RAIU

Railway Accident Investigation Unit

Investigation Report 2010-R006

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

Document History

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Function of the Railway Accident Investigation Unit

The Railway Accident Investigation Unit is an independent investigation unit within the Railway Safety Commission. The purpose of an investigation by the Railway Accident Investigation Unit is to improve railway safety by establishing, in so far as possible, the cause or causes of an accident or incident with a view to making recommendations for the avoidance of accidents in the future, or otherwise for the improvement of railway safety. It is not the purpose of an investigation to attribute blame or liability.

The Railway Accident Investigation Unit's investigations are carried out in accordance with the Railway Safety Act 2005 and European railway safety directive 2004/49/EC.

Any enquiries about this report should be sent to:

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Executive Summary

At approximately 06.20 hours, on Monday the 16th of November 2009, an empty train travelling from Connolly to Arklow, derailed when it collided with an obstruction caused by a landslip.

The immediate cause of this landslip was the result of soil deposition by a landowner, at the crest of the cutting. This was as a result of the following combination of factors:

- The blocking of the drainage ditch for the field which was adjacent to the field;
- The presence of sand lenses in the cutting which facilitated the flow of water through the cutting;
- The heavy rainfall for the month of November which resulted in the saturation of the field adjacent to the cutting.

The above factors were necessary for the accident to happen. Contributory to the accident happening were the following factors:

- The patrol ganger was unable to identify defects associated with the early signs of the landslip as the cutting was covered in dense vegetation, resulting in an unrealistic expectation that the patrol ganger could carry out these inspections effectively;
- The patrol ganger was unable to identify the water pouring down the pedestrian overbridge as an early defects associated with the failure of the cutting due to poor drainage as this was not identified as a condition to be looked for in the Track Patrolling Standard, I-PWY-1307, and not included in track patrolling training, again resulting in an unrealistic expectation that the patrol ganger could identify all signs of defects associated with cuttings;
- The only formal monitoring of cuttings during periods of heavy rainfall is through inspections carried out by the patrol ganger, through the Standard for Track Patrolling, I-PWY-1307. Given the fact that the track patroller has not received the appropriate training to identify all defects associated with the early signs of earthworks failure, there is some doubt that only carrying out these inspections is sufficient;
- The patrol ganger was not aware of the spreading of soil in the field adjacent to the cutting, which would be considered an “unusual events” being undertaken inside and outside the railway boundaries, as per the track patrolling standard, I-PWY-1307, as track patrols are carried out from track level, and therefore there was no way for the patrol ganger to be aware of the works being carried out in the adjacent field, which is approximately three metres above track level;
- A programme of Structural Inspections for the cutting was not adopted as required by Structural Inspections Standard, I-STR-6510, as the cutting was not identified as a structure under the Assistant Divisional Engineer’s structures list, which resulted in no structural inspection being carried out on the cutting;

- The landowner did not believe that the works he was carrying out on the adjacent field would affect Iarnród Éireann's cutting;
- The landowner was also unaware of the requirement to contact Iarnród Éireann to inform them of any work, undertaken by him, which may affect the railway, as he had not been issued, nor was he aware of Iarnród Éireann's Guidance on Third Party Works, I-DEP-0120. He was also unaware of the Railway Safety Commission's guidance document, RSC-G-011-A, Third Party Guidance on Railway Risk Volume 2 Neighbours, which again would have required him to contact the Division Engineer.

Underlying to the accident occurring were the following factors:

- Iarnród Éireann's Structural Inspection Standard, I-STR-6510, only requires for visual inspections to be carried out on cuttings greater than 3m, with no requirement for any geotechnical assessment to be carried out. As a result the sand lenses present in the cutting, which was identified as a contributory factor to the accident occurring, were not identified. Therefore, there is some doubt as to the efficacy of only having visual inspections, when a more intrusive inspection would identify the geotechnical properties of the cutting, allowing Iarnród Éireann to identify structures that may be vulnerable to failure;
- There is some doubt that all private landowners, adjacent to the railway, are aware of the requirement to consult with Iarnród Éireann in relation to any works that may affect Iarnród Éireann assets as set out in IÉ's Guidance on Third Party Works, I-DEP-0120 and the Railway Safety Commision's guidance document, RSC-G-011-A, Third Party Guidance on Railway Risk Volume 2 Neighbours. Considering there has been no advertising to make third parties aware of this guidance document there is an unrealistic requirement on a landowner to be familiar with these documents.

From this investigation, the Railway Accident Investigation Unit have made six recommendations:

- Iarnród Éireann 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;
- Iarnród Éireann should review the effectiveness of their standards in relation to conducting earthworks inspections during periods of heavy rainfall, ensuring that earthworks vulnerable to failure are inspected during these periods by appropriately trained patrol gangers or inspectors;
- Iarnród Éireann should review their Standard for Track Patrolling, I-PWY-1307, for its effectiveness in identifying any third party activities that occur inside and outside the railway boundaries that could affect safety and where any deficiencies are found, Iarnród Éireann should develop an alternative process for the identification of these third party activities.

- Iarnród Éireann should review their structures list and ensure that all earthworks are identified and included on this list. Upon updating this list, a programme for the inspection of earthworks is to be developed and adopted at the frequency requirements set out by the Structural Inspections Standard, I-STR-6510;
- Iarnród Éireann and the Railway Safety Commission should review their process for the issuing of guidance documents, to ensure that the third parties affected by these guidance documents are made aware of their existence.
- Iarnród Éireann should review the effectiveness of their Structural Inspections Standard, I-STR-6510, with consideration for the possibility of more thorough inspections being carried out on cuttings to establish the topography and geotechnical properties of cuttings; and from this information identify any cuttings that are vulnerable to failure.

1 Factual information

1.1 Parties involved

1.1.1 Iarnród Éireann

Iarnród Éireann[1] (IÉ)[2], is the owner and operator of the national mainline rail service in Ireland. IÉ is responsible for managing the design, installation, testing, inspection, maintenance and renewal of its physical assets.

The Chief Civil Engineer (CCE) Department of IÉ carries out the inspections and maintenance of track and structures and is divided into three different geographical areas, known as Divisions, with offices based at Dublin, Athlone and Limerick Junction. The location of the failed cutting falls within the Dublin Division.

The Divisional Engineer (DE) is the Person Responsible for the inspections and maintenance of all fixed infrastructure such as bridges, including the failed cutting. The DE may nominate an Assistant Divisional Engineers (ADE) to be the Person Responsible for certain tasks.

The ADEs are responsible for the track and structures and the conduct of structural inspections for the fixed infrastructure in designated areas and report to their respective DEs.

Inspectors, who are generally qualified Engineers, carry out the inspections on the instruction of the ADE.

Patrol Gangers carry out continuous systematic examination of the track to locate conditions that are unsafe. The Patrol Ganger reports any faults to the Permanent Way Inspector (PWI) who is responsible for the day to day track inspection and maintenance activities for both track and structures. The PWI also ensures that the patrol gangers undertake their inspections to the required frequency and submit defect reports. PWIs then report any defect reports to the Chief PWI, who in turn, reports these defect reports directly to the ADE.

[1] Terms which appear in italics, the first time they appear in the report, are explained in the 'Glossary of Terms' section of this report.

[2] Abbreviations are defined in the 'List of Abbreviations' section of this report.

1.1.2 Railway Safety Commission

The Railway Safety Commission (RSC) was established under the Railway Safety Act 2005 and has responsibility for matters of railway and cableway safety on passenger carrying systems and freight carrying systems where they interface with public roads.

The RSC has three main functions set out in Section 10 of the Railway Safety Act 2005. These main functions are to:

- Foster and encourage railway safety;
- Enforce the Railway Safety Act 2005 and other legislation relation to railway safety;
- Investigation and report on railway incidents.

1.1.3 Private landowner

A private landowner owns the field adjacent to the failed cutting.

1.2 The accident

On Monday the 16th of November 2009, an empty *Diesel Multiple Unit* (DMU), train identification number J608, was travelling from Connolly Station to Arklow Station. At approximately 06.20 hours (hrs) the train passed through Wicklow Station and was travelling along a curve when the train driver noticed branches on the line and applied the emergency brake, the location is indicated in Figure 1.

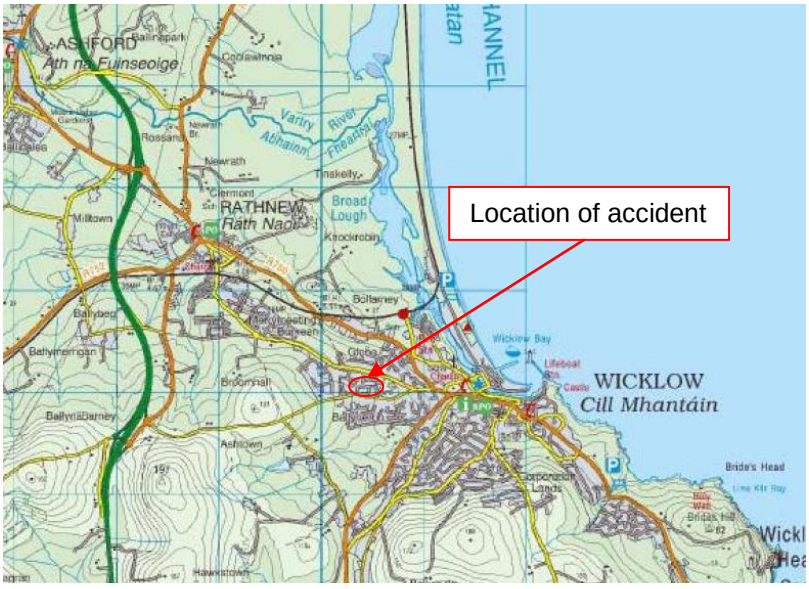


Figure 1 – Location map

The train came to a stop approximately 300 metres (m) beyond the station with the *leading carriage* derailed and coming to a stop on top of the debris from a landslip, see Photograph 1.

Photograph 1 – Derailed train on landslip debris

1.3 General description of infrastructure

The line at the site of the accident is a *single track* route from Bray to Rosslare. The failed *cutting* was located on the *down* side of the track, approximately 300m from Wicklow Station which is located between the 28 ¼ and 28 ½ *Mileposts* (MP) on the Dublin to Rosslare Europort Line, within the Wicklow and Rathdrum Section.

The track is plain line with *flat bottom continuously welded rail* (CWR) mounted on concrete sleepers in ballast. No factors in relation to the condition of the track were found to have contributed to the accident.

There is a disused pedestrian *overbridge* which travels over the railway line near the accident location.

1.4 The cutting

1.4.1 Cutting topography and drainage

The cutting varies in height between 10 – 13m. The lower 7 – 8m of the cutting is at an angle of between 50 – 55˚ (degrees). The cutting then becomes flatter in the top 3 – 4m.

The cutting has existed since 1861, with no record to indicate that the cutting has been altered in recent years.

The cutting is drained through an IÉ drain at its base. An inspection of this piped drain, after the accident, confirmed it was in working order with water observed to be flowing through it. On subsequent inspections, this piped drain remained in working order and therefore is not considered to have contributed to the accident.

1.4.2 Cutting geotechnical properties

Boreholes taken from the top of the slope, after the accident, indicate that the top 4 – 5m of soil is an orange brown sandy *clay* with *sand lenses* which was soft to firm in texture. Below this, the soil consisted of clay that was medium to soft in texture, see Photograph 2.

The photograph also indicates the new soil spread material which is approximately 1m in height, this is discussed further in Section 1.5.4.

Photograph 2 – Cutting geotechnical properties

1.4.3 Cutting condition on the day of the accident

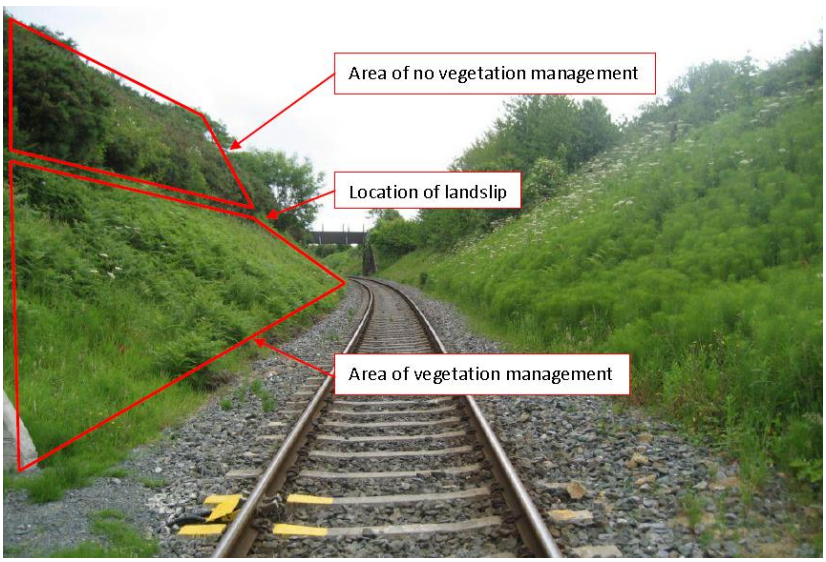
On the day of the accident, there was water pouring down the landslip scar, see Photograph 2. It was noted that the soil in the adjacent field was *saturated*, see Photograph 3. There was also water pouring down the parapet of the footbridge located in the vicinity of the land slip, see Photograph 4.

Photograph 3 – Saturated soil with standing water

Photograph 4 – Water pouring down the parapet of the footbridge

1.4.4 Cutting vegetation

The cutting slope is covered with dense vegetation, mainly gorse bushes, with larger vegetation and small trees towards the top of the cutting slope. Vegetation management is carried out by the Permanent Way staff (patrol ganger and PWI). IÉ have confirmed that some vegetation management had occurred in the location of the cutting slope during March 2008, where a flail mower was used to reduce the vegetation at the lower section of the cutting slope. No flailing had occurred in the upper section of the cutting slope. This is clearly illustrated in Photograph 5, which was taken on the 12th of August, prior to the cutting failing.



Photograph 5 – Areas of vegetation management

1.5 Third party activity

1.5.1 Railway Safety Act 2005

Section 37, General Duties of Railway Undertakings, Persons Working on Railways and Other Persons, of the Railway Safety Act, 2005, states:

> "It shall be the general duty of every person, in carrying out any activity on or near a railway or railway premises or railway land, to ensure in so far as is reasonably practicable that no person who is involved in the operation of a railway or who is being carried on a railway is exposed to danger as a consequence of any act or omission on the part of such person."
> - *page (p) 27, Section 37(3), Railway Safety Act, 2005*

1.5.2 Guidance on Third Party Works from IÉ

In relation to Section 37(3) of the Railway Safety Act, IÉ have developed a guidance document, available through their website, titled Guidance on Third Party Works, I-DEP-0120, which provides information and guidance for third parties intending to carry out works over, under, adjacent to, or otherwise affecting the railway. Section 4.1.3 of this document specifies:

> "Third parties who intend to carry out work on adjacent (non-railway) property are requested to contact the relevant Divisional Engineer's (DE's) office well in advance if the work has the potential to impact the railway. They will be advised by DE staff of the specific process to be followed."
> - *p7, Section 4.1.3, Guidance on Third Party Works*

I-DEP-0120 provides categorises the third party works into minor and major impact projects. In relation to minor impact projects, I-DEP-0210 states:

"A minor impact project is one that affects few IÉ stakeholders and has little impact on the railway. Examples include:

- A small diameter pipe inserted under the railway;
- A cable erected over the railway;
- New boundary fencing or wall to be constructed."

In relation to major impact projects, I-DEP-0210 further states:

"A major impact project may affect several IÉ stakeholders, and could have significant consequences for the railway. It may involve alterations to signalling or Overhead Line Equipment (OHLE) etc. The safety implications of these projects require thorough assessment. Examples of a major impact project include:

- Construction of a new overbridge or *underbridge*;
- Construction of a new structure, adjacent to the track, with foundations that could impact the stability of the railway track;
- Construction of a new station that requires alteration to the OHLE and/or new signalling."

I-DEP-0120 goes provides further information on the following who to contact in IÉ, pre-project planning; safety management, maintenance, insurance, cost and timescales. In addition, an overview of process for major impact projects is provided.

IÉ have confirmed to the Railway Accident Investigation Unit (RAIU) that I-DEP-0210 has been issued to the local planning authorities, however, the guidance document has not been issued to any individual members of the public.

1.5.3 Third party Guidance from the RSC

In relation to Section 37(3) of the Railway Safety Act, 2005, the RSC has also prepared guidance for parties external to the railway on how their activities might impact on railway safety. The guidance document, of particular relevance to this accident, is document RSC's Third Party Guidance on Railway Risk Volume 2 Neighbours, RSC-G-011-A, which is freely available through the RSC's website.

The RCS recommend that this document should be read by anyone who owns, rents, uses or has responsibilities for the land next to the railway. The guidance document identifies the hazard of "cutting/embankment instability if ground waterlogged" for the "changing the field drainage arrangements" activity, which the RSC assigns this the highest risk rating, and states:

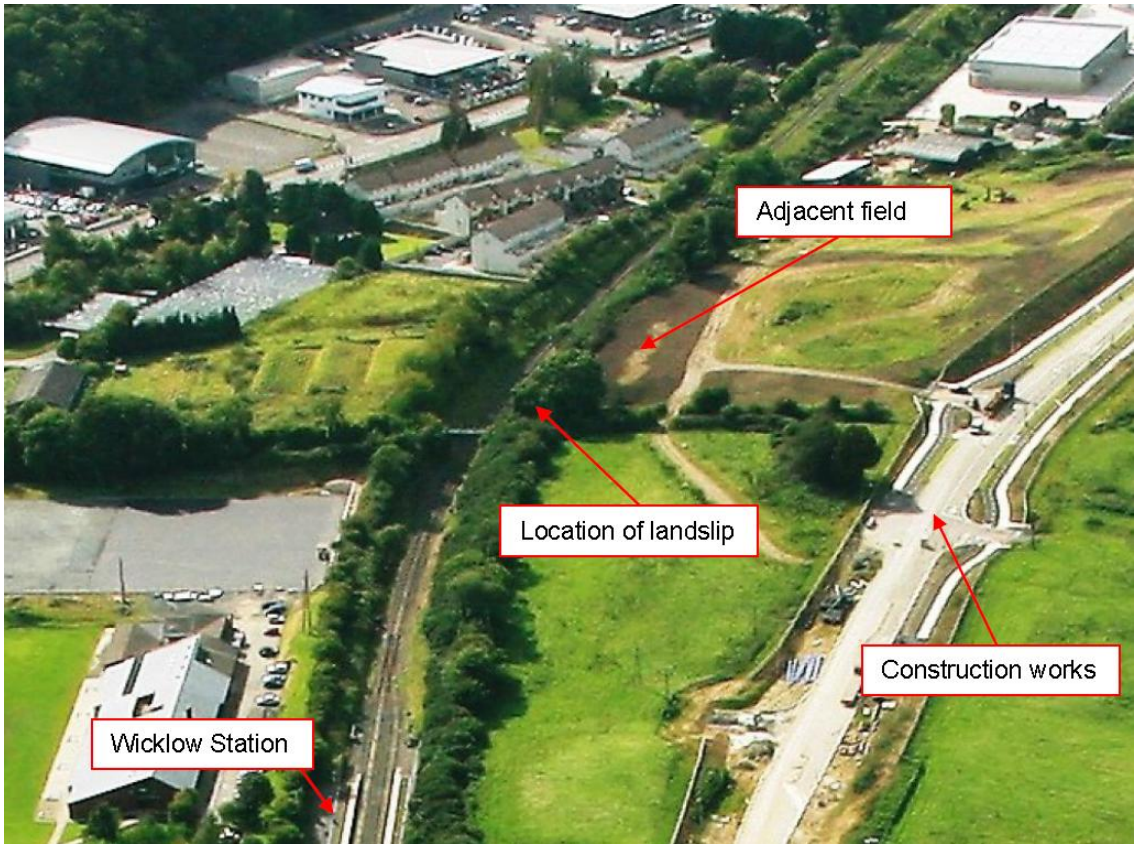
> "Sloped ground next to the railway is vulnerable to changes in water drainage, flooding or digging/excavation. If the ground begins to slip, the track may be undermined or material might fall onto the running line. The stability of the track is also dependent on the adequacy of the drainage from the railway.
>
> Drains sited near the railway should not be altered and railway drainage facilities should not be used without the permission of the railway company. If you are considering altering

drainage arrangements in any way, you should get permission from the local Divisional Engineer (Iarnród Éireann)."

RSC-G-011-A includes the contact numbers for the local DEs. As mentioned previously, RSC-G-011-A is freely available to the public through the RSC's website. The RSC have confirmed to the RAIU that RSC-G-011-A has been issued to the local planning authorities, however, the guidance document has not been issued to any individual members of the public.

1.5.4 Third party activity in field adjacent to failed cutting

There is a privately owned field north of the cutting, see Photograph 6. Prior to the accident, a hedge marked the boundary between the IÉ and private property and a drainage *ditch* existed at the top of the cutting, which ran parallel to the railway.



Photograph 6 – Location of landslip and adjacent field

A contractor was carrying out major road construction works in the vicinity of the adjacent field. The contractor had consulted with IÉ in the planning permission stage for the construction of the road as there were two overbridges to be constructed over the IÉ railway infrastructure as part of the major road works. No other works carried out by the contractor were considered to affect IÉ.

The road construction works included for soil to be excavated to facilitate the construction of the road. The contractor agreed the provision of part of this soil to the private landowner of the field adjacent to the field and since January 2008, the excavated soil was spread in this adjacent field by the private landowner. The soil was spread across the field (up to a height of 1m), along the crest of the cutting and across the boundary and into IÉ property, see Photograph 2 (soil identifiable by brown colour). This deposition of soil had, at least partially, filled the existing drainage ditch.

The landowner confirmed to the RAIU that he was not aware of the requirement to inform IÉ of any work, undertaken by him, which may affect the railway. The landowner also confirmed that he was not aware of either IÉ's Guidance on Third Party Works, I-DEP-0120, or the RSC's Third Party Guidance on Railway Risk Volume 2 Neighbours, RSC-G-011-A.

1.6 Cutting inspections

1.6.1 Track Patrolling Inspections

The cutting is inspected as part of the track patrols, carried out by a designated Patrol Ganger three times a week. IÉ's standard for track patrolling, Standard for Track Patrolling, I-PWY-1307, states that the "patrol gangers must carry out continuous systematic examination of the track to locate conditions that are unsafe, potentially unsafe or likely to cause delay to trains"; and that the "patrol ganger must be alert for any signs of unsafe conditions developing in adjacent assets which can be observed from the track, as well as for any unusual events inside or outside the railway boundaries that could affect safety".

In relation to all cuttings, the same standard states that the patrol gangers must carry out an inspection on a cutting on each patrol "during heavy rain or prolonged dry spells", thereafter inspections are to be carried out once a month. I-PWY-1307 provides information on the conditions to be looked for by the patrol ganger in relation to cuttings, these are as follows:

- "Slipped material from cuttings or embankments, especially after flooding or heavy rainfall";
- "Excavations or undermining of earthworks in the vicinity of the track or adjoining assets";
- "Signs of movement or instability, especially after flooding or heavy rainfall" including leaning fence posts, OHLE masts, signal posts, telegraph poles".

I-PWY-1307, Appendix C, illustrates the format of the Patrol Ganger's Report Form. The Patrol Ganger's Form has three different sections to be completed by the patrol ganger during a routine patrol, which are as follows:

- Section 1 – Patrol details;
- Section 2 – Faults cleared by ganger during patrol;
- Section 3 – Faults for the attention of PWI (items still requiring attention).

From the Patrol Ganger's Report Forms provided by IÉ to the RAIU, the track patrols for this area were carried out at the required frequency and there were no "Faults cleared by ganger during patrol" or "Faults for the attention of PWI (items still requiring attention)" recorded by the patrolling ganger in the three months prior to the failed cutting.

1.6.2 Track and Structures Inspections

The Requirements for Inspection of Track and Structures by Engineers and Supervisors, of IÉ's Track and Structures Inspection Requirements Standard, I-PWY-1107, sets out the frequency of inspections to be carried out by the DEs, ADEs, the Chief Inspector, PWIs, Engineers/ Technical Supervisors for cuttings.

The table below, taken from the standard, illustrates the frequency of inspections required is illustrated below, see Table 1.

By Whom	**Inspection type**	**Frequency**
DE	Inspection Car	Six months
ADE	Inspection Car	Two months
Chief Inspector (Chief PWI)	Walk	As directed
	Inspection Car	Two months
PWI	Inspection Car	Two months
PWI with Patrol Ganger	Walk	Four months
Engineers/ Technical Supervisors	Inspection	Two yearly

Table 1 – Type and frequency of inspections by IÉ staff

IÉ have confirmed to the RAIU that these inspections were carried out at the required frequency by specified personnel. As in the case of the patrol gangers, only defects are required to be identified. However, unlike the patrol ganger inspections, there is no formal mechanism to record these inspections, therefore there is no documentation available from these inspections to determine whether any faults were recorded during these inspections.

1.6.3 Structural Inspections

Inspections of cuttings greater than 3m in height should be carried out under the requirements of IÉ's Structural Inspection Standard, I-STR-6510. These cuttings should be included on the ADEs list of structures to be inspected, along with all other structures identified in I-STR-6510.

I-STR-6510 states that General Engineering Inspections (GEI) should be carried out on cuttings. 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". The frequency of these inspections is dependent on the *condition rating* recorded for the cutting.

The inspection frequency as set out in the Structural Inspections Standard, I-STR-6510, Issue 3, is summarised in Table 2, below:

Condition Rating	**Cutting Condition Description**	**Maximum Interval between inspections**
1–2.5	Fair – good	10 years
3–3.5	Poor	5 years
4	Very poor	1 year

Table 2 – Inspection frequency of I-STR-6510, Issue 3.

It should be noted, that I-STR-6510, Issue 3, was only adopted on the 01/10/2009, six weeks prior to the accident (16/10/2009). I-STR-6510, Issue 2, was introduced on the 23/10/2008, which required the same frequency of inspections as I-STR-6510, Issue 3, but in this case the inspections were referred to as Ground Level Inspections. A Ground Level Inspection is "an inspection of all visible elements of a structure undertaken from ground or water level, with the assistance of binoculars where necessary. If significant elements of the structure are not visible, the relevant inspector must make arrangements for access. This level of inspection is intended to monitor the general condition of the structure on a regular basis without the need for special access". I-STR-6510, Issue 1, was introduced on the 05/07/2005 which required Ground Level Inspections to be carried out at a maximum interval of five years for all cuttings, irrespective of the condition rating. This inspection information, in relation to the Structural Inspection Standard issues, is summarised in Table 3, below:

Structural Inspections Standard, I-STR-6510, Requirements			
Issue	**Issue 3**	**Issue 2**	**Issue 1**
Date of issue	01/10/2009	23/10/2008	05/07/2005
Inspection type	GEI	Ground Level Inspection	Ground Level Inspection
Frequency requirement	As set out in Table 2 of this report	As set out in Table 2 of this report	Maximum 5 year interval

Table 3 – Summary of inspection requirements of all three issues of the Structural Inspections Standard, I-STR-6510

I-STR-6510 provides a template of a "Cuttings, Embankments, Coastal/River Defences Inspection Card" (Cuttings Inspection Card) which should be used for reporting on the GEIs[3]. I-STR-6510 states that the Cuttings Inspection Card for GEIs must include the information on the following:

- Presence and type of vegetation (e.g. bare ground, grass, brambles/scrubs, trees);
- Presence of water (e.g. seepage, ponding, marshy);
- Any apparent distress of the cutting (e.g. soil slip, rock falls, bulging, cracks, frost shattering, dislocated vegetation, vegetation damage, ravelling, wedge failure, planar failure, topping failure);
- Condition of drainage for the cutting.

The IÉ Division, in which this cutting is included, have confirmed to the RAIU that the requirements of I-STR-6510, have not been completed in full in relation to the cutting involved in this accident, in that Cuttings Inspection Cards have not been completed for the cutting, and no programme of inspections, as outlined in I-STR-6510, was adopted for this cutting.

Guidance on procedures for these inspections and the identification of defects is provided in the "Earthworks and Coastal and River Defences: Inspection Guidance Notes". This standard was introduced on the 01/10/2009, just six weeks before the accident. However, prior to the introduction of this standard, the "Civil Engineering Earthworks and Structures – Inspection Guidance" training course had been completed by Inspectors and the notes of this course were available to inspectors. The content of both the standard and the training course notes is similar, and both state:

- Where possible, earthworks inspections should be carried out between the months of October and March, (when vegetation is low and ground water high);
- The structures inspector should traverse (i.e. physically walk over) the surface of the cutting or from toe to crest at the minimum intervals (i.e. Condition Rating 4 at 20 m intervals; Condition Rating 3 at 50 m intervals; Condition Rating 2 at 100 m intervals; Condition Rating 1 at 200 m).

In addition, the training notes state that "Where access is difficult initial examination shall be undertaken from accessible areas of the toe or crest, or both where this is possible. Where necessary, access equipment and/or vegetation clearance shall be undertaken to provide the necessary access to earthwork areas."

[3] Cutting Inspection Cards were also required for the previous two issues of I-STR-6510.

1.7 Traction and rolling stock

The train involved in the accident was a four piece Class 29000 DMU. The train identification number was J806, and the carriage numbers were 29126, 29226, 29326 and 29426. Carriage 29426 was the leading carriage at the time of the accident. The four-car set is 81.46 metre (m) long, 3.985 m high and 2.9 m wide and weighs a total of 160.8 tonnes.

The event recorder fitted to the leading carriage recorded that the train was travelling at 41 kilometres per hour (km/h) when the emergency brake fully applied. The event recorder indicates that the braking rate for the train was within the IÉ specification of 0.88 metre squared per second (m^2/s).

The condition of the train was not contributory to the accident.

1.8 Operations and communications

The line at the site of the accident is a single track route from Bray to Rosslare is signalled using two and three aspect *colour light signals*, controlled by the Rosslare Line Signalman based in the Greystones signal cabin. *Track Circuit Block* (TCB) regulations apply to this route.

The means of communication between train drivers and Rosslare Line Signalman on the route is through train radio.

The maximum speed for the line, and at the location of the accident is 110 km/h.

The driver was competent to drive trains, and his response to seeing the obstruction and applying the emergency brake was satisfactory, therefore, no factors relevant to the train driver were found to have contributed to the accident.

1.9 Fatalities, injuries and material damage

1.9.1 Fatalities and injuries

There were no fatalities or injuries to the train driver or any third parties as a result of the derailment.

1.9.2 Infrastructure damage

Apart from the landslip, there was no other damage to the track or other infrastructure as a result of the landslip.

1.9.3 Traction and rolling stock damage

The impact from the train striking the debris resulted in extensive damage to the train. The driver's access steps on both sides of the driver's *cab* were bent. The leading carriage sustained damage to components of and mountings for the main engine, cooling system, exhaust system, braking system, secondary suspension, generator, *wheel slip prevention system*, *flange lubrication system*, battery, and fire suppression system.

There was also damage at the connection between the first and second carriages, to the electrical *coupling*, *bellows*, *floor plates* and inter-carriage doors. The carriage panelling and *underframe equipment* cases on the leading carriage sustained some damage. There was evidence of contact between second *bogie* in the direction of travel and the carriage underframe and the end cap of one of the *axles* was broken off.

1.10 History of recent similar accidents and incidents

1.10.1 Landslide on the Limerick to Ennis Line on the 23rd November 2009

On the 23rd November 2009 a patrol ganger reported a landslip at the 22 MP, with the debris from the failure cutting on the track over a length of 20m. The IÉ investigation identified a number of findings which resulted in the accident, these included heavy rainfall, the angle of the cutting (greater than 45˚ angle), the ingress of water for the adjacent field, and the composition of the soil in the cutting, and the poor vertical drainage of the slope.

1.10.2 Landslide on the Limerick to Ennis Line on the 19th November 2009

On the 19th November 2009 a driver reported that debris from a landslip had fallen on the track at the 19 MP on the Limerick to Ennis Line. At the time of the accident, there was had been a previous landslip nearby, and remedial works were being carried out to the cuttings in the nearby area. The IÉ investigation identified a number of findings which resulted in the accident, these included the ongoing issue of failed cuttings in the area. In addition, the above average rainfall in the area, the saturation of the adjacent field, the steep angle of the cutting (55˚ angle) and the composition of the soil were all identified as factors which contributed to the landslip.

1.10.3 Embankment subsidence near Inch on the 13th November 2009

On the 13th November 2009 a patrol ganger reported an embankment slip near Inch, County Wexford. The IÉ investigation found that the immediate cause of the accident was as a result of extremely heavy rainfall the evening prior to the slip, couple with the fact that the embankment was already saturated as a result of heavy rainfall in the previous months. Contributory factors to the accident

were differential settlement as a result of the embankment being made up of different materials (gravelly clay and clay/silt) which have different saturation behaviours; and the additional loadings on the embankment as a result of a remedial *berm* being constructed in 2002.

1.10.4 Embankment subsidence at Bogland, Arklow, on the 4th February 2009

On the 4th February 2009 a patrol ganger reported significant subsidence of the track over a length of 10m, at MP 50 ¼. The line was closed for eleven days as a result of the subsidence. The IÉ investigation into the landslip, identified that the immediate cause of the accident was as a result of a weak point in the vicinity of the centreline of the landslip which would have been in existence since the original construction of the embankment in the 1860s. The saturation of the embankment as a result of heavy rainfall in the months of January and February 2009 was identified as an underlying cause to the landslip.

1.10.5 Landslides between Cabra and the Phoenix Park, on the 21st January and the 4th February 2009

On the 21st January and the 4th February 2009 landslips occurred between Cabra and the Phoenix Park tunnel. The IÉ investigation identified that the immediate cause of the accidents was as a result of the saturation of the slopes as a result of the presence of water. Underlying causes were identified as the steep angle of the earthworks, the lack of drainage, the overgrowth of vegetation, the depositing of waste materials along the embankment and the high water table.

1.10.6 Landslip on the Tara Mines Branch, Navan, on the 9th December 2008

On the 9th December 2008, on the Tara Mines Branch in Navan, a patrol ganger carrying out a routine inspection noted a landslip had occurred. IÉ noted that an overbridge was being constructed adjacent to the cutting, with water being discharged down the embankment, causing saturation of the earthworks, which resulted in the landslip occurring.

1.10.7 Embankment collapse at Portarlington on the 16th August 2008

On the 16th August 2008 an embankment collapsed, south of Portarlington Station, on the Dublin to Cork line. A passenger train, travelling from Dublin to Cork, struck debris from the failed embankment and derailed the first bogie of the train. There were no injuries to staff or passengers. The IÉ investigation found that the immediate cause of the embankment collapse was the deep ponding of water in the field ditch against the already saturated embankment brought about by a localised 1 in 150 year rainfall, causing a shear failure of the embankment. Contributory factors to the accident were that the embankment inclination was reliant on *soil suction* for stability, which was reduced by

excessive rainfall; there was also ineffective field drainage which allowed ponding of water such that saturation levels for the embankment increased; the historical practice of depositing waste material along the embankment after engineering works (e.g. re-signalling works) altered the shape of the embankment further reducing the stability of the embankment.

1.10.8 Embankment slip near Manulla Junction on the 1st August 2007

On the 1st August 2007 there was an embankment slip near Manulla Junction. The day before the accident IÉ had commenced engineering works to strengthen the embankment. As part of these strengthening works IÉ removed the vegetation and excavated a strip of material from the bottom of embankment. The following day, a local farmer reported the movement of materials at the slip location, when IÉ arrived at the location, they found that the embankment had slipped. At the time of the slip, the works were not completed. The IÉ investigation concluded that the embankment slip was as a result of the differential settlement of materials under the embankment (as the embankment was made up of ballast, limestone and clay). Contributory factors to the embankment slipping were: the fact that the bottom of the embankment had been excavated making it unstable; and removal of the vegetation, which had a stabilising influence on the structure, made the embankment more susceptible to slippage and water ingress; and the severe rainfall occurring around the time of the accident. As a result of this landslip IÉ recommended the development of a standard on remedial works to embankments.

1.10.9 Landslip north of Phoenix Park Tunnel on the 25th June 2007

A landslip north of the Phoenix Park Tunnel, was reported by a driver on the 25th June 2007. The debris fouled the line. An informal investigation was carried out by IÉ which found that a developer had broken through IÉ's boundary wall, and placed site offices, steel and spoil on the top of the cutting, without the consent or knowledge of IÉ. The developer was also pumping water down face of the cutting which saturated the cutting slope. These factors would have contributed to the landslip.

1.11 Weather conditions

On the 16th November 2009, between 00.00 hrs to 06.00 hrs there was persistent to heavy rain in the vicinity of Wicklow Station. According to Met Éireann there was twice the average rainfall for November, which was the highest rainfall recorded for November in over 150 years, which resulted in severe localised flooding experienced around the country.

2 Analysis

2.1 Failure mechanism of the cutting

The ditch at the top of the slope, located in the field adjacent to the cutting, was filled in as a result of the soil deposition in the field. This deposition is likely to have blocked the water from draining freely and probably resulted in the field being saturated. With the field saturated, it is likely that excess water flowed down the parapet of the footbridge and the scar of the landslip.

With the water now blocked, the presence of sand lenses in the upper layer of the cutting is likely to have facilitated the travel of water through and out of the cutting. This may have occurred from the time of the initial deposition of soil in January 2008, causing erosion, *sloughing* and the eventual failure of the slope. This process is likely to have been hidden from the IÉ staff carrying out inspections due to the presence of dense vegetation along the cutting.

At the time of the accident, the cutting slope was steep, at an angle of 50 – 55˚, but despite this had remained stable for over 100 years. It should be noted that on the day of the accident, IÉ's drain at the base of the cutting was working correctly, and therefore not likely to be contributed to the drainage issue.

2.2 Third Party Activity

From information provided by the landowner, it is clear that he was not aware of the consequences of the spreading of soil, in particular the filling in of the drainage ditch, on his own land or IÉ's cutting.

The landowner also confirmed that he was not aware of the Railway Safety Act 2005, IÉ's Guidance on Third Party Works, I-DEP-0120, or the RSC's Third Party Guidance on Railway Risk Volume 2 Neighbours, RSC-G-011-A. As a result, the landowner was completely unaware of his requirements under any of these documents.

As IÉ and the RSC only issue these documents to the local planning authorities, there is some doubt that all parties affected by IÉ's Guidance on Third Party Works, I-DEP-0120 and the RSC's Third Party Guidance on Railway Risk Volume 2 Neighbours, RSC-G-011-A are aware that the documents are available on the website.

2.3 Inspections

2.3.1 Track Patrolling Inspections

As noted earlier, IÉ's track patrolling standard I-PWY-1307 states that a "patrol ganger must be alert for any signs of unsafe conditions developing in adjacent assets which can be observed from the track, as well as for any unusual events inside or outside the railway boundaries that could affect safety".

The deposition of soil in the field adjacent to the cutting would be considered an "unusual event" being undertaken inside and outside the railway boundaries. However, these works went unnoticed by IÉ as they were not visible to the patrol ganger from track level and therefore were not brought to the attention of the PWI or the ADE for further inspection.

During periods of wet weather the patrol gangers are to carry out inspections of cuttings on each patrol. In the case of this accident, November was a wet month, which meant the patrol ganger would be required to carry out the inspection three times a week (patrolling frequency in this case). However, patrol gangers typically only log faults and given that the patrol ganger did not identify any faults with the cutting, it is therefore assumed that the patrol ganger did carry out these inspections but could not see any of "the conditions to be looked for" in relation to cuttings, such as "slipped material", "excavations or undermining of earthworks" or "signs of movement" as a result of the presence of dense vegetation on the cutting. The only visible evidence indicating the risk to the earthworks was the water pouring down the parapet of the pedestrian overbridge, however, this was not included as a "condition to be looked for" in the track patrolling standard or training and therefore it would not have been expected that the patrol ganger would have been able to identify this early indication that the cutting was at risk of failure.

2.3.2 Track and Structures Inspections

IÉ have confirmed to the RAIU the Requirements for Inspection of Track and Structures by Engineers and Supervisors, of IÉ's Track and Structures Inspection Requirements Standard, I-PWY-1107, were carried out at the prescribed frequency. However, as no record of the inspection of individual assets is required, except in the case where defects have been identified, there is no information available in relation to the condition of the cutting at the time of these inspections, therefore there is some doubt that the cutting was inspected in any great detail.

2.3.3 Structural Inspections

IÉ have confirmed to the RAIU that no Cutting Inspections Card has been completed for the failed cutting, nor had any programme of inspections (GEIs) been adopted, since the introduction of the

Structural Inspection Standard, I-STR-6510 in 2005, as the cutting had not been identified as a structure on the ADEs structures list.

Had a programme of GEIs been adopted, the inspection may have identified the fact that soil was being deposited in the adjacent field; and the defects associated with the early signs of failure may have been identified by IÉ Inspectors.

GEIs are "systematic visual inspection of a structure that is generally adequate to monitor and assess its condition", and therefore the inspection is entirely visual with no intrusive examination of the cutting to establish its geotechnical properties.

2.4 Previous earthwork failures

From this RAIU investigation and a review of previous similar incidents and accidents, it is apparent that there have been numerous significant earthworks failures in the three years previous to the accident, with the following factors identified as immediate or underlying causes to the previous accidents and incidents:

- Heavy rainfall is a constant factor into the all the failures of the reviewed earthwork failures;
- The topography and geotechnical properties of the cutting, with particular consideration to differential settlement and the deposition of waste materials;
- The steep angle of the earthwork slopes is a reoccurring factor identified as a cause of these earthwork failures.

3 Relevant actions already taken or in progress

In relation to the cutting, IÉ immediately carried out remedial works to the failed cutting, these works included:

- Re-profiling and backfilling the cutting with stone fill to a gradient of 30-35˚;
- Re-profiling the crest of the cutting slope for a length of 80 m to mitigate the risk of further failures developing;
- Installation of a transverse drainage pipe in the field behind the slope failure to intercept surface water and shallow drainage flows in the direction of the cutting face and discharge them into the crest drainage ditch in the adjacent field to the east, where no up-filling had occurred and the cutting depth was reduced.

4 Conclusions

At approximately 06.20 hours, on Monday the 16th of November 2009, an empty train travelling from Connolly to Arklow, derailed when it collided with an obstruction caused by a landslip.

The immediate cause of this landslip was the result of soil deposition by a landowner, at the crest of the cutting. This was as a result of the following combination of factors:

- The blocking of the drainage ditch for the field which was adjacent to the field;
- The presence of sand lenses in the cutting which facilitated the flow of water through the cutting;
- The heavy rainfall for the month of November which resulted in the saturation of the field adjacent to the cutting.

The above factors were necessary for the accident to happen. Contributory to the accident happening were the following factors:

- The patrol ganger was unable to identify defects associated with the early signs of the landslip as the cutting was covered in dense vegetation, resulting in an unrealistic expectation that the patrol ganger could carry out these inspections effectively;
- The patrol ganger was unable to identify the water pouring down the pedestrian overbridge as an early defects associated with the failure of the cutting due to poor drainage as this was not identified as a condition to be looked for in the Track Patrolling Standard, I-PWY-1307, and not included in track patrolling training, again resulting in an unrealistic expectation that the patrol ganger could identify all signs of defects associated with cuttings;
- The patrol ganger had not received the appropriate training to identify all defects associated with the early signs of earthworks failure, and therefore there is some doubt that only carrying out inspections as per the Standard for Track Patrolling, I-PWY-1307 is sufficient during periods of heavy rainfall where there is an increased potential for earthwork failures;
- The patrol ganger was not aware of the spreading of soil in the field adjacent to the cutting, which would be considered an “unusual events” being undertaken inside and outside the railway boundaries, as per the track patrolling standard, I-PWY-1307, as track patrols are carried out from track level, and therefore there was no way for the patrol ganger to be aware of the works being carried out in the adjacent field, which is approximately three metres above track level;
- A programme of Structural Inspections for the cutting was not adopted as required by Structural Inspections Standard, I-STR-6510, as the cutting was not identified as a structure under the ADEs structures list, which resulted in no structural inspection being carried out on the cutting;

- The landowner did not believe that the works he was carrying out on the adjacent field would affect IÉ's cutting;
- The landowner was also unaware of the requirement to contact IÉ to inform them of any work, undertaken by him, which may affect the railway, as he had not been issued, nor was he aware of IÉ's Guidance on Third Party Works, I-DEP-0120. He was also unaware of the RSC's guidance document, RSC-G-011-A, Third Party Guidance on Railway Risk Volume 2 Neighbours, which again would have required him to contact the DE.

Underlying to the accident occurring were the following factors:

- IÉ's Structural Inspection Standard, I-STR-6510, only requires for visual inspections to be carried out on cuttings greater than 3m, with no requirement for any geotechnical assessment to be carried out. As a result the sand lenses present in the cutting, which was identified as a contributory factor to the accident occurring, were not identified. Therefore, there is some doubt as to the efficacy of only having visual inspections, when a more intrusive inspection would identify the geotechnical properties of the cutting, allowing IÉ to identify structures that may be vulnerable to failure;
- There is some doubt that all private landowners, adjacent to the railway, are aware of the requirement to consult with IÉ in relation any works that may affect IÉ assets as set out in IÉ's Guidance on Third Party Works, I-DEP-0120 and the RSC's guidance document, RSC-G-011-A, Third Party Guidance on Railway Risk Volume 2 Neighbours. Considering there has been no advertising to make third parties aware of this guidance document there is an unrealistic requirement on a landowner to be familiar with these documents.

5 Recommendations

As a result of the RAIU investigation, the RAIU have made six safety recommendations[4].

As the overgrowth of vegetation on the cutting contributed to the patrol ganger being unable to identify any early indications of cutting failure, the RAIU make the following safety recommendation:

- 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.

Heavy rainfall was identified as a contributory factor to this accident and previous earthwork failure investigations carried out by IÉ. From review of the formal standards for inspection of structure, only the patrol ganger is responsible to carrying out additional inspections of cuttings during periods of heavy rainfall; and considering there is some doubt that patrol gangers have received adequate training to carry out these additional inspections, the RAIU make the following safety recommendations:

- IÉ should review the effectiveness of their standards in relation to conducting earthworks inspections during periods of heavy rainfall, ensuring that earthworks vulnerable to failure are inspected during these periods by appropriately trained patrol gangers or inspectors.

IÉ's Track Patrolling Standard I-PWY-1307 states that a "patrol ganger must be alert for any signs of unsafe conditions developing in adjacent assets which can be observed from the track, as well as for any unusual events inside or outside the railway boundaries that could affect safety". Given that the track patrols are carried out from track level, and therefore the patrol ganger was unaware of the works being undertaken in the field adjacent to the cutting, the RAIU make the following safety recommendation:

- IÉ should review their Standard for Track Patrolling, I-PWY-1307, for its effectiveness in identifying any third party activities that occur inside and outside the railway boundaries that could affect safety and where any deficiencies are found, IÉ should develop an alternative process for the identification of these third party activities.

[4] Recommendations shall be addressed to the safety authority and, where needed by reason of the character of the recommendation, to other bodies or authorities in the Member State or to other Member States. Member States and their safety authorities shall take the necessary measures to ensure that the safety recommendations issued by the investigating bodies are duly taken into consideration, and, where appropriate, acted upon. (Railway Safety Directive, 2004/49/EC)

The failed cutting was not included in the ADEs structure list, and therefore not inspected as per the Structural Inspections Standard, I-STR-6510, which requires all cutting greater than 3m to be inspected to the requirements of this standard. Therefore the RAIU make the following safety recommendations:

- IÉ should review their structures list and ensure that all earthworks are identified and included on this list. Upon updating this list, a programme for the inspection of earthworks is to be developed and adopted at the frequency requirements set out by the Structural Inspections Standard, I-STR-6510.

As the landowner was unaware of any requirements to contact IÉ in relation to works being carried out on his land, as IÉ's Guidance on Third Party Works, I-DEP-0120 and the RSC's Third Party Guidance were not widely advertised to the public. Therefore, the RAIU make the following safety recommendation:

- IÉ and the RSC should review their process for the issuing of guidance documents, to ensure that the third parties affected by these guidance documents are made aware of their existence.

The Structural Inspections Standard, I-STR-6510, only requires for visual inspection of cuttings, and as there is some doubt that this is sufficient given the geotechnical properties of cuttings has been identified as a contributory factor to this investigation and previous IÉ investigations, the RAIU make the following safety recommendation:

- IÉ should review the effectiveness of their Structural Inspections Standard, I-STR-6510, with consideration for the possibility of more thorough inspections being carried out on cuttings to establish the topography and geotechnical properties of cuttings; and from this information identify any cuttings that are vulnerable to failure.

6 Additional information

6.1 List of abbreviations and acronyms

°	Degrees
ADE	Assistant Divisional Engineer
CWR	Continuous Welded Rail
DE	Divisional Engineer
DMU	Diesel Multiple Unit
GEI	General Engineering Inspections
hrs	Hours
km/h	Kilometres per hour
m	Metre
PWI	Permanent Way Inspector
RAIU	Railway Accident Investigation Unit
RSC	Railway Safety Commission

6.2 Glossary of terms

*Terms with * are taken directly from Ellis' British Railway Engineering Encyclopaedia*

Axle	Shaft connecting the wheels of a wheelset.
Axle end cap	Cover fitted to the end of an axle that allows the axle bearing to be held in place by being fixed to the axle with screws
Bellows	Flexible surround at the areas between the carriages that seals the carriages from the environment whilst allowing the carriages to move relative to each other.
Berm	Bank of earth
Bogie	A metal frame equipped with two or three wheelsets able to rotate freely in plan.
Cab	A term for the driving cab, which is the driver's compartment in a train.
Chief Inspector	A person responsible for ensuring that inspections of track and structures in their areas are carried out in accordance with the standards and for carrying out further inspections specified by the ADE and/or DE.
Clay	A fine-grained, firm earthy material that is plastic when wet and hardens when heated.
Colour light signals*	Signals which convey movement authorities to train drivers by means of coloured lights.
Condition Rating	Numerical value to describe the condition of an IÉ asset.
Continuous Welded Rail	Rails welded together, utilising flash butt welding, to form one continuous rail that may be several kilometres long, or thermite welding to repair or splice together existing CWR segments.

Córas Iompair Éireann	A statutory corporation and wholly owned by the Irish Government. CIÉ has three wholly owned subsidiary limited liability companies established under the Companies Acts, as provided for in the Transport (Reorganisation of Córas Iompair Éireann) Act 1986. Iarnród Éireann is one of these subsidiary companies.
Coupling	A device used to connect rail vehicles together for haulage purposes.
Cutting*	An area excavated to permit a railway to permit its level and gradient through high ground without excess deviation from a straight course
Ditch	A long, narrow excavation made in the ground for draining of land.
Diesel Multiple Unit*	A multiple unit train whose source of power is a diesel engine.
Down	North-bound railway line.
Flange lubrication system*	A rail lubricator arranged to apply grease to the wheel backs, to reduce wear between the wheels and check rails.
Flat bottom Rail	A rail section having a flat base.
Floor plate	moveable floor panels resting on the underframe and inter carriage coupling that create a walking surface between the carriages whilst allowing the carriages to move relative to each other
General Engineering Inspection	This 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.
Iarnród Éireann	A wholly owned subsidiary of Córas Iompair Éireann. IÉ is the owner and operator of the national mainline service in Ireland.
Leading carriage	The front end of a train, in the direction of travel.
Milepost	A post placed at one mile intervals along the railway, (quarter mile intervals similarly marked).
Overbridge*	A bridge that allows passage over the railway.
Sandy lenses	Horizontal pocket of sand.
Saturated	A condition in which all easily drained voids between soil particles are temporarily or permanently filled with water.
Single track	A route with one track.
Soil suction	A measure of the affinity of soil to retain water.
Slough	Collapse or slide of (soil or rock) into a hole or depression.
Track Circuit Block	A method of signalling to trains in a section of line where safety is ensured by the use of track circuits or other means of automatic train absence detection system and without the use of block instruments.
Underbridge*	A bridge that allows passage under the railway.
Underframe	Structure that supports the body of a rail vehicle.
Wheelset	Two rail wheels mounted on their joining axle.

Wheel slip prevention system	A control system, fitted to modern trains, that prevents the driving wheels spinning out of control or locking up during times of reduced adhesion.

6.3 References

Iarnród Éireann (2008), Civil Engineering and Earthworks Structures: Guidance Notes on Inspections Standard Issue 1.0

Iarnród Éireann (2006), Infrastructure Departmental Standard, Guidance on Third Party Works, I-DEP-0120, Issue No. 1.0

Iarnród Éireann (2005), Infrastructure Structures Standard, Structural Inspections Standard I-STR-6510 Issue 1.0

Iarnród Éireann (2008), Infrastructure Structures Standard, Structural Inspections Standard I-STR-6510 Issue 2.0

Iarnród Éireann (2009), Infrastructure Structures Standard, Structural Inspections Standard I-STR-6510 Issue 3.0

Iarnród Éireann (2006), Infrastructure Track Standard, Standard for Track Patrolling, I-PWY-1307, Issue No. 1.1

Iarnród Éireann (2006), Infrastructure Track Standard, Track and Structures Inspection Requirements, I-PWY-1107, Issue No. 1.0

Railway Safety Commission (2008), Third Party Guidance on Railway Risk – Volume 2 Neighbours RSC-G-011-A, Rev. A 25.04.08