Railway Accident Investigation Unit

Ireland

INVESTIGATION REPORT

Rock fall at Plunkett Station, Waterford, 31st December 2013

RAIU Report No: R2014 – 006

Published: 18/12/2014

Report publication

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The original publication details are given below:

Title	Rock fall at Plunkett Station, Waterford, 31st December 2013
Document type	Investigation Report
Document number	2014-R006
Document issue date	18/12/2014

Where the report has been altered following its original publication, details on the changes are given below:

Revision number	Revision date	Summary of changes

Reader guide

All dimensions and speeds in this report are given using the International System of Units (SI Units). Where the normal railway practice, in some railway organisations, is to use imperial dimensions; imperial dimensions are used and the SI Unit is also given.

All abbreviations and technical terms (which appear in italics the first time they appear in the report) are explained in the glossary.

Descriptions and figures may be simplified in order illustrate concepts to non-technical readers.

Paragraphs from the report will be referenced throughout the report for ease of reading.

Report preface

The RAIU is an independent investigation unit within the Department of Transport, Tourism and Sport which conducts investigations into accidents and incidents on the national railway network, the Dublin Area Rapid Transit network, the LUAS, heritage and industrial railways in Ireland. Investigations are carried out in accordance with the Railway Safety Directive 2004/49/EC and the Railway Safety Act 2005.

The RAIU investigate all serious accidents. A serious accident means any train collision or derailment of trains, resulting in the death of at least one person or *serious injuries* to five or more persons or *extensive damage* to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety.

The RAIU may investigate and report on accidents and incidents which under slightly different conditions might have led to a serious accident.

RAIU investigations are conducted for the purpose of accident and incident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and, when appropriate, the making of safety recommendations in order to prevent accidents and incidents in the future and improve railway safety.

It is not the purpose of an RAIU investigation to attribute blame or liability.

Report summary

At approximately 18:45 hours (hrs) on Tuesday 31st December 2013 the *Signalman* at Waterford Central Cabin (Signal Cabin) heard a loud rumble from outside. When the Signalman went out onto the steps of the Signal Cabin to investigate, he saw that a large portion of the *rock face* running adjacent to the station had collapsed onto the two tracks which run under the Signal Cabin and through Plunkett Station (Waterford).

Consultant geologists were engaged to inspect the rock face after the incident concluded that the *immediate cause* of the rock fall at Plunkett Station was likely due to the toppling of the upper part of the rock mass to the north of the structure, followed by rotation of the toppled rock mass, resulting in rock fall debris flowing onto the ground. Possible *contributory factors* include the actual formation of the rock (steeply inclined structure with pervasive joints and faults). The final trigger was likely due to the intense rainfall of the preceding weeks.

The RAIU investigation, and the consultant geologist's report, determined that it is unlikely that the potential for rock fall could have been identified during routine Iarnród Éireann (IÉ) inspections. It is also unlikely that a member of IÉ staff would have been able to identify that the structure would fail, or that there would have been any warning to the imminent failure prior to the day of the incident. Therefore no other immediate causes, contributory factors, *underlying causes* or *root causes* were identified as a result of this incident. However, the RAIU made a number of additional observations during the investigation, which include:

- AO-01 – The condition rating scoring tool, set out in CCE-STR-STD-2100 and CCE-STR-GDN-2802, does not appear to be an effective system for Structures Inspectors in illustrating the condition of the asset or applying inspection frequencies;
- AO-02 – Inspection cards appear to be consistently failing to meet the requirements of CCE-STR-STD-2100, in that Structures Inspectors are editing the approved template, using incorrect terms and incorrectly labelling the inspection cards; and the Senior Track & Structure Engineer (STSE) is not approving the documents;
- AO-03 – CCE-STR-GDN-2802 includes guidance on maintenance requirements which are not mandatory and therefore not applied;
- AO-04 – The compliance verification process, as set out in CCE-SMS-001 and CCE-SMS-008 was ineffective at identifying the long-standing issues associated with the correct use of the Inspection Card;
- AO-05 – The Structures Inspectors competence did not meet the requirements set out in CCE-STR-STD-2100 as he had not completed the required refresher training within the required timescales;

- AO-06 – The STSE did not meet the requirements set out in CCE-TMS-420 in relation to the continued competence of the Structures Inspector, in that he did not undertake a documented annual review of the Structures Inspector's inspection work.

As a result of these AOs, the RAIU has made five safety recommendations:

- IÉ Infrastructure Manager (IM) CCE (Chief Civil Engineer's Department) should complete a thorough review of CCE-STR-STD-2100 in relation to the application of condition ratings on assets to ensure that condition ratings are a true reflection of the condition of the asset; and that the appropriate inspection frequency is applied;
- IÉ IM CCE should complete a thorough review of the Cutting, Embankments and Coastal/River Defences Inspection Card set out in CCE-STR-STD-2100 to ensure that Structures Inspectors have the correct means to complete the card without the requirement for alterations to templates or defined terms. The process of approval of these Inspection Cards should also be reviewed to ensure that they are reviewed and approved by the STSE;
- IÉ IM CCE should complete thorough reviews of CCE-STR-STD-2100 and CCE-STR-GDN-2802 in terms of maintenance requirements to ensure consistency throughout both documents;
- IÉ IM CCE should fully adopt the compliance verification process and ensure the process includes an effective means of reviewing the quality of documents completed by staff;
- IÉ IM CCE should review its Competence Management System in terms of both: its identification and tracking of mandated refresher training for Structures Inspectors competence; and its annual review of Structures Inspectors inspection work.

CONTENTS

The incident

Summary of the incident

1 At approximately 18:45 hrs on Tuesday 31st December 2013 the Signalman at Signal Cabin, at Plunkett Station (Waterford) heard a loud rumble from outside, see Figure 1 for the location of the incident.

Figure 1 – Location of incident

2 When the Signalman went out onto the steps of the Signal Cabin to investigate, he saw that a large portion of the *rock face* running adjacent to the station had collapsed onto the two tracks which run under the Signal Cabin and through Plunkett Station, see Figure 2.

Figure 2 – Rock fall adjacent to the Signal Cabin at Plunkett Station

3 The 16:40 hrs passenger service from Heuston (Dublin) to Waterford was due to arrive at Plunkett Station at 19:00 hrs (approximately fifteen minutes later) but it was stopped at another signal cabin, Waterford West Signal Cabin (located approximately one kilometre (km) from Plunkett Station) and returned to Kilkenny Station.

4 IÉ made the decision to evacuate and close Plunkett Station and cordon off the areas around the affected platforms for the protection of IÉ staff, customers and members of the public.

5 There were no injuries to any persons as a result of the incident.

6 There was extensive damage caused to the signalling and communications system within Plunkett Station which resulted in Plunkett Station remaining closed for a number of days.

General description of the railway

Infrastructure

7 Plunkett Station, Waterford, is located at the 75 ¾ milepost (MP), measured from Mallow via Fermoy, on the Mallow to Rosslare Line on the banks of the River Suir. The station consists of four tracks running through the station and four platforms (3,4,5 & 6), with the Signal Cabin situated at the Dublin end of Platform 4.

8 In 1864, to facilitate the building of Plunkett Station, rock from the Mount Misery rockface was excavated. In 1905 further excavation was carried out to facilitate the Plunkett Station extension works and additional Fishguard & Rosslare Railways and Harbours Line, see Figure 3.

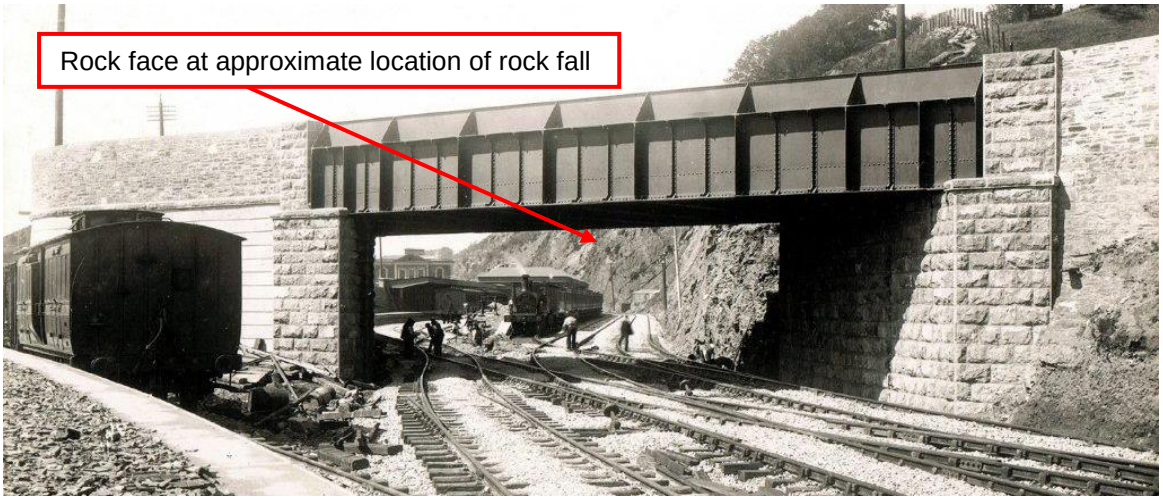

Figure 3 – 1905 photograph of Plunkett Station, including Mount Misery

9 This rock face has a length of approximately 375 metres (m) resulting in the rock face running along and beyond the extremities of Plunkett Station. Its closest point to the track is approximately 5 m; and its height varies between 10 – 30 m. At the location of the rock fall, and within 10 m of the nearest rail the rock face reached a height of 17 m; rising to 27 m within 20 m of the nearest rail. At the top of the rock face there is a golf course and a disused hotel. The sloping of the land at the top of the rock face results in the drainage running towards and down the rock face.

10 Prior to the incident, the rock face was extensively covered in vegetation, mainly gorse.

11 The topography of the rock fall will be further discussed in the 'Evidence' section of this report.

Rolling stock

12 No rolling stock was directly involved in the incident. The last outbound train to depart Plunkett Station was the 18:25 hrs Plunkett (Waterford) to Heuston (Dublin), train identification number A517, which departed on time. The next train due to arrive at Plunkett Station, after the incident, was the 16:40 hrs service from Heuston Station (Dublin), train identification number A510, which was due at Plunkett Station at 19:00 hrs which was running on time, and expected to arrive at Platform 4. As previously mentioned, this service was stopped at Waterford West Signal Cabin and returned to Kilkenny Station.

13 No factors in relation to the rolling stock were found to have contributed to the incident.

Signalling and communications

14 The signalling system in Plunkett Station is a combination of *mechanical signal control* and *electro-mechanical signal control*. Movements are controlled locally by a signalman in the Signal Cabin. Plunkett Station is not fitted with a Continuous Automatic Warning System or Automatic Train Protection.

15 *Track circuits* show the presence of a train at Platforms 3, 4, 5 and 6 as well as on the *Up and Down Main Lines* as far as the end of the Platform Line on the Rosslare side.

16 The means of communication between the signalman and train drivers is over an open channel radio system, which provides communication between the signal cabins and train radios.

17 No factors in relation to the condition of the signalling and communications systems were found to have contributed to the incident.

Operations

18 Movements are controlled by a signalman in the Signal Cabin. The line speed in Plunkett Station is 20 miles per hour (mph), (32 kilometres per hour (km/h)).

19 No factors in relation to operations were found to have contributed to the incident.

Fatalities, injuries and material damage

Fatalities and injuries

20 There were no fatalities or injuries as a result of this incident.

Material damage

21 The rock fall resulted in minor damage to the track and the footings for Signal Cabin. However, there was considerable damage to the signalling system, in particular, the disabling of the signalling connected to the Signal Cabin which resulted in a number of points and signals being rendered inoperable.

Parties & roles associated with the incident

Parties involved in the incident

22 IÉ is the railway *infrastructure manager* (IM), managing the design, installation, testing, inspection, maintenance, renewal and operation of the railway's physical assets. The IÉ department associated with this incident is the CCE Department – responsible for the design, inspection, maintenance and renewal of the railway's structural infrastructure, including cuttings and embankments, and the management of risks associated with these assets.

Roles involved, directly an indirectly, in the incident

23 The roles involved in the incident, directly and indirectly are as follows, are the:

- CCE – Accountable for setting Occupational Safety, Plant & Machinery Safety, Track Safety and Structures Safety objectives and objectives for the Safety of Buildings & Facilities and for providing resources to all the parts of the CCE Department to achieve those objectives. The CCE has ultimate responsibility for the safety of the line with regards to infrastructure. The CCE has a number of key staff with a defined reporting hierarchy, which includes the Technical Manager CCE, Infrastructure Managers and a Safety Manager. The CCE is accountable for setting the strategy for the management of safety in the CCE department;
- Technical Manager CCE – The is the professional head of the CCE Department who is accountable for track and structures safety for IÉ through the risk management and actions taken by them or a member of their team;
- STSE - Reports to the Technical Manager CCE. The STSE is accountable for track safety and structures safety within their respective *CCE Locations*. This includes ensuring all the inspections of track and structural assets with the exception of track patrolling duties are undertaken to mandated frequencies and that identified risks are managed accordingly. They are also responsible for implementing a programme of compliance verification, through audit, investigation, observance and review and have a number of engineers and technical staff at their disposal;
- Infrastructure Manager – Responsible for all aspects of the management of production activities within a *Division* (made up of a number of regions and several CCE Locations); and accountable for all the aspects of track safety, structures safety, plant & machinery safety and occupational safety of all the production operations and supplier operations associated with the CCE Locations under his control. They work closely with their STSE, meeting regularly to discuss work activities that must be undertaken;
- Accountable Line Manager – The manager directly accountable for the Occupational Safety and plant and machinery safety for those workplaces and equipment under their control and also for the quality of work that affects track safety and structures safety;
- Structures Inspectors – Persons competent to carry out inspections on behalf of the STSE;
- Regional Manager – Responsible and accountable for all aspects of the management of the production activities within a Region: including track, structures, plant and machinery safety; occupational safety operations and supplier operations;
- Permanent Way Inspectors (PWI) – Responsible for the day to day track inspections and maintenance activities for both track and structures at a CCE Location;
- Signalman – Based in the Signal Cabin at Plunkett Station, and first saw the rock fall.

Parties not directly involved in the incident

24 The RSC is the national safety authority, which is responsible for the regulatory oversight of the Safety Management System (SMS) and enforcement of railway safety in the Republic of Ireland in accordance with the Railway Safety Act 2005 and the European Railway Safety Directive. The RSC issues *Safety Certificates* to *Railway Undertakings* (RU) and *Safety Authorisations* to IMs in accordance with European legislative requirement. A 'Safety Authorisation' is only issued once the IM has satisfied the RSC that it has an adequate SMS in place capable of managing all risks associated with their (IM) activities.

25 Consultant geologists were engaged by IÉ IM CCE to carry out an examination of the rock face post incident and carry out a number of papers on the incident, these papers will, collectively, be referred to as the Consultant's Report for the remainder of this report.

External circumstances

26 The weather at the time of the incident was recorded by Met Éireann as wet with temperatures of between 5.3°C to 9.6°C degrees Celsius. Mean wind speed was recorded at 26 kilometres per hour (km/h) with gusts up to 85 km/h. There was no weather alert in place at the time of the incident. The previous weather alert, for heavy rainfall, expired 36 hrs previous to the incident occurring. There had been heavy rainfall in the area for a number of weeks preceding the incident.

RAIU Investigation

RAIU decision to investigate

27 In accordance with the Railway Safety Act 2005 the RAIU investigate all serious accidents. Given that under slightly different conditions, this incident may have led to a serious accident where there would have been potential for fatalities and serious injuries due to the falling of debris, had there been operating passenger trains or IÉ staff in the vicinity. Therefore a decision was made to investigate under Article 19 (2) of the Railway Safety Directive (EC, 2004).

Scope of investigation

28 The RAIU must establish the extent of the investigation to ensure that only pertinent information is recovered and reviewed. Therefore, for this incident, the RAIU have defined the following scope:

- Establish the sequence of events;
- Establish, where applicable, the immediate cause, contributory factors, underlying causes and root causes;
- Examine the inspection and maintenance regime for cuttings;
- Examine the standards and procedures associated with the inspection and maintenance regime;
- Examine the relevant elements of the SMS associated with the inspection and maintenance of the asset;
- Examine the competency and actions of the staff involved in the incident;
- Examine any other significant safety deficiencies identified as a result of this investigation.

29 The RAIU also published the investigation report 'Malahide Viaduct Collapse on the Dublin to Belfast Line on the 21st August 2009' in August 2010. The scope will include the review of relevant findings made in this report in relation to inspection standards.

30 In addition to the RAIU's investigation, the RSC published a report in March 2011 entitled 'RSC Audit – IÉ's management of cuttings and embankments' and a report published in December 2013 entitled 'IÉ's management of vegetation'. The findings of these audits will be reviewed in the context of this investigation. The RSC also undertook a Post Incident Inspection (PII) and produced a report into the 'Collision of train with a landslip at the 38 ¼ milepost on the Kilkenny to Waterford line' which occurred on the 31st December 2013, this will also be reviewed in the context of this investigation.

Investigation and evidence

31 During the on-site and off-site investigation the RAIU collated the following evidence:

- Photographic record of rock fall;
- Witness evidence from parties involved in the incident;
- Other evidence from members of the IM with information pertaining to the incident;
- IM standards, procedures and other documentation;
- Standards, procedures and documentation from other relevant bodies;
- SMS documentation from the CCE related to inspections and maintenance;
- Relevant compliance investigations and audits carried out by the RSC;
- RAIU investigation report 'Derailment of empty train due to collision with landslip debris outside Wicklow Station, 16th of November 2009' and associated documentation;
- RAIU investigation report 'Malahide Viaduct Collapse on the Dublin to Belfast Line on the 21st August 2009' published in August 2010, in terms of inspections;
- RSC Audit, 'IÉ's management of cuttings and embankments', published in March 2011;
- RSC Audit, 'IÉ's management of vegetation', published in December 2013;
- RSC PII, published in April 2014, 'Collision of train with a landslip at the 38 ¼ milepost on the Kilkenny to Waterford line' which occurred on the 31st December 2013;
- Evidence of actions taken by IÉ as a result of the RAIU investigation, the RSC audits and RSC PII;
- Consultant's Report of the rock face carried out post incident.

Evidence

Description of the rockface

General description

32 The length of the rock face is approximately 375 m and runs the entire length of Plunkett Station. The rock fall occurred within the proximately of Plunkett Station, adjacent to the Signal Cabin, see Figure 4.

Figure 4 – Aerial view of the rock face and location of the rock fall

33 Rock netting is also present at some locations along the rock face, this was erected at some time between 1993 and 1995.

Topography of the rock face

34 A consultant geologist was engaged post incident to carry out an inspection of the rock face at Plunkett Station to determine its geology. This Consultant's Report determined that the *bedrock* at Plunkett Station is very strongly deformed and fractured and is characterised by laminated green, green-grey and grey slately *mudstones* and green or pale grey *siltstones* with occasional *sandstones*[1].

35 The bedrock contains a strong northerly steeply dipping structure, approximately 76 – 85° which is referred to as *bedding*.

36 The bedrock contains pervasive *joints.* There are two general types of joints at the site, these are:

- Small scale joints which are closely to medium spaced[2] (60 – 600 millimetres (mm)) which are limited in lateral extent, inclined to either the east or the west, and are abundant at the site, see black lines in Figure 5;
- Larger scale mega joints which are medium to widely spaced (200 – 2000 mm) which are more laterally extensive, see red lines in Figure 5.

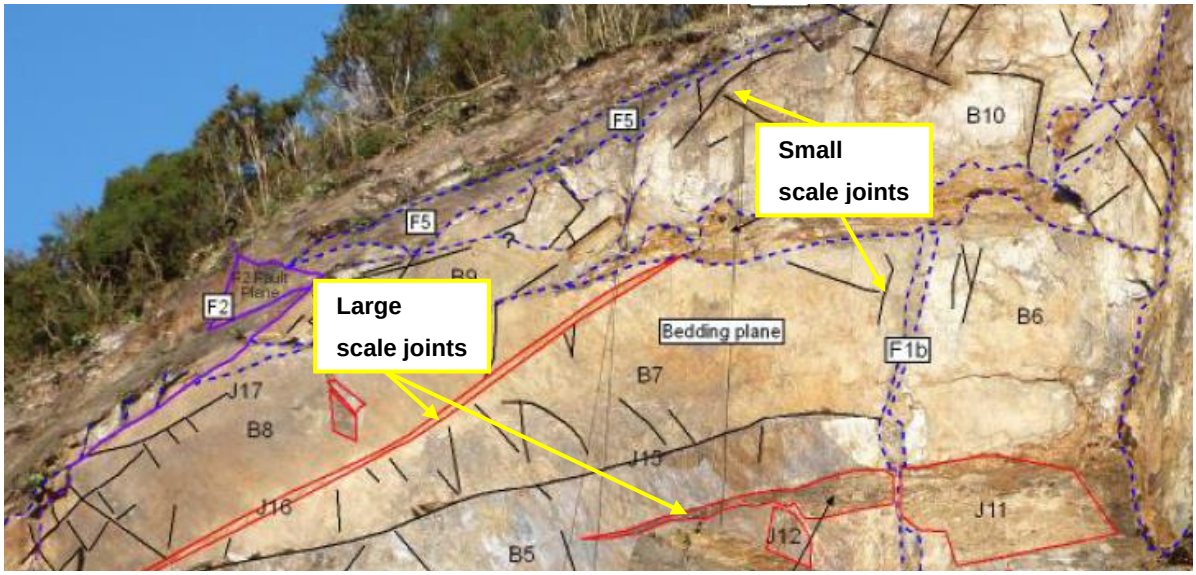

Figure 5 – Joints at incident site

[1] The site of the incident is part of the Ballylane Formation, of the Ordovician Ribband Group.

[2] As per BS 5930:1999 'The code of practice for site investigations', Fracture/Bed/Layer Spacing Classification Table

37 Two major *faults*, Fault 1 (F1) and Fault 2 (F2) were found to be present on site; some of the main characteristics of these faults are as follows:

- F1 – Located on the eastern side of the Central Block (area of rock fall), see Figure 6. F1 is inclined at approximately 82° to the west-southwest with the *fault zone* showing relatively intense weathering probably due to groundwater migration;
- Fault 2 – Located on the western side of the Central Block, see Figure 6. F2 consists of a 1 metre (m) wide fault zone containing a number of internal fault elements, suggesting a history of multi-event *tectonic movements*.

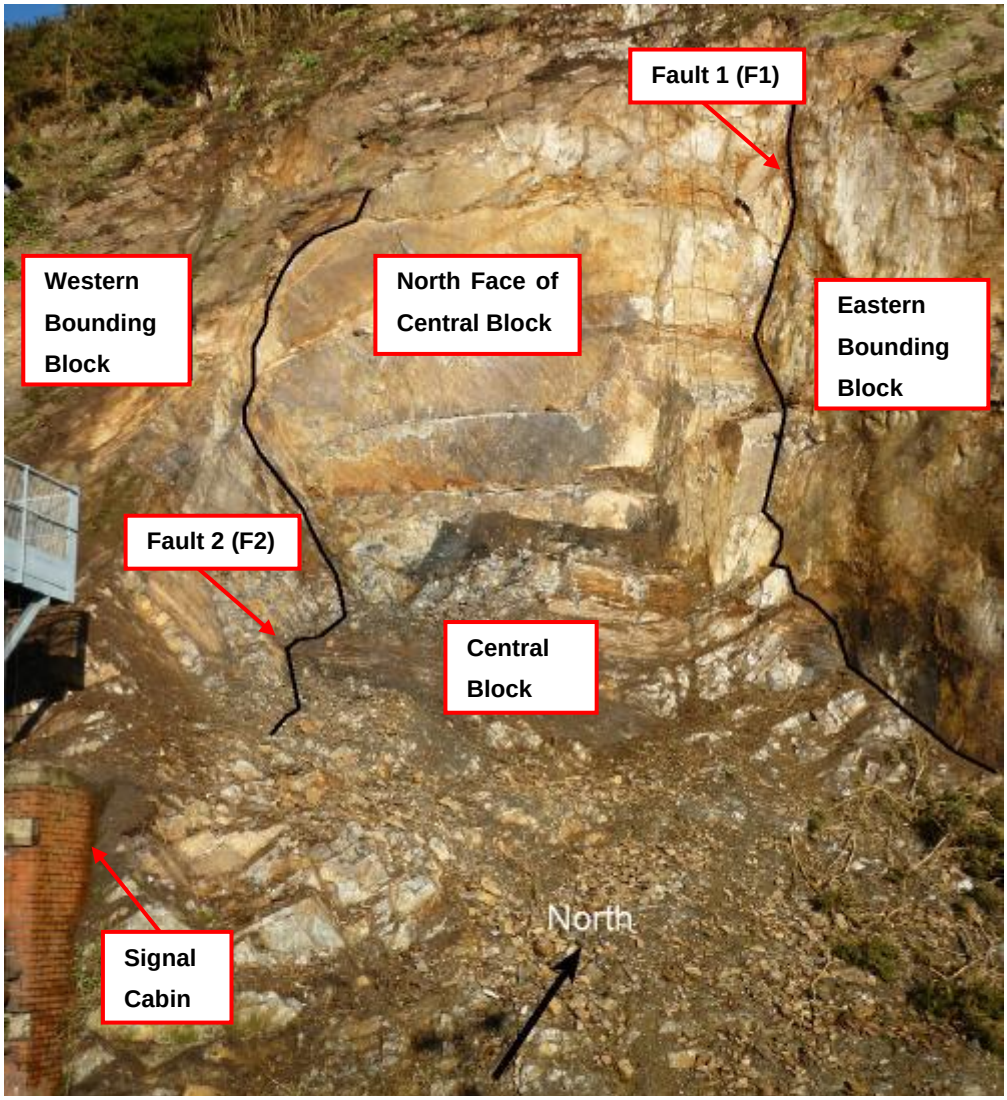

Figure 6 – Rock face after the debris was removed

38 There are another three possible faults, (Faults 3 (F3), Fault 4 (F4) & Fault 5 (F5)):

- F3 – Spans the Central Block, consisting of a number of interconnected *fractures*, linking F1 and F2. Joint 6 (J6) and Joint 7 (J7) may be joints or maybe part of F3. Irrespective of whether they are joints or faults, they are major planes of weakness which facilitated the collapse by providing a surface on which the rock mass was able to slide southwards;
- F4 – Southward inclined fault zone in the northern part of the Central Block, see Figure 7, which is also an important surface of weakness due to its direction of inclination;
- F5 – Southward inclined fault zone, which may be a fault, located at the top of the Central Block north face, see Figure 7.

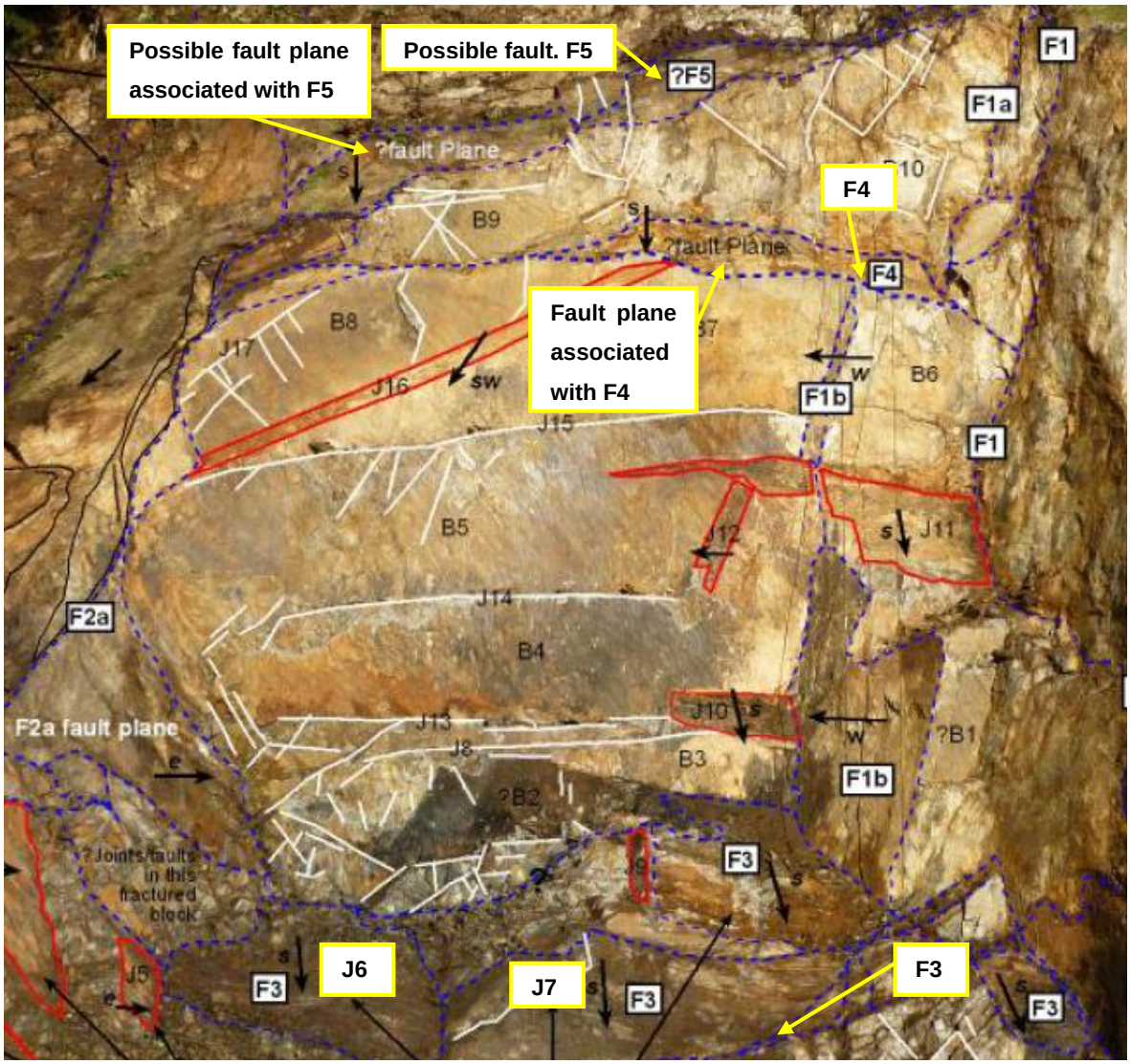

Figure 7 – Joints and faults around the Central Block

39 Internally, away from the joints and faults, the rock is relatively fresh and unweathered with the rock classified as strong to very strong, as defined in BS 5930: 1999.

Inspections of the rock face

General information

40 Section 4.2.4.1 of CCE-STR-STD-2100, Technical Standard for Structural Inspections, defines a cutting as "excavations whose toe is at least 3 metres below the surrounding general natural ground level when measured from the top of the rail and where collapse could affect the railway" and therefore the rock face at Plunkett Station falls into the programme of inspections for "Cuttings & Embankments".

Technical documentation for the inspection of cuttings

41 At the time of the incident, the primary technical documentation in relation to the inspections of cuttings & embankments, by IÉ CCE were:

- CCE-STR-STD-2100, Technical Standard for Structural Inspections, issued October 2011 (Version 1.2 live at the time of the incident). This is a technical standard which sets out the mandatory requirements, frequency and type of technical inspections for structures;
- CCE-TMS-360, Track and Structures Inspection Requirements, issued in January 2012 (Version 2.0 live at the time of the incident). This is a technical management standard which sets out the requirements of CCE staff in relation to inspections of track and structures;
- CCE-TMS-361, Technical Standard for Track Patrolling, issued March 2011 (Version 1.1 live at the time of the incident). This is a technical standard in relation to the requirements of Patrol Ganger inspections, which provides for additional inspection during adverse weather conditions;
- CCE-STR-GDN-2802, Guidance Notes for the Inspection of Earthworks and Coastal River Defences, issued in October 2010 (Version 1.0 live at the time of the incident). This is the associated guidance document supporting the technical standard CCE-STR-STD-2100 which provides information to the Structures Inspectors on preparing and conducting inspections and how to determine the condition of the asset.

CCE requirements set out in CCE-STR-STD-2100

42 Under the requirements set out in 5.2 of CCE-STR-STD-2100, cuttings and embankments are subject to General Engineering Inspections (GEI). A GEI is a "systematic visual inspection of a structure that is generally adequate to monitor and assess its condition. The inspection is usually undertaken from ground or water level with the assistance of binoculars or ladders where necessary so that all visible elements are examined." It should be noted that in addition to GEIs, Special Inspections can be carried out if deemed necessary by the STSE.

43 To complete a GEI, the Structures Inspector must complete an 'Inspection Card', see Figure 8, which requires the inputs of Good (G), Requires Repair (R) or Element requires further examination (E), for the following:

- Vegetation – bare ground, grass, brambles/scrubs and trees;
- Water – seepage, ponding or marsh;
- Apparent distress – soil slip, rock falls, bulging, cracks frost shattering, dislocated vegetation, ravelling, wedge failure, planar failure, toppling failure;
- Drainage – top, slope, bottom.

44 Other features or comments can be added, as well as any other notes or weather conditions at the time of inspection. In addition, the Inspection Card must be supplemented with photographs and/or sketches of the structures and defects.

Iarnród Éireann CCE Department
Cuttings, Embankments and Coastal/River Defences Inspection Card
(Page 2 of 2)

Division		**Line**		**Up or Down**	
Cutting/Embankment/ Defence		**Avg Height**		**Avg Toe/Shoulder Dist to RE**	
Type of Inspection		**Avg Slope**		**Material Interface**	
Serial No		**Start Mileage & Yds**		**Finish Mileage & Yds**	

Date	Vegetation				Water			Apparent Distress										Drainage			Other Features or Comments	D[1]	C[2]	D[3]	AEM[4] Req'd
	Bare Ground	Grass	Brambles/Shrub	Trees	Seepage	Ponding	Marshy	Soil Slip	Rock Falls	Bulging	Cracks	Frost Shattering	Dislocated Veg.	Veg. Damage	Ravelling	Wedge Failure	Planar Failure	Toppling Failure	Top	Slope	Bottom					

G = Good R = Requires repair E = Element requires further examination

[1]Design Rating [2]Condition Rating [3]Deterioration Rating [4]Additional Examination Measures Required? Indicate Yes or No

DATE	NOTES	Weather Conditions	Inspected by	Approved by

Figure 8 – Inspection Card for Cutting & Embankments

45 The Inspection Card also requires the Structures Inspector to determine the Design Rating, the Condition Rating and the Deterioration Rating, these are determined using the guidelines set out in the 'Inspection Cards' of Appendix A of CCE-STR-STD-2100, see Figure 9.

46 The ratings are given numeric values, with the description of each rating provided, for example in the case of Condition Ratings, if the asset is in good condition, with no defects or minor defects

well within tolerance, a value of 1 is given. The value 2 is Fair; 3 is Poor and; 4 is Very Poor, see Figure 9.

Design Ratings Table

Design	*Rating*
Fully controls all identified failure modes	1
Controls of identified failure modes have minor weaknesses	2
Controls of identified failure modes have significant weaknesses	3
Deficient – fails to control identified failure modes	4

Condition Ratings Table

Condition	*Rating*
Good (no faults or minor faults well within tolerance)	1
Fair (tolerable faults, no restriction in use necessary)	2
Poor (significant structural defects, i.e. out-of-tolerance faults)	3
Very poor (seriously deficient, mitigation measures necessary)	4

Deterioration Ratings Table

Deterioration	*Rating*
No discernible deterioration (constant failure rate).	1
Slight deterioration (slow increase in failure rate).	2
Discernible deterioration (moderate increase in failure rate). Condition rating expected to increase by 1 in 5 years time.	3
Catastrophic deterioration (rapid or exponential increase in failure rate). Condition rating expected to increase by 2 in 5 years time.	4

Figure 9 – Rating Tables for GEIs

47 It should be noted that the condition rating scoring applied during the GEI is one means of determining the condition of the asset. The condition of the asset may change due to the:

- Design and deterioration ranking;
- Risk rating of the asset;
- Results of other inspections carried out under CCE-TMS-360 and CCE-TMS-361 (discussed in paragraph 50) or other specialist inspections.

48 The condition rating determines the future intervals between inspections for 'Cuttings & Embankments' as set out in Section 6 of CCE-STR-STD-2100, as follows:

- Every 1 year for cuttings with a condition rating of 4;
- Every 5 years for cuttings with a condition rating of less than 4 and greater than or equal to 2;
- Every 10 years for cuttings with a condition rating of less than 2.

49 However, it should be noted that the frequency of inspection may be affected by the factors set out in paragraph 47.

CCE requirements set out in CCE-TMS-360 and CCE-TMS-361

50 Together CCE-TMS-360 and CCE-TMS-361 set out the requirements for staff in relation to inspections related to track and structure assets. CCE-TMS-360 and CCE-TMS-361 require Track Patrollers and PWIs to carry out inspections on cuttings and embankments every six months. CCE-TMS-361 refers to these inspections as a "Detailed inspections". Both documents also allow for "supplementary inspections due to exceptional weather".

CCE requirements set out in CCE-STR-GDN-2802

51 CCE-STR-GDN-2802 is the associated guidance document supporting the technical standard CCE-STR-STD-2100 which provides information to the Structures Inspectors on preparing and conducting inspections and how to determine the condition of the asset. It constitutes "mandatory standard practices", however, the requirements are not mandatory.

52 CCE-STR-GDN-2802 states that "The condition rating is relevant to decisions about maintenance. If a defect with a condition rating of 3 or 4 is observed, the Structures Inspector must immediately inform the STSE and the Infrastructure Manager if immediate intervention is required".

53 CCE-STR-GDN-2802 also provides additional details in relation to the Condition Rating, in "practical terms", as set out in Figure 10. For example, a Condition Rating of 3 should be awarded where there are "Slopes with loose blocks, water erosion, some seepages or wet patches, loss of joint infill soil (gauge) – 5% to 45% of the slope affected". It also states that there should be an "Increase in maintenance to correct defects".

Condition Rating	Description
1 – Good	Slopes are stable, with no signs of movement, and well drained. Slopes show no sign of movement of blocks of rock or loose surface debris (scree), and toes are secure.
2 – Fair	Slopes are reasonable with some minor loose blocks (less than 5% of slope face) or minor small slips. May need some maintenance to prevent deterioration of the slope.
3 – Poor	Slopes with loose blocks, water erosion, some seepages or wet patches, loss of joint infill soil (gauge) – 5% to 45% of the slope affected. Increase in maintenance to correct defects.
4 – Very Poor	Actually unstable, mass movement of blocks or major ravelling of loose surface debris (scree). Evidence of major planar/toppling failures, major erosion features. Structurally unsound; repair work needed now or in the short term.

Figure 10 – Condition ratings set out in CCE-STR-GDN-2802

54 CCE-STR-GDN-2802 also includes numerous photographs in relation to examples of cutting and embankments condition ratings to assist the structures inspectors in allocating a condition rating.

Inspections carried out on the rock face against CCE-STR-STD-2100

55 Requirements in relation to inspections, as set out in CCE-STR-STD-2100 are mandatory.

56 The most recent GEI carried out on the rock face at Plunkett Station was on the 2nd March 2012, the rock face was broken up into three different GEIs to accommodate for the long nature of the rock face and the inspections were carried out from the track. The GEI included a photograph of the rock face, taken on the day of the GEI, see Figure 11.

Figure 11 – Photograph taken in 2012, in the location of the 2013 rock fall

57 The Inspection Card noted “loose rocks” in three locations, and allocated a Design Rating of 2, a Condition Rating of 3 (Poor) and a Deterioration Rating of 3 (Discernible deterioration).

58 From Appendix A of CCE-STR-STD-2100, the Structures Inspectors interpretation of these numeric values (paragraph 46) meant that he thought that:

- The design controls of identified failure modes had minor weaknesses;
- The poor Condition Rating was as a result of significant structural defects (i.e. out of tolerance defects);
- There was discernible deterioration (moderate increase in failure rate);
- The Condition Rating was expected to increase by 1 in the next five years (i.e. increasing to a Condition Rating of 4, meaning the structure is in a very poor condition with serious deficiencies requiring mitigation measures).

59 The Condition Ratings of 3 and 4, differ greatly in terms of inspection frequency, i.e. from one in every five years to annually, respectively (paragraph 48). As part of the RAIU investigation, this Condition Rating was queried with the Technical Manager CCE, where he stated in correspondence with the RAIU on the 24th September 2014 that "while the condition of the asset was rated as Condition Rating 3, along with many thousands of other assets throughout the network, this is simply representative of the aged and legacy infrastructure which we manage". This is generally as a result of the fact that a number of structures on the IÉ network are in excess of 100 years old, including earthworks.

60 The RSC Audit 'IÉ's management of cuttings & embankments', published in March 2011, noted "From the Inspection Card a Condition Rating of 3 rates the asset as being in poor condition, i.e., it has significant structural defects, i.e. out-of-tolerance faults. This condition rating requires an inspection once every 5 years. This compares to an annual inspection for a condition rating of 4 which would appear to be only marginally worse. It is not clear how these condition ratings were determined and they should be reviewed to ensure assets are inspected at appropriate intervals".

61 The RSC made a recommendation based on this finding "IÉ should review the condition rating scoring for cuttings and embankments. IÉ should review the condition rating scoring system and frequencies specified for these ratings for cuttings and embankments to ensure they are appropriate. Based upon this the standard should be amended (as appropriate) and the rating system briefed to structural inspection personnel". This recommendation has not been closed, given that the Condition Rating system remains the same.

62 The Inspection Card also noted that the continuation of the rock netting was required, but not urgent; and suggested the possible consideration of a catch fence when the "siding" was removed. The rock netting was present at other locations on the rock face, see Figure 12 for an example of the rock netting. It should be noted that the Consultant's Report confirmed that the continuation of rock netting was not urgent.

Figure 12 – Rock netting present in 2012 GEI

63 In terms of the completion of the Inspection Card, the requirements set out in CCE-STR-STD-2100 for GEIs were not met in their entirely in that:

- The Inspection Card completed on the 2nd March 2012, used an altered template from those provided in CCE-STR-STD-2100 and CCE-STR-GDN-2802, in that "Fair (F)" and "Poor (P)" have been entered into the template (see Item 1, Figure 13) by the Structures Inspector;
- The terms "Fair (F)" and "Poor (P)", are specific to the Condition Rating, which should be entered numerically, where Fair and Poor are represented by 2 and 3, respectively. However, the Structures Inspector has used F and P in assessing the drainage (see Item 2, Figure 13);
- The Structures Inspector also used "Y" and "N" in completing the Inspection Card instead of the required "G", "R", "E" terms (see Item 3, Figure 13) to indicate the presence of features, but not their condition;
- The Inspection Card was not approved by the STSE (see Item 4, Figure 13).

64 The RAIU reviewed a sample number of inspection cards as part of the investigation in terms of quality and completeness and it was found that the inspection cards are consistently failing to meet the requirements set out in CCE-STR-STD-2100.

CCE-STR-GDN-2802, Version 1.0 - Guidance Notes for the Inspection of Earthworks and Coastal and River Defences

Iarnród Éireann CCE Department
Cuttings, Embankments and Coastal/River Defences Inspection Card

INSP (2)

Division	10	Line	Waterford to Rosslare	Up or Down	Down
Cutting/Embankment/ Defence	ROCKFALL	Avg. Height		Avg Toe/Shoulder Dist to RE	
Type of Inspection	General	Avg. Slope		Material Interface	
Serial No. CTH0010		Start Mileage & Yds 75-1140		Finish Mileage & Yrds 75-1210	

WATERFORD STATION ROCKFALL SIGNALBOX → STATION BUILDING

Date	Vegetation				Water			Apparent Distress											Drainage			Other Features or Comments	D[1]	C[2]	D[3]	AEM[4] Req'd
	Bare Ground	Grass	Brambles/Shrubs	Trees	Seepage	Ponding	Marshy	Soil slip	Rock Falls	Bulging	Cracks	Frost Shattering	Dislocated Veg.	Veg. Damage	Ravelling	Wedge Failure	Planar Failure	Toppling Failure	Top	Slope	Bottom					
	Y	N	Y	N	Y	N	N	N	Y	N	Y	Y	N	N	N	N	N	Y	F	F	F	2	2	3	3	
										3																

BOTTOM 3M x 2M x 3 SPOTS

1 G = Good R = Requires repair F = Fair P = Poor
E = Element requires further examination

[1]Design Rating [2]Condition Rating [3]Deterioration Rating
[4]Additional Examination Measures Required? Indicate Yes or No

Date	Notes	Weather Conditions	Inspected by	Approved by
2/3/2012	2 LENGTHS OF ROCK NETTING	DRY	[redacted]	
	→ CONTINUATION FROM ROCK NET 2 REQ'D NOT URGENT			
	3 LOOSE ROCK SPOTS HERE			4
	POSSIBILITY OF CATCH FENCE AFTER SIDING REMOVED			

Figure 13 – Inspection Card from GEI carried out on the 2nd March 2012

65 An investigation carried out by the RAIU into the Malahide Viaduct collapse, published in 2010, found one of the underlying factors/causes associated with the cause of the accident to be IÉs failure to meet all the requirements of their Structural Inspections Standard, I-STR-6510, in that Inspection Cards, for recording findings of inspections, were not completed to standard and were not approved by the relevant personnel. I-STR-6510 was IÉ's Structural Inspections Standard at the time of the Malahide Viaduct Collapse, which was replaced with CCE-STR-STD-2100, however, the format of the Inspection Cards remained the same in both standards.

66 Also worth noting, post incident, are the findings of an RSC PII into the 'Collision of train with a landslip at the 38 ¼ milepost on the Kilkenny to Waterford line' which occurred on the 31st December 2013 (the same day as this incident), with the PII being published in April 2014. During this inspection, the RSC recommended that the Technical Manager CCE (or their nominated deputy) "could consider reviewing the cutting & embankment inspection card as records supplied suggest they are not being completed as per standard, e.g., individuals are entering 'Y's' and 'N's' as opposed to G (Good), R (Requires Repair) or E (Element requires further examination)".

67 Apart from the Inspection Card, the remainder of the inspection undertaken by the Structures Inspector was of good quality, with numerous photographs and sketches.

Inspections carried out on the rock face against CCE-TMS-360 and CCE-TMS-361

68 The requirements set out in CCE-TMS-360 and CCE-TMS-361 (paragraph 50) were undertaken. The Track Patroller patrolled the area three times a week; and the twice-yearly inspections of the cutting for any indication of slip were undertaken. For example, in 2013, two visual inspections were carried out on the 28th March and the 24th September by the Track Patroller and PWI; with the inspection cards completed in full. The inspection card noted "loose rock fall", "loose rocks", "leaning trees" and "vegetation control".

69 Section 4.3, Track Patrolling Schedule of CCE-TMS-361, in relation to cuttings and embankments requires that "special attention to be given during heavy rain". Section 4.4, Supplementary Inspections, of the same standard requires that additional inspections are required during periods of adverse weather conditions, however, this is limited to the condition of the track.

70 The CCE stated that "further inspections of various 'weather hotspots' were undertaken on 28th December during the adverse weather. This was done by verbal request from the Regional Manager/ PWI and so was not documented and no issues were found".

71 Due to the absence of any documentation in relation to these "further inspections", it is not clear whether the rock face was one of these assets subject to further inspections or just the condition of the track.

Inspections carried out on the rock face against CCE-STR-GDN-2802

72 Requirements in relation to inspections, as set out in CCE-STR-GDN-2802 provide additional guidance to Structures Inspectors. The following paragraphs provide supplementary information in relation to the results of the GEI carried out against CCE-STD-STR-2100.

73 The Structure Inspector awarded a Condition Rating of 3 to the rock face, as required in CCE-STR-STD-2100. Reviewing the Condition Rating of 3 against the guidance document, CCE-STR-GDN-2802 describes a Condition Rating of 3, in practical, terms as follows: "Slopes with loose blocks, water erosion, some seepages or wet patches, loss of joint infill soil (gauge) – 5% to 45% of the slope affected. Increase in maintenance to correct defects", (paragraph 53).

74 CCE-STD-STR-2100 is primarily related to the inspection of the asset; unlike CCE-STR-GDN-2802 there are no references, at all, in CCE-STR-STD-2100 in relation to an increase to maintenance for a Condition Rating of 3. In addition, there was no increase to maintenance as a result of this GEI's Condition Rating of 3. In correspondence from the Technical Manager CCE on the 24th September 2014, to the RAIU, the Technical Manager CCE stated "that CCE-STR-GDN-2802 is part of guidance that is offered to Structures Inspectors and does not constitute a

mandatory requirement to undertake maintenance", and further states that "over the many hundreds of thousands of assets that are the responsibility of CCE Department, many of them are Condition Rating 3, however, in practical terms, applying maintenance to each such asset is highly unrealistic. Instead the root definition of a Condition Rating 3 asset, is that it represents a 'Poor' asset".

75 CCE-STR-GDN-2802 states that where a Condition Rating of 3 is observed, the Structures Inspector "must immediately inform the STSE and the Infrastructure Manager if immediate intervention is required". The Technical Manager CCE stated (in correspondence with the RAIU on the 24th September 2014) that "a Condition Rating 3 (or 4) asset should be reported to the STSE and/or the Infrastructure Manager if it is felt that an urgent maintenance intervention is required", (paragraph 52).

76 This immediate notification did not occur, but it is not set out in CCE-STR-GDN-2802 what conditions require immediate notification. In addition, there is no reference to any immediate notification requirements in CCE-STR-STD-2100 in relation to embankments and cuttings (the only reference is in relation to scour at structures and steel bridges). It should also be noted that CCE-STR-GDN-2802 is not a mandatory requirement and therefore the Structures Inspector is not mandated to carry out this immediate notification.

Compliance Verification

77 CCE-SMS-001, CCE Safety Management System' published 2011 (Version 2.0 live at the time of the incident) is the primary safety management standard for the CCE which defines the activities, accountabilities and roles of CCE staff in the management of the workplace and/or worksite in terms of safety. Section 5, 'Accountabilities & Responsibilities' of CCE-SMS-001, requires that the appropriate, correct and complete CCE Technical Documentation is implemented at all CCE Locations. CCE-STR-STD-2100 would therefore fall under this remit.

78 To ensure the correct implementation of CCE-SMS-001, the Technical Manager CCE, should implement "an appropriately in-depth programme of *compliance verification* (through audit, investigation, observance and review) to ensure the safety of track and structures. This programme should be conducted by the relevant STSE to verify that all the tasks required from the Accountable Line Managers (and their staff) are being completed in a manner that is technically correct, at the correct frequency, with the correct care and in accordance with the CCE technical documentation. Specifically, ensuring that all the inspections, examinations, condition assessments, technical evaluations and/or testing (and all associated documentation) as required to correctly maintain, operate, assess and determine the condition of all the track and structures

are done consistently". This compliance verification should then be reviewed as a key performance indicator (KPI) with all the STSE every period and ensure that acceptable progress is made with corrective actions.

79 CCE-SMS-008, 'Safety Tours and Compliance Verification', published in January 2011 (Version 2.0 was live at the time of the incident) has a policy "to meet the statutory and IÉ obligations regarding the monitoring of safety and to execute Safety Tours and Compliance Verification in order to reduce the level of Risk in the workplace and at worksites". In terms of compliance verification, CCE-SMS-008 states that "the STSE is accountable for deploying compliance verification in order to ensure that the quality of work as done by employees is in accordance with the technical documentation". And requires, the STSE to plan and schedule a compliance verification programme annually; and to be reviewed by the CCE Technical Manager. This compliance verification programme should sample 15% of the completed tasks through verification checks, audit, investigation, observance and review in order to verify that the tasks have been completed correctly, to the correct frequency and the results must be tabulated such that corrective actions can be identified and executed.

80 The rock face at Plunkett Station was not one of the 15% subject to this compliance verification process. However, the compliance verification programme sample of 15% did not to identify that Structures Inspectors were not meeting all the requirements of CCE-STD-STR-2100 in terms of completing and approving the Inspection Cards.

81 In addition, there is some doubt that this process would "ensure that the quality of work as done by employees is in accordance with the technical documentation" given that the compliance verification form (sample included, Figure 14) does not refer to any documentary review in terms of quality and appears to be an addition inspection of the asset and a check on the frequency of inspection and an assurance that work orders generated by inspections are complete.

82 In correspondence with the RAIU, dated the 24th September 2014, the Technical Manager CCE stated that "It should be noted that we have been developing over a long period of time our compliance verification processes to have it as an automated and integrated process within our overall asset management system. The information technology (IT) development associated with this has been system is only coming fully into effect over the last while, due to delays on the IT side of things, beyond the control of CCE – it has been somewhat manual heretofore".

83 Although, a "manual" compliance verification process was in place at the time of the incident, the CCE were unable to provide any documented evidence that there was any formal review between the CCE Technical Manager and the STSE in relation to KPIs resulting from the compliance verification process or provide any evidence related to the progress of identified corrective actions. In the place of any formal review, the KPIs are discussed, when necessary, at periodic

review meetings. Again, the Technical Manager CCE cited the lack of an IT system as the reason for no formal documentation.

Compliance Verification Form — **No. 2013/25**

Location: Shaws Bridge Kilcock — Date: 14-03-2013

Asset type: Bridge – (OBG25 Broadstone to Galway Line) 18, 1080 MP — Serial Number: 30000186

Inspection Work Orders

All inspection WO are up to date

Work Orders Raised following Inspections

Order	Equipment	Serial Number	Description	Description	Bas. start date	Basic fin. date	System status
70051464	30000186	OBG25	Shaw Bridge Kilcock - Protected	Thorough Inspection	13/11/2009	04/03/2010	TECO NMAT PRC
70087804	30000186	OBG25	Shaw Bridge Kilcock - Protected	General Engineering Inspection	23/07/2011	23/07/2011	TECO NMAT PRC SETC
510018846	30000186	OBG25	Shaw Bridge Kilcock - Protected	Replace Emergency Bridge Plate	25/10/2011	02/11/2011	TECO NMAT PRC SETC
510018847	30000186	OBG25	Shaw Bridge Kilcock - Protected	Repair masonry facade on Dub elevation d	25/10/2011	31/12/2012	CRTD MANC NMAT NTUP PRC
510018845	30000186	OBG25	Shaw Bridge Kilcock - Protected	Install Bridge Plate (Track Level)	25/10/2011	31/12/2012	CRTD MANC NMAT NTUP PRC
530073533	30000186	OBG25	Shaw Bridge Kilcock - Protected	General Engineering Inspection	19/10/2013	19/10/2013	CRTD CSER MANC NMAT PRC

Observations:

This bridge is in good condition but there are some outstanding work orders.

Recommended Actions

No.	What	Who	PCD
1	Work Orders 510020074 - 510020076 are still outstanding	RM	
2		RM	
3		RM	
Signed	[redacted]	Date	20/05/2013

Figure 14 – Sample Compliance Verification Form

84 It should be noted that IÉ affirmed to the RSC during an audit conducted in September 2013, into vegetation management entitled 'IÉ's management of vegetation' that the compliance verification programme would be implemented in full by the end of September 2013. However, the RSC noted, at the time of the audit, that "it was evident that the CCE Department remain non-compliant

with the requirements to undertake compliance verification activities and thus prompt attention is now required to remedy this non-compliance". In summary, the RSC found that "A programme of compliance verification across the CCE divisions was not fully or consistently implemented", resulting in a *minor non-compliance*. The minor non-compliance is as follows: "No evidence was available to demonstrate a programme of compliance verification is undertaken in all divisions".

85 The RSC indicated that lack of resources was a contributing factor into the above minor non-compliance, and recommended that the "Director of IM should review CCE Departmental resource requirements to ensure that required level of divisional resources is available to comply with the IM SMS".

Structures Inspection Competence

Competence of Structures Inspectors

86 Inspections of cuttings are carried out by Structures Inspectors. According to the structures technical documentation 'Technical Standard for Structural Inspections', document number CCE-STR-STD-2100, published in October 2011, Structures Inspectors are persons who are competent to carry out inspections on behalf of the STSE and who have:

- Completed the required training as outlined in the relevant technical documentation;
- Knowledge and experience of the design, construction and maintenance of the type of structure to be inspected;
- Attended the IÉ Structures Inspection Training Course and has undertaken supervised "follow up" mentoring in the field by experienced, competent staff;
- Attended a 'Refresher Structures Inspection Training Course' every three years, where applicable.

Management of Structures Inspection Competence

87 The CCE further set out the requirements for training and assessment for personnel carrying out structures inspections on IÉ structures through their technical management standard, 'Management of Structural Inspection Competence', CCE-TMS-420 (Version 1.0 published in May 2011, and active at the time of the incident).

88 CCE-TMS-420 sets out the requirements for the implementation of competency, such as: initial selection; training; mentoring; assessment and achieving competence, and; finally maintaining competence.

89 In relation to the 'maintaining competence', Section 3.6.1.1 states that "Structures Inspectors must have their inspection work reviewed by their STSE to confirm continued competence". This is required to be undertaken annually and be documented by the STSE. The RAIU requested the documentation in relation to these reviews in relation to the Structures Inspector who carried out the GEI in March 2012 on the rock face. IÉ CCE were unable to provide this information, stating that a review process had been undertaken as part of the normal review of inspection cards, but no specific annual review of the Structures Inspectors work had been documented.

90 In relation to the implementation of CCE-TMS-420, Section 2.2.3 states that the Technical Manager CCE is accountable for ensuring that "this standard is implemented through a programme of compliance verifications and review".

Competence of the Structures Inspector

91 The last inspection carried out by a Structures Inspector at the rock face at Plunkett Station, was carried out on the 2nd March 2012, by a Structures Inspector that was found to be competent, in that he:

- Completed the required training as outlined in technical documentation;
- Had been carrying out structures inspections within IÉ for four years at the time of the incident;
- Had knowledge and experience of design, construction and maintenance of cuttings, as he is a competent chartered Civil Engineer, and has completed a two day course on 'Slope Stability' which was run for IÉ Structures Inspectors in 2011;
- Attended an IÉ Structures Inspection Training Course in November 2010, and received follow up mentoring from a specialist external consultant.

92 However, he had not completed a 'Refresher Structures Inspection Training Course' until March 2014, four months after the required three year refresher deadline, set out in CCE-STR-STD-2100.

Maintenance of the rock face

93 Previous to the incident, in sections further along the rock face, rock netting had been placed on the rock face, between 1993 and 1995, in areas susceptible to minor ravelling of rock. The Consultant's Report found the rock netting to be an "effective action" for this area of the rockface. There is no other recorded maintenance at the rockface. Vegetation maintenance occurred at the rock face.

Post incident inspection of the rockface

94 Part of the remit of the Consultant's Report was to determine any possible geological factors which might have contributed to the rock fall. The Consultant's Report concluded that the initial failure mechanism, causing the rock fall, was probably due to the toppling of the upper part of the rock mass (northern Central Block), followed by rotation of the toppled rock mass, resulting in rock fall debris flowing onto the ground. The mobilisation of these processes was probably finally triggered by the intense rainfall of the preceding weeks. The report lists a number of possible contributory factors which resulted in this conclusion, which are as follows:

- The Central Block, had limited supporting or stabilising influence from the bounding blocks (Western & Eastern Bounding Blocks) on either side due to intervening faults (F1 & F2), see Figure 6;
- The bedding in the Central Block is inclined steeply to the north i.e. the beds were dipping into the rock face, which resulted in a highly unstable situation, given the extensive jointing;
- Several major south to southwest dipping joints (J6 & J7) and at least two faults (F3 & F4) intersect a number of thick northerly dipping beds on the north face, see Figure 7. The southerly dip of the joints and faults would have resulted in major reduction in the ability of the rock mass/beds to remain intact once supporting material in front of and below these now exposed beds was removed, leading to the toppling of these upper beds;
- The pervasive jointing, bedding planes and faults, provided abundant pathways for groundwater percolation, which would have increased the porosity and permeability of the rock mass over time due to the opening of fractures due to weathering; loosening up the rock mass and enhancing the passage of groundwater through the rock mass (these would have been further enhanced at the time due to the recent heavy rainfall); resulting in an increase in the loading within the rock mass and increasing the internal hydrostatic pressure. These processes in combination with the intense fracture pattern in the bedrock may have exceeded its bearing capacity, causing failure.

Sequence of events

General information on the sequence of events

95 The following paragraphs highlight the key events before, during and after the incident. Not all events associated with the rock face have been included, only those events relevant to the incident.

Events before the incident

96 Between 1864 and 1905 excavations works were carried on Mount Misery to facilitate the construction of Plunkett Station and extension works, resulting in the exposure of the rock face.

97 Rock netting was erected at some time between 1993 and 1995 at certain areas of the rock face.

98 In March 2012, the most recent GEI was carried out on the rock face by a Structures Inspector, where no obvious defects were detected.

99 In March and September of 2013 two visual inspections were carried out by the Track Patroller and the PWI. The visual inspection card noted “loose rock fall”, “loose rocks”, “leaning trees” and “vegetation control” during these inspections, but no other major defects were detected.

100 On the 28th December 2013 due to the adverse weather conditions in the area, the Track Patroller carried out inspections at various 'weather hotspots' were undertaken on 28th December during the adverse weather. However, it is not clear whether the rock face was one of these assets subject to further inspections.

Events during the incident

101 At approximately 18:45 hrs on Tuesday 31st December 2013 the Signalman at the Signal Cabin heard a loud rumble from outside. When the Signalman went out onto the steps of the Signal Cabin to investigate, he saw that a large portion of the rock face running adjacent to the station had collapsed onto the two tracks which run under the Signal Cabin.

102 There were no trains or passengers in the vicinity of the rock fall, with no injuries to passengers or staff.

Events after the incident

103 Trains were stopped from entering Plunkett Station and IÉ made the decision to evacuate and close Plunkett Station and cordon off the areas around the affected platforms for the protection of IÉ staff, customers and members of the public.

104 Specialist consultants were engaged by IÉ IM to undertake a geological inspection of the rock face.

Similar occurrences

General information

105 The RAIU conducted an investigation into landslides after the derailment of the train due to a collision with a landslide in November 2009, entitled, 'Derailment of empty train due to collision with landslip debris outside Wicklow Station, 16th of November 2009'. During this investigation, landslides which occurred between June 2007 and November 2009 were reviewed. The following three landslides occurred after November 2009.

Landslide near Rushbrooke Station on the 25th January 2013

106 At approximately 17:35 hrs, on the 25th January 2013, a train driver travelling from Cobh to Cork noticed that a part of the embankment adjacent at the 176 MP, near Rushbrooke Station, on the up line (towards Cork) had collapsed. The lower front part of the train brushed off the debris as the train past. There was no damage to the train and the train driver reported the occurrence to the controlling signalman. The line was closed by the CCE Department pending further assessment and remained closed until 15:00 hrs the following day to carry out works on making the embankment safe.

107 In relation to this specific section of track, it should be noted that in December 2009, IÉ engaged specialists to carry out an inspection in the vicinity of this incident (174 ¼ MP – 176 ¼ MP). Overall they found that the embankment was in a "reasonable" condition, and made a number of specific recommendations in relation to drainage, vegetation removal and removal of loose rock on the down line; with no recommendations for the up line. All recommendations were reported to be undertaken by IÉ. Of note, in relation to the RAIU investigation, is that the specialists also included, in their appendices, an Inspection Card; this Inspection Card did not meet all the requirements set out in CCE-STR-STD-2100, in that the correct terminology was not used, the design and deterioration ratings were not included and the Inspection Card was not signed by the STSE or nominated STSE deputy.

Landslide between Ballyhale & Lavistown on the 31st December 2013

108 At approximately 06:40 hrs on the 31st December 2013, the 06:05 hrs passenger service from Waterford to Heuston struck a landslip just north of Legan Level Crossing (XW113) at the 38 ¼ MP, between Ballyhale and Lavison. The first three coaches of the train sustained damage to the undercarriage and the train came to a stop with the rear coach over the bulk of the debris, see Figure 15. There were eight passengers onboard and there were no injuries reported.

Figure 15 – Landslide between Ballyhale and Lavison

109 An internal IÉ investigation report into the incident found that the immediate cause of the landslide was due to the saturation of the cutting material following heavy rainfall over the days preceding the 31st December 2013; the rainfall for the month of December was above average. Causal to the incident was the saturation of the embankment due to higher levels of water within the field and insufficient drainage at the crest of the slope, which allowed water to infiltrate the steep cutting slope, causing the top layer of the cutting material to slip down the bank, see Figure 16. Underlying to the incident was the difficulty in observing changes in water levels and drainage in adjacent land during routine track patrolling and GEIs.

Figure 16 – Aerial photograph water at crest of the cutting slope

110 The internal investigation report found that the inspections were carried out to the required frequencies as set out in CCE-TMS-361 and CCE-STR-STD-2100. However, the investigation report noted that the labelling of the assets on the Inspection Card was not as set out in CCE-STR-STD-2100, in that the Structures Inspector identified the incorrect asset.

111 Also of note is the fact that the Structures Inspector did not traverse the cutting, at specified intervals as set out in CCE-STR-GDN-2802, due to the overgrown vegetation. However, the requirements set out in this document are not mandatory. The RAIU, in their investigation report into the "Derailment of empty train due to collision with landslip debris outside Wicklow Station, 16th of November 2009", published on the 15th November 2010, addressed a safety recommendation to IÉ in relation to vegetation management, stating "IÉ should review their vegetation management processes to ensure that vegetation covering substantial earthworks structures is adequately maintained to facilitate the monitoring and inspection of earthwork structures by patrol gangers and other inspection staff". This recommendation was closed by the RSC in December 2013, after the RSC carried out an audit in September 2013 "IÉ management of vegetation". The RSC made a number of recommendations on findings which are currently being undertaken by IÉ.

Landslide near Rushbrooke on the 7th March 2014

112 At approximately 22:40 hrs on the 7th March 2014, a rock fall, consisting of approximately thirty tonnes of debris, occurred on the cutting near the 176 MP between Rushbrooke and Cobh Stations. The rock fall occurred on the side of the down line (towards Cobh). The line was under *possession* (with no passenger services) at the time of the incident, to facilitate the renewal of an *overbridge*. Staff who were working at the overbridge heard the rock fall and went to investigate and found that the down line was blocked as a result of rock fall debris, see Figure 17.

Figure 17 – Landslide at 176 MP

113 An internal Technical Investigation Remit was commissioned by IÉ and published on the 14th March 2014; it found that the ingress of water passing through the mudstone/shale rock, and the general weathering of the rock reduced the integrity of the rock to a state where the rock became unstable; resulting in the rock collapsing due to its reduced ability to support itself, causing the failure of the bond between two layers of rock along a 60 degree plain. The remit found that the constant flow of water through the cutting was contributory to the incident occurring.

114 The remit resulted in a number of recommendations, namely: an increased inspections frequency (once a month); application of a temporary speed restriction on the line; short term and long term remedial works to stabilise the structure.

Analysis

Failure mechanism of the rock face

115 The Consultant's Report concluded that the initial failure mechanism, causing the rock fall, was probably due to the toppling of the upper part of the rock mass (northern Central Block), followed by rotation of the toppled rock mass, resulting in rock fall debris flowing onto the ground. The mobilisation of these processes was probably finally triggered by the intense rainfall of the preceding weeks. The report found a number of possible contributory which were all associated with the topography of the rock face (paragraph 94).

116 The RAIU investigation, and the Consultant's Report, determined that it is unlikely that the potential for rock fall could have been identified during routine IÉ inspections. It is also unlikely that a member of IÉ staff would have been able to identify that the structure would fail, or in fact that there would have been any warning to the failure prior to the day of the incident. Therefore no other immediate causes, contributory factors, *underlying causes* or *root causes* were identified as a result of this incident.

117 However, during the course of the RAIU investigation, the RAIU analysis made a number of additional observations associated with the inspection process of the asset, which warrant further discussion. These additional observations are analysed below.

Inspection of the rock face

Inspections carried out on the rock face against CCE-STR-STD-2100

118 The last GEI, required through CCE-STR-STD-2100, was carried out on the rock face at Plunkett Station was on the 2nd March 2012 (paragraphs 56). The Inspection Card noted some minor defects and improvements such as "loose rocks" and the non-urgent provision of rock netting (paragraph 57).

119 The Structures Inspectors allocated the following:

- Design Rating of 2 – meaning "controls of identified failure modes have minor weaknesses";
- Condition Rating of 3 – meaning "Poor" due to "significant structural defects (i.e. out of tolerance defects)"; and the Condition Rating was expected to increase to a Condition Rating of 4 in the next five years, meaning the structure was expected to be in a very poor condition with serious deficiencies requiring mitigation measures;
- Deterioration Rating of 3 – meaning "Discernible deterioration" due to the "moderate increase in failure rate" (paragraph 58).

120 Therefore, in summary, the Structures Inspector identified that the rock face was in poor condition resulting in serious deficiencies within the next five years and identified that maintenance was required, through the provision of rock netting.

121 However, there is some doubt as to the efficacy of the Condition Rating scoring, given that the Condition Ratings of 3 and 4 differ greatly in terms of inspection frequency (five years versus annual inspections). In addition, where a Condition Rating 3 is awarded to an asset, this results in a Condition Rating of 4 after five years.

122 This efficacy is further in doubt, given the Technical Manager CCE stated that the Condition Rating 3 is representative of the age of the IÉ network, where a number of the structures are in excess of 100 years, (paragraph 59). In addition, the condition of the asset is also affected by other inspections and risk tools. Therefore it appears that the condition rating scoring is not a true reflection of the actual condition of the asset.

123 The RAIU finding is similar to an RSC finding, identified during an audit on 'IÉ's management of cuttings & embankments', published in March 2011. The RSC recommended that the condition rating scoring system be reviewed (paragraphs 60 and 61). This has not occurred to date.

124 On reviewing the completed Inspection Card for the 2nd March 2012, the requirements set out in CCE-STR-STD-2100 for GEIs were not met in their entirely in that the Structures Inspector altered the approved template and did not use the approved terms in assessing the condition of the assets. In addition, the STSE did not approve the Inspection Card (paragraph 64).

125 On reviewing further samples of Inspection Cards to the RAIU, it is apparent that the Structures Inspectors are consistently failing to meet the requirements set out in CCE-STR-STD-2100 (paragraph 64). In addition the specialists engaged to carry out an inspection as a result of the landslide near Rushbrooke Station on the 25th January 2013 also incorrectly filled out the form and it remained unsigned by the STSE (paragraph 107); and an internal investigation into the

landslide between Ballyhale & Lavistown on the 31st December 2013 noted that the Inspection Card had been labelled incorrectly.

126 CCE-TMS-420 states that "Structures Inspectors must have their inspection work reviewed by their STSE to confirm continued competence". However, the STSE was unable to provide the RAIU with any specific annual review documentation confirming this requirement for compliance verification had been undertaken, as it was informally addressed through reviewing of Inspection Cards, as required (paragraphs 88 and 89). However, given that that Inspection Cards were continuously filled out incorrect, this informal system adopted was not effective at correcting the Structures Inspectors quality of work.

127 This is not the first time the RAIU have identified that Inspection Cards are not being completed correctly. In 2010, the RAIU found that one of the underlying factors/causes associated with the cause of the collapse of the Malahide Viaduct was as a result of IÉs failure to meet all the requirements of their Structural Inspections Standard, I-STR-6510, in that Inspection Cards, were not completed to standard and were not approved by the relevant personnel. The format of the I-STR-6510 Inspection Card is identical to the CCE-STR-STD-2100 Inspection Card (paragraph 65).

128 More recently in April 2014, the RSC also identified that the Inspections Cards "are not being completed as per standard" during their PII resulting from a landslip. The RSC required that the Technical Manager CCE "could consider reviewing the cutting & embankment inspection card", (paragraph 66).

Inspections carried out on the rock face against CCE-TMS-360 and CCE-TMS-361

129 The requirements set out in CCE-TMS-360 and CCE-TMS-361 were undertaken, in terms of the track being patrolled three times a week and the twice-yearly visual inspections of the asset, for signs of slip, were undertaken. These inspections did not identify any major concerns with the rockface (paragraph 68).

130 In addition, "further inspections of various 'weather hotspots' were undertaken on 28th December during the adverse weather", as required of CCE-TMS-361. The vicinity of the rock face was patrolled with "no issues" found. However, as these inspections were not documented, therefore it cannot be confirmed whether the rock face was one of these assets subject to further inspections or whether it was the condition of the track that was inspected (paragraphs 69 and 70).

Inspections carried out on the rock face against CCE-STR-GDN-2802

131 Requirements in relation to inspections, as set out in CCE-STR-GDN-2802 provide guidance to Structures Inspectors. However, there are a number of irregularities with the CCE-STR-GDN-2802 when compared to the mandatory CCE-STR-STD-2100 which are set out below.

132 A Condition Rating of 3 in CCE-STR-GDN-2802 states that there should be an "Increase in maintenance to correct defects". However, there are no references, at all, in CCE-STR-STD-2100 in relation to an increase to maintenance for a Condition Rating of 3 for cuttings and embankments. In addition, the Technical Manager stated that it was impractical and highly unrealistic to expect to apply any maintenance to such a structure (paragraph 74). Therefore, it is questionable why such a statement would be made in CCE-STR-GDN-2802, given it's inconsistency with CCE-STR-STD-2100.

133 In addition, CCE-STR-GDN-2802 states that where a Condition Rating of 3 is observed, the Structures Inspector "must immediately inform the STSE and the Infrastructure Manager if immediate intervention is required"; and the Technical Manager CCE stated this "should be" reported where "urgent maintenance intervention is required" (paragraph 75). However, given that this is a guidance document, and not included in CCE-STR-STD-2100, it again shows an inconsistency through both documents.

134 In any event, the Structures Inspector did not report this to the STSE or the Infrastructure Manager, and there is some question as to whether the condition of the asset was in anyway formally conveyed to the STSE, given that the Inspection Card, was not approved (and unlikely reviewed) by the STSE (paragraph 76).

Compliance Verification

135 The compliance verification process is to ensure that all the tasks required from the Accountable Line Managers (and their staff) are being completed in a manner that is technically correct, at the correct frequency, with the correct care and in accordance with the CCE technical documentation (paragraph 78). This compliance verification process should sample 15% of the completed tasks through verification checks, audit, investigation, observance and review in order to verify that the tasks have been completed correctly, to the correct frequency and the results must be tabulated such that corrective actions can be identified and executed (paragraph 79).

136 However, the Technical Manager CCE indicated to the RAIU that the compliance verification, although adopted manually was a paper based process as it was undergoing IT updates (paragraph 80), resulting in an informal approach to the management of KPIs being developed (paragraph 83).

137 Structures Inspectors were not meeting all the requirements of CCE-STD-STR-2100 in terms of completing and approving the Inspection Cards. There is some doubt that the compliance verification process would have identified this issue, given that the Compliance Verification Form does not refer to any documentary review in terms of quality and appears to be an additional inspection and check on frequency of inspections and a check on the completion of work orders (paragraph 81).

138 In addition, CCE-TMS-420 states that "Structures Inspectors must have their inspection work reviewed by their STSE to confirm continued competence" and requirements of CCE-TMS-420 should be verified by the Technical Manager CCE "through a programme of compliance verifications and review". The Technical Manager CCE was unable to provide the RAIU with any evidence confirming this part of the compliance verification process had been undertaken (paragraphs 88 and 89).

139 In September 2013, during an RSC audit, 'IÉ's management of vegetation', the RSC also found that the compliance verification process was not fully or consistently implemented, resulting in the following minor non-compliance "No evidence was available to demonstrate a programme of compliance verification is undertaken in all divisions" (paragraph 84).

140 The RSC indicated that lack of resources was a contributing factor into the above minor non-compliance, and recommended that the "Director of IM should review CCE Departmental resource requirements to ensure that required level of divisional resources is available to comply with the IM SMS" (paragraph 85).

Competence of Structures Inspector

141 The Structures Inspector who carried out the latest GEI on the rock face was competent to carry out inspections on behalf of the STSE, and met all the training requirements set out in CCE-STR-STD-2100 (paragraph 86), apart from one requirement related to the refresher training for structural inspection (paragraph 92). However, this was unlikely to be contributory to the incident.

142 In relation to competence management, CCE-TMS-420 states that "Structures Inspectors must have their inspection work reviewed by their STSE to confirm continued competence" and

requirements of CCE-TMS-420 should be verified by the Technical Manager CCE "through a programme of compliance verifications and review". However, the STSE was unable to provide the RAIU with any evidence confirming this Structures Inspector's work was reviewed; and the Technical Manager CCE were unable to provide the RAIU with any evidence showing that this part of the compliance verification process had been undertaken (paragraphs 88 and 89). However, given that that Inspection Cards were continuously filled out incorrect, this informal system adopted was not effective at correcting the Structures Inspectors quality of work.

Maintenance of the rock face

143 Previous to the incident, in sections further along the rock face, rock netting had been placed on the rock face, between 1993 and 1995, in areas susceptible to minor ravelling of rock; which had been found as an "effective action" for this area of the rockface (paragraph 93). There is no other recorded maintenance at the rockface (paragraph 93); apart from vegetation removal (paragraph 93).

Conclusions

Failure mechanism of the rock face

144 The failure mechanism of the rock fall, was probably due to the toppling of the upper part of the rock mass, followed by rotation of the toppled rock mass, resulting in rock fall debris flowing onto the ground. The mobilisation of these processes was probably triggered by the intense rainfall of the preceding weeks; and a number of topographical issues with the rock face (paragraph 115).

145 The RAIU investigation, and the Consultant's Report, determined that it is unlikely that the potential for rock fall could have been identified during routine Iarnród Éireann (IÉ) inspections. It is also unlikely that a member of IÉ staff would have been able to identify that the structure would fail, or in fact that there would have been any warning to the failure prior to the day of the incident (paragraph 116). Therefore no other immediate causes, contributory factors, *underlying causes* or *root causes* were identified as a result of this incident.

146 However, the RAIU made a number of additional observations as a result of the investigation, not directly associated with the incident, which warrant further discussion in the conclusions.

Inspection of the rock face

Inspections carried out on the rock face against CCE-STR-STD-2100

147 The last GEI, required through CCE-STR-STD-2100, was carried out on the rock face at Plunkett Station was on the 2nd March 2012, where no major defects with the structure were identified (paragraphs 118 and 118).

148 The Structures Inspectors allocated a Design Rating, Condition Rating and Deterioration Rating or 2, 3 and 3, respectively. This meant, as set out in CCE-STR-STD-2100, that the Structures Inspector considered the rock face to be in poor condition due to significant defects, with discernible deterioration, meaning that the rock face would have serious deficiencies in the next five years and that the controls of identified failure modes (presumably the rock netting) had minor weaknesses (paragraphs 119 and 120).

149 In terms of the Condition Rating (which is important in terms of planned maintenance) there is some doubt as to the efficacy of the scoring, given that the Condition Ratings of 3 and 4 differ so greatly in terms of inspection frequency (five years versus annually). This is further compounded by the Technical Manager CCE stating that thousands of assets have the same Condition Rating due to the age and legacy of the IÉ infrastructure. In addition, the condition of the rating is also

affected by the design and deterioration ratings, risk ratings and results from other inspections. Therefore there is some question of the Condition Rating system, particularly in terms of planning maintenance given that this Condition Rating (of 3) appears to be awarded to the majority of aged structures (paragraph 121).

150 The RAIU finding is similar to an RSC finding, identified during an audit on 'IÉ's management of cuttings & embankments' published in March 2011. The RSC recommended that the condition rating scoring system be reviewed (paragraph 123). This has not occurred to date.

151 In terms of the Inspection Card for the GEI, the Structures Inspector and STSE failed to meet all of the requirements set out in CCE-STR-STD-2100 for GEIs in their entirely, in that the approved template was altered, the incorrect terms were used throughout and it was not approved, as required (paragraph 124). The same faults were also noted on further samples provided to the RAIU (paragraph 125). In addition, the RAIU found that specialists engaged to carry out an inspection after a landslide in 2013 also incorrectly filled out the form and it remained unsigned by the STSE; and an internal investigation by IÉ into the landslide in December 2013 noted that the Inspection Card had been labelled incorrectly (paragraph 125).

152 This informal approach to the completion of the Inspection Cards was also identified by the RAIU during the Malahide Viaduct Collapse investigation; and was even found to have been one of the underlying factors/causes associated with the cause of the collapse of the viaduct (paragraph 127).

153 This incorrect approach to the Inspections Cards was also found more recently (April 2014), by the RSC, who recommended that the Technical Manager CCE should consider reviewing the format of the Inspection Card (paragraph 128).

Inspections carried out on the rock face against CCE-TMS-360 and CCE-TMS-361

154 The mandatory requirements set out in CCE-TMS-361 were undertaken in full, in terms of the track being patrolled three times a week and the twice-yearly visual inspections of the asset were undertaken. These inspections did not identify any major concerns with the rockface (paragraph 129).

155 In addition the vicinity of the rockface was subject to further inspections on the 28th December (three days before the incident) due to the adverse weather conditions. No issues were found in the vicinity, however, it is unclear how much of an inspection the rock face received, if any, due to the fact that there was no documented evidence as to the inspections (paragraph 130).

Inspections carried out on the rock face against CCE-STR-GDN-2802

156 Requirements in relation to inspections, as set out in CCE-STR-GDN-2802 are for guidance only. However, there are a number of irregularities with the CCE-STR-GDN-2802 when compared to the mandatory standard CCE-STR-STD-2100, which are as follows. CCE-STR-GDN-2802 states that, a Condition Rating of 3 requires an "Increase in maintenance to correct defects", however, the Technical Manager CCE stated that this is impractical and highly unrealistic (paragraph 132).

157 In addition, it states that the Structures Inspector "immediately inform the STSE and the Infrastructure Manager if immediate intervention is required", the Technical Manager CCE confirmed this requirement; however, given this is guidance only and not included in CCE-STR-STD-2100 this causes confusion (paragraph 133). In the case of the incident, the Structures Inspector did not report this to the STSE or the Infrastructure Manager; and there is some question as to whether the STSE was aware of the current condition of the asset, given that the Inspection Card was not approved by the STSE (paragraph 134).

158 In conclusion, the mandatory requirements of CCE-STR-STD-2100 and the guidance set out in CCE-STR-GDN-2802 are inconsistent with each other, this may lead to confusion given that they are both related to inspections of assets.

Compliance Verification

159 The compliance verification process (which is used to ensure that all the tasks required from staff are being completed in a manner that is technically correct, at the correct frequency, with the correct care and in accordance with the CCE technical documentation) was not effective at identifying the fact that the Structures Inspectors were not completing the Inspection Cards to the requirements of CCE-STR-STD-2100 (paragraph 135) and there is some doubt that the compliance verification form would have identified any issues with the quality of the documentation, given that is appears to only review frequency of inspections and work orders generated form inspections (paragraph 137).

160 The Technical Manager CCE indicated to the RAIU that the compliance verification process had been adopted, as a manual paper based process due to IT issues (paragraph 136).

161 In addition, the requirements set out in CCE-TMS-420 related to use of the compliance verification process and review for the specific annual review of Structures Inspectors inspection work had not been under taken (paragraph 138).

162 In September 2013, during an RSC audit, 'IÉ's management of vegetation', the RSC also found that the compliance verification process was not fully or consistently implemented, mainly due to resourcing issues (paragraph 140), resulting in a minor non-compliance (paragraph 139), and recommending the "Director of IM should review CCE Departmental resource requirements to ensure that required level of divisional resources is available to comply with the IM SMS" (paragraph 140).

Competence of Structures Inspector

163 The Structures Inspector who carried out the latest GEI on the rock face was competent to carry out inspections on behalf of the STSE, and met all the requirements set out in CCE-STR-STD-2100, apart from one requirement related to the refresher training for structural inspection. However, this was not thought to be contributory to the incident (paragraph 141).

164 The specific annual review carried out by the STSE of Structures Inspectors' inspection work, as set out in CCE-TMS-420, in relation continued competency management had not been undertaken by the STSE, in relation to the Structures Inspector who carried out the last GEI inspection (paragraph 142). In its place an informal review of Inspection Cards had been undertaken. However, given that the Inspection Cards were continuously incorrectly completed, this system was ineffective at managing the Structures Inspector's inspection work.

Maintenance of the rock face

165 Previous to the incident, in sections further along the rock face, rock netting had been placed on the rock face, between 1993 and 1995, in areas susceptible to minor ravelling of rock; which had been found as an "effective action" for this area of the rockface (paragraph 143).There is no other recorded maintenance at the rockface; apart from vegetation removal (paragraph 143).

Immediate cause, contributory factors and underlying factors

166 The immediate cause of the rock fall at Plunkett Station was likely due to the toppling of the upper part of the rock mass to the north of the structure, followed by rotation of the toppled rock mass, resulting in rock fall debris flowing onto the ground. Possible contributory factors include the actual formation of the rock (steeply inclined structure with pervasive joints and faults). The final trigger was likely due to the intense rainfall of the preceding weeks.

167 The RAIU investigation, and the Consultant's Report, determined that it is unlikely that the potential for rock fall could have been identified during routine IÉ inspections. It is also unlikely that a member of IÉ staff would have been able to identify that the structure would fail, or in fact that there would have been any warning to the failure prior to the day of the incident. Therefore no other immediate causes, contributory factors, *underlying causes* or *root causes* were identified as a result of this incident. However, the RAIU made a number of additional observations during the investigation, which include:

- AO-01 – The Condition Rating scoring tool, set out in CCE-STR-STD-2100 and CCE-STR-GDN-2802, does not appear to be an effective system for Structures Inspectors in illustrating the condition of the asset or applying inspection frequencies;
- AO-02 – Inspection Cards appear to be consistently failing to meet the requirements of CCE-STR-STD-2100, in that Structures Inspectors are editing the approved template, using incorrect terms and incorrectly labelling the Inspection Cards; and the STSE is not approving the documents;
- AO-03 – CCE-STR-GDN-2802 includes guidance on maintenance requirements which are not mandatory and therefore not applied;
- AO-04 – The compliance verification process, as set out in CCE-SMS-001 and CCE-SMS-008 was ineffective at identifying the long-standing issues associated with the correct use of the Inspection Card;
- AO-05 – The Structures Inspectors competence did not meet the requirements set out in CCE-STR-STD-2100 as he had not completed the required refresher training within the required timescales;
- AO-06 – The STSE did not meet the requirements set out in CCE-TMS-420 in relation to the continued competence of the Structures Inspector, in that he did not undertake a documented annual review of the Structures Inspector's inspection work.

Relevant actions taken or in progress

Actions taken by IÉ

168 IÉ have undertaken works at the rock face to reduce the instability due to the steeply inclined overhanging rock, these include initial protection works to the rockface in the short term to ensure the integrity of the asset. Furthermore, detailed geological surveys have been carried out and longer term options for the protection of the rockface into the future have been developed.

169 At the time of publication of this report, IÉ CCE state that they have:

- Undertaken a detailed review of their structural inspection standard; the previous standard (CCE-STR-STD-2100) has been superseded;
- Developed and fully adopted a comprehensive compliance verification process. The process encompasses all aspects associated with the compliance and is made up of reviews of asset characteristics, documentation and data as well as on-site reviews of the asset condition and an assessment of the asset relative to governing technical standards. The compliance verification system has been developed and integrated into the overall asset management system;
- Changed the inspection frequencies associated with the condition ratings, resulting in a greater inspection frequency for a number of assets;
- Redeveloped the format for the Cuttings, Embankments and Coastal/River Defences Inspection Card.

170 At the time of publication of this report, IÉ CCE state that they are in the process of:

- Addressing non-compliances and recommendations resulting from RSC audits. This is an on-going body of work that is being carried out in conjunction with the RSC;
- Developing a ‘Cuttings & Embankments Risk Model’, a tool to assist in the identification and management of risks associated with cuttings and embankments. This project encompasses the development and introduction of a specific decision support tool for the risk management of these assets. The project is due to be completed at the end of 2015.

Safety recommendations

General description

171 In accordance with the Railway Safety Act 2005 (Government of Ireland, 2005a) and the European Railway Safety Directive (European Union, 2004), recommendations are addressed to the national safety authority, the RSC. The recommendation is directed to the party identified in each recommendation.

172 Although, the RAIU noted no causes or factors directly resulting in the incident, the RAIU made a number of additional observations in relation to the inspection standards and compliance verification process which warrant five new safety recommendations.

New safety recommendations related to additional observations

173 In terms of the requirements set out in CCE-STR-STD-2100 related to the efficacy of the Condition Rating scoring tool in illustrating the true condition of the asset (AO-01), and the large difference in inspection frequencies associated with the condition ratings, the RAIU make the following safety recommendation:

IÉ IM CCE should complete a thorough review of CCE-STR-STD-2100 in relation to the application of condition ratings on assets to ensure that condition ratings are a true reflection of the condition of the asset; and that the appropriate inspection frequency is applied.

174 In terms of the issues associated with the completion and approval of the Cuttings, Embankments and Coastal/River Defences Inspection Card (AO-02), the RAIU make the following safety recommendation:

IÉ IM CCE should complete a thorough review of the Cuttings, Embankments and Coastal/River Defences Inspection Card set out in CCE-STR-STD-2100 to ensure that Structures Inspectors have the correct means to complete the card without the requirement for alterations to templates or defined terms. The process of approval of these Inspection Cards should also be reviewed to ensure that they are reviewed and approved by the STSE.

175 There is inconsistency between the mandatory standard (CCE-STR-STD-2100) and the non-mandatory guidance document (CCE-STR-GDN-2802) in terms of requirements for maintenance e.g. CCE-STR-GDN-2802 states that there should be an "Increase in maintenance to correct defects" for a Condition Rating 3 asset, whereas CCE-STR-STD-2100 has no such requirements in terms of maintenance. As a result the RAIU make the following safety recommendation:

IÉ IM CCE should complete thorough reviews of CCE-STR-STD-2100 and CCE-STR-GDN-2802 in terms of maintenance requirements to ensure consistency throughout both documents.

176 In relation to the compliance verification process, the process has not been fully adopted and appears to be ineffective at identifying the long-standing issues associated with the incorrect completion of Inspection Cards (AO-04), the RAIU make the following safety recommendation:

IÉ IM CCE should fully adopt the compliance verification process and ensure the process includes an effective means of reviewing the quality of documents completed by staff.

177 The Structures Inspectors competence did not meet the requirements set out in CCE-STR-STD-2100, in full, in that the required refresher training was not completed within the required timescales (AO-05). In addition, the STSE did not meet the requirements set out in CCE-TMS-420 in relation to a documented annual review of the Structures Inspectors inspection work to ensure continued competency (AO-06) therefore the RAIU make the following safety recommendation:

IÉ IM CCE should review its Competence Management System in terms of both: its identification and tracking of mandated refresher training for Structures Inspectors competence; and its annual review of Structures Inspectors inspection work.

Additional information

List of abbreviations

°C	Degrees Celsius
AO	Additional Observation
CCE	Chief Civil Engineer/ Chief Civil Engineer's Department
CF	Contributory factor
GEI	General Engineering Inspection
hrs	Hours
IM	Infrastructure Manager
km	kilometres
km/h	Kilometres per hour
IT	Information Technology
M	Metre
MP	Milepost
PII	Post Incident Inspection
PWI	Permanent Way Inspector
RAIU	Railway Accident Investigation Unit
RC	Root cause
RSC	Railway Safety Commission
RU	Railway Undertaking
SI Units	International System of Units
SMS	Safety Management System
STSE	Senior Track & Structures Engineer
UC	Underlying cause

Glossary of terms

Accident	An unwanted or unintended sudden event or a specific chain of such events which have harmful consequences including collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Andesitic volcanic	Dark coloured volcanic rock.
Bedding	Consists of layering which owes it origin to the original deposition of layers of sediment on a horizontal or sloping surface.
Bedrock	The hard area of rock in the ground that holds up the loose soil above.
CCE Location	IÉ defines this as a grouping of activities or workplaces, typically organised either geographically or organisationally, that are considered as a single area of

	accountability within the CCE Department.
Colour light signals	Signals that convey movement authority to train drivers by means of coloured lights.
Compliance verification	A process of Safety verification checks whereby the Senior Track & Structures Engineer identifies Track and/or Structures Hazards in order to reduce the Track Safety Risk and Structures Safety Risk on the railway.
Continuous welded rail	Sections of rail that are welded together.
Contributory factor	Factors relating to actions taken by persons involved or the condition of rolling stock or technical installations.
Signalman	Competent person designated to control a specific section of track.
Division	IÉ term for departments made up of a number of regions and several CCE Locations. There are three Divisions on the IÉ Network – Dublin, Athlone and Limerick Junction.
Extensive damage	Damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Fault	A planar fracture in rock in which the rock on one side of the fracture has moved with respect to the rock on the other side.
Fault zone	Zone of complex deformation associated with faults.
Fracture	Any separation in a geologic formation, such as a joint or a fault that divides the rock into two or more pieces.
Incident	Any occurrence, other than an accident or serious accident, associated with the operation of trains and affecting the safety of operation.
Infrastructure Manager	Organisation that is responsible for the establishment and maintenance of railway infrastructure, including the management of infrastructure control and safety systems.
Joints	Generally, planar fractures across areas with no visible displacement and are often closely spaced (two or three sets). Joints can develop due to regional tensional forces and shear forces, which pull the rock apart or slide one rock mass past an adjacent rock mass, respectively.
Mechanical signal control	Signal control by mechanical means through the movement of levers to pull wires and change a signal aspect.
Minor non-compliance	The RSC define a minor non-compliance as an area of non-compliance with an IÉ internal standard, an applicable external standard, or legislation that is evidence of a sporadic lapse in implementation of a system or deviation from a system.
Mudstone	A fine grained sedimentary rock whose original constituents were clays or muds.
National safety	The national body entrusted with the tasks regarding railway safety in

authority	accordance with European directive 2004/49/EC.
Overbridge	A bridge over a railway line.
Possession	A period of time during which one or more tracks are blocked to trains to permit work to be safely carried out one or near the line.
Railway Undertaking	Organisation that operates trains.
Rockface	An exposure of rock in a steep slope or cliff.
Rolling stock	Railway vehicles.
Root cause	Causes related to framework conditions and application of the SMS.
Safety authorisation	Authorisation granted by the RSC confirming acceptance of the IM's SMS; and provisions adopted by the IM for IM assets and the safe running of trains; as set out in Irish and European legislation.
Safety certificate	Certification granted by the RSC confirming acceptance of the RU's SMS; and provisions adopted by the RU for the safe running of trains; as set out in Irish and European legislation.
Sandstone	A sedimentary rock composed mainly of sand-sized minerals or rock grains.
Serious accident	Any train collision or derailment of trains, resulting in the death of at least one person or serious injuries to 5 or more persons or extensive damage to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety, where extensive damage means damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Serious injury	Any injury requiring hospitalisation for over 24 hours.
Siltstone	A sedimentary rock which has a grain size in the silt range, finer than sandstone and coarser than claystones.
Tectonic movement	Mechanical movement of the earth's crust caused by forces that act in the crust and, primarily, mantle which result in the deformation of the rocks making up the crust.
Track circuit block	A signalling system that uses track circuits to confirm the absence of trains in order to control the movement of trains.
Underlying cause	Causes related to skills, procedures and maintenance.
Up Main Line	The line on which trains normally travel in a direction towards Dublin.

References

European Union (2004), Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure

capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive), 2004/49/EC, 29th April 2004.

IÉ (2010), Guidance Notes for the Inspection of Earthworks and Coastal River Defences (CCE-STR-GDN-2802), Version 1.0.

IÉ (2011), CCE Safety Management System (CCE-SMS-001), Version 2.0

IÉ (2011), Management of Structural Inspection Competence (CCE-TMS-420), Version 1.0

IÉ (2011), Safety Tours and Compliance Verification (CCE-SMS-008), Version 2.0

IÉ (2011), Technical Standard for Structural Inspections (CCE-STR-STD-2100), Version 1.2

IÉ (2011), Technical Standard for Track Patrolling (CCE-TMS-361), Version 1.1

IÉ (2012) Track and Structures Inspection Requirements (CCE-TMS-360), Version 2.0

RAIU (2010), Derailment of empty train due to collision with landslip debris outside Wicklow Station, 16th of November 2009

RAIU (2010), Malahide Viaduct Collapse on the Dublin to Belfast Line on the 21st August 2009

RSC (2014) Collision of train with a landslip at the 38 ¼ milepost on the Kilkenny to Waterford line PII

RSC (2011), RSC Audit – IÉ's management of cuttings and embankments

RSC (2013) RSC Audit – IÉ's management of vegetation