Australian Government
Australian Transport Safety Bureau

Derailment of freight train 9281

Near Charters Towers, Queensland, on 30 December 2020

ATSB Transport Safety Report
Rail Occurrence Investigation (Short)
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Addendum

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Executive summary

What happened

On 30 December 2020, Aurizon fertiliser freight train 9281, was travelling from Phosphate Hill to Townsville Jetty, Queensland. A short time, after commencing the downhill grade from 119 km towards Sellheim, train 9281 derailed while traversing over a culvert.

What the ATSB found

The investigation found that a series of rainfall events on the 29 December 2020, which included a heavy rain event between 1510 and 1615, compromised the drainage system at the 118.131 km. Water over-topped the track prior to the arrival and subsequent derailment of train 9281.

The corrugated metal pipe, that was an element of the drainage system at the 118.131 km, likely had rainwater throughput restricted. This was restriction was possibly due to sinking, debris from the upstream side blocking the corrugated metal pipe, or collapse of the corrugated metal pipe due to exceeding its service life, or a combination of the three, resulting in the rainwater pooling.

Extensive rainwater pooling resulting in over-topping of the track at the location of the corrugated metal pipe very likely undermined the track infrastructure, such that it could not support the weight of the rolling stock.

What has been done as a result

Following the derailment, Queensland Rail upgraded the culvert with three 900 mm corrugated metal pipes, which significantly improved drainage in the area. Queensland Rail is also considering actions around engineering studies, resilience works, and alternative and predictive weather monitoring.

Safety message

Rail infrastructure managers should ensure their drainage systems are fit for purpose, are clear, open, and in serviceable condition. This will minimise the risk of system inundation and track over-topping.

The investigation

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

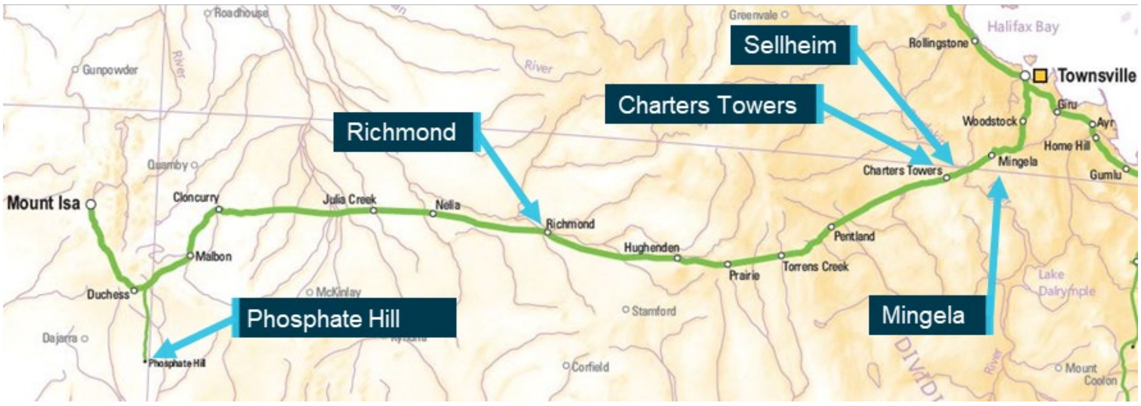
The occurrence

Train 9261/9281 was a loaded fertiliser train, operated by Aurizon, travelling from Phosphate Hill to Townsville Jetty on the Mount Isa line in Queensland. The train departed Phosphate Hill as train number 9261 on 28 December 2020, before being renumbered 9281 from Hughenden on 29 December 2020. Both the drivers of train 9281 commenced work in Hughenden at 1815 Eastern Standard Time[1] on 29 December 2020.

On 29 December, at about 1830, while travelling from Hughenden to Charters Towers, the rail traffic crew of train 9281 were asked by the network control officer to report on the weather conditions. The rail traffic crew reported they had not observed any flooding or adverse conditions on the journey. Prior to the passage of train 9281 from Charters Towers, there were 2 periods of rainfall recorded near the site of the derailment, one in the afternoon, and another in the evening.

On 30 December 2020, at 0016, train 9281 was travelling from Charters Towers towards Sellheim (Figure 1). A short time after commencing the downhill grade from 119 km towards Sellheim, 11 wagons, not including the locomotives and first wagon, derailed while traversing a culvert.[2] As a result of the derailment, fertiliser was spilt into the waterway and towards a dam on a local property.

Figure 1: Location of the derailment



Source: Geoscience Australia, annotated by the ATSB

Context

Train

The train consisted of 2 locomotives, a 2800 class (2826) leading and a 4000 class (4046) trailing. The train was hauling 35 VFMQ class hopper wagons. The train was 562 m in length and had a trailing mass of 2,754 t and was crewed by 2 rail traffic crew, consisting of a tutor driver and a driver under route tuition.

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[1] Eastern Standard Time (CST): Coordinated Universal Time (UTC) + 10 hours.

[2] A load bearing structure that supports the track, which conveys water under the railway or providing access for property owners, but not a bridge structure.

Washout of track infrastructure

Evidence collected by Queensland Rail at the site of the derailment indicated it was the result of a washout of the track infrastructure. The washout was on the downstream beside a culvert and uncovered an old concrete abutment within the foundation (Figure 2).

Figure 2: Washout location

Source: Queensland Rail, annotated by the ATSB

Weather

The Mount Isa line from Mount Isa to Richmond, which is to the west of Charters Towers, is heavily impacted by adverse weather events during the monsoon season, which can close the line for periods of time. The closures allow water to dissipate from the rail corridor and inspection to be undertaken to ensure the line is fit for service. Areas east of Richmond, towards Townsville, are less impacted by adverse weather events. Queensland rail's washout records have been kept since 1971 with no occurrence of washout or flooding recorded at the derailment site.

The northern Australian monsoon season generally lasts from December to March. The north Australian wet season encompasses the monsoon months but can extend several months on either side.[3]

The Bureau of Meteorology (BoM) forecast for Charters Towers on Tuesday, 29 December 2020, issued at 0455:[4]

> Cloudy. Very high (95%) chance of showers, tending to rain. A thunderstorm likely with possible heavy falls. Light winds becoming north-easterly 15 to 20 km/h in the middle of the day then becoming light in the early afternoon.

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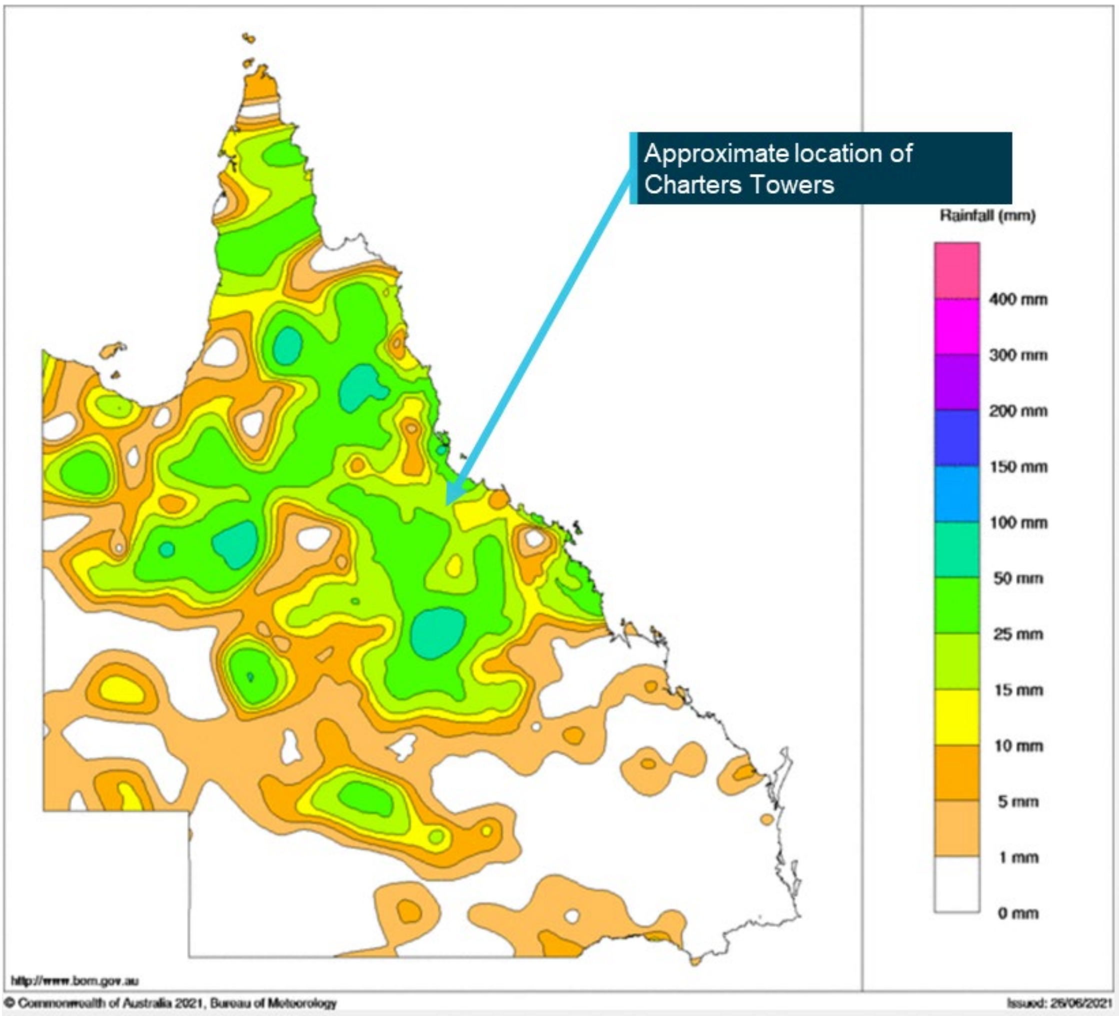
[3] Reference - http://www.bom.gov.au/climate/glossary/monsoon.shtml

[4] Bureau of Meteorology, *Severe Thunderstorm Warnings issued for Northern Goldfields and Upper Flinders,* 29 December 2020.

The BoM record of total rainfall for 29 December 2020, indicated that near the site of the derailment, the intensity of rainfall from a series of rain events was in the range of 25–50 mm over the 24-hour period. (Figure 3).

Figure 3: 29 December 2020 Rainfall Total

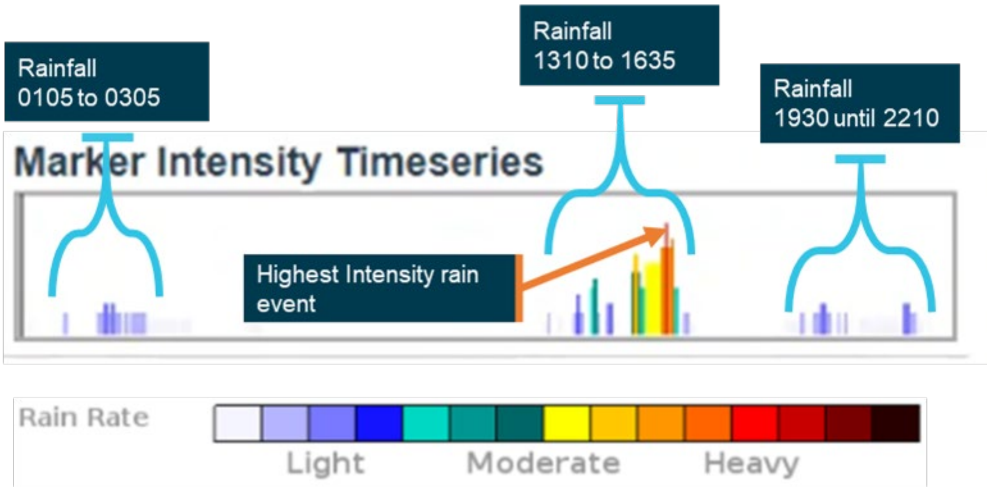


Source: Bureau of Meteorology, annotated by the ATSB

The BoM weather station at Charters Towers, located about 8.5 km from the derailment site, recorded 33.2 mm of rain between 1500 on 28 December and 1500 on 29 December. A further 26.8 mm was recorded between 1500 on 29 December and 0900 on 30 December.

Weather radar data recorded a series of rainfall events at the derailment site in the 24 hours preceding the accident. They were during the periods 0105–0305 (light rainfall), 1310–1635 (moderate to heavy rainfall) and 1930–2210 (light rainfall) (Figure 4).

Figure 4: Weather radar rainfall intensity at derailment site over 24 hours



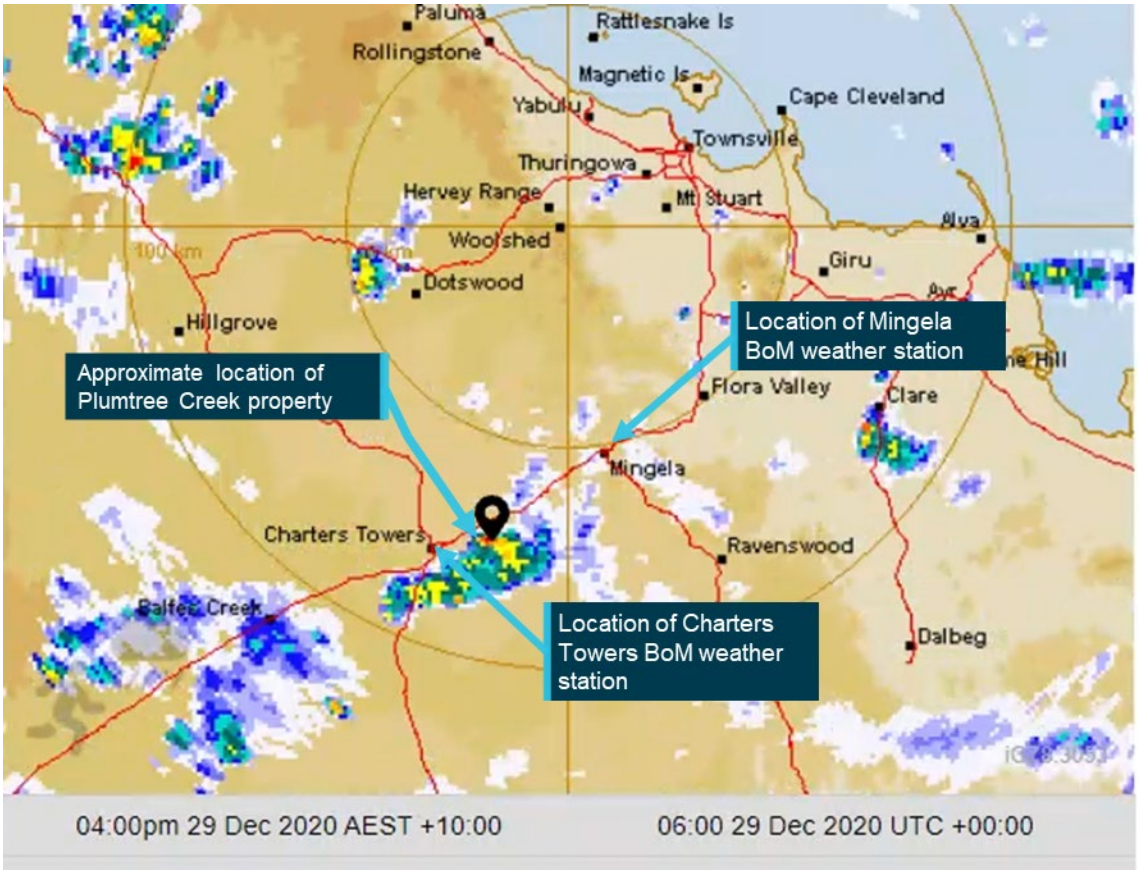
Source: The Weather Chaser, annotated by the ATSB

Queensland Rail weather monitoring systems for the region provided no alarms for flooding, significant rainfall or closed-circuit television camera images, which might have prompted a change in the operational status of the line.

The owner of a property, located about 800 m to the north of the derailment site, recorded about 84 mm of rain. The owner was in Charters Towers at the time, and was notified by their partner, who was at the property, at about 1520 on 29 December, that there was heavy rainfall. The owner stated that it was heavy rain (storm) that was isolated in a small area. The owner had last checked the rain gauge in the morning and noted the 84 mm after returning to the property from Charters Towers at about 1700.

The ATSB noted that there was a period of consistent moderate to heavy rainfall at the derailment site from about 1510-1615. The 1600 weather radar data depicted a heavy rainfall event over the accident site, which passed between the weather stations at Charters Towers and Mingela (Figure 5).

Figure 5: Weather radar rainfall intensity at derailment site



Location of Mingela BoM weather station

Approximate location of Plumtree Creek property

Location of Charters Towers BoM weather station

04:00pm 29 Dec 2020 AEST +10:00

06:00 29 Dec 2020 UTC +00:00

Source: The Weather Chaser, annotated by the ATSB

A rainfall of 84 mm from 1510–1615 equates to 78 mm/h rainfall intensity.

The BoM *Design rainfall data system* 2016 provides design rainfall data based on intensity-frequency-duration, and includes average recurrence intervals, which refer to how often a particular level of rainfall intensity can be expected to occur in years and probabilities. The BoM intensity-frequency-duration data for the derailment location near Charters Towers can be seen in Figure 6.

The 78 mm/h observed was greater than a once in 20-year event (71.9 mm/h), but less than 50-year event (83.5 mm/h) for the Charters Towers weather station.[5]

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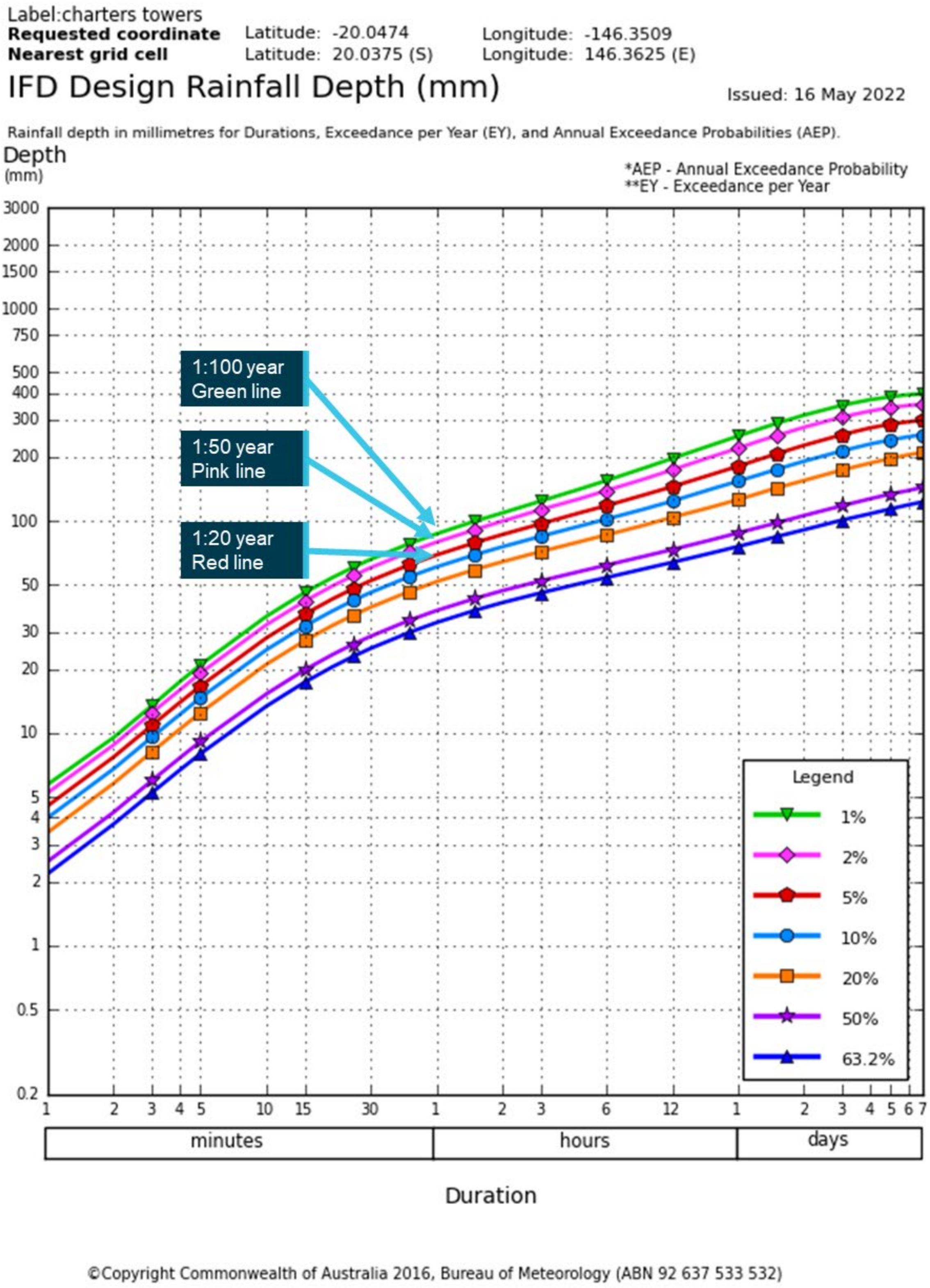
[5] The Queensland Rail internal investigation report concluded that between 2130 and midnight on 29 December, approximately 84 mm of rain in a 40-minute period had fallen from an undetected localised rain event. Queensland rail advised this was based on discussion with the landowner. The hydraulic assessment undertaken by Queensland Rail determined the rainfall intensity was about 126 mm/h (based on 84 mm in 40 minutes), which exceeded the average rainfall intensity for a 100-year event.
The ATSB notes that both the time of the rainfall, and the duration, differ from evidence provided to the ATSB by the Bureau of Meteorology and the landowner.

Figure 6: Bureau of Meteorology intensity-frequency-duration chart for Charters Towers

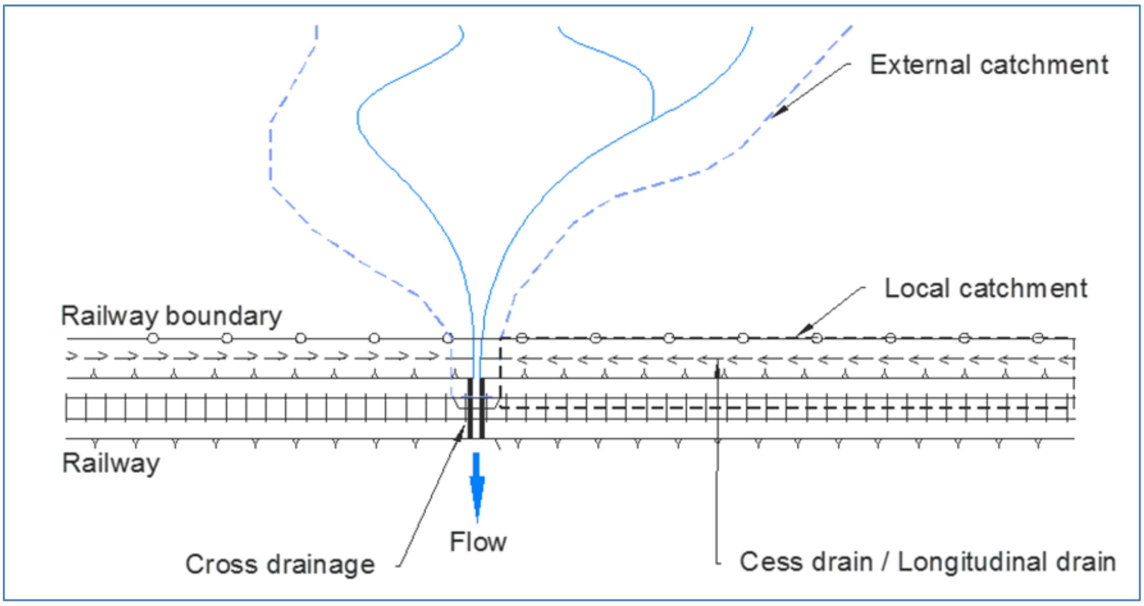


Source: Bureau of Meteorology, http://www.bom.gov.au/water/designRainfalls/revised-ifd/ accessed on 16 May 2022.

Drainage system

Drainage systems are designed to allow flow of water from known water courses under the track infrastructure, through a corrugated metal pipe (CMP) or other free-flow system, without adversely affecting the formation, ballast, sleepers, and rail. The drainage system located at the 118.130 km chainage was of a cross drainage design (Figure 7) with water flowing from a catchment area into longitudinal drains and progressing through a single CMP under the track infrastructure. The CMP was about 3 m below the rail head height (Figure 8).

Figure 7: External and local catchments, including cross drainage



Source: Rail Industry Safety and Standards Board, AS 7637 Hydrology and Hydraulics, Version 1.0, 2014

Figure 8: Drainage system

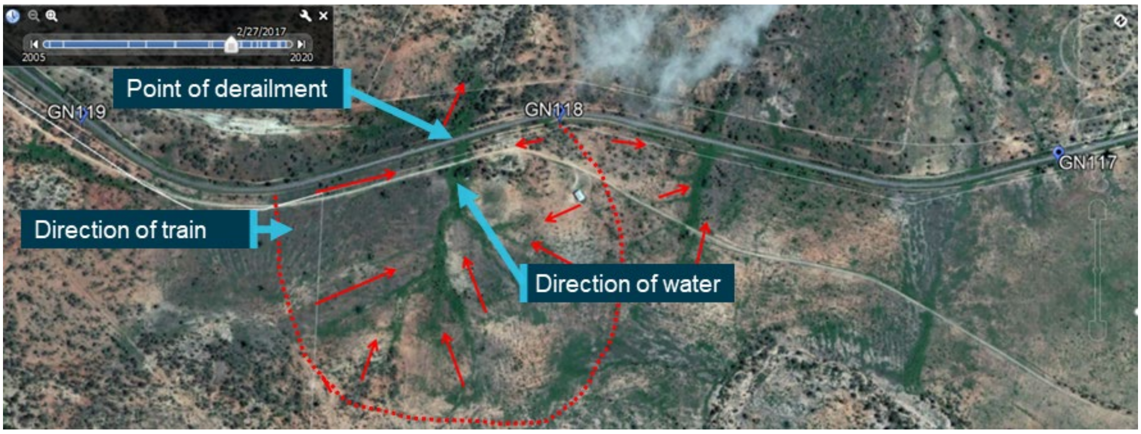
Source: Queensland Rail, annotated by the ATSB

Catchment area

The catchment area for the drainage system was about 200 m south of the rail corridor. Water flows from the catchment in a northerly direction, through the drainage system under the track infrastructure, and continues into a dam located about 800 m north of the drainage system, and about 180 m east of the home of the property owner.

The catchment area, south of the derailment site, as provided by Queensland Rail in their preliminary hydraulic assessment,[6] was about 30 ha (300,000 square metres, Figure 9 dotted red line). Within a 30-ha catchment area, this would have produced about 23,400 m^3/h, or 6.5 m^3/s (based on 78 mm/h).[7]

Figure 9: Drainage catchment system



Source: Google Earth, annotated by Aurizon and the ATSB

Construction of the culvert

Construction history

A 6 m single span timber bridge was built at the time or soon after original construction of the railway, circa 1882. At a construction date that was unknown by Queensland Rail, a 1.8 m long by 1.4 m high concrete floodway was constructed to replace the timber structure. Sometime between 1965 and 1980, a 1,050 mm CMP was installed at the location to replace the previous concrete floodway. Queensland Rail stated that it was likely constructed in the mid-1970's.

Corrugated metal pipe

The rainwater from the catchment area was directed to a drainage system, which included a single 1,050 mm diameter by 8 m long CMP, which was of free-flow discharge and designed to be self-cleaning. The water then continued to flow north towards the dam and Gladstone Creek.

Based on the preliminary hydraulic assessment undertaken by Queensland Rail, the design flow rates of the CMP in the drainage system were between about 8 m^3/s for a 50-year event and 9.5 m^3/s for a 100-year event.

Corrugated metal pipe service life

Queensland Rail reported that the design life and the planned service life of CMPs was 50 years. Evidence provided showed the design life was determined for all CMPs, without consideration of local factors that could reduce the service life.

Service life of a CMP could be affected by pH soil levels, electrolysis and material/fluid passing through pipe, zinc or other coatings, wall thickness and method of installation.

Australian Standard AS/NZS 2041:1998 Appendix C provided guidance on factors that could affect service life assessment, such as:

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[6] Preliminary Hydraulic Assessment – Culvert, Mount Isa Line at 118.13 km.

[7] As noted in footnote 5, the Queensland Rail internal investigation report concluded rainfall at 126 mm/h based on a discussion with the landowner. This would have produced 37,800 m3/h, or 10.5 m^3/s.

- pH and resistivity of backfill
- aggressive backfill conditions
- atmospheric corrosion of exposed surfaces
- perforation of metal.

The service life of a CMP could be reasonably predicted based on the environmental conditions discussed above.

CMPs are galvanised using a zinc coating to prevent corrosion. The corrosion resistance provided by the zinc coating is in direct proportion to the coating's thickness. Current galvanising, in accordance with AS/NZS 2041.1:2011, is Z600 (600 g/m^2 minimum zinc coating mass). Discussions with a manufacturer of CMP's determined that, mid 1970's, the CMP probably had galvanised at a Z250 coating[8] (250 g/m^2 minimum zinc coating mass).

The studies conducted in the United States show that corrugated steel pipe has a life expectancy of 10 years to about 35 years before perforation of the metal occurs.[9] Combined with the wall thickness, dynamic loads and infrastructure foundations, and backfill soils, the service life of a CMP may be less than the planned design life of the drainage system in its entirety.

Installation

The process for installation of CMPs from the mid-1970s to present day has evolved. There were no Australian rail industry standards in the 1970s for their installation. The Australian rail industry currently use AS/NZS 2041: *Buried Corrugated Metal Structures* and AS/NZS 2041.2: *Buried Corrugated Metal Structures – Part 2: Installation*.

During the installation of the new culvert, between 1965 and 1980, which, according to Queensland Rail, was likely in the mid-1970s, a concrete abutment that was part of the old concrete floodway structure, was not removed. Interviews with the Queensland Rail structures planners found that they were unaware that the concrete abutment was in-situ until it was exposed by the washaway and derailment. They noted that the location of the concrete abutment could have inhibited the compaction of the foundation and created a weakened area of earthworks.

Weather effect on corrugated metal pipes

With the cyclic dry-wet weather that occurs across the north of Australia, stressors from the passage of rolling stock would apply different dynamic loads to the drainage system and foundation. During dry weather, the foundation is hardened, and stressors from the dynamic loads would be applied across the foundation with minimal stressors applied to the barrel of the CMP.[10]

During wet soaking weather, as occurred during December 2020, the foundation becomes more malleable, and with the softening of the soils around the CMP, the stressors would be applied more to the barrel of the CMP as rolling stock traversed over the track. For CMP's to withstand significant fill loads[11] and heavy repetitive dynamic loads, an effective soil-structure interaction is necessary. This composite behaviour uses the compressive strength of the culvert wall, with the compressive or bearing strength of the well-compacted soil surrounding the structure. As loads are applied to the culvert, the flexible structure attempts to deflect, with the vertical diameter decreasing and the horizontal diameter increasing.[12]

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[8] CMP Manufacturing Pty Ltd.

[9] New Jersey Department of Transportation, Bureau of Research, *Corrugated Steel Culvert Pipe Deterioration*, Final Report, August 2009.

[10] Wysokowski, A. Impact of Live Load on Changes of Backfill Properties of Buried Flexible Steel Railway Structure. Transp. Infrastruct. Geotech. (2021). https://doi.org/10.1007/s40515-021-00204-4.

[11] An essential element of composite soil-structure pipe and/or culvert systems is the backfilling process, where compaction efforts are applied to newly placed soil layers surrounding flexible CMPs.

[12] Queensland Transport and Main Roads, November 2015, *Criteria for Inspection, Life Extension and Rehabilitation of Circular Corrugated Metal Culverts*, Rev 2, p14

Corrugated metal pipes may fail due to rolling stock inducing buckling or crushing of the CMP. Factors such as overloading, corrosion of the CMP, soil loss from behind the CMP wall, and softening of the soil due to increased moisture content, the soil being washed away from around the CMP during wet periods and aging can contribute to a CMP failure. The soil can also be lost due to over-topping, loss of headwalls, as well as loss of soil through perforations in the culvert, or a combination of those elements.

Structures and track inspection

The Queensland Rail structures' planners undertake detailed inspections of bridges, culverts, and associated drainage systems. Queensland Rail had 2 structures' planners who usually undertook these inspections on the Townsville to Mount Isa and Phosphate Hill lines, which were conducted in accordance with the Queensland Rail Civil Engineering Structures Standard (CESS).[13] The structures' planners usually inspected about 370 drainage systems per fortnight. On average, the structures planners inspect about 8 drains per hour. Drainage systems with multiple CMP cells, or more defects, took longer to inspect. The planners had undertaken enterprise[14] training with Queensland Rail and were deemed competent to undertake the tasks.

Detailed inspections

The CESS specified scheduled inspections, including that the Rail Infrastructure Manager shall determine the inspection interval for a structure based on the condition of the structure, the rate of deterioration, and local environmental factors. However, it also specified the intervals between scheduled inspections shall not exceed the maximum intervals specified. The CESS specified that ground level inspections of corrugated and sheet steel pipes, drains and arches were to be conducted at a maximum interval of 2 years.

In addition to the maximum interval, it also stated that:

> The Rail Infrastructure Manager is to determine the interval according to the condition of the structure and the prevalence of damp silt and permanent water in the culvert throughout the year and an annual visual inspection just before the start of the wet season to check if the waterway is clear.

A detailed inspection in accordance with Appendix 1J of the CESS[15] was undertaken between the 111.224 km and the 129.534 km in July 2019. Sections of the CESS have requirements for inspection of drainage systems, including inspection for corrosion of CMPs.

Between 30 March and 29 April 2020, the CMP at the 118.130 km to 118.131 km was identified as scouring and sinking, which was the location of the derailment. A corrective work order further noted that the gabion baskets on the right side were rolling off the CMP. The CMP was also noted as scoured and sinking on the right side, which was clarified by Queensland Rail as the downstream side of the CMP.

The sinking of the CMP would restrict the outflows of any rainwater that would be diverted to the culvert from the local catchment area. If the CMP was restricted, the design flows would be reduced, and rainwater would pool if input flow from the catchment exceeded the output flow. The report of sinking on the northern side indicated that the CMP was sinking on the downstream side, which suggested that the siltage would be at a greater depth at the outlet.

The work order stated the gabions were to be removed and replaced with two 4 m by 1 m by 1 m gabion baskets. This work was given a low priority of 26 weeks, which was in accordance with the CESS. The work order was closed at the time of the derailment, which indicated that the work had been completed. While the replacement of the gabion baskets would alleviate the scouring around the formation, they would not address the sinking of the CMP.

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[13] Queensland Rail, *Civil Engineering Structures Standard,* MD-10-586, version 6.0, dated 8 June 2020

[14] Training provided internally by an organisation that is not aligned to Australian Industry and Skills Committee accredited training products.

[15] Queensland Rail, *Civil Engineering Structures Standard,* MD-10-586, version 6.0, dated 8 June 2020, p34

Cleaning and clearing of culverts

Queensland Rail had undertaken cleaning and clearing of their culverts about December 2020 in accordance with CESS Appendix 1J. Their records indicated that culverts were cleaned and the work order was closed on 6 December 2020. There were no dates in their records for individual culverts.

The cleaning and clearing should remove any debris and other objects from the upstream side of the culvert, preventing the foreign material from entering the CMP when rainwater from the catchment area flowed towards the culvert. The area cleaned was restricted to the rail corridor on the upstream side for as far as the structures planner decided was adequate to prevent debris from entering the drainage system. Any material from outside of the rail corridor could still be deposited into the culvert and the CMP during rain events that had enough volume and force to move the debris. If debris entered the CMP, it could become lodged and restrict the flow of water, resulting in a dam-like effect and subsequent pooling of water on the upstream side.

Pooling of rainwater at the culvert and scouring of infrastructure

Photographs provided by Queensland Rail show that there was debris located on the ballast shoulder on the upstream and downstream side of the track and between the rails, which indicated over-topping of the track infrastructure at that location (Figure 10). Water over-topping of the rail would likely create a waterfall effect and scouring on the downstream side of the track infrastructure (Figure 11). The waterfall effect could also cause the gabion baskets on the downstream side to slide over the exit of the CMP, thereby further restricting the outflows from the CMP.

Figure 10: Evidence of debris on ballast shoulder and between rails

Source: Aurizon, annotated by the ATSB

Figure 11: Evidence of scouring on the downstream (outlet) side

Source: Queensland Rail, annotated by the ATSB

Operational information

Track inspection

Queensland Rail managed the railway where the derailment occurred, with the movement of rail traffic controlled from the Queensland Rail Network Control Centre located at Townsville. The section between Charters Towers and Sellheim was inspected by a Queensland Rail road-rail vehicle at about 1000 on 29 December 2020. The track was certified as fit for service. Aurizon ballast train OCB3 travelled across the section from Charters Towers to Sellheim about 1220 on 29 December 2020 and reported no issues.

Event recorder data

The analysis of the event recorder from diesel electric locomotive 2826 was undertaken by the ATSB and found at 00:20:25 (event recorder time, incident time about 00:16) the equalising reservoir (ER) and brake pipe (BP) pressure simultaneously begin to decrease. This was a likely indication that the initial brake application was driver induced as the ER is generally a good proxy for driver BP request.

Track speed at the 118 km was posted as 60 km/h, however, there was a speed restriction of 50 km/h on the section. The approach speed of train 9281 at the derailment point was, based on recorded data, about 38 km/h. The driver applied the brakes at about 37 km/h, following the derailment, and the train travelled a further 137 m before coming to a complete stop.

Operations

During the travel from Hughenden to Charters Towers, the rail traffic crew were requested by the network control officer to observe weather and effects on the rail infrastructure. The rail traffic crew relayed information to the network control officer at several locations on the travel, with no areas of concern observed.

There were no anomalies identified with the train speed, handling, rolling stock condition, or operational performance preceding the derailment.

Queensland Rail's management of operations in response to the wet weather event was generally in accordance with their existing policies and procedures.

Safety analysis

On 30 December 2020, Aurizon fertiliser freight train 9281, derailed while traversing a culvert to the east of Charters Towers, Queensland. There was no evidence to suggest that any medical or physiological factors affected the driver's performance leading up to or during the incident, or that the driver's actions or health contributed to the derailment. This analysis will discuss the localised weather event, over-topping, and undermining of the track infrastructure.

Localised weather event

The ATSB reviewed several sources of evidence for the rainfall on the afternoon of 29 December. A property owner reported that 84 mm was recorded at the property. The phone call to the property owner at 1520 about the heavy rain indicated that rainfall in the vicinity of the derailment site had started earlier than 1520. Weather radar imagery at 1600 (Figure 5) depicted heavy rainfall over the derailment site from a cell that passed between the 2 nearest weather stations of Charters Towers to the west and Mingela to the east. The weather radar time series charts captured moderate to heavy rainfall over the derailment site in the period 1510 to 1615. As this was consistent with the time the property owner received the phone call reporting heavy rain at the property, this was the likely period over which the heaviest rainfall occurred on the afternoon of 29 December.

The weather radar rain rate intensity marker timeseries is a qualitative indicator only, and therefore the actual rainfall in the vicinity of the derailment could not be determined from weather radar imagery. The rainfall at the weather stations of Charters Towers and Mingela were not considered to be reliable indicators for the derailment site as the weather radar imagery depicted a heavy rain cell pass between these stations and over the top of the site. Therefore, the 84 mm of rain reported by the property owner, over a 65-minute period, was the best measurement available.

Corrugated metal pipe failure

Cleaning and clearing inspections of CMP in the area of the derailment was completed on 6 December 2020, which likely included the incident CMP. Therefore, it was likely that the CMP was open and clear at the time of the incident.

Using the period 1510-1615 as the worst-case scenario for the entire 84 mm of rainfall in the gauge, produced an average rainfall intensity of 78 mm/h. Within a 30-ha catchment area, this would have produced about 23,400 m^3/h, or 6.5 m^3/s, which was less than the CMP design flow rate (of between 8 m^3/s and 9.5 m^3/s). As such, the drainage system should have been able to manage this flow of rainwater, through an unrestricted CMP.

The inside of the CMP was not photographed or inspected at the derailment site, and no other evidence was provided to verify the condition of the pipe post-derailment. Therefore, while the age of the CMP combined with the wet conditions suggested the possibility of a collapse, it could not be confirmed if a collapse had occurred or if the CMP had become obstructed by debris. However, the maintenance records for the CMP indicated it had been reported as sinking on the northern side (downstream side) and that no rectification work was performed prior to the derailment. Imagery from the upstream end of the CMP post-derailment also indicated a high level of silt build-up around the inlet (upstream side).

While the amount of sinkage and build-up of silt pre-derailment could not be determined, it would nevertheless have reduced the CMP flow rate to below the design rate. It was therefore likely that the combination of a localised heavy rainfall event and restricted flow through the CMP resulted in the rainwater over-topping the track infrastructure.

Track infrastructure undermined

Prior to the localised heavy rain fall from 1510 on 29 December, the track was twice seen to be serviceable (road-rail track inspection and previous train). However, after the derailment of train 9281, debris in the middle of the track indicated the formation was over-topped by rainwater. This must have occurred in the afternoon of 29 December, after the passage of ballast train OCB3. Extensive pooling resulted in over-topping, very likely resulted in the undermining of the track infrastructure and the subsequent derailment.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include ‘contributing factors’ and ‘other factors that increased risk’ (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition ‘other findings’ may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the derailment of freight train 9281 on 30 December 2020.

Contributing factors

- A series of rainfall events on the 29 December 2020, which included a heavy rain event between 1510 and 1615, compromised the drainage system at the 118.131 km and water over-topped the track prior to the arrival and subsequent derailment of train 9281.
- The corrugated metal pipe, that was an element of the drainage system at the 118.131 km, likely had rainwater throughput restricted due to sinking, debris from the upstream side blocking the corrugated metal pipe, or collapse of the corrugated metal pipe due to exceeding its service life, or a combination of the 3, resulting in the rainwater pooling.
- Extensive rainwater pooling resulting in over-topping of the track at the location of the corrugated metal pipe very likely undermined the track infrastructure, such that it could not support the weight of the rolling stock.

Safety actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. All of the directly involved parties are invited to provide submissions to this draft report. As part of that process, each organisation is asked to communicate what safety actions, if any, they have carried out to reduce the risk associated with this type of occurrences in the future. The ATSB has so far been advised of the following proactive safety action in response to this occurrence.

Safety action by Queensland Rail

Following the derailment, Queensland Rail have completed the following proactive safety actions:

- Upgraded the culvert with three 900 mm corrugated metal pipes, which significantly improved drainage in the area.
- Engaged a contractor to conduct a hydrology study to include the derailment area from Stuart, through Hughenden to Cloncurry, Mount Isa and Flynn to Phosphate hill. This package of works has now been completed.
- Commenced implementation of infrastructure reliance works that will form part of the outcome of the hydrology study. Notwithstanding significant works already completed as part of the last hydrology study including bridge strengthening in a number of locations.
- Identified a further 44 sites for new and upgraded weather monitoring equipment. A business case to request capital expenditure has been progressed. Approval has been given to implement a monitoring system that is currently under trial in the far north. This system provides a level of predictive information based on set points. It collates the data from all current available weather monitoring devices not currently utilised by Queensland Rail e.g. registered farmer rain gauges and also the Bureau of Meteorology. The system then notifies Queensland Rail via text that a specific set point has been hit.
- The condition affecting the network procedure has been reviewed and included the traffic light process to inform the broader business as to how Queensland Rail will be treating the event and train operators' obligations.
- Implementation of an additional engineering study into flooding to cover previously unassessed areas of Mount Isa Line to include review of engineering basis for bridges and culverts.
- Implementation of infrastructure resilience works.
- Review of alternative weather monitoring technology and consideration of installation of additional weather monitoring stations.

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Queensland Rail
- Rail traffic crew of 9281
- Bureau of Meteorology.

References

Ezzeldin I & El Naggar H 2022, 'Numerical Modelling of Induced Stresses in Buried Corrugated Metal Structures Due to Compaction Efforts'*, Transportation Geotechnics* (100706), vol. 32.

Haviland JE, Bellair PJ & Morrell VD n.d., *Durability of Corrugated Metal Culverts*, Bureau of Physical Research, New York State Department of Transportation.

Rail Industry Safety and Standards Board 2014, *Hydrology and Hydraulics*, Version 1.0, AS 7637:2014.

Standards Australia 2011, *Buried Corrugated Metal Structures Part 1: Design methods*, Australian/New Zealand Standard AS/NZS 2041.1-2011.

Standards Australia 1998, *Buried Corrugated Metal Structures*, Australian/New Zealand Standard AS/NZS 2041:1998.

Wysokowski A 2021, *Impact of Live Load on Changes of Backfill Properties of Buried Flexible Steel Railway Structure,* Retrieved from https://doi.org/10.1007/s40515-021-00204-4.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- Aurizon
- rail traffic crew of 9281
- Queensland Rail
- Office of the National Rail Safety Regulator.

Submissions were received from:

- Aurizon
- Queensland Rail
- Office of the National Rail Safety Regulator.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

Date and time:	30 December 2020 – 0016 EST	
Occurrence category:	Accident	
Primary occurrence type:	Derailment	
Location:	9 km east of Charters Towers, Queensland	
	Latitude: 20º 2.848' S	Longitude: 146º 21.051' E

Train details

Track operator:	Queensland Rail	
Train operator:	Aurizon	
Train number:	9281	
Type of operation:	Freight	
Departure:	Hughenden, Queensland	
Destination:	Townsville Jetty, Queensland	
Persons on board:	Crew – 2	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Damage:	There was substantial damage to the track infrastructure and 11 wagons on the train.	