to identify, and assign to the appropriate organisation, the actions required at each flood defence location to maintain railway safety. This should include:*
  - *identifying the nature of the risks arising from the overtopping and/or failure of the flood defence*
  - *developing the requirements for inspection, monitoring and maintenance for each organisation*
  - *specifying how information is communicated so that each organisation can manage its own risks appropriately*
  - *determining how lessons will be learned across all of these organisations where overtopping and failures of tidal flood defences occur.*

As part of this work, Network Rail and the Environment Agency and Natural Resources Wales should review and, where necessary, improve any relevant existing agreements such as Memorandums of Understanding.

167 The Office of Rail and Road (ORR) provided RAIB with an update on 30 May 2024 based on Network Rail's response. However, ORR advised RAIB that it was not able to comment or provide a status for the response to the recommendation as it has no legal authority (vires) over EA and Natural Resources Wales. Safety authorities such as ORR and public bodies such as EA and Natural Resources Wales are required by law[4] to report to RAIB any measures taken to implement the recommendations made in its reports. Although more than 12 months has passed since the publication of RAIB's report into this accident in July 2023, RAIB has not received an update from EA or Natural Resources Wales on what action has been taken to address this recommendation as of December 2024.

Previous recommendation that had the potential to address one or more factors identified in this report

Accident at Godmersham, RAIB report 05/2017, Recommendation 5

168 On 25 July 2015, a passenger train derailed after striking eight cows at Godmersham, Kent. Upon derailing, the train lost power to its cab radio, preventing the driver from contacting the signaller.

169 Recommendation 5 in the report reads as follows:

The intent of this recommendation is to ensure that drivers have continuous access to a railway emergency call facility in the event of an accident that affects the on-board train radio.

London & South Eastern Railway Limited, in conjunction with Siemens Rail Automation Ltd and Network Rail, should complete their work to understand the nature of the problem with the GSM-R train radio system in this accident, and then implement reasonably practicable measures to ensure that its drivers have the facility to make an emergency call in similar situations in future (paragraph 93b).

Examples of such measures may include:

a. *improving the resilience of the GSM-R radio system following an accident such as a derailment;*

b. *providing drivers with GSM-R handheld units;*

c. *ensuring that all relevant signalbox telephone numbers are stored in drivers' company mobile phones; and/or*

d. *providing guidance to drivers on the actions to take if the GSM-R radio becomes inoperative.*

On completion of its work, LSER should update the National Incident Report it raised on this matter (paragraph 114). Note: This recommendation may be applicable to other train operators.

[4] Regulation 12(2) of the Railways (Accident Investigation and Reporting) Regulations 2005.

170 Southeastern in conjunction with Siemens and Network Rail carried out research to understand why the GSM-R radio did not operate properly during the Godmersham accident. The issue was fixed by the upgrade of GSM-R to version 4, which was subsequently rolled out across the GB mainline network. Before the upgrade programme was completed, Southeastern introduced an interim measure of providing drivers with the phone numbers of Network Rail signal boxes on mobile phones.

171 ORR has reported that the rail industry took sufficient action in response to this recommendation for it to be considered as 'Implemented'.

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

172 During the repair of the railway embankment involved in this accident, Network Rail installed a permanent structure to house and protect up to three temporary pipes (figure 18). This structure has been installed at the appropriate depth for buried services and currently only houses two temporary pipes, with a third available channel for increased future demands. The permanent pipe fitted by British Rail was removed as part of these works.

Figure 18: Railway embankment following repair by Network Rail (courtesy of Network Rail).

173 Network Rail's internal investigation identified the issue with unregistered drainage assets. As a result of this, Network Rail's North West and Central region has completed work seeking to identify if other similar unregistered assets exist within the region. None were found as a result. Network Rail has asked its other regions to complete a similar assurance activity.

174 LFG (paragraph 16) is seeking approvals and funds to progress a plan to dredge the River Winster. It believes that this scheme will allow the river to scour a channel across the sands to the River Kent and consequently reduce flooding on the landward side of the railway.

Recommendations and learning points

Recommendations

175 The following recommendations are made:[5]

1 *The intent of this recommendation is to manage the risk introduced when temporary pumping and drainage solutions are installed and remain in place for a protracted period.*

Building on the work already completed by its North West and Central region, Network Rail should undertake a review nationally to understand if there are other pumping or drainage assets that were originally installed as a temporary measure but that have stayed in operation for a period longer than originally anticipated.

Following this review, Network Rail should put arrangements in place to ensure that the requirements of relevant standards and procedures are correctly applied to any assets identified, and that the associated risks are controlled (paragraphs 161a.i, 161a.ii, 162b).

2 *The intent of this recommendation is to reduce the likelihood that buried services are struck during tamping operations.*

Network Rail should review how it can improve the ability of tamper operators to detect buried services. This review should include consideration of technological solutions that could inform tamper operators of approaching buried services and/or which could automatically detect and notify operators of their presence.

Once this review is complete, Network Rail should develop a timebound programme to implement any improvements identified which will help to control the risk of buried services from being struck (paragraph 161a.ii).

[5] 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, recommendations 1, 2, 3 and 5 are addressed to the Office of Rail and Road, and Recommendation 4 is addressed to the Environment Agency. This is 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.

3 *The intent of this recommendation is to reduce the likelihood of non-compliance associated with tamping operations at Carnforth maintenance delivery depot.*

Network Rail should review staffing levels within Carnforth maintenance delivery unit to ensure that it has sufficient resources to deliver its tamping operations in accordance with the requirements of its own standards and procedures. This review should specifically consider if staffing levels are sufficiently resilient to cope with absences, including when staff are unavailable at short notice (paragraph 162c).

4 *The intent of this recommendation is to encourage timely decision-making in relation to the future of the Winster catchment area in order to protect the railway from risks arising from temporary mitigations.*

The Environment Agency, working in conjunction with Westmorland and Furness council, the Marine Management Organisation, Network Rail, and other identified local stakeholders (including those mentioned in this report), should lead the development of a timebound strategy to respond to the pervasive flooding adjacent to the railway at this location to avoid the need to rely on temporary solutions (paragraph 162a).

5 *The intent of this recommendation is to reduce the risk of a derailed train being struck by a train on an adjacent line due to a failure of communication systems.*

Eversholt Rail Leasing Ltd, working in conjunction with Northern Trains and CAF, should undertake a review of the design of the battery isolation switch on class 195 trains to see if it can be better protected from an inadvertent operation during foreseeable accident and incident scenarios.

This recommendation may apply to other trains operating in the UK with a similar battery isolation switch arrangement (paragraph 163).

Learning points

176 RAIB has identified the following important learning points:[6]

1 Track quality supervisors are reminded of the importance of advance walkouts and ensuring that obstructions are marked in line with the required standards during these walkouts (paragraph 161a.ii).

2 On-call staff are reminded of the importance of ensuring they are immediately contactable for the period of their on-call duties (paragraph 161a.iii).

3 Incident controllers are reminded of the importance of correctly escalating issues in accordance with operating rules and procedures when first line on-call staff are not available (paragraph 161a.iii).

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

Appendices

Appendix A - Glossary of abbreviations and acronyms

Abbreviation / acronym	Full term
AIVR	Automated Intelligent Video Review
AONB	Area of outstanding natural beauty
ATME	Assistant track maintenance engineer
CAF	Construcciones y Auxiliar de Ferrocarriles
CCTV	Closed-circuit television
COSS	Controller of site safety
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
Geo-RINM	Geo-rail infrastructure network model
GSM-R	Global System Mobile Communications – Railway
IC	Incident controller
ISC	Incident support controller
IDB	Internal drainage board
LFG	Lynster Farmers' Group
LLFA	Local lead flood agency
MAGIC	Multi agency geographic information for the countryside
MMO	Marine Management Organisation
MHWS	Mean high-water springs
NORWEB	North Western Energy Board
ODM	Operations delivery manager
ORR	Office of Rail and Road
OTDR	On-train data recorder
OTM	On-track machine
PIC	Person in charge
PLPR	Plain line pattern recognition
PICOP	Person in charge of possession

REC	Railway emergency call
ROC	Rail operating centre
SAC	Special area conservation
SAE	Senior asset engineer
SMP	Shoreline management plan
SPA	Special protection area
SSSI	Site of specific scientific interest
TME	Track maintenance engineer
TQS	Track quality supervisor

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the train's OTDR
- CCTV recordings taken from the derailed train, the tamper, and lineside businesses
- site photographs and measurements
- weather reports and observations near to the site
- records obtained from the National Archive
- asset examination records provided by Network Rail
- rail industry logs
- signalling data
- minutes of meetings
- email correspondence records
- recorded voice communication
- consultancy reports prepared for the golf club and Network Rail
- local history book: Gilpin, Leslie R. (2009). 'The Ulverstone and Lancaster Railway: The Challenge of Morecambe Bay'. Cumbria: Cumbrian Railways Association
- a review of previous reported accidents and incidents
- a review of previous RAIB investigations that had relevance to this accident.

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