



Rail Accident Investigation Branch

# Rail Accident Report



## **Derailment near Gillingham tunnel, Dorset 28 November 2009**

This investigation was carried out in accordance with:

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

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

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## Summary

During the evening of 28 November 2009, a London to Yeovil train ran into a landslip in a cutting on the eastern approach to Gillingham tunnel in Dorset. The leading carriage of the train became derailed and the train ran into the tunnel and stopped 200 metres inside.

The landslip was caused by water overflowing from a blocked ditch at the top of the cutting slope.

Two passengers reported minor injuries. The leading carriage of the train and around 450 metres of railway track were damaged.

The RAIB have made five recommendations to Network Rail relating to management of drainage and earthworks. These include a recommendation to identify, and then adequately maintain, drainage which is required for railway safety but is not located close to the railway tracks.

## Preface

- 1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.
- 2 The RAIB does not establish blame, liability or carry out prosecutions.

## Key Definitions

- 3 All dimensions and speeds in this report are given in metric units, except speed and locations on Network Rail, which are given in imperial dimensions, in accordance with normal railway practice. In this case the equivalent metric value is also given.
- 4 Mileages in this report are measured from a zero datum at London Waterloo. References to left and right are relative to the incident train's direction of travel towards Yeovil.
- 5 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

## The Accident

### Summary of the accident

- 6 At 19:21 hrs on 28 November 2009, the 17:20 hrs London to Yeovil train, reporting number 1L53, was derailed by debris from a landslip on the northern side of the cutting on the eastern approach to Gillingham tunnel, Dorset. The landslip had been caused by water overflowing from a blocked ditch and weakening the soil.
- 7 The derailed train was a three coach, class 159, *diesel multiple unit*. It was running at 64 mph (103 km/h) when it was derailed 204 metres before the tunnel entrance. The derailed train continued to the tunnel entrance, and then for a further 200 metres into the tunnel, before stopping.
- 8 Two passengers reported minor injuries. The leading coach suffered damage to its bodywork and to equipment mounted beneath the coach body. Approximately 450 metres of track required repair. The line remained closed for five days.
- 9 The consequences could have been more severe if the train had struck the wall around the tunnel entrance instead of running into the tunnel mouth at a speed of about 45 mph (72.4 km/h).

### Organisations involved

- 10 Network Rail owns, operates and maintains the railway infrastructure at the accident site. The accident location is within Network Rail's Wessex Route which broadly covers the railways radiating from London Waterloo station.
- 11 The Network Rail *earthworks & drainage* team (E&DT) is responsible for specialist input to the earthworks and drainage management on Wessex, Sussex, Kent and East Anglia Routes; an area designated Southeast Territory (SET) by Network Rail's civil engineering organisation. The team is based at Waterloo and is led by the route geotechnical engineer (RGE). E&DT provide directly, or through contractors, routine examination of earthworks and, with the exception of some drain related activities, implement the actions necessary for the earthworks to remain fit for purpose. They are not responsible for routine inspection and maintenance of drains but they do provide professional support to these activities.
- 12 The Salisbury *track maintenance engineer* (TME) leads the Network Rail team responsible for routine inspection and maintenance of tracks, drainage and some other railway assets in the Gillingham area. At the time of the accident, the TME used the Wessex drainage team to provide the resource required at locations where significant amounts of drain maintenance were needed. The TME's staff are required to report any earthwork defects noted during track patrols etc but they do not undertake specialist earthwork inspections and are not responsible for remedying earthwork defects.
- 13 The Network Rail Wessex drainage team based at Woking was, at the time of the incident, responsible for drain maintenance throughout the Wessex Route except for minor work carried out by locally based staff.

- 14 South West Trains, part of the Stagecoach Group, maintain and operate the train involved in this incident.
- 15 Aecom (formerly Faber Maunsell but referred to as Aecom throughout this report) have undertaken all relevant earthwork examinations on behalf of Network Rail.
- 16 Network Rail, South West Trains and Aecom freely co-operated with RAIB's investigation.

## Location

- 17 The derailment occurred at a mileage of 107 miles 34 *chains* on the Basingstoke to Exeter railway. After derailing, the train continued into the eastern end of Gillingham tunnel. This tunnel is 677 metres long and runs between approximate mileages of 107 miles 44 chains and 107 miles 78 chains. It is sometimes known as Buckhorn Weston tunnel. The accident location is about 23 miles (37 km) west of Salisbury, about 1½ miles (2 km) west of Gillingham and about 14 miles (23 km) east of Yeovil (figure 1).



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

- 18 The derailment took place in a cutting which is 8 metres deep at the site of the landslip which caused the derailment. A ditch along the northern cutting crest is intended to intercept water from adjacent farmland and woodland to prevent it running down the cutting slope (figure 2). This ditch crosses the Network Rail boundary at several places and is outside the boundary at the location of the landslip (figure 4).
- 19 The railway runs through the incident area in a straight line with a maximum permitted speed of 85 mph (137 km/h). It was constructed as a double track railway in the mid nineteenth century. In 1967, it was reduced to a single track running along the middle of the area formerly occupied by the two tracks. This resulted in a wide cess along the both sides of the single track (figure 3).



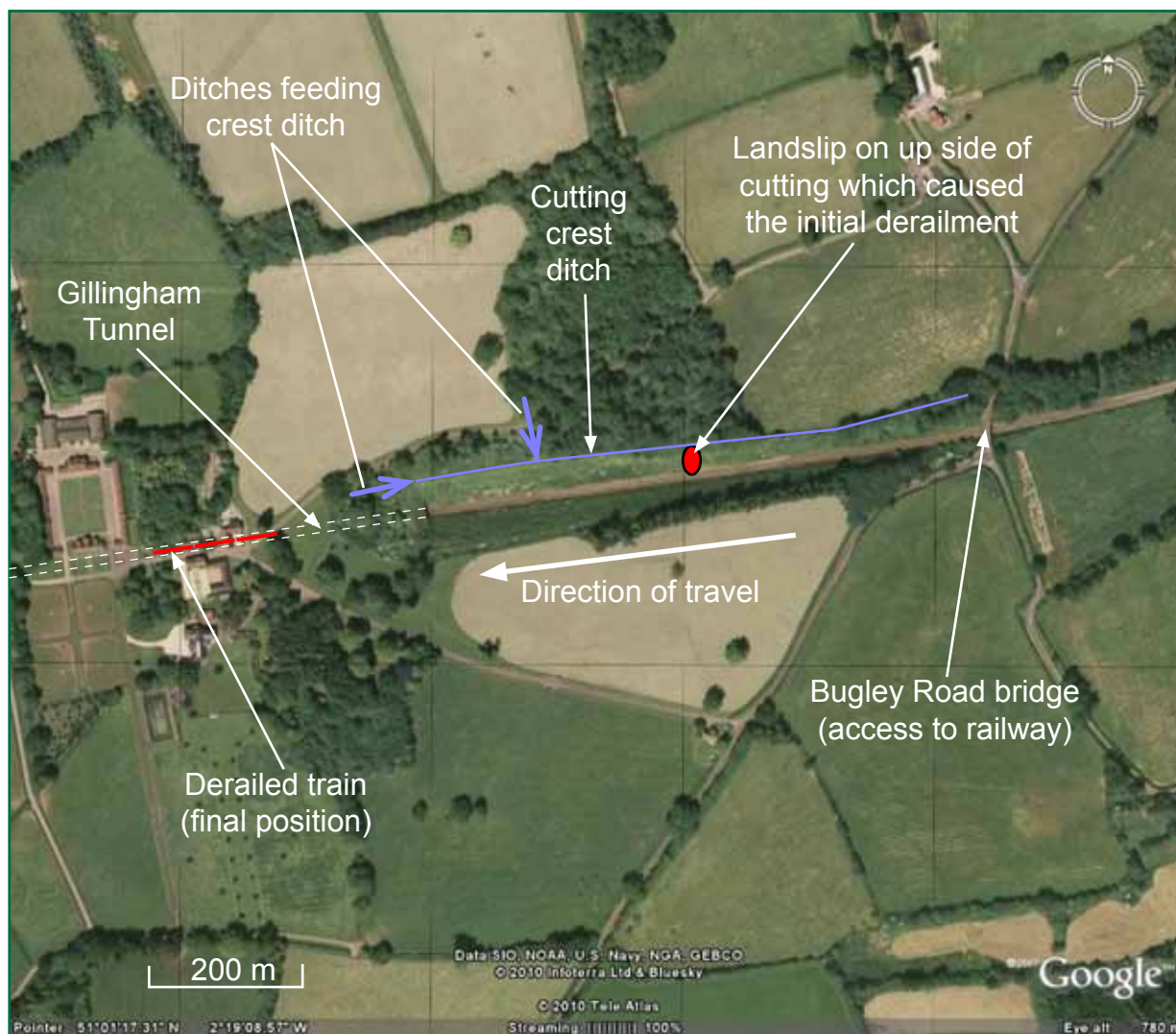


Figure 2: Accident overview (image courtesy of Google Earth)



Figure 3: Track level view of accident site

## Infrastructure

- 20 There was a greater risk of landslips occurring on the relatively steep slopes of the incident cutting than on the shallower slopes which would be adopted for a similar cutting designed to modern standards. This situation is common on the Victorian earthworks which form a large part of the UK rail network and the associated risks are intended to be managed by Network Rail's earthwork management processes.
- 21 A new cutting would be designed to Network Rail standard NR/SP/CIV/071, Design of Earthworks and Earthworks Remediations, using site specific measurements of ground strength. These measurements are not available for the Gillingham site but an initial estimate of the side slopes needed to comply with the current standard can be made using rock types noted during inspections at the incident site<sup>1</sup>. The Gillingham cutting passes through alternating layers of limestone and mudstone. The mudstone layers are several metres thick and are the main influence on slope behaviour. A survey undertaken in the 1980s shows that cuttings in mudstones typically require side slopes of between 1 in 1.5 and 1 in 2 to achieve satisfactory performance<sup>2</sup>. Although the mudstone at Gillingham is not identical to those in the survey, it is reasonable to expect that a new cutting at Gillingham would be designed with shallower slopes than the 1 in 1.2 which existed before the failure occurred<sup>3</sup>.
- 22 It was raining heavily before and during the accident but the rainfall was not exceptional. About 15 mm of rain had fallen at the accident site in the 24 hours before the accident. This included about 10 mm in the two hours immediately before the accident<sup>4</sup>. Network Rail National Control Instructions require extreme weather procedures to be implemented if more than 25 mm of rain is forecast to fall in a 24 hour period<sup>5</sup>. Actual and forecast rainfall at the accident site were below this threshold throughout the week before the accident.
- 23 The ground at the accident site was almost saturated. This is a normal condition in late November after autumn rains have recharged soil which has been subject to drying effects during the summer months. The alternating layers of limestone and mudstone meant that the ground contained alternating layers of permeable and low permeability material. Water percolating into the ground tended to move sideways over the low permeability layers and emerge on the cutting side slopes as a series of small springs which increased the amount of water on the cutting face.
- 24 The crest ditch contained leaves which had fallen from nearby trees and leaves which had entered this ditch with water from areas to the north and west of the cutting (figure 2). This was a result of normal autumn leaf fall.

<sup>1</sup> Geological Survey report (1952) and Network Rail slope inspection (29/11/09).

<sup>2</sup> Survey of Slope Condition of Motorway Earthworks in England and Wales, Transport and Road Research Laboratory (1989). 1 in 1.5 means 1 metre (vertical) in 1.5 metres (horizontal).

<sup>3</sup> November 2009 examination records a 40 degree (1 in 1.2) slope.

<sup>4</sup> Rainfall data from West Stour weather station, about 2 km south of the accident site. Obtained through wunderground.com.

<sup>5</sup> Lowland rainfall limits from Appendix B of NR/L3/OCS/043/7.1 National Control Instructions and Approved Code of Practice.

- 25 Network Rail had taken over maintenance of the crest ditch in the months leading up to the accident even though parts of this ditch were just outside the Network Rail boundary (figure 4). Land owners are normally responsible for maintaining ditches on their own land but it can be difficult to establish the extent of these obligations and, even if they are known, it can be difficult to force a neighbour to undertake the work. Rather than addressing these complex issues, Network Rail sometimes decide to maintain ditches on neighbouring land if the neighbour permits access. This approach had been adopted at Gillingham.

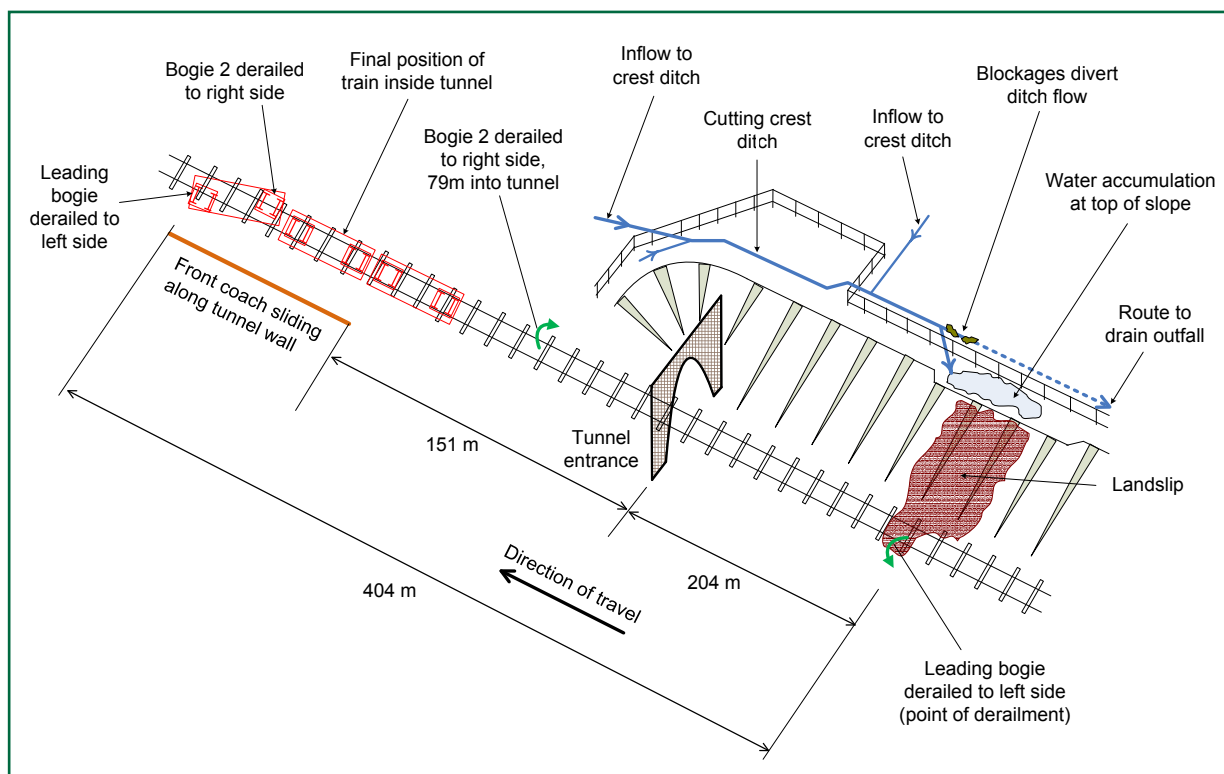


Figure 4: Plan of accident site (not to scale)

## External circumstances

- 26 Darkness and heavy rain meant that the driver could only see about 30 metres in front of the train. The accident took place about three hours after sunset and the rural location meant that there was no artificial light except the train's headlight, which is intended to illuminate trackside signs and warn staff of an approaching train rather than to illuminate the track ahead of the train.

## Equipment

- 27 The derailed unit had left Waterloo as part of a six coach train comprising two class 159 diesel multiple units. As timetabled, one unit was detached at Salisbury and only the three coaches comprising unit 159018 continued towards Gillingham. The RAIB has found no evidence to link the condition or operation of the train to the accident.
- 28 There were no significant defects in the track at the accident site and the RAIB has found no evidence to link the condition of the track to the accident.

- 29 The railway in the accident area is signalled by the tokenless block system and the location of the accident is not track circuited. The operation of the signalling system played no part in the accident.

### Earthwork stewardship processes

- 30 In the later years of British Rail and the early years of Railtrack, the overall approach to earthwork stewardship was characterised by reacting to observed problems rather than using specialist resources to inspect earthworks and manage potential problem areas in a pro-active manner. Railtrack recognised the advantages of a pro-active management system and started specialist assessment of earthworks in 1997. However, implementation of this system varied across the country and, in common with most earthworks in the South East Territory, the cutting at Gillingham had not been assessed until after an updated earthworks management system was introduced in 2005. The updated system is described below.
- 31 Network Rail standard NR/L2/CIV/086, Management of Existing Earthworks, was first issued in June 2005<sup>6</sup>. It describes how landslip risks should be managed using a system of examinations followed, where necessary, by evaluations.
- 32 Examinations are required to identify and record signs of earthwork instability at all earthworks in excess of 3 metres high, and some other earthworks. The examination process is described in Network Rail standard NR/L3/CIV/065, first issued in June 2005<sup>7</sup>. Examiners consider each five chain length of earthwork separately and record factors including slope geometry, drainage arrangements and signs of slope instability. These factors are assigned a score reflecting their possible influence on future slope performance.
- 33 Network Rail has developed a system which combines the scores for each factor to give a condition rating of satisfactory, marginal or poor for each five chain length of earthwork<sup>8</sup>.
- 34 Standard NR/L2/CIV/086 requires an evaluation to be carried out on earthworks classified as poor. The evaluation process is described in this standard and in Network Rail guidance note NR/GN/CIV/203 issued in October 2007<sup>9</sup>. The evaluation process comprises an appraisal of all relevant information (including relevant historic documentary evidence) regarding the stability, condition and use of an earthwork, to determine the actions required to maintain acceptable levels of safety and performance.
- 35 Actions arising from an evaluation can include detailed slope monitoring and implementation of drainage and/or strengthening works. However, the most common action is to carry out annual examinations. This is more frequent than the five or ten year examination intervals applied to earthworks with condition ratings better than poor.

<sup>6</sup> Known as RT/CE/S/086 when first issued.

<sup>7</sup> Known as RT/CE/S/065 when first issued.

<sup>8</sup> The combined score is the soil slope hazard index which is related to slope condition rating in Table 1 of NR/L3/CIV/065. Specialist Network Rail HQ staff are custodians of the calculation methodology and modify it as experience is gained from actual earthwork performance.

<sup>9</sup> No compliance date is given in the guidance note implying that immediate compliance was expected.

- 36 The geotechnical competencies required by staff undertaking examinations and evaluations are described in Network Rail standard NR/SP/CTM/017, Competence & Training in Civil Engineering. The standard also outlines a system of initial assessment and annual performance review for people undertaking these tasks. Earthwork examiners must have competency EWE 3, “examine the condition of earthworks”. Evaluators must have competency EWE 1, “ensure that earthworks remain fit and safe for use”. Appendix E of NR/SP/CTM/017 gives detailed requirements for both these competencies.
- 37 The quality of examinations is verified by checking selected examinations in accordance with Network Rail standard NR/L2/CIV/086.

## Historical background

- 38 The cutting was constructed in the 1850s. The crest ditch was constructed many years ago, probably at the same time as the cutting, but there is no record of this.
- 39 The cutting appears to have suffered from landslips on several occasions since it was dug. Although no records have been found describing instability before 1999, it is improbable that the several different slope failures reported in paragraphs 40 and 43 would suddenly start in a short period of time after 150 years without instability. On-going instability over many years, not necessarily affecting railway operation, is also consistent with documentary evidence and visible repairs showing similar performance at comparable cuttings elsewhere on the rail network.
- 40 Three landslips on the *up* side of the cutting affected the railway in 1999. A train was damaged in July 1999 when it struck a tree which had been dislodged by a landslip<sup>10</sup>. Landslips blocked the line in October 1999 at 107 miles 35 chains and in December 1999 at 107 miles 30 chains. The October and December events are described in a Railtrack memo dated 3 March 2000 which says that the December landslip was caused by the crest ditch being overwhelmed by runoff from the adjacent fields. This memo also mentions a landslip at 107 miles 40 chains on the up side which had not slid over the base of the cutting to block the line.
- 41 The March 2000 memo noted that further landslips might occur and suggested installation of drainage grips (stone filled trenches which improve slope stability) on the cutting slope as a possible remedy. It also suggested that Railtrack should investigate acquisition of the land adjacent to the up side cutting crest to allow unspecified improvements to the maintenance of the crest drain. Neither of these measures were implemented. The RAIB has not been able to establish why they were not implemented. The memo’s suggestion that the vegetation should be removed from the cutting slope was carried out at an unknown time; however it had been completed by the time the slope was examined in May 2007.
- 42 No formal records have been found relating to the performance, maintenance or inspection of the earthworks and drainage between March 2000 and May 2007. Witnesses report that some ditch maintenance was undertaken after the 1999 events but cannot recall details.

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<sup>10</sup> Network Rail Safety Management Information System report QSR/1999/04/307.

- 43 The first examination of the incident cutting under Network Rail standards NR/L2/CIV/086 and NR/L3/CIV/065 was undertaken in May 2007. Evidence of previous landslips was recorded on the up side of the cutting, the same side as the incident landslip, at the locations listed below. These landslips had not affected the track<sup>11</sup> and it is not known when they had occurred.
- 107 miles 30 chains (about 80 metres from the accident site)
  - 107 miles 32 chains (about 40 metres from the accident site)
  - 107 miles 36 chains (about 40 metres from the accident site and possibly the slip reported in the March 2000 memo, see paragraph 40).
- 44 The landslips and other ground features seen during the examination resulted in this section of earthwork being given a condition rating of 'poor'. This triggered the need for an evaluation which was carried out by a member of the E&DT in July 2007. The evaluator concluded that risks related to cutting slope instability should be managed by annual examinations. This conclusion was partly based on the belief that any landslip debris was unlikely to cross the wide cess and block the line.
- 45 The evaluator followed normal practice in SET and considered only features visible during his own visit to the site and visual observations recorded during the May 2007 examination. (If earlier examinations had been carried out, he would also have considered reports from these visits.) Contrary to Network Rail processes (paragraph 34), he did not seek documentary evidence of previous slope performance such as the March 2000 memo which recorded slips blocking the line in 1999.
- 46 An Aecom employee undertook the first annual re-examination at the incident site on 8 January 2008 as part of the 2007/08 examination season. The next inspection, part of the 2008/09 season, was made on 17 December 2008 when the examiner observed a recent landslip at 107 miles 34 chains and immediately reported this to Network Rail (figure 5). As a result, the E&DT visited the site on 8 January 2009 and located a blockage in the crest drain which had led to water overflowing and triggering the landslip. The E&DT asked the Wessex drainage team to clear this blockage .

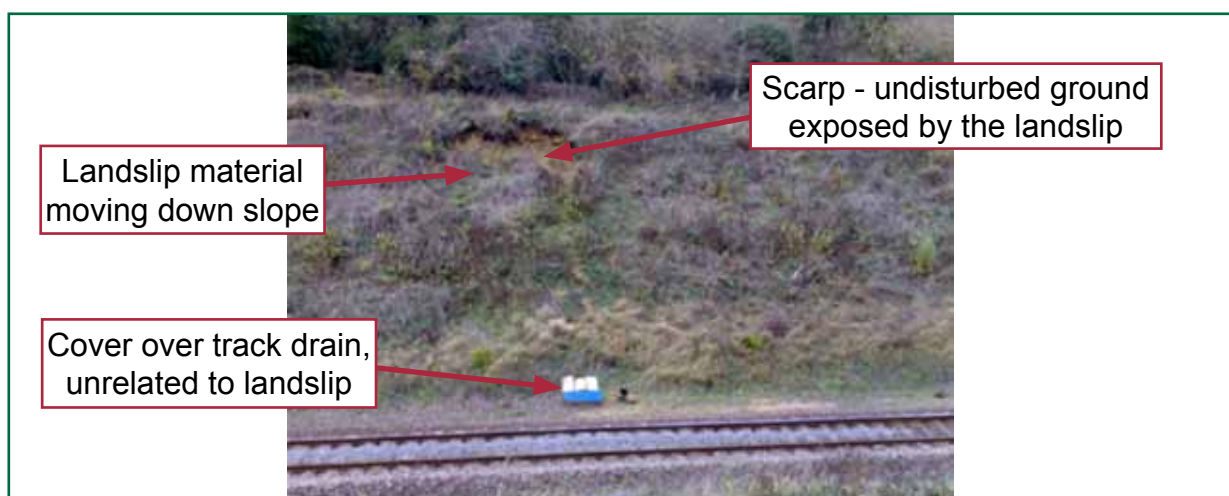


Figure 5: Landslip which occurred shortly before 17 December 2008 (image courtesy of Network Rail)

<sup>11</sup> Landslips not affecting the track can take several forms; an example is shown in figure 5.

- 47 The Wessex drainage team had been unaware of the crest drain until they were asked to remove the blockage by the E&DT. The drainage team removed the blockage on 28 January 2009 and spent 18 person-days on more extensive maintenance of the ditch in July 2009.
- 48 The next annual examination of the slope was undertaken by an Aecom employee on 25 November 2009. He found no significant deterioration of the slope since his previous visit in December 2008.
- 49 Members of the Wessex drainage team inspected the drain on 26 November 2009 and reported verbally to the drainage team manager that it was in a satisfactory condition.

### Events preceding the accident

- 50 On 28 November 2009 a train travelling towards London passed the accident site in darkness and without incident at about 18:40 hrs; approximately 40 minutes before the accident. After this train passed, debris from a landslip caused by an overflowing drainage ditch blocked the line at 107 miles 34 chains. There were no witnesses to this event, which took place adjacent to the landslip reported in December 2008 (figure 6).



Figure 6: Accident and December 2008 landslips (Image courtesy of Network Rail)

## Events during the accident

- 51 The train involved in the accident departed from Gillingham station and started climbing the incline towards Gillingham tunnel at 19:18 hrs. Three minutes later, and travelling at 64 mph (103 km/h), the leading bogie of the front coach hit a landslip blocking the line 204 metres before the tunnel entrance (figure 4), and derailed to the left in the direction of travel.
- 52 Only the leading bogie was derailed at the landslip site, and the train continued moving towards the tunnel entrance. It entered the tunnel approximately 8 seconds after the derailment at a speed of about 45 mph (72 km/h) and with a clearance of about 0.6 metres between the leading coach and the tunnel wall. At about this time, the driver shut off power and applied the brakes.
- 53 The rear bogie of the front coach derailed when it was 79 metres inside the tunnel. The front coach leant towards the left until the front left corner of this coach struck the tunnel wall 151 metres from the tunnel entrance. This coach slid along the tunnel wall until, 27 seconds after the initial derailment, the train stopped with its leading end 200 metres inside the tunnel (figure 7).



*Figure 7: Train leaning against tunnel wall after the accident*



## Consequences of the accident

- 54 Two passengers reported minor injuries. The leading coach sustained damage to the bodywork and components including wheels, brakes and the engine (figure 8).
- 55 Approximately 450 metres of track required repair. The line remained closed for five days until 04:52 hrs on 3 December 2009.



Figure 8: Body and wheelset damage (Images courtesy of South West Trains and Railcare)

## Events following the accident

- 56 The driver contacted the Gillingham signaller at 19:25 hrs to report the accident and summon assistance.
- 57 At 20:02 hrs, railway emergency response staff arrived at the road access nearest the accident site and accompanied emergency services to the derailed train. Following an assessment of the site, they decided to evacuate the passengers using a rescue train. This arrived at 22:20 hrs and departed with the rescued passengers and train crew at 23:12 hrs.

## The Investigation

### Sources of evidence

58 The following sources of evidence were used:

- witness interviews;
- data recorded by the train's *on train data recorder*;
- site photographs and measurements;
- observations from weather stations near the site;
- train condition & examination reports;
- drainage maintenance records (no relevant drain inspection records were found);
- a Geological Survey report on Gillingham tunnel;
- Network Rail Safety Management Information System (SMIS) reports
- Network Rail standards;
- Highways Agency's Design Manual for Roads and Bridges (DMRB);
- Construction Industry Research & Information Association (CIRIA) Report C591;
- Transport and Road Research Laboratory Research Report 199; and
- a review of previous RAIB investigations relevant to this accident.

### Previous occurrences of a similar character

59 Since 2004 there have been typically one or two derailments each year due to cutting landslips on Network Rail infrastructure. These are discussed in paragraph 105.

## Key facts and analysis

### Identification of the immediate cause<sup>12</sup>

- 60 **The immediate cause of the accident was a landslide triggered by water overflowing from a blocked ditch.**
- 61 Inspection of the site after the accident showed that leaves had blocked the crest ditch causing water to overflow and accumulate at the top of the cutting slope (figure 9). This would have made a landslide more likely because:
- Some of the accumulated water would have seeped into the slope augmenting the seepage normally experienced due to rainfall. Water seeping into soil reduces the strength of the soil, with additional seepage causing further strength reduction. Soil strength is required to prevent landslips on the side of cuttings.
  - Water seeping into soil may increase soil weight and cause slope instability. Additional seepage increases this effect.
- 62 Landslips have occurred on several occasions and at several locations in the cutting, showing that they are not associated with very unusual conditions such as very extreme rainfall. This indicates that the strength of the steep cutting slope was close to the minimum needed to prevent landslips under normal conditions (paragraphs 20 and 21) and that heavy rain (or ditch overflow due to heavy rain) could trigger a landslide.
- 63 A similar landslide in December 1999 had been caused by the same ditch overflowing and no long term solution had been provided to prevent the event being repeated (paragraph 40).
- 64 There is no evidence suggesting that the landslide on 28 November 2009 was triggered by any cause except the overflowing ditch.
- 65 It is impossible to carry out a theoretical analysis demonstrating with certainty that water overflowing from the ditch caused the landslide. This is because it is always difficult to measure ground parameters precisely and it would have been impossible after the ground had been disturbed by the landslide.

### Ditch maintenance and inspection process

#### Adequacy of ditch maintenance

- 66 **The ditch, at least in the area where tree roots caused the blockage, was not dug out to an adequate size during maintenance work. There is no evidence that, in the absence of obstructions, the ditch capacity would have been inadequate. It is uncertain whether the ditch size was sufficient to deal with the leaves, branches and twigs expected to fall from the surrounding vegetation. It is certain that the roots caused leaves and twigs to accumulate and block the ditch. The presence of roots is a causal factor and the ditch size is a possible causal factor.**

<sup>12</sup> The condition, event or behaviour that directly resulted in the occurrence.

- 67 The ditch overflowed due to a blockage caused by leaves and twigs being trapped in tree roots which partially obstructed the ditch (figure 9). These roots would have been present when the ditch was maintained in July 2009, and had not been removed. Neither the volume of water nor the leaf fall were exceptional so it can be concluded that the roots were, at least in part, the reason why the ditch overflowed.

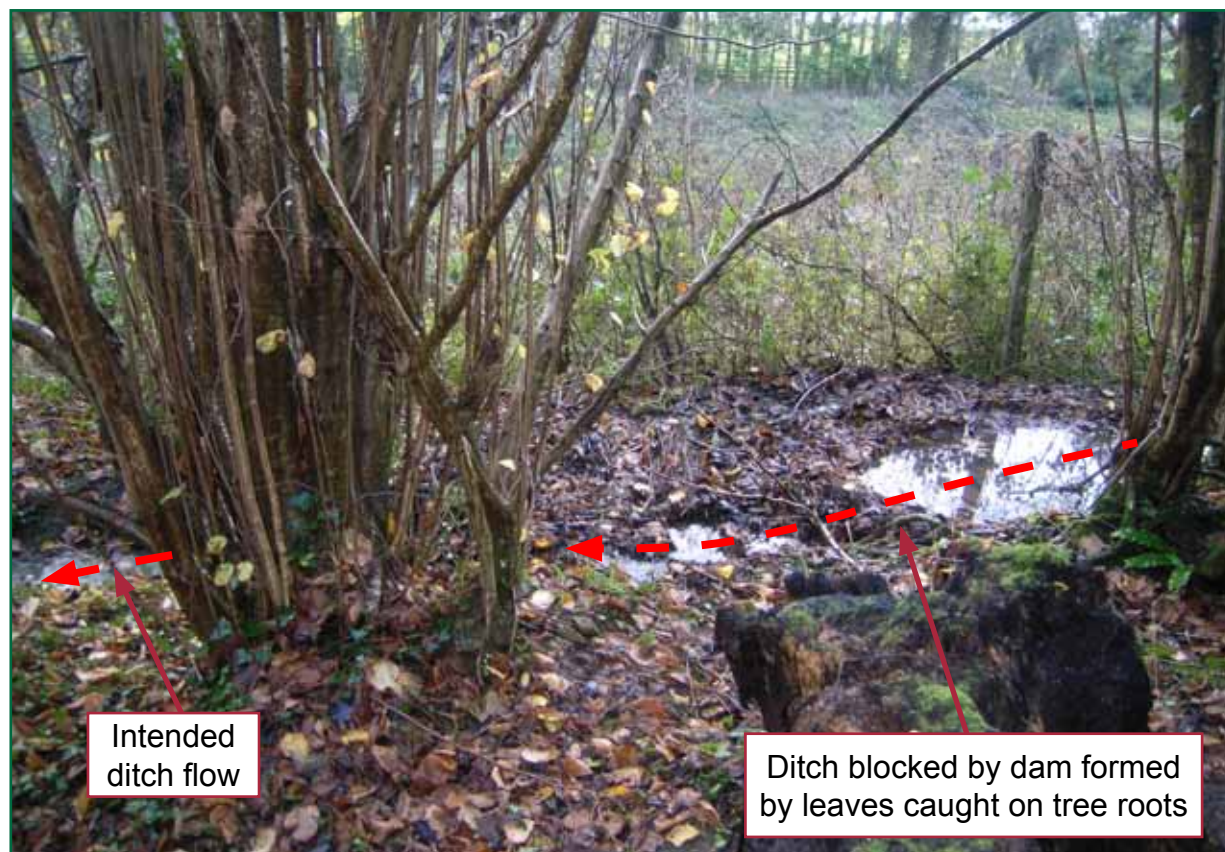


Figure 9: Blocked cutting crest ditch (railway boundary fence and cutting in background)

- 68 The Wessex drainage team had not removed the roots as it was impractical to do this with the hand tools they normally carried. There is no record of how they dealt with the roots but it is likely that they followed their normal practice and widened the ditch by an amount they judged to be sufficient to compensate for the blocking effect of the roots.
- 69 The roots should have been removed to meet the requirements of Network Rail standard NR/L3/TRK/002/D07, Off Track Open Channels and Ditch Maintenance. Although this standard envisages use of hand tools, it does not say how vegetation should be removed if this cannot be done with hand tools. The Wessex drainage team were unaware of this standard.
- 70 The Wessex drainage team had no means of determining the size of ditch needed to provide adequate capacity if clear of roots and other obstructions. They dug out the ditch to a size they considered appropriate based on their experience elsewhere on the railway. RAIB has not established whether, in the absence of roots, the drain would have been of sufficient size as this is outside the scope of the investigation and would require a disproportionate amount of work<sup>13</sup>.

<sup>13</sup> Assessing actual ditch capacity and actual ditch flows is more complex than routine ditch design as the simplifications and conservatisms implicit in standard design methods must be eliminated.

- 71 All maintenance on this ditch had been carried out in response to observed problems. Although the absence of a regular maintenance cycle did not contribute to this particular incident, the wider implications of this issue are discussed in paragraph 94.

### Adequacy of ditch inspection

- 72 Staff inspecting the ditch did not know the extent to which tree roots were permitted to obstruct the ditch, the amount of ditch widening needed if roots remained in place or the ditch size needed to ensure satisfactory ditch performance. The lack of adequate guidance on tree roots is a causal factor; the lack of adequate guidance on ditch size is a possible causal factor.**

- 73 People inspecting the ditch had no guidance concerning tree roots whose removal was impractical with hand tools and no ditch size criteria to assist with deciding whether the ditch was in an acceptable condition.
- 74 There was no regular inspection regime for the incident ditch. Although the absence of a regular inspection regime did not contribute to this particular incident, the wider implications of this issue are discussed in paragraph 94.

### Ensuring adequate ditch size

- 75 Network Rail had no process for establishing ditch conditions to be achieved during maintenance work, including how to deal with roots whose removal was impractical with hand tools, and the size of ditch required. The absence of this process is a causal factor.**

- 76 The RAIB found no evidence that Network Rail had established the dimensions required for satisfactory operation of the incident ditch. Witness evidence indicates that this also applies to most ditches on the rail network. Network Rail documents did not require ditch size criteria to be used for maintenance and inspection purposes.

## Earthwork Examination and Evaluation

### Recent examinations and evaluation

- 77 The incident earthwork had been evaluated on the basis that landslip debris was unlikely to cross the wide cess and block the line. Historical records showed that landslips had previously blocked the line and that mitigation against this risk was needed. Neither the need to consider these records, nor their significance, were appreciated. Not taking account of historical records is a possible causal factor.**
- 78 All examinations at Gillingham have been undertaken on behalf of Network Rail by Aecom earthwork examiners. The first examination was undertaken on 2 May 2007 and resulted in the cutting slope being classified as poor. This meant that an evaluation was required.

- 79 Evaluation requires an assessment of future cutting slope behaviour. This behaviour is difficult to predict, partly because it is governed mainly by ground characteristics which are hidden below the ground surface and vary with weather conditions. In most instances, it is impractical to carry out the sub-surface investigations needed to measure these characteristics, so slope prediction relies on a specialist using judgement and experience to interpret features visible on the ground surface. Predictions for a slope can sometimes be improved if the specialist has documents or other records showing how the slope, or a similar slope, has performed in the past. Although Network Rail standards include sub-surface investigation data as a possible input to evaluations, this is not generally interpreted as requiring sub-surface investigation for most evaluations triggered only by an examination report saying that an earthwork is in poor condition. This type of evaluation should, for a minority of poor condition slopes, recommend a sub-surface investigation followed by a more detailed evaluation.
- 80 A member of Network Rail's E&DT evaluated the incident slope on 25 July 2007 and concluded that the risk of landslips affecting railway safety could be adequately controlled by annual examinations intended to allow potential problems to be identified and dealt with before they affected the railway. The evaluator appreciated that landslips might occur, but judged that the wide cess was likely to catch landslide debris before it reached the railway.
- 81 The evaluator was unaware that slips had blocked the line twice in 1999 because, following the normal SET practice, the evaluator had not attempted to obtain historical documentation such as the March 2000 memo describing the 1999 slips. SET normal practice concerning use of historic documents was contrary to Network Rail standards.
- 82 Network Rail standard NR/L2/CIV/086 requires that a preliminary investigation comprising "a desk study of...maps, and readily available records on the history and maintenance of an earthwork...shall be used to define the detail of the examination and geotechnical assessment regime for the earthwork, including requirements for monitoring works, for example." The same standard requires that "an evaluation shall take into account...as applicable...findings of a site investigation" with site investigation defined as including desk-based studies; a term familiar to ground engineering professionals as including the review of historical documents. Network Rail guidance note NR/GN/CIV/GN/203 defines evaluation as "an appraisal of all relevant information regarding the stability...of an earthwork".
- 83 Ground engineering professionals consider it good practice to review historic records as part of the information needed when considering the stability of slopes. A project supported by all major UK transport infrastructure owners led to CIRIA report C591, Infrastructure Cuttings - Condition Appraisal and Remedial Treatment. This was published in 2003 and uses the term inspection to cover the collection of data to permit a risk assessment to be carried out for cutting slopes. Paragraph 2.4.3 of this report states that 'both historical and contemporary knowledge of hazards, factors affecting their probability and their consequences are necessary to ensure that the asset inspection provides useful information'.

- 84 The Route Geotechnical Engineer (RGE) responsible for the evaluation team in SET believed that reference to previous examination reports (if any) was sufficient to meet the Network Rail requirements to consider historical data. The RGE appreciated that other historical data could assist evaluations but he believed that the possible benefits did not justify the resource needed to obtain and review these records. This belief was influenced by the availability of resources and the number of evaluations required in SET.
- 85 Post incident investigations show that the E&DT evaluator would have made the same recommendation for annual examinations even if he was aware of the memo describing the 1999 slips.
- 86 RAIB considers that the amount of instability visible on the slope should have led the evaluator to review any reasonably accessible historical documents. The March 2000 Railtrack memo and the SMIS reports relating to the previous instability (paragraph 40) were sufficiently recent, and of sufficient importance, that they should have been kept in a manner allowing reasonably easy access by the evaluator. The RAIB has reviewed these documents and considers that they contained sufficient information for an evaluator to recognise that annual inspections did not provide sufficient mitigation against the risk of landslip debris blocking the line.
- 87 Although the RAIB considers that the 2007 evaluation should have recommended more mitigation than annual examinations, it is unlikely that a recommendation for more mitigation would have prevented the accident because:
- if mitigation had been provided by a ditch maintenance regime, it is likely to have been similar to the regime implemented after the December 2008 slip and this proved inadequate (paragraph 66 to 70);
  - if mitigation had been provided by monitoring more often than the annual interval adopted, the more frequent monitoring may not have given sufficient warning to prevent the accident; and
  - if slope strengthening had been recommended as mitigation, it is unlikely that this would have been implemented before the accident.
- 88 As a different evaluation result is unlikely to have prevented the accident, inadequate consideration of historical information during the evaluation process is only a possible causal factor.

### Examination and evaluation competencies

- 89 Network Rail and Aecom had implemented the assessment and review processes necessary to show that all staff who examined the incident slope met the earthwork examiner competencies specified by Network Rail standard NR/SP/CTM/017. This standard describes the examiner and evaluator competencies in more detail, and to at least the same skill level, as those used in comparable situations such as highways management<sup>14</sup>.
- 90 The Aecom examiners had been briefed annually on changes to the examination process and lessons learnt from previous examinations. Network Rail monitors on-going performance by carrying out periodic checks on examiners' work as required by Network Rail standard NR/L2/CIV/086.

<sup>14</sup> DMRB 4.1.3, Chapter 2, Inspection of Geotechnical assets, paragraphs 2.2 & 2.3.

- 91 The member of Network Rail's E&DT who evaluated the incident slope on 25 July 2007 had first been assessed as competent to undertake evaluations on 31 May 2007 in accordance with the requirements of Network Rail standard NR/SP/CTM/017. He did not require reassessment until May 2008. The evaluator assessment process is a combination of reviewing an individual's experience, workplace observations and test scenarios. This method of assessment should be sufficient to determine an evaluator's competence.

### Response to the 1999 landslips

- 92 **The March 2000 memo described the need for works to prevent a landslip such as that which caused the November 2009 accident. Neither the works described in the memo or equivalent works were properly implemented. This is a causal factor.**

- 93 The March 2000 memo recognised the on-going risk from landslips and suggested long term mitigation measures including acquisition of additional land to facilitate ditch maintenance and construction of drainage grips to strengthen the cutting slope. The memo is not a definitive statement of the exact long term mitigation needed to safeguard the railway but it clearly showed the need for such measures. Some short term measures were taken (paragraphs 41 and 42) but longer term mitigation measures were not implemented.

## Identification of underlying factor<sup>15</sup>

### Network Rail off track drainage management process

- 94 **Network Rail's off track drainage<sup>16</sup> management process at the time of the accident was inadequate and was an underlying cause of the accident. The inadequacies extended beyond the incident site. Many of these inadequacies have already been recognised by both Network Rail and the Office of Rail Regulation (ORR) (paragraph 131).**

- 95 The following inadequacy in Network Rail's off track drainage management underlies some causal factors identified for the accident:
- There is no process to ensure that adequate information about required ditch sizes is provided to enable the effective implementation of inspection and maintenance work. The required information should include both ditch dimensions and actions to be taken when dealing with roots which obstruct the ditch but cannot be removed with hand tools.

<sup>15</sup> Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

<sup>16</sup> Off track drainage includes pipes and ditches running along the crest of cuttings, along the toes of embankments and from the railway to locations where water is discharged into rivers. It excludes track drains which run alongside the tracks, a short distance below the rails.



- 96 The following inadequacies in Network Rail's off track drainage management system were identified during the investigation but were not directly related to the accident:
- Network Rail standards are unclear. For example, instructions for maintaining off track open channels<sup>17</sup> refer to the standard for lineside drainage which appears to cover only *track drainage*<sup>18</sup>.
  - Some Network Rail staff responsible for maintenance do not understand the responsibilities allocated to them and/or lack the resources to undertake the necessary work. This is apparent from witness evidence and the absence of comprehensive Network Rail procedures for maintenance and inspection of off track drains.
  - There was no regular inspection regime for off track drains on the Wessex Route – the cutting crest ditch inspection at Gillingham on 26 November 2009 took place only because the Wessex drainage team were undertaking another task nearby. Witness evidence shows that regular inspections do not take place on a substantial proportion of Network Rail off track drainage.
  - There was no formalised off track drainage maintenance programme on the Wessex Route. Witnesses report that maintenance on the Wessex Route and some other parts of Network Rail infrastructure is carried out mainly in response to observed problems. Witnesses also report that, on the Wessex Route, planned maintenance intended to prevent problems forms only a small part of the maintenance activity.
  - The Wessex drainage team had no records showing the location of drains for which they were responsible except where they had made their own records. These records were limited to sites they had visited since 2007. A plan attached to Railtrack's 3 March 2000 memo shows that some drainage records do exist. Witness evidence indicates that drainage records are not available to front line staff in some other areas of Network Rail infrastructure.

## Events during and following the accident

### Events during the accident

- 97 The driver had minimal warning of the derailment. Tree branches almost touched the cab window a moment before there was a bang and the driver was thrown about as the train started to bounce due to the derailment.
- 98 Approximately 8 seconds after the derailment, the driver shut off power and applied brake step 3, the maximum available brake force. The time taken for the driver to take this action may be related to him being shocked by the event and/or being thrown about during the earlier stages of the accident.

### Passenger evacuation

- 99 Passenger evacuation was delayed because the only train available to rescue passengers was sent away from the accident site by control centre staff before a safe evacuation strategy had been established.

<sup>17</sup> NR/L3/TRK/002/D07 (Aug 2007) Off-track – Open Channels and Ditch Maintenance.

<sup>18</sup> Paragraph 8.1 of NR/SP/TRK/9006 (Dec 2005) Design Installation and Maintenance of Lineside Drainage refers only to drains in the cess or between tracks.

- 100 The driver reported the accident to the signaller after a short delay due to poor radio reception in the tunnel. The signaller informed the joint Network Rail/South West Trains Wessex *integrated control centre* (WICC) in London at 19:27 hrs, about six minutes after the derailment.
- 101 WICC staff initially expected that passengers would be evacuated by walking them to the nearest road access at Bagley Road bridge, about 440 metres from the east end of the tunnel. WICC staff attempted to discuss evacuation arrangements with the train guard but were unable to do so due to poor mobile phone reception in the tunnel.
- 102 The immediate railway response was provided by a manager based at Yeovil. He and an off duty manager living near the accident scene arrived at Bagley Road access at about 20:02 hrs. After walking to the derailed train with the emergency services, they decided that it would be unwise to walk passengers in darkness from the train to Bagley Road bridge access point, a distance of about 575 m. At 20:23 hrs WICC agreed to provide a rescue train. As the derailed train had damaged the track at the eastern end of the tunnel, the rescue train had to approach the tunnel from the west, ie from Yeovil.
- 103 The nearest train suitable for passenger rescue had been dispatched from Yeovil Junction at 20:20 hrs along a diversionary route to Salisbury via Castle Cary and Westbury. The decision was made by WICC staff in London at 19:55 hrs and was partly based on the rostered availability of train crew<sup>19</sup>. The decision was made and had been implemented before the WICC staff had sufficient information to know whether the Bagley Road bridge access was appropriate for passenger evacuation.
- 104 The processes required to recall the rescue train to Yeovil Junction and to send it forward to the accident site are summarised in figure 10. It took approximately one hour to bring the train back to Yeovil Junction before it could be sent to the accident site. The rescue train reached the accident site at 22:20 hrs and departed with the rescued passengers and staff at 23:12 hrs.

## Network Rail earthwork management

- 105 RAIB has investigated several earthwork related incidents including those at Oubeck (report number 19/2006), Moy (22/2006), Merstham (05/2008), and Kemble (07/2008). RAIB has also undertaken a class investigation into earthwork issues as described in Report 25/2008, Network Rail's Management of Earthworks. These reports can be downloaded from [www.raib.gov.uk](http://www.raib.gov.uk).
- 106 In 2004, Network Rail introduced the current method of collecting information about earthwork failures with the potential to affect railway safety. Information for the period from 2004 to 2008 was reviewed in the RAIB class investigation. Information is now available for failures in the period 2008 to 2010. The combined data shows an initial rise in the annual failure rate, followed by an improvement in recent years (figure 11). Since 2004, approximately 67% of the recorded earthwork failures, and eight of the nine earthwork related derailments, have occurred in cuttings. There were no fatalities due to these incidents.

<sup>19</sup> Train crew were later asked to, and agreed to, alter their rostered arrangements to operate the rescue train.

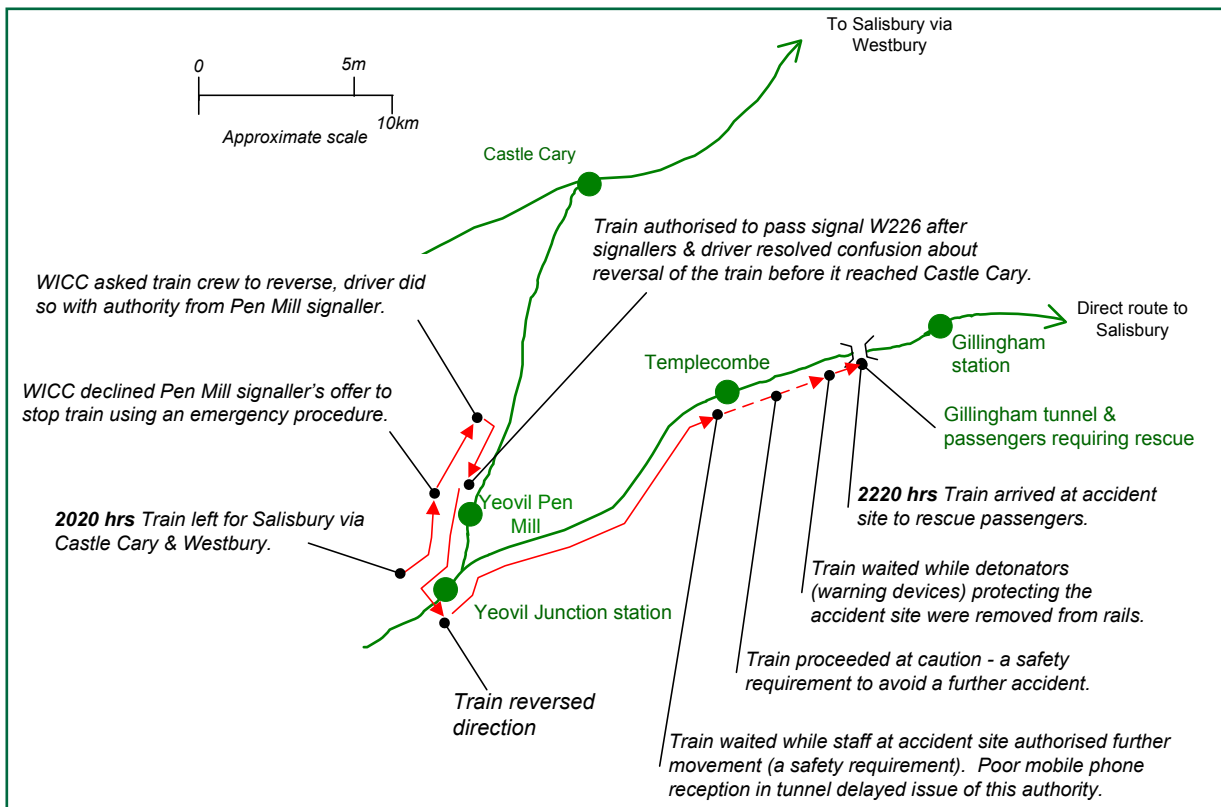


Figure 10: Rescue train mobilisation

107 As weather conditions have a large effect on earthwork performance, a significant part of the annual variation in earthwork failures may be a consequence of annual differences in weather conditions. In addition, improved reporting of events may have contributed to the increasing number of failures recorded in early years. These factors mean there is insufficient information to draw firm conclusions about trends in earthwork performance.

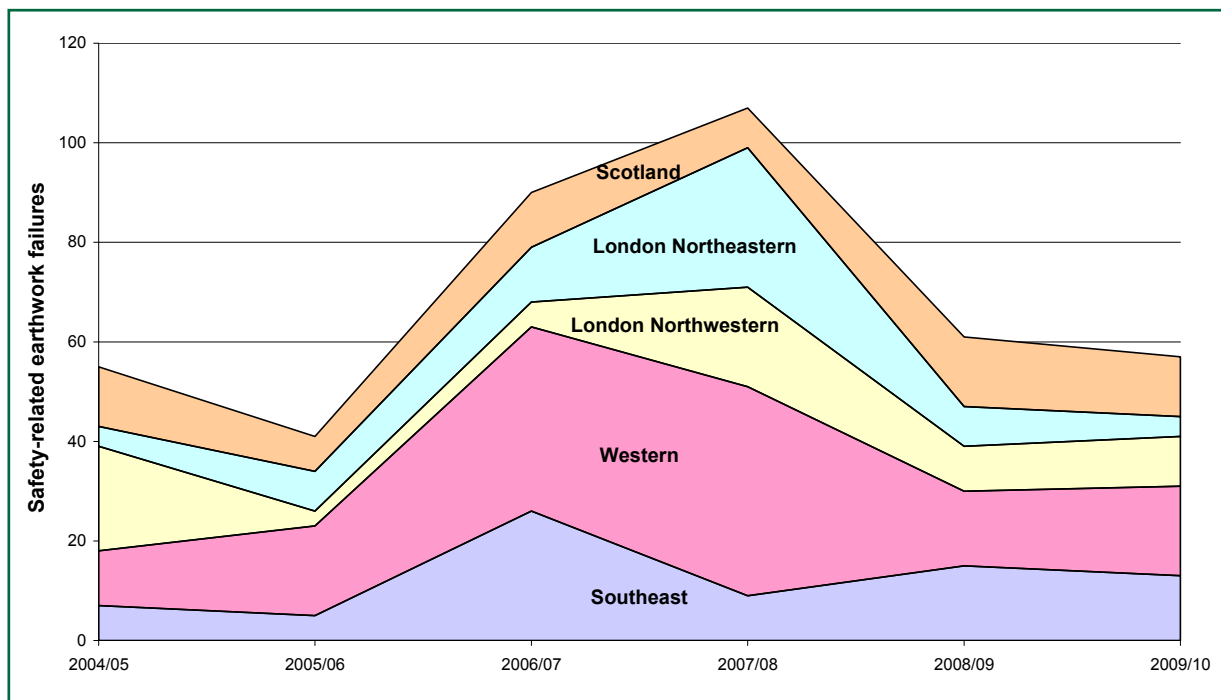


Figure 11: Earthwork failures 2004 to 2010 by Network Rail territory

## Severity of consequences

108 Two people reported minor injuries in the accident. The train ran through the tunnel entrance before tilting to touch the tunnel wall and coming to rest. The severity of the accident could have been significantly worse if the train had hit the wall around the tunnel entrance rather than missing this by about 0.6 metres as it ran into the tunnel.

## Observations<sup>20</sup>

### Earthwork Management

#### Repeating earthwork evaluations if earthwork condition worsens

109 The E&DT evaluate an earthwork on the first occasion that it is classified as 'poor' by an examination. After this, Network Rail standard NR/L2/CIV/086 requires E&DT to undertake evaluations whenever the earthwork condition has worsened since the previous examination. The scoring system used to establish earthwork condition (paragraph 33) is the only practical means that E&DT have to monitor earthwork condition. The scoring system includes upper (worst condition) limits and, once these limits are reached, E&DT are unaware of further earthwork deterioration unless a step change in slope condition means that an examiner makes a special report. Earthworks can deteriorate further after upper limit scores are reached but E&DT will be unaware of this and so do not carry out the re-evaluation which may show that the earthwork management regime should be changed.

110 Evaluations were not being repeated because:

- E&DT staff were concentrating on first-time examinations and evaluations; and/or
- E&DT had tried to find a reliable means of using examination data to identify poor earthworks which had deteriorated but had been unable to do this.

#### Checking examination data

111 Existing examination data items such as the location of drains are not always checked during re-examinations if the earthwork examiner believes that the information remains unchanged since the previous evaluation. This was apparent from witness evidence and results in Network Rail's earthworks management system using erroneous data if the original information was incorrect or if it has changed.

112 Checking of all data during a re-examination is implied by Network Rail standard NR/L3/CIV/065. Network Rail intended to include the need for checking in the briefing given to earthwork examiners at the start of the 2009/10 examination season. It is uncertain whether the need for checking was actually included in these briefings. The up side crest ditch near the incident site is an example of data being recorded incorrectly. Although clearly visible, it was omitted from the May 2007 examination of the section from 107 miles 40 chains to 107 miles 44 chains.

<sup>20</sup> An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

113 Earthworks examiners do not check whether the drainage described in their examination reports is consistent with drainage knowledge held by maintenance teams. This would provide a partial check on examinations without the need for additional site visits unless these are needed to resolve any inconsistencies. The value of these checks would increase as Network Rail's drainage records are upgraded as part of the improved drainage management system described in paragraph 131.

#### Recording drainage

114 The May 2007 examination did not record the crest drainage ditch between 107 miles 40 chains to 107 miles 44 chains (paragraph 112). The November 2009 examination of the tunnel portal at 107 miles 44 chains was undertaken by a different person but also omitted some drainage. Recording of all drainage forms part of the earthwork examination process mandated by Network Rail standard NR/L3/CIV/065.

115 The importance of recording drains formed part of Network Rail's annual rebriefing of earthwork examiners at the start of the 2009/10 examination season. The November 2009 Gillingham examination was done by an examiner who had attended this briefing and it is uncertain why he missed the tunnel portal drain.

#### Southeast Territory Drainage Engineer Resource

116 The drainage engineer resource in SET may be inadequate. One of the two drainage engineer posts in the E&DT was removed by Network Rail in mid-2009 at a time when Network Rail were introducing additional drainage related work as part of the improved drainage management strategy described in paragraph 131.

117 Network Rail's rationale for the reduction notes that geotechnical staff in the E&DT also undertake drainage work and says that "demonstrable progress has been made both in forward planning and dealing with day to day activities over recent years" with a minimum earthworks and drainage team size of six people in a territory. Network Rail has not assessed the workload of the E&DT, and relying on historic performance makes no allowance for the additional resource needed to implement the improved drainage management system.

#### Extreme Weather planning

118 Formal documentation for extreme weather events on the Wessex Route is deficient because it deals only with actions required to deal with flood and *scour* events. Extreme weather documentation should comply with Network Rail company standard NR/L3/TRK/1010 (issue 2) which requires it to cover responses to storms and to include actions required at earthworks liable to any type of damage from water, not just flooding/scour.

119 Extreme weather planning for the Wessex Route is described in SET Civil Engineering Instruction SETCE001 (Issue 1), Managing the Danger to the Railway from Flooding and Tidal Action, dated August 2005. This only addresses flood and scour issues.

120 The E&DT have issued patrollers with cards describing indicators of actual or potential earthwork failures to watch for during "Special Inspections in Adverse Weather". A presentation has been prepared to assist patrollers in using these cards but it is unclear how widely this has been distributed. At least in some locations, patrollers are never instructed to carry out these special inspections and do not do them.

- 121 Although earthwork and drainage responses for extreme weather events are not fully documented, the E&DT do participate with other railway managers in the conference calls arranged to deal with these events. This is partly because there are some earthworks within SET which require special measures during extreme weather. Witness evidence also shows that, although there is no formal plan showing where track maintenance staff should undertake inspections after heavy rainfall, maintenance staff do undertake these inspections at locations where their experience suggests problems may have developed.
- 122 Track maintenance engineers (TMEs) are given access to maps issued weekly showing the amount of recent rainfall and the amount of water in the ground<sup>21</sup>. As these factors affect earthwork performance, the maps are intended to assist TMEs in maintaining earthworks. There is no mandated process for how this information should be used by TMEs. Although briefings have been held, some TMEs do not use the information and some do not understand how it may help them in periods of particularly wet and particularly dry weather.

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<sup>21</sup> Weekly Rainfall and SMD [soil moisture deficit] for South East. A low soil moisture deficit indicates near saturated ground.

## Summary of Conclusions

### Immediate cause

123 The immediate cause of the accident was a landslip triggered by water overflowing from a blocked ditch (paragraph 60).

### Causal factors

124 Causal factors were:

- the Victorian cutting design did not take adequate account of the interaction between geology, groundwater and heavy rainfall (**paragraphs 20 to 23, no recommendation**);
- roots were not dealt with properly during maintenance work (**paragraph 66, Recommendation 1**);
- the person who inspected the ditch did not have appropriate guidance about how to deal with roots (**paragraph 72, Recommendation 1**);
- there was no Network Rail process for establishing the drainage ditch condition to be achieved during maintenance work (**paragraph 75, Recommendation 1**); and
- lack of action in response to the March 2000 memo (**paragraph 92, no recommendation as action already in hand, see paragraph 131**).

125 Possible causal factors were:

- the ditch may have been dug out to an inadequate size during maintenance work (**paragraph 66, Recommendation 1**);
- the ditch was inspected without appropriate guidance about the size of ditch required (**paragraph 72, Recommendation 1**); and
- the evaluation did not consider information available from historic documents (**paragraph 77, Recommendation 2**);

### Underlying factor

126 Network Rail's off track drainage management process was an underlying factor because it does not include a process for providing inspection and maintenance staff with adequate information about required ditch sizes (**paragraph 94, Recommendation 1**).

## Additional observations

127 Although not linked to the accident on 28 November 2009, the RAIB observes that:

- earthworks in Southeast Territory previously evaluated after being classified as poor are not re-evaluated if they deteriorate further (**paragraph 109, Recommendation 2**);
- formal documentation of responses to extreme weather events on the Wessex Route are limited to flood and scour effects rather than also including effects of heavy rain (**paragraph 118, Recommendation 2**);
- examination data is not always checked on subsequent examinations if the earthwork examiner believes the information is unchanged (**paragraph 111, Recommendation 3**);
- some drains near the incident site were not recorded during earthwork examinations (**paragraph 114, action already taken (paragraph 133)**);
- the Southeast Territory drainage engineer resource may be inadequate (**paragraph 116, Recommendation 4**); and
- earthwork examination data is not verified against drain maintenance records (**paragraph 113, Recommendation 5**);



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

- 128 The cutting slope has been trimmed to a more gentle (ie more stable) slope and the crest drain capacity has been increased at the accident site.
- 129 Network Rail and South West Trains are currently installing a new mobile phone system known as GSM-R which will considerably improve communication with trains in tunnels.
- 130 Controllers at the Wessex Integrated Control Centre have been reminded that, if a rescue train may be needed to evacuate passengers from an incident site, suitable train(s) should be kept available until there is sufficient information to reach a final decision on the means of evacuation.

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

- 131 Network Rail has been planning improvements to its off track drainage management system since around 2007 and implementation of these improvements has started. Key aspects relevant to the Gillingham incident include:
- allocation of £50 million for off track drainage and £100 million for on track drainage in the period 2009 to 2014, together with appropriate expenditure beyond 2014;
  - network wide survey to locate and record all off track and on track drainage by March 2014;
  - development of documentation clearly defining inspection and maintenance regimes for drainage assets (these do not include a requirement to verify the adequacy of existing drains or those being rehabilitated);
  - implementation of a formalised, risk based system for inspection and maintenance of drainage assets starting in spring 2011 and encompassing all relevant assets as they are identified by the survey;
  - an increase in the number of staff allocated to off track maintenance staff despite an overall reduction in maintenance staff;
  - staff briefings stressing the importance of drainage issues; and
  - reporting to the ORR allowing it to monitor Network Rail's implementation of the improved drainage management strategy.
- 132 The improved drainage management system is expected to deal with most of the issues identified by the RAIB during investigations into the Gillingham accident. The planned improvements will be monitored by ORR who will take appropriate action if there are significant shortfalls. RAIB has therefore limited recommendations to those issues which are not covered by the planned improvements.
- 133 Network Rail met Aecom in December 2009 to reinforce earlier briefings about the importance of recording drainage information during earthwork examinations.

## Recommendations

134 The following recommendations are made<sup>22</sup>:

### Recommendations to address causal factors

- 1 *This recommendation is intended to reduce the risk which may be created by off track drainage overflowing.*

Network Rail should instigate a process to:

- Identify all locations where unsatisfactory operation of off track drainage is a significant risk to railway safety. Identifying these locations should be assisted by use of information being collected as part of Network Rail's on-going drainage asset surveys, knowledge already required for adverse weather planning and data being obtained from on-going studies to identify locations where ground topography concentrates water flows.
- For all such locations establish a programme to:
  - Determine for each location the site specific parameters which are sufficient to ensure satisfactory off track drainage performance. These parameters should include ditch sizes and the extent to which roots may remain in place. The parameters shall be verified by a drainage professional.
  - Maintain off track drainage to comply with these parameters.

*continued*

<sup>22</sup> Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

- (a) ensure that recommendations are duly considered and where appropriate acted upon; and
- (b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's website [www.raib.gov.uk](http://www.raib.gov.uk).

- 2 *The intention of this recommendation is to improve compliance with Network Rail's requirements for earthwork stewardship in South East Territory.*

Network Rail should examine the extent of compliance with its requirements for the management of earthworks in Southeast Territory and put in place management processes to ensure full compliance. These processes should cover:

- Briefing staff and, if necessary, clarifying standards, so that all earthwork evaluations take full account of all relevant historical records already held by Network Rail, and any other readily available records. (If necessary, Network Rail should modify its archive retrieval system to allow efficient recovery of these records.)
- Improving compliance with the NR/L2/CIV/086 requirement that all earthworks in 'poor' condition are subject to re-evaluation whenever examinations show their condition has worsened.
- Providing a comprehensive extreme weather plan (including actions unrelated to flood and scour) in accordance with TRK/1010 for the Wessex Route and for any other areas where extreme weather plans are not fully compliant with TRK/1010. Current practice should be included in these plans as soon as practical.

#### **Recommendations to address factors observed during the investigation**

- 3 *This recommendation is intended to prevent errors from previous earthwork examinations being carried forward into later examination reports.*

Network Rail should modify the earthwork re-examination process so that earthwork examiners must positively confirm the accuracy of all examination data including any data which remains unchanged from the previous examination.

- 4 *This recommendation seeks to ensure sufficient professional drainage expertise is available in SET without compromising other necessary activities.*

Network Rail should determine, and subsequently keep under review, both the actual workload of the E&DT and whether existing resources are sufficient. If not sufficient, Network Rail should provide additional resources to suit the workload.

- 5 *This recommendation is intended to improve the accuracy of earthwork examination reports.*

Network Rail should modify its earthwork standards to require that the earthwork examination process includes checking that the drainage observations included in the examination report are consistent with any drain location and drain performance information known to maintenance teams.

## Appendices

### Appendix A - Glossary of abbreviations and acronyms

CIRIA	Construction Industry Research & Information Association
DMRB	Design Manual for Roads & Bridges
E&DT	Earthworks & drainage team covering SET
ORR	Office of Rail Regulation
RAIB	Rail Accident Investigation Branch
RGE	Route geotechnical engineer
SET	Southeast Territory
SMIS	Safety Management Information System
TME	Track maintenance engineer
WICC	Wessex integrated control centre

## Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (\*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. [www.iainellis.com](http://www.iainellis.com).

Chain	Unit of measurement equal to 22 yards (approximately 20 metres).*
Cess	The area along the edge of the outermost railway track(s).
Diesel multiple unit	Diesel powered train with a driving cab at both ends and consisting of either one vehicle or more than vehicle semi permanently coupled together.*
Earthworks	Collective term for all earth related constructions such as cuttings and embankments.
Integrated control centre	Control centre where Network Rail and South West Trains (or other train operators) jointly manage railway operations.
On train data recorder	A data recorder fitted to a train that collects information about its performance and about the status of systems such as speed and brake controls.
Off track drainage	A drainage channel/pipe intended to drain water from areas other than the immediate vicinity of the track (eg from the top of a cutting); a drainage channel/pipe leading to or from the railway and maintained as part of the railway infrastructure.
Scour	The removal of material from the bed or bank of a watercourse or material from a beach by current or wave action.*
Track drainage	A channel or pipe close to the tracks and intended to drain water from the immediate vicinity of the track.
Track maintenance engineer	Person responsible for managing maintenance within a given area of the railway.
Up	In a direction towards London.*

## Appendix C - References

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- NR/L3/TRK/1010 (issue 2) *Management of Responses to Extreme weather Conditions at structures, Earthworks and other Key Locations*, Network Rail standard (August 2008, immediate compliance required).
- NR/SP/CTM/017 (Issue 1) *Competence & Training in Civil Engineering*, Network Rail standard (June 2006, compliance required by August 2006).
- Research Report 199 *A Survey of Slope Condition on Motorway Earthworks in England and Wales*, Transport and Road Research Laboratory (1989). Available from [www.trl.co.uk](http://www.trl.co.uk)
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