Rail Accident Investigation Branch

Rail Accident Report

Collision between a passenger train and a fallen tree at Broughty Ferry, Dundee
27 December 2023

Report 13/2024
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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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Collision between a passenger train and a fallen tree at Broughty Ferry, Dundee, 27 December 2023

Contents

Summary

At around 13:09 on 27 December 2023, the 10:46 Perth to Aberdeen passenger service collided with a fallen tree approximately 1 mile (1.6 km) east of Broughty Ferry, Dundee. The train was travelling at around 84 mph (135 km/h) when the collision occurred. The train suffered significant damage to the leading driving cab. There were no physical injuries to the 37 passengers and three staff members on board the train.

The tree had fallen from Barnhill Rock Gardens, a public park owned by Dundee City Council, and was brought down by winds during Storm Gerrit. This storm had been subjecting the area to high winds and heavy rain for several hours preceding the accident. RAIB's investigation found that the soil in which the tree was rooted had characteristics which limited the tree's ability to resist the wind forces acting on it. In addition, three other trees at this location had been felled before May 2023, increasing the exposure of the tree which fell to winds from the Firth of Tay.

Around 12 minutes before the collision, a member of the public became aware that a tree had fallen across the railway and contacted Network Rail using the public helpline. The helpline call handler attempted to pass this information on to Network Rail's Scotland route control on a number of occasions, but the call from the helpline call handler was not answered until after the accident. This meant that a warning about the fallen tree did not reach the driver of the train in time to prevent the accident.

The risk of trees in Barnhill Rock Gardens falling onto the railway not being effectively controlled was the factor underlying the accident. Network Rail is reliant on neighbouring landowners controlling the risk associated with visually healthy trees falling onto the railway lines from outside of the railway boundary. However, Dundee City Council did not effectively manage the risk of trees falling from its land onto the adjacent railway lines.

As a consequence of the accident, the survival space in the cab was considerably reduced. The driver only escaped serious injury by crouching behind the driving seat once they had made an emergency brake application on realising the collision was inevitable. RAIB also observed that the telephone equipment used at Scotland integrated control centre did not display missed call information.

Since this accident, Network Rail has provided helpline staff with an additional contact telephone number for use in emergencies.

RAIB has made three recommendations as a result of its investigation. The first of these is to Network Rail to consider how technology could assist in the detection of trees subject to altered exposure, including those trees on third-party land. The second recommendation is that Dundee City Council should review its management of the trees for which it is responsible to ensure that it is effectively controlling the risk of them falling onto the railway.

RAIB has also recommended that the Rail Safety and Standards Board's Carmont recommendations steering group should review its response to recommendation 19 made within RAIB report 02/2022, following the investigation into the derailment of a passenger train at Carmont, Aberdeenshire on 12 August 2020.

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. Left and right relate to the train’s direction of travel.

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 13:09 on 27 December 2023, the 10:46 Perth to Aberdeen passenger service collided with a tree which had fallen onto the line from outside the railway boundary approximately 1 mile (1.6 km) east of Broughty Ferry, Dundee. The train, reporting number 1A37, was returning south to Dundee because flooding had closed the line further north.

4 A member of the public had contacted Network Rail about the fallen tree 12 minutes before the collision, but this warning did not reach the driver in time to stop the train and prevent the accident.

5 The train was travelling at around 84 mph (135 km/h) when the collision occurred, and the driver only escaped serious injury by crouching behind the driving seat. The train suffered significant damage to the leading driving cab. This disabled the train and prevented access to the driver's control desk and communications equipment.

6 Shortly after the collision, the signaller at Dundee signalling centre received an automated alarm from the train. The signaller attempted to contact the driver but, when the call connected, the signaller heard only engine noise. By this time, the driver had walked back along the train to ask the conductor to report the accident. After meeting partway along the train, the driver asked the conductor to make an emergency call. The driver also reported the accident to the Arbroath signaller by mobile telephone.

7 There were no injuries to the 37 passengers and three staff members on board, but it was necessary for the fire service to assist in the evacuation of the train. The evacuation was completed 2 hours after the train had come to a stand.

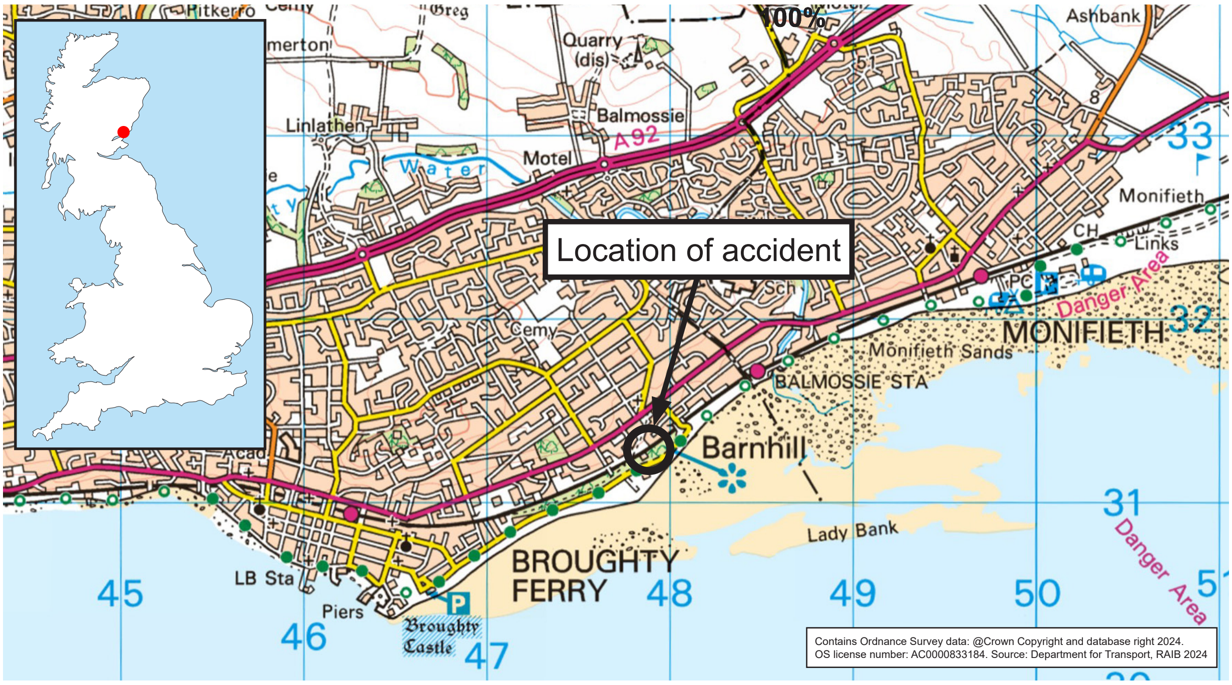

Figure 1: Extract from Ordnance Survey map showing the location of the accident near Broughty Ferry, a suburb of Dundee, Scotland.

Context

Location

8 The collision occurred approximately 1 mile (1.6 km) east of Broughty Ferry station on the Dundee to Aberdeen line. Travelling south from Aberdeen, the railway broadly follows the eastern coastline of Scotland before turning inland through Arbroath and following the northern shoreline of the Firth of Tay passing through Carnoustie, Broughty Ferry and onwards to Dundee (figure 2).

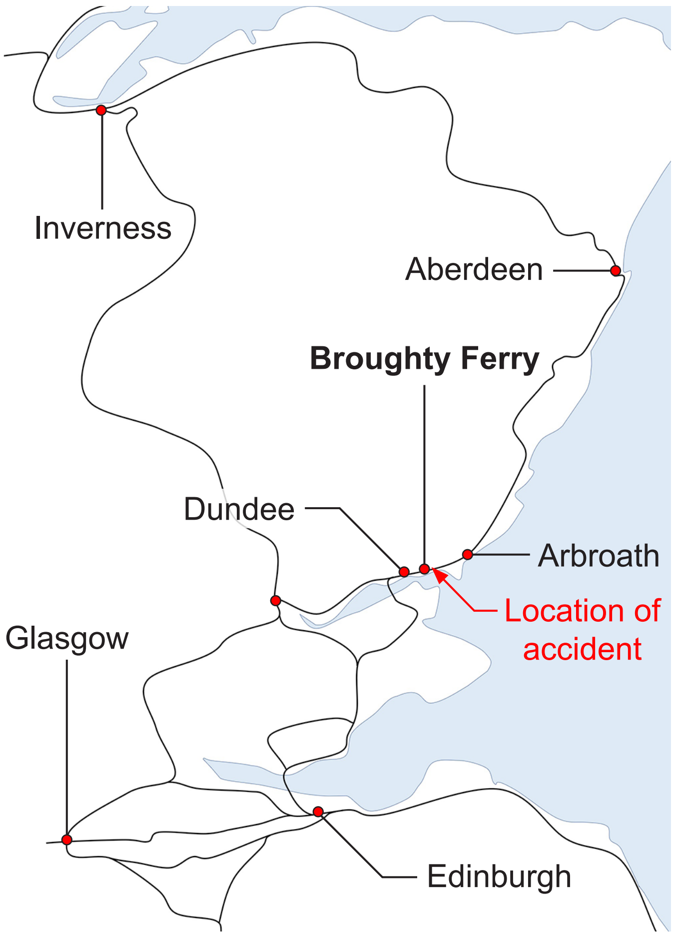

Figure 2: Railway context.

9 At the location the railway is made up of two lines. The up line is used by trains heading towards Dundee and the down line is used by trains heading towards Arbroath, Aberdeen and beyond to Inverness.

10 Train 1A37 was travelling on the up line from Arbroath. On the approach to the fallen tree, the line passes under a road bridge and curves to the right. These features limit the view of the location where the tree fell to a maximum of 240 metres, although at the time of the accident this was probably further reduced by adverse weather conditions. The maximum permitted train speed at the location was 90 mph (145 km/h).

11 The tree had fallen from within Barnhill Rock Gardens, part of a public park situated to the left of the railway between the railway boundary and the shore of the Firth of Tay. The gardens include tree species which are native and non-native to the United Kingdom. The tree that fell onto the railway was a Monterey cypress tree which grows naturally in North America (figure 3).

Figure 3: Google Street View image of Barnhill Rock Gardens (courtesy of Google).

Organisations involved

12 ScotRail Trains Limited (ScotRail) was the operator of the train and is the employer of the driver and conductor who formed the train crew on board train 1A37.

13 Angel Trains Limited (Angel Trains), a rolling stock leasing company, leased the rail vehicles which formed train 1A37 to ScotRail.

14 Network Rail is the owner and maintainer of the infrastructure at this location, which forms part of its Scotland route, and Scotland's Railway region. Network Rail also employs the signallers and the Scotland integrated control centre (SICC) staff who were on duty at the time of the accident.

15 Journeycall Limited (Journeycall) is contracted by Network Rail to provide customer service resources including handling of calls to the Network Rail public helpline number. Journeycall also handles enquires for other non-railway companies and therefore its staff are not railway experts.

16 Dundee City Council (DCC) owns the public Barnhill Rock Gardens from where the tree fell onto the railway. The forestry office, part of the DCC Environmental Department, is responsible for maintenance of the trees within the gardens.

17 ScotRail, Angel Trains, Network Rail, Journeycall and DCC all freely co-operated with the investigation.

Train involved

18 Train 1A37 was a high speed train (HST) set. This comprised four mark 3 passenger coaches with a class 43 diesel-electric power car at each end (figure 4). Power car 43129 was leading and power car 43133 was at the rear of the train when the accident occurred. These vehicles were originally constructed by British Rail Engineering Ltd and entered service between 1976 and 1980. The construction and approval into service of HSTs pre-dates a number of modern railway standards relevant to crashworthiness and, because rolling stock does not require ongoing permission to remain in operation, HSTs remain in passenger service on the mainline rail network.

19 The power cars are each fitted with forward-facing closed-circuit television (FFCCTV) and an on-train data recorder (OTDR). The FFCCTV recorders store short periods of video in a short-term memory before saving it. During the collision, the FFCCTV equipment fitted to the leading power car lost power and did not save the contents of its short-term memory. As a consequence, the last seconds of video before the collision were not retrievable. The train was also fitted with a remote monitoring system which recorded the location of the train using satellite positioning technology.

Figure 4: A typical ScotRail HST with power cars and mark 3 coaches (courtesy of ScotRail).

Staff involved

20 The driver of train 1A37 started as a conductor in 2011 and began training as a driver in 2018. They qualified as a driver in December 2019.

21 The call handler who dealt with the call from the member of the public joined Journeycall in February 2023 and had been trained to handle Network Rail public helpline enquires from August 2023.

22 The Network Rail route control manager (RCM), who was on duty at SICC during the period immediately leading up to the accident, had 33 years' operational railway experience and 6 years' experience in the RCM role.

23 The DCC senior tree officer had 45 years' experience as a forestry officer and holds a higher national diploma qualification from the Scottish School of Forestry.

External circumstances

24 At the time of the accident, the Met Office had issued a weather warning associated with named Storm Gerrit. This warning was for high winds and heavy rain which extended across the country. The subsequent Met Office report stated that '*Storm Gerrit brought damaging winds and heavy rain to the United Kingdom from 27 to 28 December with Wales, north-west England and Scotland worst affected. In the most exposed locations, winds gusted at over 70 Knots (130 km/h) while heavy rain led to increased flooding concerns*.' The maximum gusts recorded during the storm are shown in figure 5.

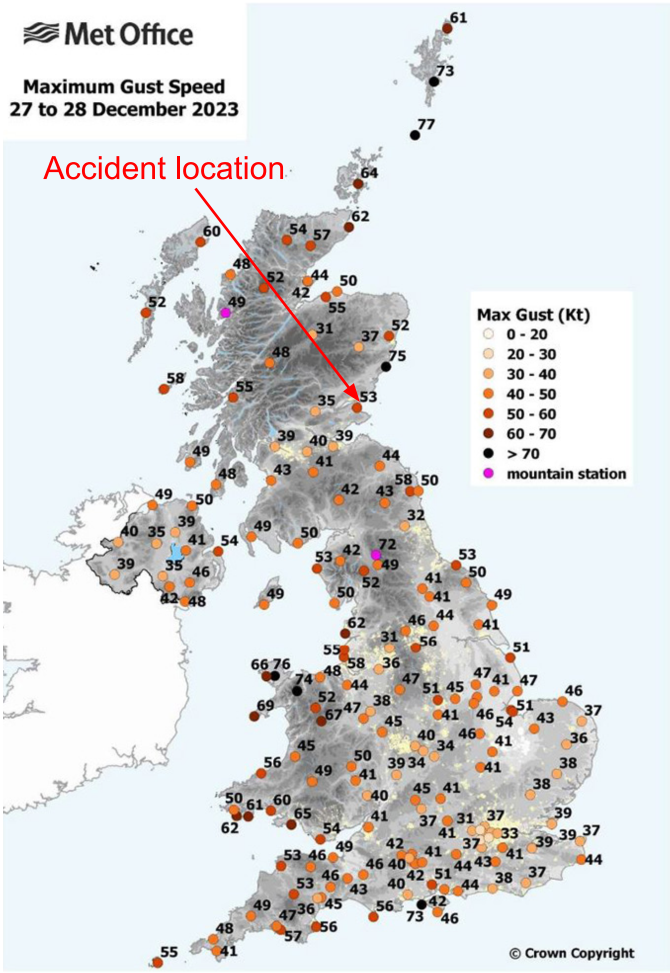

Figure 5: Met Office chart indicating 53 Knots (98 km/h) maximum wind gusts associated with Storm Gerrit near accident location (courtesy of the Met Office).

The sequence of events

Events preceding the accident

25 Network Rail had received a weather forecast from the Met Office predicting extreme weather on 27 and 28 December 2023 associated with Storm Gerrit. On the morning of the accident, the forecast included red (extreme) warnings for heavy rain and strong winds effecting much of Scotland. To mitigate the hazards associated with these weather conditions, a decision was made to apply blanket speed restrictions (BSRs) in the worst affected areas. A BSR had been applied between Carnoustie and Aberdeen in anticipation of the heavy rain causing flooding along the coastal section of the route to be taken by train 1A37. No BSR was in place on the route between Dundee and Aberdeen, on which the accident occurred (see paragraph 81).

26 Train 1A37 departed Perth on time at 10:46 on 27 December and began its journey northwards towards Aberdeen. The train passed through Broughty Ferry station on the down line at 11:24 and, a few minutes afterwards, passed the location where the tree would later fall. At that time nothing untoward was reported by the driver of the train. Train 1A37 was the last train to pass through the area in either direction before the accident.

27 As the train approached Carnoustie station, around 6 miles (9.6 km) from Arbroath, the driver reduced the train's speed in accordance with the BSR. The driver complied with the 40 mph (64 km/h) BSR until coming to a stand at a red (stop) signal at Arbroath station around 11:39. The Arbroath signaller informed the driver via the train's GSM-R (Global System for Mobile Communications – Railway) radio system that it was necessary to return the train to Dundee following reports of flooding closing the line ahead. After a short wait, the train was driven into a siding north of Arbroath and signalled back into the station on the up line for the return journey. Because no other hazards had been identified on the inland portion of the route, the driver was not given any special instructions by the signaller as to how to proceed (see paragraph 81). The train departed Arbroath and headed back towards Dundee on the up line at 12:54.

28 At 12:57, shortly after the train had departed Arbroath, a member of the public contacted the Network Rail public helpline. The member of the public reported that a tree had fallen across the tracks from Barnhill Rock Gardens located on the opposite side of the railway to their property. During this telephone conversation, the call handler attempted to contact the SICC, but the call was not answered. The call handler attempted to contact the SICC again after completing the call with the member of the public, but each time the call remained unanswered.

29 After departing Arbroath, the train travelled at 40 mph (64 km/h) until reaching the end of the BSR where the driver increased the speed of the train. The train reached 96 mph (155 km/h) and travelled around 3.5 miles (5.6 km) before the driver shut off traction power and began to slow down to meet a reduction in permissible speed from 100 mph (161 km/h) to 90 mph (145 km/h) which started around 1 mile (1.6 km) before the accident location.

Events during the accident

30 The train was negotiating a right-hand curve and passing under a road bridge when the driver became aware of the tree across the track ahead. The driver made an emergency brake application around 80 metres before the collision. Realising that an accident was unavoidable, the driver then crouched on the floor behind the driving seat.

31 According to OTDR data, the collision occurred at 13:09 while the train was travelling at 84 mph (135 km/h). The train did not derail and continued to travel on the up line until it came to a stand approximately 850 metres beyond the fallen tree.

32 The stem of the tree, commonly known as the trunk, was broken into two lengths during the collision. The lower portion was around 9 metres in length and after being uprooted it remained where it fell. The upper portion, which was around 6 metres long, was thrown through the boundary fence and landed approximately 20 metres forwards in the direction of travel of the train and to the left of the line.

33 During the collision, the tree stem entered the cab area around driver's eye level, passing through the cab pillars either side of the windscreen, before cutting through the body of the cab, the quarter light window and the driver's door. The tree stem's progression through the driving cab stopped just above the driver as it reached the bulkhead structure separating the driving cab from the power car equipment compartment behind the cab (figure 6).

Figure 6: Damage sustained to left-hand side of driving cab.

34 The driver was showered in glass and other debris by the impact but escaped serious injury. The windscreen had shattered and was lying across the cab controls and, after clearing enough of the debris to be able to stand, the driver realised it was not possible to reach the GSM-R radio to make an emergency call. The driver left the cab and began to walk back along the train to understand the extent of the damage and to liaise with the train's conductor.

35 Around 1 minute after the train had come to a stand, the signaller at Dundee signalling centre received an automated emergency alarm generated by equipment on board the damaged train. The Dundee signaller attempted to contact the driver on the GSM-R radio system but, when the call connected, the signaller was only able to hear engine noise because the driver had left the driving cab.

Events following the accident

36 After meeting partway along the train, the driver asked the conductor to make an emergency call. The driver also reported the accident to the Arbroath signaller by mobile telephone. Around this time, a second train driver, who had been travelling as a passenger on the train, also joined the driver and conductor. The second driver agreed to assist the driver to apply the parking brake to secure the train. The two drivers then made their way forwards and together managed to move enough debris to enable them to shut down the engine in the front power car. The engine in the rear power car was kept running to maintain an air supply to the train's braking system and power to the communications, heating, lighting and other facilities for the passengers.

37 After ensuring the lines were blocked to other trains, the two drivers returned to the conductor to assist looking after the 37 passengers reported to be on board. A rail incident officer appointed by Network Rail arrived on site at 14:29 to facilitate the evacuation of the passengers with assistance from the fire and rescue service, as well as prepare for the recovery of the stranded train.

38 To evacuate the passengers, the fire and rescue service provided a ladder to reach the ground from one of the carriage doors and cut an access route through the railway boundary fence into an adjacent public park. The evacuation took around 17 minutes, with the last passengers leaving the train around 2 hours after the collision. Around 6 hours after the evacuation, the damaged train was recovered to sidings near to Dundee station by an assisting HST.

Analysis

Identification of the immediate cause

39 Train 1A37 was unable to stop before colliding with a fallen tree that was obstructing the railway.

40 When driving back to Dundee, having been turned back at Arbroath because of flooding closing the line ahead, the driver of train 1A37 complied with the 40 mph (64 km/h) BSR which was in place on the journey to Carnoustie (paragraph 25). After passing through the limits of the BSR, and with no additional instruction to drive at a reduced speed, the driver obeyed the permanent speed restrictions for the route (see paragraph 81).

41 The train passed under a road bridge on the approach to Barnhill Rock Gardens and entered a right-hand bend. At this point, the train was travelling at approximately 84 mph (135 km/h) and the driver was allowing it to coast to keep within the permitted line speed of 90 mph (paragraph 29). Analysis undertaken by RAIB shows that the driver would have had a maximum of around 6 seconds sighting of the fallen tree in good conditions. However, on the day of the accident, heavy rain had been falling throughout the journey from Arbroath. This would have reduced the driver's visibility of obstructions ahead and the time available for them to perceive any hazards and react to them. This is discussed further in paragraphs 91 to 93.

42 OTDR data shows that the driver commanded an emergency brake application around 2 seconds before the collision occurred, when the train was 80 metres from the tree. This left insufficient time and distance for the braking application to reduce the speed of the train.

Identification of causal factors

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

a. A tree on adjacent land and in close proximity to the railway boundary fell across the lines (paragraph 44).

b. Notification of the obstruction did not reach the driver following a call from a member of the public telling the railway that the tree had fallen across the lines (paragraph 72).

c. On sighting the fallen tree, the driver was unable to stop the train before colliding with it (paragraph 81).

Each of these factors is now considered in turn.

Fallen tree on the railway lines

44 A tree on adjacent land and in close proximity to the railway boundary fell across the lines.

45 During the time between train 1A37 travelling northwards past Barnhill Rock Gardens, and its return journey south, a tree had fallen across both lines. The tree had fallen from within the gardens and was lying horizontally across both lines at around windscreen height of the approaching train (paragraph 33).

46 The tree was a Monterey cypress (*Cupressus macrocarpa*), a species only native to the coastal areas of California, which was growing in a small group of trees of the same species. Historic imagery from the National Collection of Aerial Photography shows no trees in the location of the fallen tree in 1941 and a collection of established trees in 1969. Barnhill Rock Gardens is the responsibility of DCC and its website states that the garden was started in 1955 on the site of a former golf course. Therefore, it is likely the tree was planted in the gardens sometime between 1955 and 1969.

Figure 7: Site of the future Barnhill Rock Gardens in 1941 (courtesy of NCAP/ncap.org.uk).

Figure 8: Barnhill Rock Gardens in 1969 with RAIB annotation (courtesy of NCAP/ncap.org.uk).

47 The tree was located about 15.5 metres away from the railway boundary. The impact occurred around 17.5 metres from where the lower section of the tree's stem would have entered the ground and where the stem was approximately 300 mm in diameter. The tree was severely damaged in the collision, with the stem of the tree being broken into two parts (paragraph 32). The two stem sections together measured approximately 21 metres in length, but it is likely that with the leaf canopy intact the tree would have stood taller than this. An exact measurement was not possible as almost all the branches were stripped from the stem either by the impact or work undertaken to clean up the site after the collision.

48 RAIB engaged the services of an expert arboriculturist to examine the remaining parts of the tree after the accident. The expert concluded that the tree was healthy with no signs of disease or decay that would account for it falling onto the railway. Further examination of the roots indicated that the tree had suffered windthrow. This is where a tree has been uprooted by wind forces acting on it which are greater in magnitude than the tree can withstand.

49 In this case, the tree fell due to windthrow because of a combination of the following factors:

a. The soil at this location had poor mechanical adhesion characteristics which limited the ability of the tree to resist the wind forces acting on it (paragraph 50).

b. The tree had been subjected to increased wind loading due to altered exposure (paragraph 58).

c. The wind loading acting on the tree was elevated by the high winds associated with Storm Gerrit (paragraph 65).

Each of these factors is now considered in turn.

Soil adhesion

50 The soil at this location had poor mechanical adhesion characteristics which limited the ability of the tree to resist the wind forces acting on it.

51 The Monterey cypress is a coastal species adapted to thrive in its natural habitat, including withstanding high winds and sandy soil. When wind is stopped by the surface of an object, a pressure is generated. This creates a force which acts on the object. Anchor roots provide most of a tree's stability to resist the forces acting upon it, including those generated by wind. Anchor roots typically only extend 1 to 2 metres beyond the stem and form a mass known as the mechanically active rootplate (MAR) (figure 9).

52 Roots broadly perform three functions. These are anchorage, harvesting of soil water and dissolved nutrients, and the transportation of those nutrients and water. Harvester roots are very fine and are mainly without bark. Transport roots are much thicker and extend beyond the MAR into the surrounding soil and provide a means of transporting the nutrients and water absorbed by the harvester roots back to the tree. The area of transition between the MAR and the transport roots is known as the 'zone of rapid taper'.

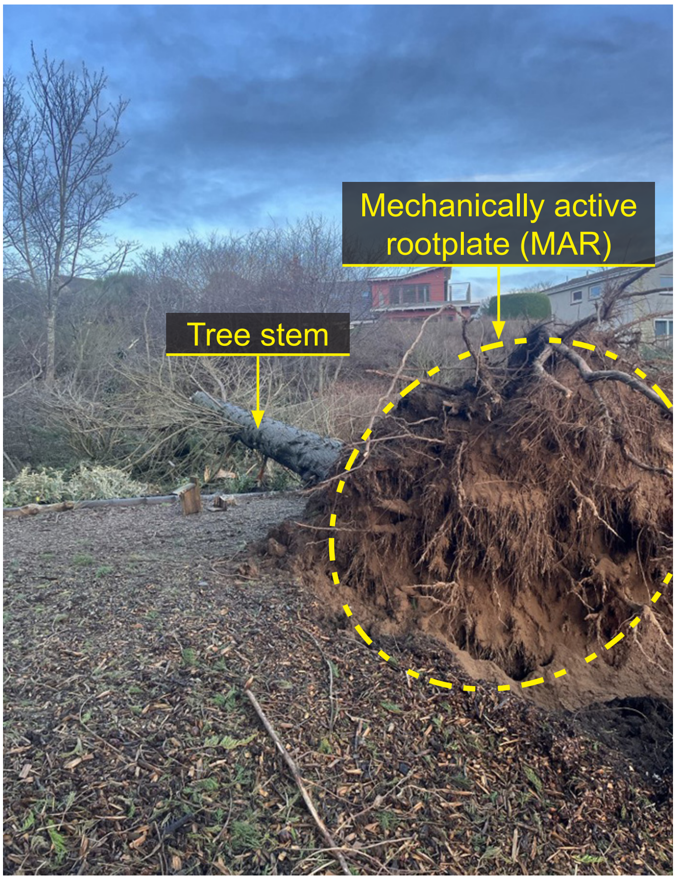

Figure 9: Fallen tree before work to clear the site.

53 Failure of a tree by windthrow generally occurs if the roots are unable to resist the forces acting on the tree by one or a combination of the following modes:

1. a loss of anchor root integrity inside the radius of the MAR (usually due to decay or by root severing, for example, by cutting during excavation works)
2. root breakage at the zone of rapid taper caused by wind loads exceeding the shear strength of the roots causing them to fracture, together with a loss of soil shear strength, resulting in rootplate rotation
3. a loss of soil adhesion, with a number of the transport roots pulling out of the soil, rather than most or all roots fracturing (as would be seen in mode 2).

54 Breakage of some roots at the edge of the tree's MAR indicated a wind load which had exceeded the shear strength of those roots and the surrounding soil. This loss of the soil shear strength had allowed the rootplate to rotate and apply a greater force on the transport roots extending beyond the MAR. These transport roots remained intact and were pulled through the soil as the rootplate rotated. This is an indication of poor mechanical adhesion within the soil (figure 10).

55 Examination of the soil depression left by the uprooted tree showed that the tree was located on soil made predominantly of sand. Sand is an inherently non-cohesive soil with poor mechanical properties for tree root adhesion. Water within the soil can also reduce the mechanical strength of a non-cohesive soil and the ability of a tree root to adhere to it.

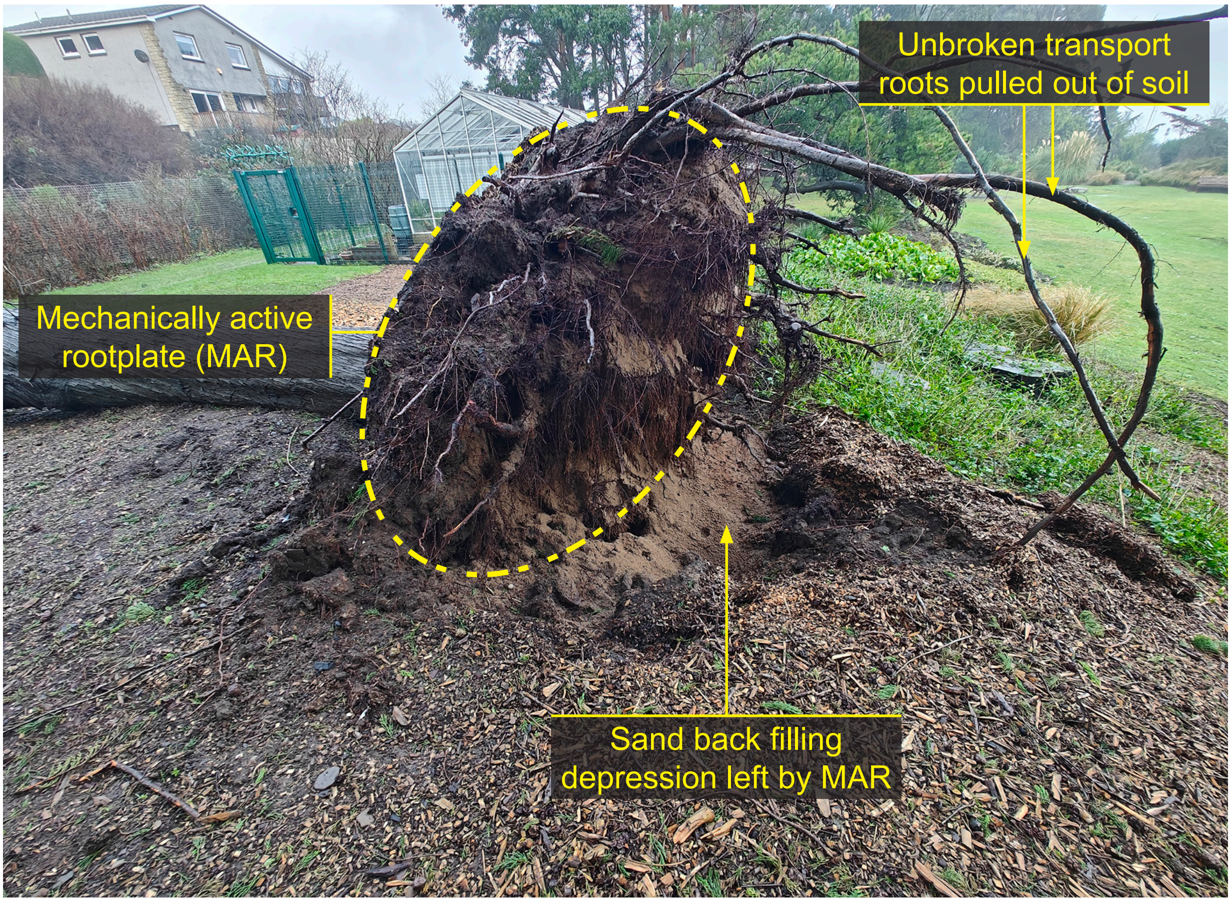

Figure 10: Uprooted tree showing MAR, transport roots and sandy soil back fill.

56 The fallen tree had been established in a small group of trees of the same species. It was apparent from tree stumps remaining in the ground that four other trees from the group had been lost, including one which had suffered windthrow. Although this work was not documented or recorded by DCC, the council stated that two of these removed trees had suffered storm damage, one had been removed due to its proximity to an adjacent glasshouse and it was necessary to remove the fourth tree due to suppressed growth. The expert arboriculturist assessed the rest of Barnhill Rock Gardens and found three other trees (two pine trees and a eucalyptus tree) which had suffered complete windthrow and estimated that this had occurred in the last 5 years. The expert arboriculturist concluded this was indicative of an area where poor soil adhesion exists.

57 When exposed to extremes of wind loading, a tree will follow a strategy of progressive collapse. A tree will first shed leaves, twigs and small branches ahead of catastrophic stem breakage or uprooting for as long as the soil provides sufficient root adhesion. Several trees suffering complete windthrow in a localised area can be an indication of root disease or decay. Where no signs of ill health exist, as found at Barnhill Rock Gardens, this can be an indication that the trees have insufficient support from the soil for the wind loading conditions.

Altered exposure

58 The tree had been subjected to increased wind loading due to altered exposure.

59 The fallen tree was located within a group of trees and for most of its life it had been in a position nearest to the railway and furthest from the Firth of Tay. As the tree developed, three of the four companion trees, which had been recently lost (paragraph 56), would have provided shelter from winds from the Firth of Tay.

60 Google Earth and Street View images show how this group of trees has changed over a 12-year period. It can be seen in the satellite image taken of the group in June 2018 that the group of trees was well established. By May 2023, Google Earth images show that the group had been much reduced (figures 11 and 12). The Street View images capture this change from ground level and show how the trees on the southern side of the group provide shelter from the ground up to those trees behind (figures 13 and 14).

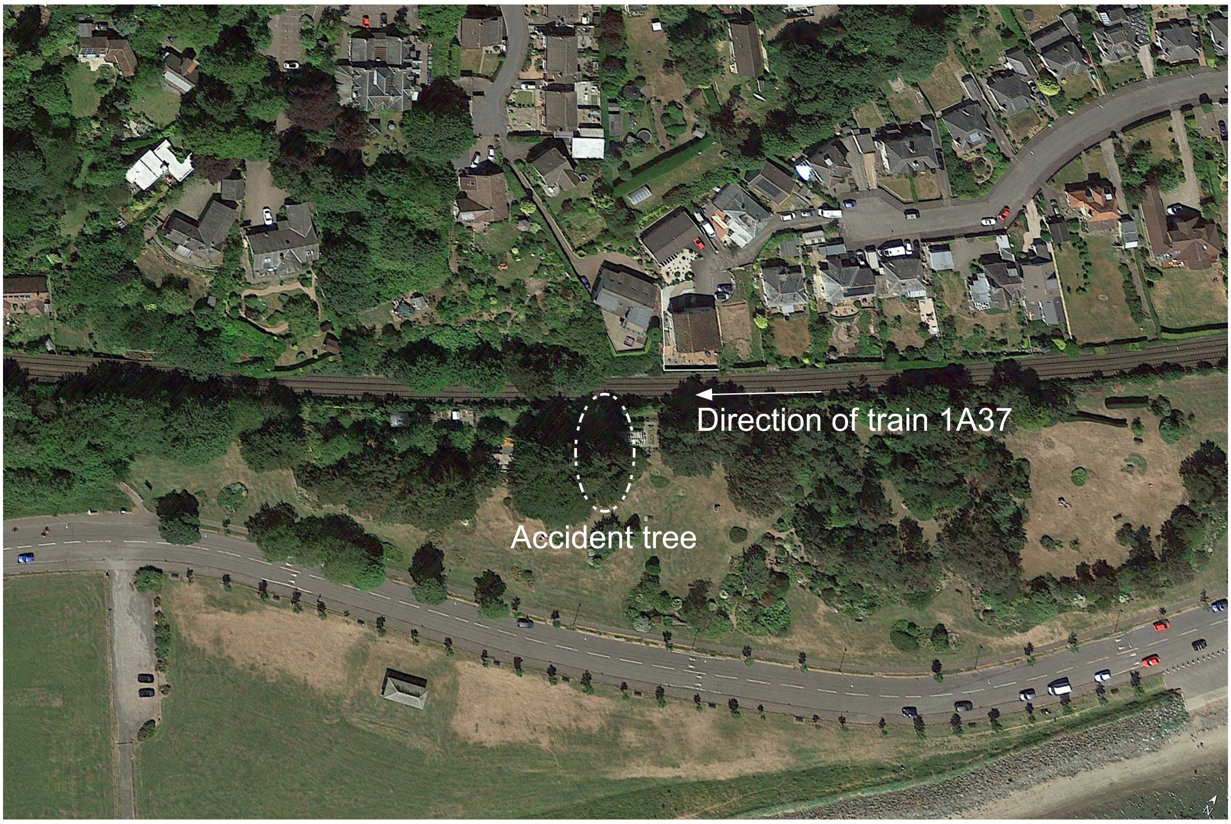

Figure 11: Google Earth image showing the group of trees in June 2018 (courtesy of Google with RAIB annotations).

Figure 12: Google Earth image showing the group of trees May 2023 (courtesy of Google with RAIB annotations).

Figure 13: Google Street View image showing the group of trees in July 2012 (courtesy of Google with RAIB annotations).

Figure 14: Google Street View image showing the group of trees in May 2023 (courtesy of Google with RAIB annotations).

61 These historical images also show that the fallen tree had thicker growth in the upper foliage, but thinner growth further down the stem. This is characteristic of a tree growing in the shelter of companion trees. These images also show how the fallen tree had been left standing apart from the rest of the group following the loss of the companion trees. This loss of shelter meant the tree was no longer receiving shelter from winds blowing from a southeasterly direction over the Firth of Tay.

62 Network Rail uses aerial images of the railway to assist in its management of the infrastructure. These images extend outside of the railway boundary and, in this case, include images of the tree before it fell. The aerial images show that the tree had been growing with a natural inclination towards the railway, but that the angle of inclination had remained unchanged between April 2022 and May 2023 (figures 15 and 16). A tree to the north of a group such as this will naturally grow away from trees to its south and towards the better light.

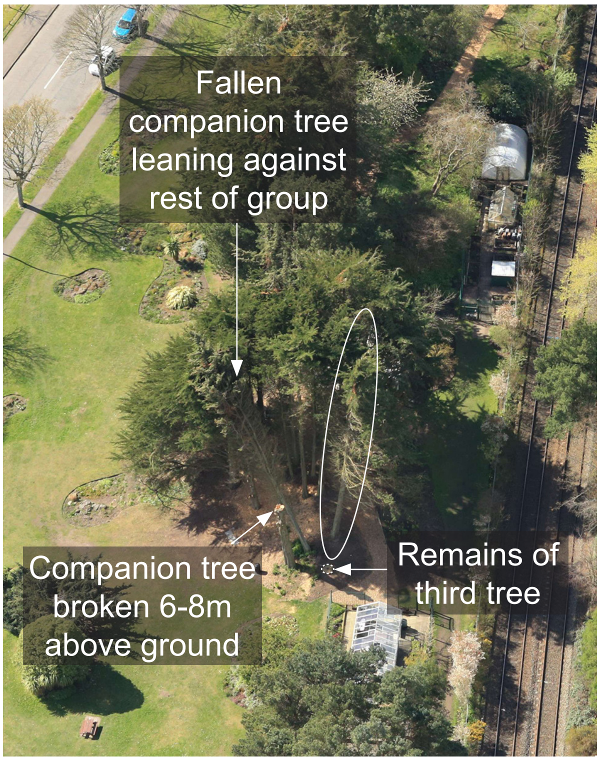

Figure 15: Network Rail aerial image showing the trees in April 2022 (courtesy of Network Rail with RAIB annotations).

Figure 16: Network Rail aerial image showing the trees in May 2023 (courtesy of Network Rail with RAIB annotations).

63 The Network Rail aerial image dated 19 April 2022 (figure 15) shows two of the companion trees and the storm damage they had suffered (paragraph 59). One of the trees had suffered windthrow and fallen into another tree in the group. The other tree suffered stem breakage approximately 6 to 8 metres above ground level. The image taken in May 2023 (figure 16) shows that both trees have been removed and a stump remnant from the third tree providing shelter, which could be seen in the previous year, is no longer visible. DCC stated that it was necessary to fell these trees following damage sustained during Storm Arwen, which occurred in 2021.

64 A tree and its roots will grow to be as strong as is necessary to survive the loads present in its microenvironment. Its strength will also incorporate an additional safety factor to allow the tree to withstand exceptional events. This safety factor is in the region of 3 to 3.5 times the normal loadings the tree has experienced up to that point. If this microenvironment subsequently changes, a tree must adapt to the change, or it will perish. An example of such a change is an increase in wind loading because of a loss of sheltering companion trees, a situation known as altered exposure. This will necessitate the subject tree to increase the strength of its stem and root anchorage over the years following the altered exposure. During the time a tree will take to adapt to this altered exposure, it can withstand increases in wind loading for as long as this increase remains less than the ingrown safety factor. If the additional wind loading forces caused by altered exposure exceed the safety factor, then the tree will fail, even if it is otherwise healthy and structurally sound.

Timing of tree failure

65 The wind loading acting on the tree was elevated by the high winds associated with Storm Gerrit.

66 On 27 December 2023, much of the United Kingdom was subjected to extreme weather brought by Storm Gerrit. High winds and heavy rainfall accompanied this storm before and after the tree fell. This weather had been preceded by two other wet and windy named storms (Storm Elin on 9 December 2023 and Storm Fergus on 10 December 2023).

67 Dundee City Airport (located 7 miles (11 km) to the west of Broughty Ferry) reported average wind speeds of 47 km/h to 70 km/h and gusts of up to 95 km/h throughout the morning leading up to the accident. In the hour between 12:00 and 13:00 during which the tree fell, the weather station reported gusts up to 87 km/h from an east to southeasterly direction.

68 Although originally developed for use at sea, the Beaufort wind force scale was adapted in 1906 for use by 'land-based observers' by the then director of the Met Office. The Beaufort scale assigns a number of 'forces' to approximate a range of wind speeds. For example, force 8 represents a 'gale' with a wind speed from 62 km/h to 74 km/h. Rather than using sea state observations, the Met Office describes how the wind acted on trees and other land-based observations to provide visual indication of wind force.

69 The description for a force 8 gale includes twigs breaking from trees, rising to a loss of branches at force 9, a strong gale. For a force 10 storm, the description includes trees being uprooted. These descriptions were based on observations made at Royal Botanic Gardens, Kew, which has a free-draining loamy soil. While this description for force 10 includes whole tree failure, it is the view of the expert arboriculturist engaged by RAIB that this is the onset of a wind force which might see failure in some trees, rather than the complete failure of all trees subjected to the gale.

70 The precise wind speed which the failed tree was subject to is unknown. Observations taken from Dundee City Airport saw gusts up to 87 km/h for the hour in which the tree failed, which is just below the wind speed range for force 10 of 88 km/h to 101 km/h. Although the weather station is located further along the Firth of Tay shoreline from the tree, RAIB considers that the speeds recorded are likely to be similar to the wind experienced by the failed tree (figure 17).

71 The tree had been grown in an area of sandy soil which provided poor adhesion for the roots (paragraph 50). It is also possible that the soil had been softened by an increase in the ground water content following the three storms. This might have reduced the ability of the root anchorage system to continue to resist the overturning forces acting on the tree. In addition to this, the primary structure of the tree (the stem and roots) was subject to an increase in loading from southeasterly winds resulting from the altered exposure. Although the fallen tree had weathered several named storms since the loss of the companion trees, it was still adapting to the change in its microenvironment (paragraph 58). This predisposing factor would have made the tree more susceptible to windthrow, providing an explanation for its isolated failure during Storm Gerrit, adjacent to a group of similar trees which remained standing.

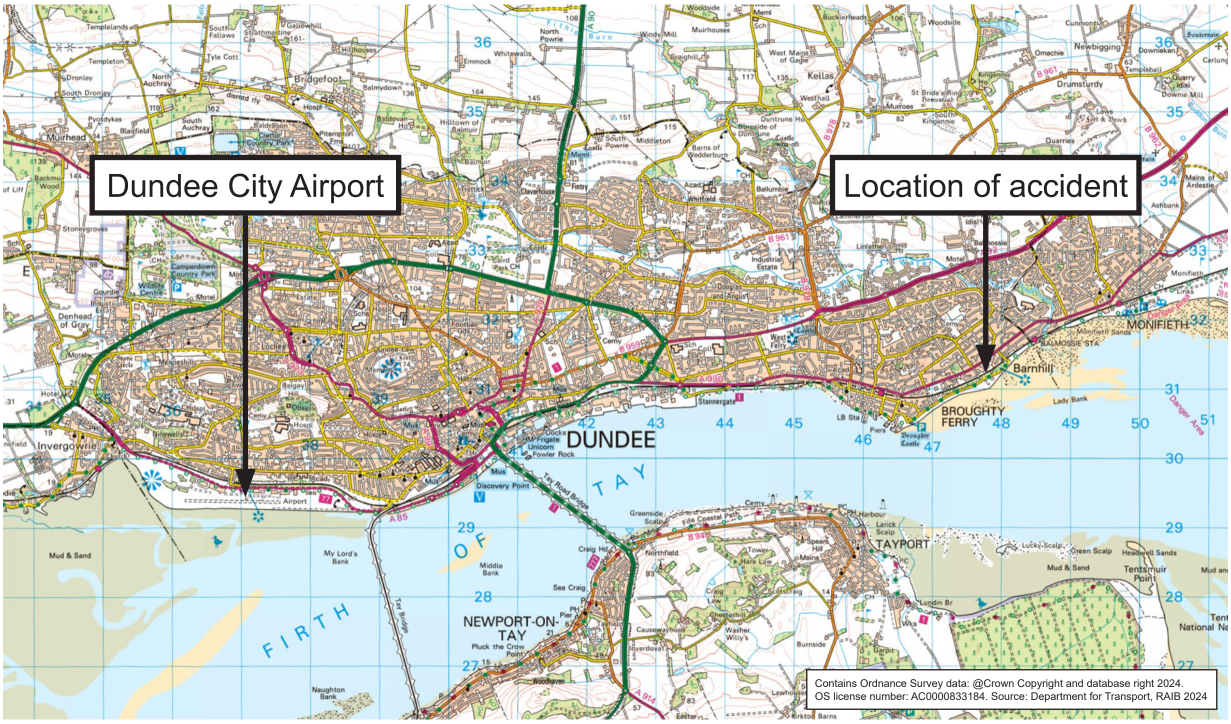

Figure 17: Map showing Dundee City Airport and accident location relative to Firth of Tay.

Notification of the fallen tree

72 Notification of the obstruction did not reach the driver following a call from a member of the public telling the railway that the tree had fallen across the lines.

73 During the storm, a member of the public heard a loud noise coming from the railway which ran along the bottom of their garden. Concerned about what might have happened, they looked out of their window and saw the tree across the railway lines. At 12:57, around 12 minutes before the collision, the member of the public called the Network Rail public helpline to report the fallen tree.

74 The Network Rail public helpline deals with all calls from members of the public relating to matters ranging from general enquiries to incidents which might affect the safety of the railway. The helpline is operated by Journeycall, a third-party organisation on behalf of Network Rail, which employs call handlers who triage incoming calls to determine what course of action to take.

75 The call handler established the location of the fallen tree and that it would be necessary to advise the SICC of the obstruction. Around 9 minutes before the collision, and while the member of the public was put on hold, the call handler attempted to contact the SICC.

76 The call handler did not have access to a priority telephone number for the SICC, so rang the same number which would be used for non-urgent enquiries. This initial call to the SICC was not answered, and because the line had gone silent while on hold, the member of the public had hung up. Following the first attempt to contact the SICC, the call handler completed the incident report before attempting to contact the SICC again. This second call was made at 13:07, around 2 minutes before the collision, and was again unanswered.

77 Calls from the helpline to the SICC would normally be answered by incident support controllers who assist incident controllers in the management of ongoing and out-of-the-ordinary operational incidents. Network Rail stated that calls to the SICC from the helpline rarely relate to safety of the line incidents, and as such they are given a lower priority when SICC staff are busy dealing with ongoing incidents.

78 In the hour before the incoming helpline call, there had been five railway line closures in Scotland due to flooding. This included the closure of the Dundee to Aberdeen line which had caused train 1A37 to turn back (paragraph 27). It is probable that the two calls made before the collision had been unanswered due to the incident support controllers giving the helpline call a lower priority while dealing with these flood closures.

79 RAIB considers that there was sufficient time available from the initial helpline call for SICC staff to prevent the collision. This could have been achieved either by sending a railway emergency call via GSM-R to stop all trains within the area, using radio equipment at the SICC, or by advising the signaller at Dundee about the obstruction so that the train could be stopped. It is possible, but not certain, that there was also sufficient time for this to have also occurred after the second helpline call.

80 After the two calls made before the collision, the call handler called the SICC a further five times. One of these unanswered calls occurred around the time of the collision and a further three unanswered calls were made afterwards. The seventh call made by the call handler was answered at 13:18, around 9 minutes after the collision had occurred.

Distance to stop

81 On sighting the fallen tree, the driver was unable to stop the train before colliding with it.

82 Several BSRs had been put in place across Scotland in response to the adverse weather brought by Storm Gerrit (paragraph 24). This included a BSR which had been applied due to the risk of flooding on the coastal part of the route between Carnoustie and Aberdeen, a distance of around 61 miles (98 km). No BSR was in place on the route between Dundee and Aberdeen, on which the accident occurred.

83 Route control centre staff respond to forecast extreme weather in accordance with Network Rail standard NR/L2/OPS/021, ‘Weather – Managing the Operational Risks’. The version in place at the time of this accident was issue 8 dated June 2019. Notification of extreme weather comes from 5-day weather forecasts which are issued daily by the Met Office to each of the Network Rail route control centres, such as the SICC. They consist of a detailed forecast for that day together with an outlook for the following 4 days. These forecasts are broken down into railway routes which are given a colour code based on the severity of the weather it is likely to experience. These codes range from ‘red’ for extreme weather, through ‘yellow’ and ‘amber’, to ‘green’ for normal conditions.

84 Each morning, a designated manager will review the weather report and determine if it is necessary to convene a meeting with representatives of the affected infrastructure to manage the effects of the incoming weather. In the case of extreme weather, this meeting is referred to as an extreme weather action teleconference (EWAT).

85 On the morning of 27 December 2023, an EWAT was held and chaired by the route control manager in the SICC. Attendees included representatives from the infrastructure delivery units and train operators. The updated weather forecast included red warnings for predicted wind gusts of 65 mph (105 km/h) on the line between Dundee and Arbroath, and 70 mph (112 km/h) for the coastal route between Arbroath and Aberdeen. The forecast also included red warnings for rain throughout these sections.

86 The EWAT attendees use their historical knowledge of the route, any hazards present on the route, and actions previously taken when deciding what mitigating responses are required. These responses can include closing the line, applying BSRs or, where appropriate, continued monitoring of the weather or affected infrastructure. When deciding on what action to take and on what routes, the EWAT attendees balance the need to continue train operations and avoid unnecessary delays against the need to operate services safely.

87 Network Rail expects route control centre managers to follow a framework for the decisions made during the EWAT conference. This framework is documented in Network Rail National Operating Procedure 3.17, ‘Weather Arrangements’ (issue 3 dated June 2020, in force at the time of the accident). This procedure states that BSRs should be considered to reduce the likelihood or consequence (or both) of a train striking obstructions blown onto the line.

88 When considering mitigations during forecast high winds, section 13 of this procedure provides guidance in the form of a ‘weather trigger table’ (table 1). The procedure states that structured expert judgement can take precedence over the guidance provided in this table. This requires those considering the implementation of BSRs to account for information such as local features (including lineside trees), darkness, wind speed and other weather conditions. Any decisions taken and the reasons for them are required to be recorded and should be revised as required, as weather conditions change.

Wind speed	Action	Element
Forecast of gusts up to 39 mph [63 km/h] Forecast of mean wind speeds of up to 29 mph [47 km/h]	No action	Normal
Forecast of gusts from 40 to 49 mph [64 to 79 km/h] Forecast of mean wind speeds of 30 to 39 mph [48 to 63 km/h]	Be aware of the possibility of higher speeds being reached	Aware
Forecast of gusts from 50 to 59 mph [80 to 95 km/h] Forecast of mean wind speeds of 40 to 49 mph [64 to 79 km/h]	Be aware of the possibility of higher speeds being reached	Adverse
Forecast of gusts 60 mph [96 km/h] or over Forecast of mean wind speeds of 50 mph [80 km/h] or over	50 mph speed restriction for all trains in the affected Weather Forecast Area	Extreme
Forecast of gusts 90 mph [145 km/h] or over	All services suspended in the affected Weather Forecast Area	Extreme

Table 1: Weather trigger table taken from Network Rail procedure.

89 Given the forecast gusts of wind in excess of 65 mph (105 km/h) between Dundee and Aberdeen the applicable action from the guidance in table 1 would have been the imposition of a 50 mph (80 km/h) BSR. However, Storm Gerrit was forecast to bring severe weather across Scotland requiring restrictions on most routes. To limit the impact of these restrictions, the EWAT conference considered where known hazardous trees (for example, those trees which have been identified as at risk of falling across the railway) were located between Dundee and Aberdeen.

90 Network Rail had identified trees at risk of falling along the coastal section north of Arbroath but found that there were no trees of concern to the south (figure 18). With this information, the EWAT conference attendees concluded it was not necessary to recommend a BSR for high winds on the section alongside the Firth of Tay on which the accident occurred.

91 In the absence of any weather-related speed restriction, the driver was observing the permitted speeds on the approach to Broughty Ferry. Around 1.25 miles (2 km) from the point of collision, the train was travelling at 90 mph (145 km/h). At that location, the railway is on an exposed section of track with the shoreline immediately to the left and no shelter from the incoming wind and rain. The railway line then passes under a road bridge where it curves to the right, with Barnhill Rock Gardens to the left and residential properties to the right.

92 The curvature of the railway means it is just possible to see the location where the tree fell, some 240 metres (around 6 seconds at the train’s speed) beyond the road bridge, but the visibility would have been reduced by the heavy rain and poor sunlight conditions on the day of the accident. The conspicuity of the fallen tree would also have been affected by the motion of the train and a lack of contrast between the tree and lineside vegetation (figure 19).

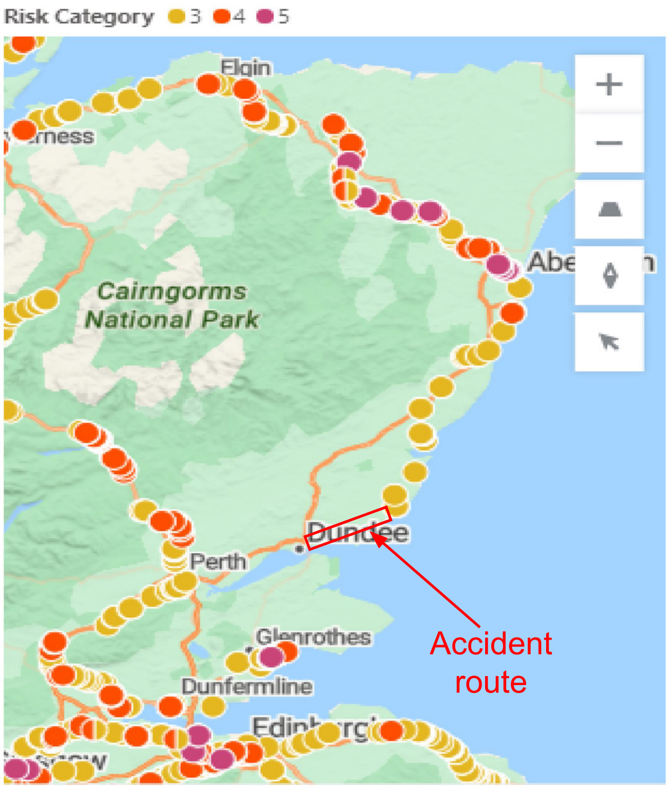

Figure 18: Network Rail database of hazardous trees north of Dundee.

Figure 19: Image taken from train 1A37 forward-facing CCTV as it passed under the road bridge (courtesy of ScotRail with RAIB annotations).

93 The driver stated they made an emergency brake application immediately upon seeing the fallen tree across the track. Satellite location data from on-board train equipment records the emergency brake being applied around 80 metres, or just over 2 seconds, from the site of the collision. The train was travelling at 84 mph (135 km/h) and at this speed it would not have been possible to stop the train in that distance, which made the collision unavoidable.

94 Had a BSR had been applied to this part of the route, it would have reduced the maximum permitted speed of the train from 90 mph (145 km/h) to 50 mph (80 km/h). This would not have affected how far away from the train the tree became visible (paragraph 92) but at lower speed this would have been a longer time and reduced the distance covered during the driver's reaction time. However, the view of the tree would still have been limited to a maximum of 240 metres by the railway's alignment and the road bridge. Even if an emergency brake application had been made at 50 mph (80 km/h) at the road bridge, there remained insufficient distance to stop the train and avoid the collision. Therefore, the collision was unavoidable regardless of the decision not to recommend a BSR made by the attendees of the EWAT conference (paragraph 90).

95 A lower speed would have reduced the energy of the collision. This is discussed further in paragraph 121.

Identification of underlying factor

Management of risk

96 The risk of trees in Barnhill Rock Gardens falling onto the railway was not effectively controlled.

97 Landowners in Scotland have a duty of care to prevent foreseeable harm to members of the public or adjacent property including hazards arising from falling trees (similar requirements apply in England and Wales, making this a requirement which applies across Great Britain). The means of managing risk arising from a falling tree is covered by several industry guidance publications. A common requirement of these guidance documents is for the landowner to inspect their trees for any indication of possible failure arising from the growing conditions or the onset of disease or decay. The guidance also requires assessment of what harm a falling tree might present based on its surroundings. For example, a tree located within falling distance of a regularly used public space has a higher potential for harm compared to a tree in a rural area with little or no public access.

98 The effectiveness of this risk assessment process requires access to inspect the tree and its surroundings, making and maintaining accurate records, tracking changes in the microenvironment and an understanding of the tree species being assessed.

99 The risk of a visually healthy tree falling onto the railway lines from outside the railway boundary was not being effectively controlled in the case of the tree involved in this accident because:

a. Network Rail is reliant on neighbouring landowners controlling the risk associated with visually healthy trees falling onto the railway lines from outside of the railway boundary (paragraph 100).

b. DCC did not effectively manage the risk of trees falling from its land onto the adjacent railway lines (paragraph 107).

Network Rail

100 Network Rail is reliant on neighbouring landowners controlling the risk associated with visually healthy trees falling onto the railway lines from outside of the railway boundary.

101 Network Rail inspects the vegetation within its boundary in accordance with standard NR/L2/OTK/5201/Mod01, ‘Lineside vegetation inspection and risk assessment’. At the time of the accident this standard was at issue 4 dated December 2020. The standard required that inspections be carried out regularly and that these should include the assessment of trees which could present a hazard to the railway and its infrastructure or to property beyond the railway boundary. The inspections were required to be undertaken by local maintenance teams from the off track section as a minimum every 36 months, but no more than 44 months. These inspections were supplemented with a second inspection undertaken by an arboricultural specialist, at a similar interval.

102 The standard required the inspection to assess vegetation on neighbouring land where it posed a risk to the railway. Such trees were described as those situated within falling distance of the running line which could cause derailment or harm and having a stem diameter more than 150 mm, when measured at chest height. These conditions would have applied to the tree which fell onto the railway lines from Barnhill Rock Gardens.

103 Inspections were to be undertaken on foot by Network Rail or specialist contract staff trained to identify whether a tree is dead or suffering from either disease or decay which might lead to failure. Where the tree was on neighbouring land, the inspection was to be carried out from within the railway boundary. It would not have been routine practice under the standard to have assessed the tree further, even if it was in a publicly accessible location. The inspections reported hazardous trees by exception, that is, a tree which was not identified as dead, diseased or decayed would not be reported for further action.

104 Where a tree was found to be at risk of failure it would be scheduled for remedial work. Where such a tree was identified outside of the railway boundary, then Network Rail would notify the landowner. The contents of this notification would include a reminder of the landowner’s obligations and the potential harm which could arise to the railway if action were not taken.

105 There had been two inspections on the section of line which passes Barnhill Rock Gardens, both undertaken in 2021. The first inspection was undertaken by a member of the local maintenance team and the second was carried out by a specialist arboricultural contractor. The tree was not dead, diseased or decayed (paragraph 48) and would not be considered hazardous in line with the criteria set out by Network Rail. Neither inspection, therefore, identified the tree as posing a risk to the railway. Network Rail had a working relationship with the forestry office at DCC and it is likely that, had the tree been identified as presenting a hazard, Network Rail would have notified DCC, and suitable remedial action would have been undertaken.

106 It might have been possible for the inspections to identify that the sheltering companion trees had been removed, exposing the tree to the risks associated with altered exposure (paragraph 58). However, to undertake an inspection for trees on neighbouring land would require a level of detailed assessment and record keeping which Network Rail did not include in its inspection processes. It instead relied on its neighbouring landowners to manage this.

Dundee City Council

107 Dundee City Council did not effectively manage the risk of trees falling from its land onto the adjacent railway lines.

108 To meet its obligations, DCC stated that in part they rely on Network Rail to advise them of trees presenting a hazard, but they also *'strive towards industry best practice principles'.* To support this, DCC stated that it uses the following reference documents:

- National Tree Safety Group publication '*Common Sense Approach to Managing the Risk of Falling Trees'* [1]
- Health and Safety Executive publication SIM 01/2007/05 '*Management of the risk from falling trees or branches'* [2]
- Arboricultural Association publication '*Tree Surveys a Guide to Good Practice*'.

109 In particular, '*Common Sense Approach to Managing the Risk of Falling Trees'* describes a methodical process for assessment of the risk presented by falling trees. The process begins with the identification of the species, age and condition of the tree to be assessed, along with the location and potential for a tree to cause harm. The method of recording this information is not specified in the publication, but in January 2009, DCC published its document '*Tree and Urban Forestry Policy*'.[3] Within this policy document was a commitment to audit the trees within the care of DCC using a geographic information system (GIS) computer-based tree recording system.

110 DCC initially used a proprietary product to meet this 2009 policy commitment. However, the ongoing costs associated with the use of this product were later considered unacceptable, so DCC discontinued its use. This brought with it a consequential loss of data. To replace the proprietary product, DCC developed a new system internally but, following staff changes within DCC, it was not possible to continue its use.

111 DCC stated that it follows a risk-based approach to tree inspections, prioritising areas throughout the city where a falling tree is likely to cause greater harm. DCC provided a copy of its 'risk zoning matrix' which provides guidance on the frequency and standard of tree inspection to be adopted based on the tree's surroundings. Trees at risk of falling onto the railway were not included within the risk zoning matrix and DCC stated that this was an oversight.

[1] Available from https://ntsgroup.org.uk/publications/.

[2] Available from https://www.hse.gov.uk/foi/internalops/sims/ag_food/010705.htm.

[3] Available from https://www.dundeecity.gov.uk/sites/default/files/publications/urbanpolicy.pdf.

112 The risk zoning matrix used by DCC does not specifically categorise trees in public gardens. However, areas with public access are included in several categories, based on the type of pedestrian use. DCC was not able to advise RAIB in which zone Barnhill Rock Gardens had been categorised, or the frequency at which tree inspections had been conducted. However, DCC stated that the location was considered to be low risk.

113 In November 2021, Storm Arwen caused widespread damage across the north-east of the United Kingdom. DCC stated that following the work to remedy the damage caused by this storm, the trees in Barnhill Rock Gardens were visually inspected. This inspection did not raise any concerns related to the fallen tree as it appeared to be in good health. DCC stated that no reports were raised by DCC staff, Network Rail or volunteers from the gardens relating to concerns about the tree between the inspection in 2021 and its failure during Storm Gerrit.

114 DCC stated that its forestry office resources had been primarily focused on urgent high-priority storm damage recovery work since Storm Arwen and that this recovery work was ongoing because of the continued red and amber severe winter storms affecting the area. DCC also stated that staff resources had been depleted over a number of years which had impacted the ability of the forestry section to carry out routine tree inspections.

115 DCC stated that the visual inspection of the fallen tree would have taken into account wind coming from the Firth of Tay, although the loss of the companion trees and increased wind loading (paragraph 58) was not recorded as presenting an additional risk (paragraph 113). With a successive loss of records, it is unlikely that an effective assessment could be made of the potential risk arising from windthrow, specifically that caused by altered exposure.

Factors affecting the severity of consequences

116 Serious injury from the loss of survival space was avoided by the driver's actions.

117 The HST was first introduced into mainline service in the mid-1970s and there is no restriction on these trains operating in passenger service on the mainline network in Great Britain. HSTs pre-date a number of modern crashworthiness standards, including those relating to the design of the driving cab. The structure of the driver's cab is made of glass fibre reinforced plastic and bolted directly to the underframe and bulkhead separating the driving cab from the power car equipment and engine compartments. This is unlike most other modern train driving cabs, which have a steel or aluminium cab superstructure.

118 The driver described making an emergency brake application immediately upon seeing the fallen tree across the track. This occurred around 80 metres or 2 seconds from the collision while the train was travelling at 84 mph (135 km/h) (paragraph 93). This emergency brake application remained until the train came to a stop and there was nothing more the driver could do to avoid the collision. In the seconds before impact, the driver therefore left the driving seat and sheltered on the floor between the seat and the rear of the cab. Doing this meant serious physical injury was avoided.

119 The tree stem impacted the cab at windscreen height, across the A pillars that support the windscreen at either side of the cab front and the weakest point of the HST cab structure. The energy was greater than the cab structure was intended to withstand and so it did not prevent the tree stem penetrating the cab area previously occupied by the driver. The tree broke through the A pillars and continued to break through the left-hand side of the cab, showering the inside with glass and debris.

120 The rootplate of the tree did not rotate in the ground with the forward motion of the train, with the tree instead beginning to bend until it finally broke into two pieces. This bending motion limited the damage to the right-hand side of the cab, but the tree continued to cut through the left-hand side adjacent to the driver's seat. The structural damage to the left-hand side of the cab extended from the windscreen back to the much stronger bulkhead at the rear, stopping just above where the driver was sheltering (figures 20 and 21).

Figure 20: External damage sustained to leading power car of 1A37.

Figure 21: Internal damage sustained to leading power car of 1A37.

121 The collision occurred at 84 mph (135 km/h) because no speed restriction had been applied for the adverse weather. However, the collision with the fallen tree would still have occurred even if a 50 mph (80 km/h) BSR had been in place (paragraph 94). RAIB has not quantified exactly how a 50 mph (80 km/h) collision speed would have changed the degree of damage sustained by the driver's cab in this collision, but analysis suggests that the collision energy would have been reduced by around 65% at this lower speed.

Observation

122 The telephone concentrator equipment at Network Rail's Scotland integrated control centre was not able to show the history of multiple missed calls from the public helpline call centre.

123 The helpline call handler made several attempts to contact the SICC. During this time, the route control centre staff were dealing with other incidents and did not pick up the call (paragraph 76). The route control centre staff handle calls using desktop equipment known as a telephone concentrator. These combine several incoming telephone lines to a single handset with each line allocated a button to use to answer an incoming call. An incoming call is indicated on the concentrator display for the duration of the call. If the incoming caller terminates the call, the indication stops, but with no history of the missed call provided.

Figure 22: Telephone concentrator at the SICC (courtesy of Network Rail).

124 It is probable that the two calls made before the collision had been unanswered due to the incident support controllers giving the helpline call a lower priority while dealing with flood closures (paragraph 78). However, the absence of a missed call reminder on the concentrator display removes any prompt to the SICC staff that someone might have called and that they may need to be called back.

125 Network Rail stated that calls from the helpline do not normally concern safety of the line issues, and so were generally considered by SICC staff to be a lower priority. For this reason, it is unknown when or if the SICC staff would have returned the helpline call had they been aware that such a call had been missed, or if this would have been done in time to warn the driver of train 1A37 and prevent the collision.

Previous occurrences of a similar character

126 On 5 October 1999, an HST was involved in a fatal accident at Ladbroke Grove near Paddington station which claimed the lives of 31 people. Rolling stock leasing companies reviewed crashworthiness of HSTs in response to Recommendation 53 of the Ladbroke Grove Inquiry and concluded that modifications to HSTs to improve driver protection would not be reasonably practicable (Health and Safety Commission Report November 2005[4]).

127 On 10 July 2010, an HST passenger train collided with a tree at Lavington, Wiltshire at 90 mph (145 km/h) (RAIB report 08/2012). The tree involved had fallen across the two railway lines from land outside the railway boundary. In common with the accident at Broughty Ferry, the impact occurred at windscreen level, with the tree breaking through the left-hand A pillar of the driving cab. The tree caused substantial damage to the left-hand side of the cab, but the damage stopped at the leading edge of the driver’s door. On the basis of the November 2005 Health and Safety Commission report findings, RAIB concluded that the costs associated with retrospective HST cab modifications were likely to exceed the benefits gained if continued use for another 15 years was assumed, so no recommendation was made in this area.

128 On 12 August 2020, an HST passenger train derailed after it had collided with debris washed from a drain onto the track near Carmont, Aberdeenshire, following heavy rainfall (RAIB report 02/2022). This accident resulted in three fatalities, including the train driver. The driving cab of the HST was subjected to severe impact conditions and became detached from the power car. The impact conditions were significantly beyond those in which even modern cabs are designed to provide protection for occupants. A relevant RAIB recommendation resulting from this investigation is discussed in paragraph 135.

[4] https://www.railwaysarchive.co.uk/documents/HSE_Public2005.pdf.

Summary of conclusions

Immediate cause

129 Train 1A37 was unable to stop before colliding with a fallen tree that was obstructing the railway (paragraph 39).

Causal factors

130 The causal factors were:

a. A tree on adjacent land and in close proximity to the railway boundary fell across the lines (paragraph 44).

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

   i. The soil at this location had poor mechanical adhesion characteristics which limited the ability of the tree to resist the wind forces acting on it (paragraph 50).

   ii. The tree had been subjected to increased wind loading due to altered exposure (paragraph 58).

   iii. The wind loading acting on the tree was elevated by the high winds associated with Storm Gerrit (paragraph 65).

b. Notification of the obstruction did not reach the driver following a call from a member of the public telling the railway that the tree had fallen across the lines (paragraph 72, actions taken paragraphs 140 and 141).

c. On sighting the fallen tree, the driver was unable to stop the train before colliding with it (paragraph 81).

Underlying factors

131 The risk of trees in Barnhill Rock Gardens falling onto the railway was not effectively controlled because:

a. Network Rail is reliant on neighbouring landowners controlling the risk associated with visually healthy trees falling onto the railway lines from outside of the railway boundary (paragraph 100, **Recommendation 1**).

b. Dundee City Council did not effectively manage the risk of trees falling from its land onto the adjacent railway lines (paragraph 107, **Recommendation 2**).

Factors affecting the severity of consequences

132 Serious injury from the loss of survival space was avoided by the driver's actions (paragraph 116, **Recommendation 3**).

Observation

133 Although not linked to the accident on 27 December 2023, RAIB observes that the telephone concentrator equipment at the SICC was not able to show the history of multiple missed calls from the public helpline call centre (paragraph 122, no Recommendation).

Previous RAIB recommendation relevant to this investigation

134 The following recommendation, which was made by RAIB as a result of a previous investigation, has relevance to this investigation.

Derailment of a passenger train at Carmont, 12 August 2020, RAIB report 02/2022, recommendation 19

135 This recommendation reads as follows:

Recommendation 19

The intent of this recommendation is to evaluate the additional risk to train occupants associated with the continued operation of HSTs, which entered service before modern crashworthiness standards were introduced in July 1994. This will enable the future planning of HST deployment to be informed by a fuller understanding of any additional risk and the costs and safety benefits of any potential mitigation measures. This learning should also inform thinking about the mitigation of similar risks associated with the operation of other types of main line rolling stock.

Operators of HSTs, in consultation with train owners, ORR, DfT, devolved nations' transport agencies and RSSB should do the following:

a) Assess the additional risk to train occupants associated with the lack of certain modern crashworthiness features compared to trains compliant with Railway Group Standard GM/RT2100 issue 1 (July 1994), also taking account of age-related factors affecting condition (such as corrosion). This assessment should include a review of previous crashworthiness research (including driver safety), a review of previous accidents, consideration of future train accident risk, the findings presented in this report and any relevant engineering assessments.

b) Based on the outcome of a) and cost benefit analysis, identify reasonably practicable measures to control any identified areas of additional risk for HSTs, and develop a risk-based methodology for determining whether, and if so when, HSTs should be modified, redeployed or withdrawn from service.

c) In consultation with operators of other pre-1994 passenger rolling stock, develop and issue formalised industry guidance for assessing and mitigating the risk associated with the continued operation of HSTs and other types of main line passenger rolling stock designed before the introduction of modern crashworthiness standards in 1994.

136 On 6 April 2022, in response to this and other recommendations, the Office of Rail and Road (ORR), the safety authority for railways in Great Britain, hosted a meeting with owners and operators of HSTs, together with government bodies and the Rail Safety and Standards Board (RSSB), to consider how this recommendation should be addressed. The initial consideration of the recommendation by relevant parties was completed by the 'Carmont Seniors Group' co-ordinated by Angel Trains. Actions arising included commissioning a consultancy to undertake an HST design review and including the co-ordination function of the Carmont Seniors Group in a group known as the 'RSSB Carmont Recommendations Steering Group.'

137 On 15 February 2023, RSSB reported to ORR that it had commissioned SNC Lavalin to undertake a literature search of previous relevant accidents to inform engineering analysis of HST trailer vehicles.

138 On 9 March 2023, ORR reported to RAIB that while RSSB had taken the recommendation into consideration and is taking action to implement it, it considered the recommendation to still be open.

139 As a result of the accident at Broughty Ferry, RAIB has made a recommendation to the RSSB Carmont Recommendations Steering Group to review the circumstances of this accident as part of developing its response to Carmont recommendation 19 (see recommendation 3, paragraph 145).

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

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

140 Network Rail has provided the helpline call handlers with a priority call telephone number for their route control centres. If a helpline call hander becomes aware of an issue affecting the safety of a railway line, they can use these numbers to warn control centre staff.

141 Network Rail also reported that incoming calls to a route control centre using the priority call telephone number will be answered as a high priority and by a larger pool within the existing route control centre staff. This should prevent future delays in answering calls relating to safety of the line matters. Other, more general calls from the helpline will use the previous telephone number to avoid diluting the status of the high priority calls.

142 Network Rail's internal investigation into the accident recommended a review of the existing telephone system within the SICC to determine its suitability for modern-day railway control operations. This review should address the observation regarding the adequacy of the current system (paragraph 122).

Other reported actions

143 DCC stated that work required to manage the effects of ash dieback has led to the adoption of a new GIS system which DCC plans to apply to all trees for which the council is responsible. DCC plans to share information from the GIS system with Network Rail to improve collaboration.

144 Network Rail's Technical Authority is developing an aerial survey system to assist with the lineside inspection of trees. The system known as digitised lineside inspection (DLI) uses data produced from equipment on board aircraft to survey the railway corridor. The data is supplemented by light detection and ranging (LiDAR) scans and hyperspectral imaging which is processed by software to identify dead, diseased or decayed trees. Network Rail states that use of aerial survey techniques allows the survey to better incorporate trees on neighbouring land which are within falling distance of the railway.

145 On 3 September 2024, the Scottish Government announced that the procurement process will begin to replace the HST sets operated by ScotRail.

Recommendations

146 The following recommendations are made:[5]

1 *The intent of this recommendation is to use emerging technology to identify trees which have been subject to altered exposure and are potentially at risk of falling onto the railway.*

Network Rail, as part of its development of aerial surveying technology, should consider how current and emerging technology of this nature could assist in the detection of trees subject to altered exposure, including those trees on third-party land, which could present a risk to the railway (paragraph 131a).

2 *The intent of this recommendation is for Dundee City Council to improve its management of the trees which are its responsibility, and which are at risk of falling onto the railway.*

Dundee City Council should review its management of the trees for which it is responsible to ensure that it is effectively controlling the risk of trees falling onto the railway. This review should consider:

i. compliance with legal requirements and available good practice related to tree management

ii. how trees within falling distance of the railway are identified

iii. how factors that could increase the risk of healthy trees falling onto the railway such as tree species, growing requirements (including soil condition and effects of windthrow) are understood and accounted for

iv. how a risk-based approach to tree inspections is to be established

v. how accurate records of tree inspections are to be maintained.

Dundee City Council should develop a timebound programme to make any appropriate changes identified to their policies, procedures and systems (paragraph 131b).

[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 and 3 are addressed to the Office of Rail and Road (ORR) and Recommendation 2 is addressed to Dundee City Council 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 provide additional information to the rail industry group which is currently evaluating the additional risk to train occupants associated with the continued operation of high speed trains, which entered service before modern crashworthiness standards were introduced in July 1994.*

The Rail Safety and Standards Board Carmont Recommendations Steering Group should review its response to recommendation 19 made within RAIB report 02/2022, following its investigation into the derailment of a passenger train at Carmont, Aberdeenshire on 12 August 2020 to ensure that the circumstances of this accident have been addressed (paragraph 132).

Appendices

Appendix A - Glossary of abbreviations and acronyms

Abbreviation / acronym	Full term
BSR	Blanket speed restriction
DCC	Dundee City Council
DLI	Digitised lineside inspection
EWAT	Extreme weather action teleconference
FFCCTV	Forward-facing closed-circuit television
FLAC	Forbes-Laird Arboricultural Consultancy Ltd
GIS	Geographic information system
GSM-R	Global System for Mobile Communications – railway
HST	High speed train
LiDAR	Light detection and ranging
MAR	Mechanically active rootplate
ORR	Office of Rail and Road
OTDR	On-train data recorder
RAIB	Rail Accident Investigation Branch
RCM	Route control manager
RSSB	Rail Safety and Standards Board
SICC	Scotland integrated control centre

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, remote monitoring and FFCCTV equipment
- site photographs and measurements
- weather reports from Dundee City Airport
- a report prepared by Forbes-Laird Arboricultural Consultancy Ltd (FLAC), commissioned by RAIB. The report included FLAC's conclusions on the examination of the tree and the site where it grew, and its view on the reasons for why the tree fell. This work is documented in Forensic Accident Investigation (Arboriculture) Expert's Report 44-1005_JFL. Since 2009, FLAC has provided specialist advice on tree risk matters to Network Rail Infrastructure Ltd and acted as a consultant on arboricultural matters to the world body for railways, Union Internationale des Chemins de Fer, Paris.
- a review of documentation and information provided by Dundee City Council
- a review of documentation and information provided by Network Rail
- a review of the rail industry investigation report into the accident, prepared by Network Rail
- a review of previous RAIB investigations that had relevance to this accident.

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