Transport and Main Roads

Independent Audit into the reliability of Queensland Rail's south-east Queensland network

Final report

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Contents

Terms of reference

Independent Audit into the reliability of Queensland Rail's south-east Queensland network

Background

The Queensland Government seeks independent advice to validate Queensland Rail's asset (network infrastructure) management practices for south-east Queensland to improve network reliability and safety.

Each year the south-east Queensland network carries more than 55 million passengers and over one billion gross tonne kilometres of freight. The Railway Manager for south-east Queensland is Queensland Rail who is responsible for maintaining the applicable assets, with financial support provided by the Department of Transport and Main Roads, on behalf of the Queensland Government, through the Transport Service Contract (Rail Infrastructure).

Terms of reference

The Independent Audit will:

1. investigate and assess the 28 February and 14 March 2012 incidents that resulted in widespread network disruption
2. investigate and assess whether the current asset management strategies in place by Queensland Rail, including maintenance, capital investment, systems and so on, contributed to the incidents
3. provide a final report that will advise on strategies to manage these assets into the future.

In conducting the Audit, the Department of Transport and Main Roads is required to:

- make an assessment of Queensland Rail's recent 2011 asset condition and management audit
- complete inspections of the rail infrastructure, including but not limited to: civil structures and track, signalling, telecommunications, and power systems and electrical overheads
- comment on the relationship between rolling stock maintenance and network issues
- review Queensland Rail's current and future maintenance and capital investment plans for south-east Queensland including Queensland Rail's broader investment strategy and prioritisation process for above and below rail capital works
- comment on the operational inter-relationships between above and below rail with a focus on impacts of the new timetable implemented in June 2011
- consider any associated reports and studies already undertaken.

Governance arrangements and reporting

The Department of Transport and Main Roads will report to the Minister for Transport and Main Roads, the Honourable Scott Emerson MP.

The Department of Transport and Main Roads is authorised to engage required officers and gain access to applicable documents, infrastructure (with safe working approval), information and records as deemed appropriate to complete the Audit.

The Audit was directed by the Minister for Transport and Main Roads on 12 April 2012 to be completed by 30 June 2012. Reports are to be provided in accordance with the following timetable:

31 May 2012	Interim Report highlighting material issues that have become apparent.
30 June 2012	Final Report

The independent Audit is to be funded from the Department of Transport and Main Roads' existing budget.

1 Executive summary

On any given weekday 160,000 people rely on the rail network in south-east Queensland to get them to and from work, school and other activities. Incidents such as the two that occurred on 28 February and 14 March 2012, severely disrupted the travel plans of tens of thousands of Queenslanders, cost Queensland taxpayers $2m for the “Fare Free Day” on 29 February 2012 and significantly eroded public confidence in Queensland Rail.

As a result of these events, on 12 April 2012, the Minister for Transport and Main Roads, the Honourable Scott Emerson MP, directed the Department of Transport and Main Roads undertake an audit to investigate the incidents and assess the reliability of the rail network in south-east Queensland.

This report is the outcome of these investigations.

26 recommendations (listed in Section 9) have been made for implementation by Queensland Rail and Transport and Main Roads.

Safety

No immediate safety issues requiring the attention of the Rail Safety Regulator or Queensland Rail were identified while the Auditors and technical experts were undertaking physical inspections of the network infrastructure and rolling stock.

The Audit team also considers that the south-east Queensland rail network is safe, and that potential safety issues are managed appropriately through relevant action and management plans and processes to ensure they do not become safety critical issues.

The incidents

The investigation of the two incidents that occurred on 28 February and 14 March 2012 has shown that actions could have been taken to prevent both incidents.

The incident on 28 February was the result of the incorrect installation of a wedge clamp, part of the overhead line equipment (OHLE). This led to a dewirement and subsequent signalling equipment failure. Had the clamp been installed correctly five years earlier the incident would not have happened.

Similarly, the incident on 14 March was the result of vegetation (Bougainvillea plant) coming into contact with the OHLE causing subsequent signalling faults. Queensland Rail had failed to identify the risk from this vegetation during regular OHLE inspections until just prior to the 14 March event. During a routine track inspection undertaken on 10 and 11 March the overhanging vegetation was identified and scheduled for removal over 17-18 March.

The terms of reference for this Audit directed Transport and Main Roads to not only investigate the two specific incidents, but also Queensland Rail’s asset management strategies and practices as they relate to track and civil structures, signalling, telecommunications, power systems and electrical overheads and rolling stock, including capital investment.

The Audit is to make recommendations to improve the reliability of the south-east Queensland rail network.

Reliability

The reliability of rail systems is commonly measured by on time running (OTR) data.

OTR on the Queensland Rail City Network is measured using a threshold of arriving at the intended destination within 3:59 (3 minutes and 59 seconds) of the scheduled arrival time.

OTR on other Australian metropolitan passenger rail networks is 4:59 (4 minutes and 59 seconds).

The Audit identified that the overall target for OTR has not been achieved by Queensland Rail for the period 1 July 2011 to 30 March 2012.

Approximately 50 per cent of the overall OTR delays can be attributed to the key asset categories of track and civil structures, overhead traction and signalling from the below rail perspective, and rolling stock from the above rail perspective.

Asset management

The rail network in south-east Queensland was first constructed in the late 1800s with expansion and additional lines continuing to be constructed. While the network continues to be replaced and enhanced, it is an aged network. Based on the independent technical advice, it is in relatively good condition for its age but does need significant upgrade. By way of example, the network was electrified in the late 1970s and early 1980s, but there has been no significant upgrade to the electrification system since. Additionally, the signalling system, while functional, is at capacity, and the end of its life must be planned in the very near future to enable timely delivery.

While the network is considered to be well managed for its age, Queensland Rail needs to ensure its current capital and operating programs consider both critical and emerging infrastructure needs while the new asset management processes and practices are maturing.

Over the past two years Queensland Rail has moved from its previous maintenance practices to adopt an asset management philosophy. This asset management approach will take time to fully implement and mature, and most importantly for the benefits to be realised.

This new asset management approach will provide a better approach to repair and replacement of infrastructure and provide greater capacity to forecast and prioritise work.

Investment

Queensland Rail provides both passenger services and network management for south- east Queensland on behalf of the state. This is currently managed through a series of Transport Service Contracts (TSC) with Transport and Main Roads and the Translink Transit Authority that include passenger, maintenance, operational and capital delivery services under varied governance arrangements and performance drivers.

The Audit team noted that significant rail capital investment has been forecast and programmed for south-east Queensland, with further requirements identified for the coming years to meet the business needs of Queensland Rail. The report notes that at times Queensland Rail has demonstrated a piecemeal approach to planning significant capital investments, including their asset replacement and enhancement programs.

The Audit team also noted that the state has multiple TSC purchasers which complicates the prioritisation and management of rail capital investment. The opportunity exists to improve the practice to better deliver on Government transport objectives and value for money outcomes.

Implementation

Queensland Rail is to provide an implementation plan in response to the findings and recommendations of this Audit by 15 August 2012. Further, reporting to the Minister will commence by 15 October 2012 and continue quarterly until the recommendations are fully implemented. Similarly, Transport and Main Roads will also provide an implementation plan by 15 August 2012 and report quarterly on the same basis.

This Audit has been undertaken within a constrained timeframe. The Audit team appreciate the cooperation given by Queensland Rail staff in the gathering of incident evidence as well as the wider audit tasks of on-site inspections and management systems analyses. This Audit could not have been achieved without their cooperation.

2 Audit on reliability

2.1 Introduction

On 12 April 2012 the Queensland Minister for Transport and Main Roads, the Honourable Scott Emerson MP, directed Transport and Main Roads to undertake an independent Audit to investigate and assess Queensland Rail Limited's (Queensland Rail) asset management strategies and practices as they relate to track and civil structures, signalling, telecommunications, power systems, electrical overhead equipment and rolling stock. The Audit was also required to consider capital investment on the south-east Queensland network and to provide a final report that will advise on the future management of these assets to improve reliability and safety.

The Audit is in response to two incidents which caused widespread disruption to train services during the morning peaks on Tuesday 28 February 2012 at Roma Street, and Wednesday 14 March 2012 at Milton.

On 13 April 2012 Transport and Main Roads brought together an Audit team of rail safety investigators, auditors and project management staff, augmented for a four week period with specialist technical expertise from Interfleet Technology. Interfleet and Transport and Main Roads undertook physical assessments of track and civil structures[1], signalling, telecommunications, OHLE and rolling stock.

The Audit examined rail reliability from the perspectives of the network infrastructure and rolling stock. It did not examine reliability from the perspectives of train operations, train control or passenger services, including passenger loading and passenger interactions.

The south-east Queensland network (Figure 1) comprises over 700km of electrified track between Nambour in the north, Rosewood in the west and Varsity Lakes in the south. The network is accessed on a daily basis by over 200 three-car trains servicing more than 55 million passengers annually on 11 lines, long distance passenger services operated by Queensland Rail and the Rail Corporation of New South Wales, and coal, general freight, seasonal livestock and grain trains.

From the south and west all passenger trains enter the city through Roma Street and from the north and east all passenger trains enter the city from Bowen Hills through Fortitude Valley, with the trains travelling along a 4km long multi track corridor between Roma Street and Bowen Hills. All passenger trains travelling to and from south of the city (Cleveland, Beenleigh, Gold Coast and Interstate Lines) travel across the Merivale Bridge. Trains travelling from Ipswich to Brisbane travel on the designated inbound tracks between Corinda and Roma Street.

An interim report was provided to the Minister for Transport and Main Roads on 31 May 2012. This report was a factual report into the incidents of 28 February and 14 March 2012.

This report summarises the findings of the investigations of the incidents which occurred on 28 February 2012 and 14 March 2012. The report also summarises the findings of the Audit of Queensland Rail's track and civil structures, signalling, telecommunications, power systems, electrical overhead equipment and rolling stock asset management systems.

1. Civil structures – Any underbridge, overbridge, footbridge, culvert, drain, earth embankment/cutting and station platform.

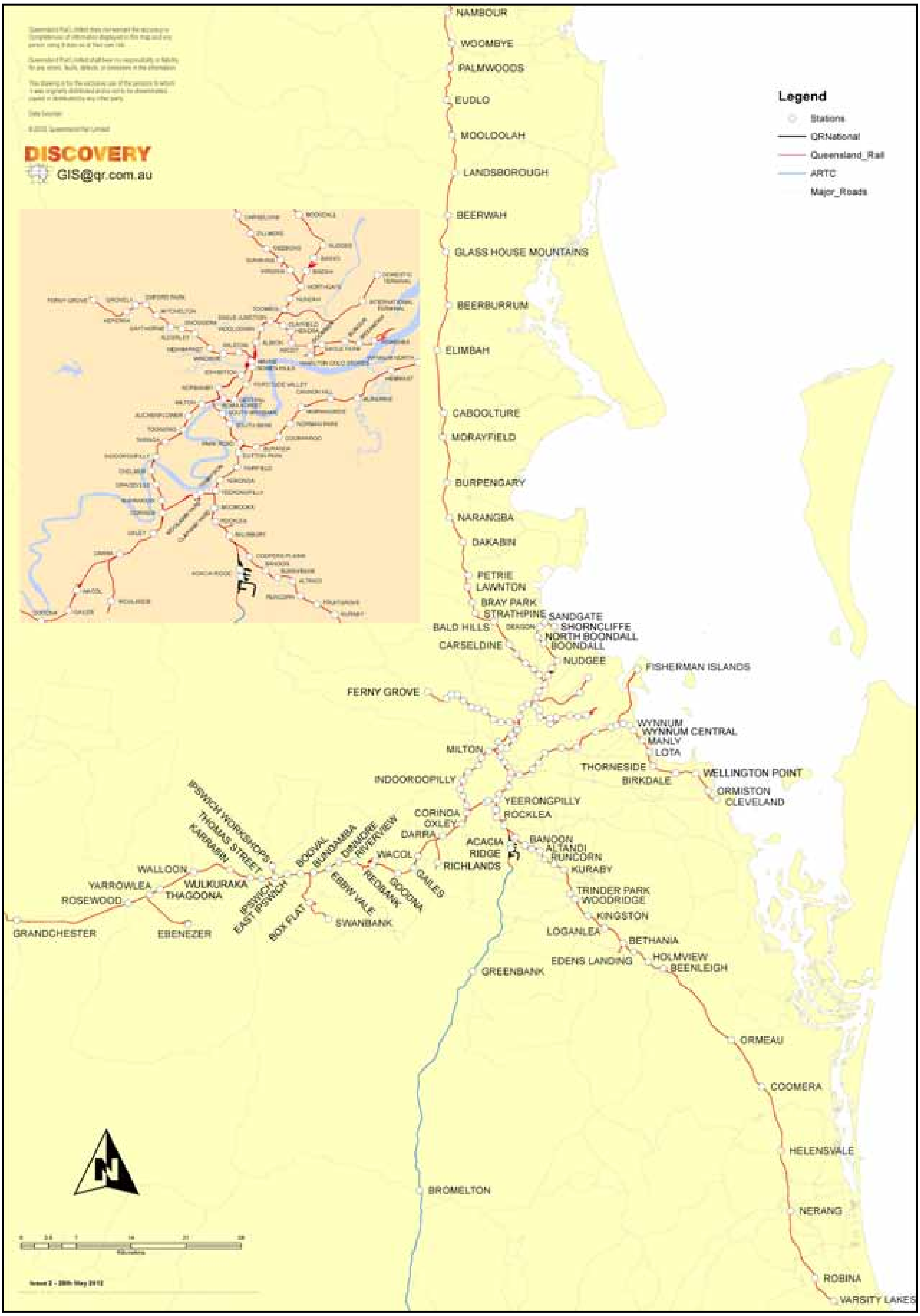

Figure 1 – South-east Queensland rail network.

2.2 Audit methodology

The Audit terms of reference required that the Audit begin with an investigation of the 28 February 2012 (Roma Street) and 14 March 2012 (Milton) incidents.

Following the collection and analysis of factual information in relation to the incidents, the Audit team broadened its investigation to include various elements of the asset management systems which may have contributed to the causes of the incidents.

As part of this approach Queensland Rail's asset management strategies and practices were audited. The Audit included track and civil structures, signalling, telecommunications, power systems, electrical overheads and rolling stock, including capital investment on the south-east Queensland network. Recommendations have been made to manage these assets in the future.

These investigations established:

- the sequence of events
- the immediate cause(s)
- the contributory elements of the asset management system.

The Audit of the asset management system included review, assessment and/or inspection of:

- the findings from the 2011 external Audit of Queensland Rail's asset condition
- Queensland Rail's rail infrastructure, including civil structures, track, signalling, telecommunications, power systems and OHLE
- the relationship between rolling stock maintenance and network issues
- Queensland Rail's current and future maintenance and capital investment plans for south-east Queensland.

The Audit analysed information obtained from a number of sources including:

- Queensland Rail standards, procedures, reports, databases and associated records
- field inspections of selected sections of track, OHLE, signalling assets and rolling stock
- interviews with Queensland Rail's frontline staff.

Interviews were also conducted with Queensland Rail managerial staff to ascertain:

- the degree of compliance being achieved by Queensland Rail with its standards
- how Queensland Rail plans, executes, monitors and reports on the various track, civil structures, electrification, signalling and rolling stock maintenance activities
- the usage of asset management database systems
- how faults are managed from identification to completion of corrective action
- how unscheduled work tasks are managed from identification to completion
- how maintenance and asset replacement activities are identified and progressed
- how staff training and competencies are identified, planned and delivered.

3 Network reliability

During the course of the Audit various reports relating to the south-east Queensland network service reliability and performance were reviewed. The review focused on asset reliability and OTR (network) data to identify the number of incidents impacting on service delays. This section discusses broad issues identified during the review.

3.1 What is reliability?

Reliability in the rail industry is measured by a variable known as OTR.

In relation to City Network services, a train service is deemed to have run on time if it reaches its destination within 3 minutes and 59 seconds of the scheduled arrival time. The 2011-12 target for peak services is 93.77 per cent and will increase to 94.53 per cent on 1 July 2012.

Other Australian metropolitan passenger rail operations use the OTR threshold of 4 minutes and 59 seconds. Queensland is the only state that uses the lower threshold.

For the period 1 July 2011 to 30 March 2012 the average OTR performance achieved by Queensland Rail was 92.87 per cent. OTR performance in March 2012 was 85.33 per cent.

In April 2012, TransLink issued Queensland Rail with a Performance Improvement Notice to provide a well structured, evidence based analysis explaining the reasons for the decline of OTR (overall) performance in the past quarter and more importantly, the steps Queensland Rail intends to take to ensure that OTR performance returns to acceptable levels. The Performance Improvement Plan was provided to and accepted by TransLink in June 2012.

3.2 Peak period[2] train service delays

Figure 2 outlines the performance delay categories for the period July 2011 to March 2012. Of the 13 delay categories, the four categories of permanent way, overhead traction wire equipment, signalling and rolling stock were audited.

These four delay categories represent 50 per cent of the delays on passenger peak period services.

2. Peak period - Defined by Queensland Rail as inbound services arriving at Central Station between 0600 and 0900, and outbound services departing Central Station between 1530 and 1830.

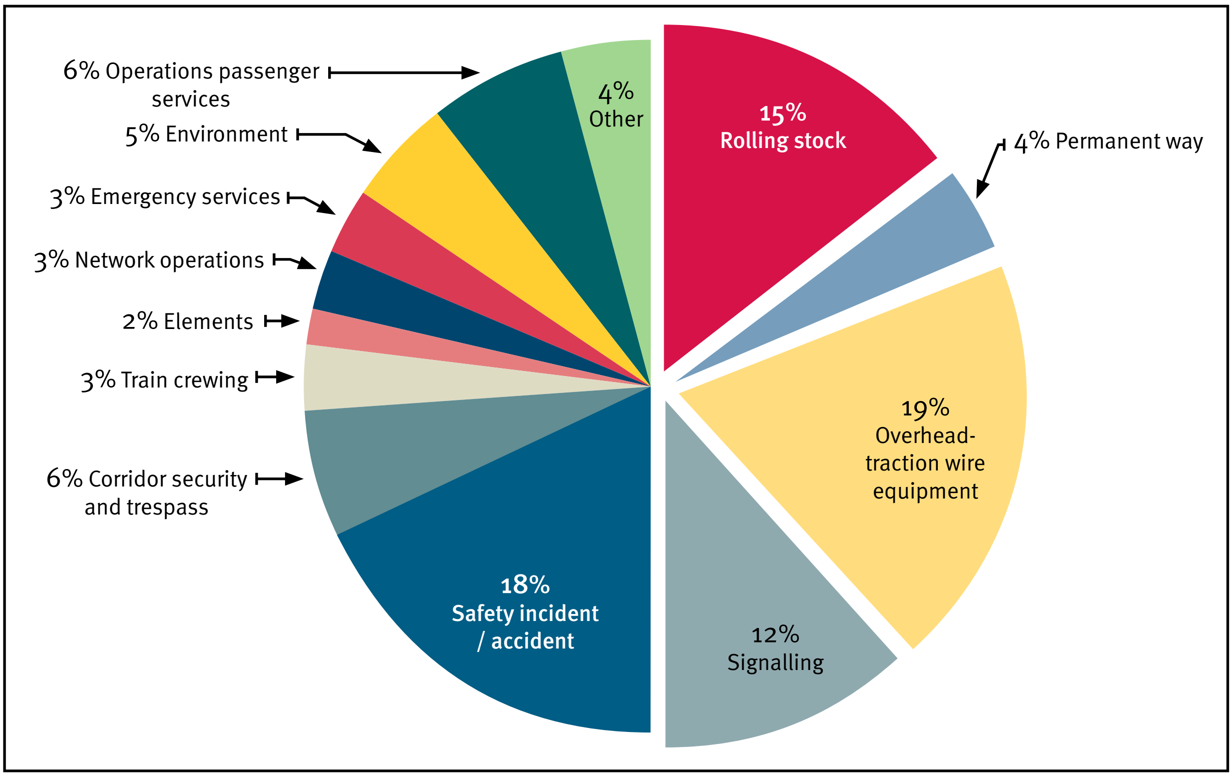

Figure 2 – Delay categories 1 July 2011 to 31 March 2012
Source: City Network Transport Service Contract – Queensland Rail Monthly Report to TransLink March 2012

The 13 categories are attributed to the broader grouping of operator, network, and force majeure which was not subject to the Audit.

- **Operator:** delays attributed to an above rail incident for example rolling stock faults are included in this audit and equate to 15 per cent of the delays as in Figure 2.
- **Network:** delays attributed to network related incidents for example, overhead traction wire equipment, permanent way or signal failure are included in this Audit and equate to 35 per cent of delays in Figure 2.

The Audit paid particular attention to asset management practices and associated elements which:

- had contributed to the incidents of 28 February 2012 and 14 March 2012
- would prevent signalling and overhead traction wire equipment related incidents
- impact rolling stock maintenance and availability.

Discussion and findings in relation to the asset management audit are included in section 6 of this report.

Finding:
50 per cent of incidents impacting on OTR performance on the south-east Queensland network are related to network and rolling stock issues.

3.3 Asset reliability

The south-east Queensland network related major incident counts for the period July 2009 to March 2012 shows an improving trend (refer figure below).

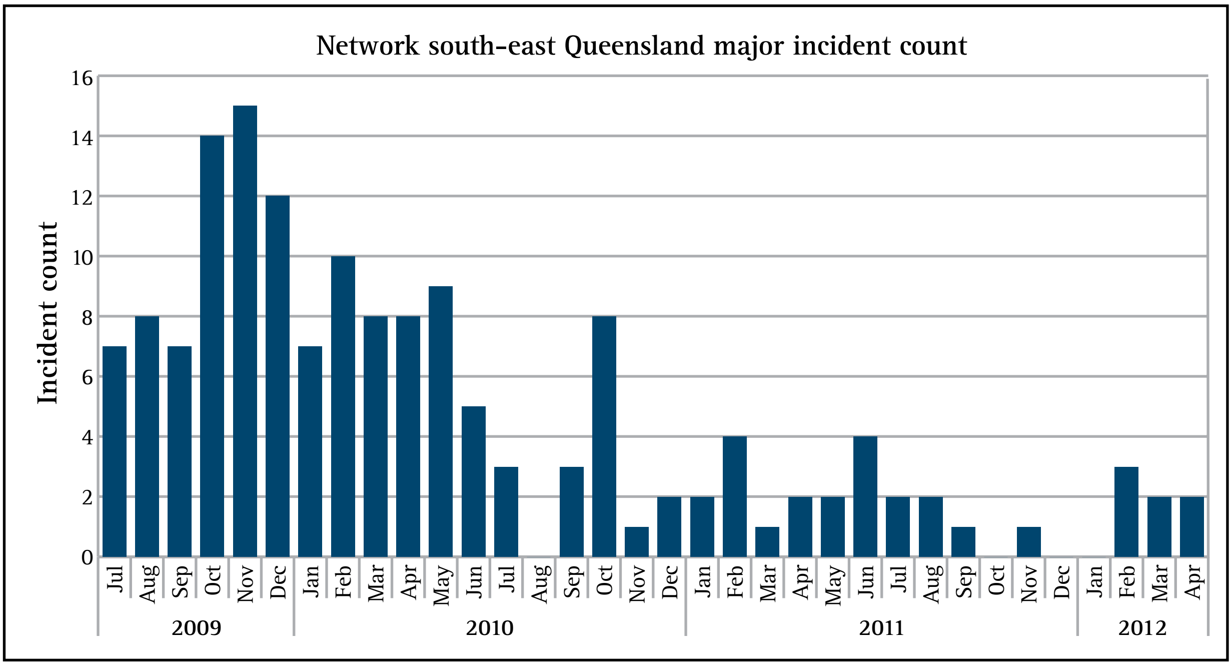

Figure 3 – South-east Queensland network major incident counts.

Although there is an improvement in major incident counts, some of these incidents, due to the location and time they occur, have a large scale impact on the OTR (network) performance. For example, in November 2011 there was only one major incident recorded, however this incident had significant impact on the OTR (network) performance, similar observations are made for the February and March 2012 incidents.

Finding:
South-east Queensland network related major incident counts from July 2009 to March 2012 showed an improving trend.

4 28 February 2012 incident at Roma Street

4.1 Factual information

4.1.1 Background

At approximately 0425 hours on 28 February 2012 an alarm was received at the Queensland Rail Train Control Centre at Mayne. The alarm indicated a trip of overhead traction power from Roma Street to Bowen Hills and Roma Street to Taringa sections on the Down Main Line. A subsequent attempt to reset the trip was unsuccessful. At around the same time, signalling and track detection faults were experienced on the Bowen Hills to Roma Street and Roma Street to Taringa rail corridors indicating an electrical irregularity in the area.

As a result of these failures, the Train Controller made an emergency radio call to all trains in the immediate vicinity of Roma Street to stop. This resulted in two trains being held on the affected sections.

Due to the signal fault failures in the Roma Street precinct all trains were terminated at South Brisbane, Milton and Fortitude Valley stations.

The affected OHLE section was left de-energised to allow the section to be safely inspected by Overhead Linesmen.

Queensland Rail personnel identified a dewirement[3] approximately 500 metres west of Roma Street station as having caused the initial trip. The dewirement was caused by an overhead line failure. Following the dewirement the failed wire fell to the ground and contacted both the signal rail[4] and traction rail[5].

Subsequent to the failed overhead wire contacting the signal rail, major signalling faults and points failures began occurring on tracks from Roma Street to Milton and some parts of the tracks from Roma Street to South Brisbane. These faults were attributed to the high electric currents flowing to earth from the dewirement. This high electrical current entered the trackside signalling system causing damage to protection modules associated with signalling data links in the Station Equipment Room at Roma Street.

The dewirement and failure of the signalling system caused significant delays to train services over an extended period of time. As a result of the incident, a total of 245 trains were affected, of which 110 train services were cancelled, 85 train services were delayed and 50 train services were terminated as close to the city as possible. A further 212 train services experienced consequential delays as a result of the incident. Buses and taxis were arranged to convey a number of passengers to their destinations.

Following repairs to the damaged OHLE and signalling systems normal train services resumed at approximately 1517 hours, approximately 11 hours after the initial failure.

4.1.2 Location

The location of the dewirement was in close proximity to OHLE mast W/0/499 which is adjacent to the Down Main Line on the western corridor, approximately 500 metres from the Roma Street railway station (refer Figure 4).

3. Dewirement - Considered to have occurred when the overhead traction contact wire dislodges from its designed installation location.
4. Signal rail - Used to provide train detection and is connected to the signalling system.
5. Traction rail - The rail that carries the traction return current.

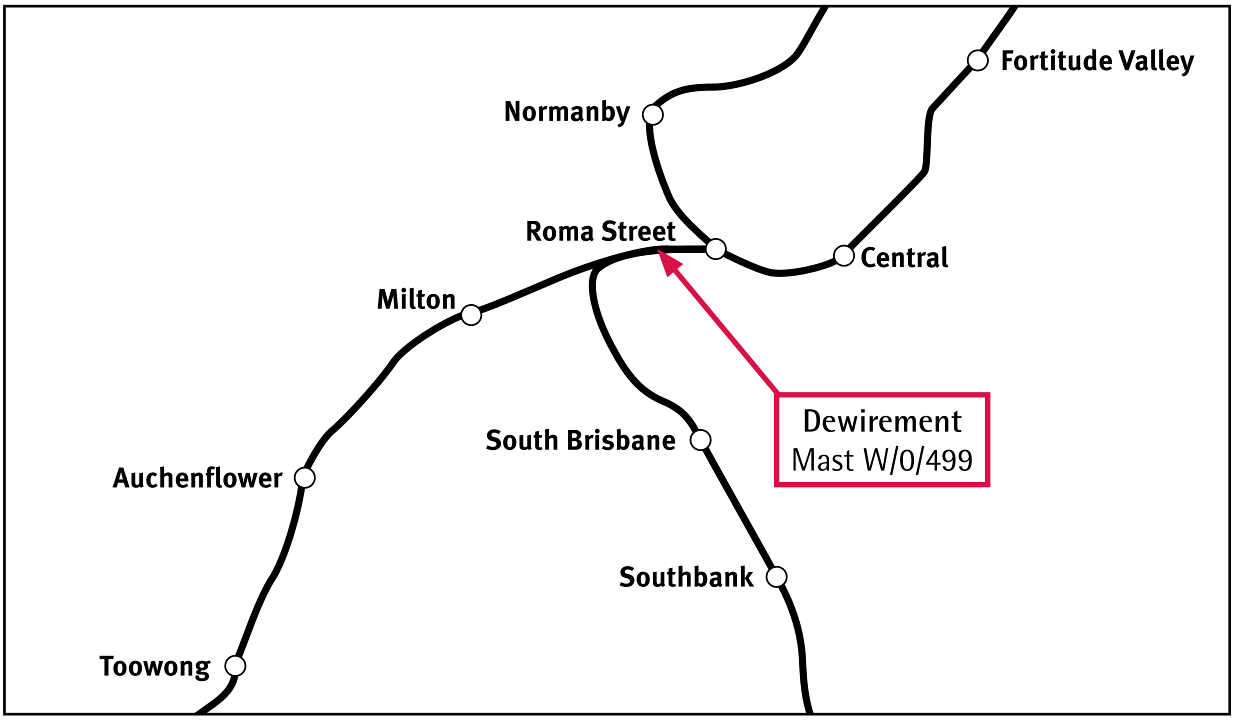

Figure 4 – 28 February 2012 Roma Street incident location.

4.1.3 Sequence of events

A chronology of events prior to, and following, the OHLE trip was collated using information gathered from sources including:

- data collected from the Train Control Centre
- interviews with Queensland Rail personnel
- incident reports prepared by Queensland Rail personnel.

At approximately 0425 hours, a contact wire secured by a wedge clamp located above the Down Main Line approximately 500 metres west of Roma Street railway station on the Western Line corridor fractured, causing a dewirement.

Following the dewirement, the parted end of the wire, carrying 25,000 volts AC made contact with both rails. One of these rails is used to provide detection for the signalling systems while the other supports the traction power system.

The flow of excess current through the traction return rail activated the protection circuit breakers fitted at the Roma Street and Mayne Feeder Stations, resulting in a traction power trip. This trip generated an alarm on the Electric Control Operator's panel located at the Train Control Centre at Mayne.

Further, the passage of excess current through the signal rail caused damage to various items of signalling equipment, mainly the track leads, an insulated rail joint and track surge arrestors. Transient faults also affected a number of other track circuits in the vicinity. Due to these signalling system faults the Universal Traffic Control[6] System which is located in the Train Control Centre displayed an alarm indicating multiple track detection faults at Roma Street station.

Shortly after the initial dewirement the Train Controller instructed a passenger train approaching platform 9 at Roma Street railway station to stop.

6. Universal Traffic Control - A remote control system that provides the operator interface between train controllers and signalling system in the field.

At approximately 0429 hours, an empty passenger train, on its pre-determined route, crossed over from the Down Suburban Line to the Down Main Line near Fortitude Valley. The driver of this train reported sparking on its pantographs[7]. The driver was immediately instructed to stop the train. The passage of this train resulted in OHLE electrical section tripping on the Up Main Line between Bowen Hills and Roma Street.

A subsequent attempt to reset sections of the OHLE was unsuccessful.

At 0456 hours an attempt to reset the signalling circuit breakers by a Queensland Rail electrician was also unsuccessful.

At 0500 hours Queensland Rail linesmen arrived at the incident site and confirmed that a contact wire on an electrical section of the western Down Main Line had fallen to the ground. The dewirement also affected the Up Main Line. The linesmen commenced isolation of the relevant OHLE sections.

At 0533 hours the track faults in the vicinity of two sets of points[8] on the Up and Down Suburban lines at Roma Street were cleared. However, a section of track circuit remained failed, which in turn prevented trains from Milton and South Brisbane from entering the Roma Street precinct.

Between 0640 hours and 0800 hours various track detection faults occurred in the vicinity of Roma Street. These faults were later attributed to intermittent failures of data line arrestors. The faults were repaired by 0800 hours. During the period of repair, trains were terminated at various inner city stations and returned to their respective points of origin to provide further services.

At 0806 hours the Up and Down Suburban Lines (which run parallel to the Up and Down Main Lines) at the location of the incident were opened for limited train operations. The opening of these lines allowed some trains to enter the Roma Street precinct, while the Up and Down Main Lines remained isolated to allow Queensland Rail personnel to continue repairs to the affected OHLE.

At approximately 1517 hours the repairs to the OHLE were completed and rail operations resumed.

4.1.4 Weather conditions

At the time of the incident the temperature was recorded as about 22 degrees C with average wind speed of about 2 km/hr. Bureau of Meteorology records indicate that Brisbane city, the closest recording station to the incident site, received no rainfall in the ten hours prior to the incident.

Local time	Wind direction	Wind speed	Temprature (degree celsius)	Rainfall from 10 hours prior (mm)
0425 hours	South West	2 kilometres per hour	22	0.0

Table 1 – Weather details for Brisbane city on 14 March 2012 (Source: Bureau of Meteorology).

4.1.5 Overhead line equipment

The OHLE is part of the network electrification infrastructure. The OHLE is made up of electrically separated sections to allow isolation of faults and maintenance to the OHLE without having to turn off the power on the entire system. Electric trains in the south-east Queensland network collect their electrical current from an overhead line system through a pantograph. The pantograph presses against the underside of the contact wire of an overhead line system.

The railway corridor at the location of the dewirement comprises a total of four lines consisting of Up and Down Main Lines and Up and Down Suburban Lines. All four lines are electrified with 25,000 volts AC overhead traction power. The Down Main Line is located on the northern side of the Western Line corridor on the far right hand track of the four track corridor when looking towards Milton (Figure 5).

7. Pantograph – A piece of equipment fitted to the roof of an electric train to draw traction power from the overhead line.
8. Points – A moveable rail that allows a train to change its route.

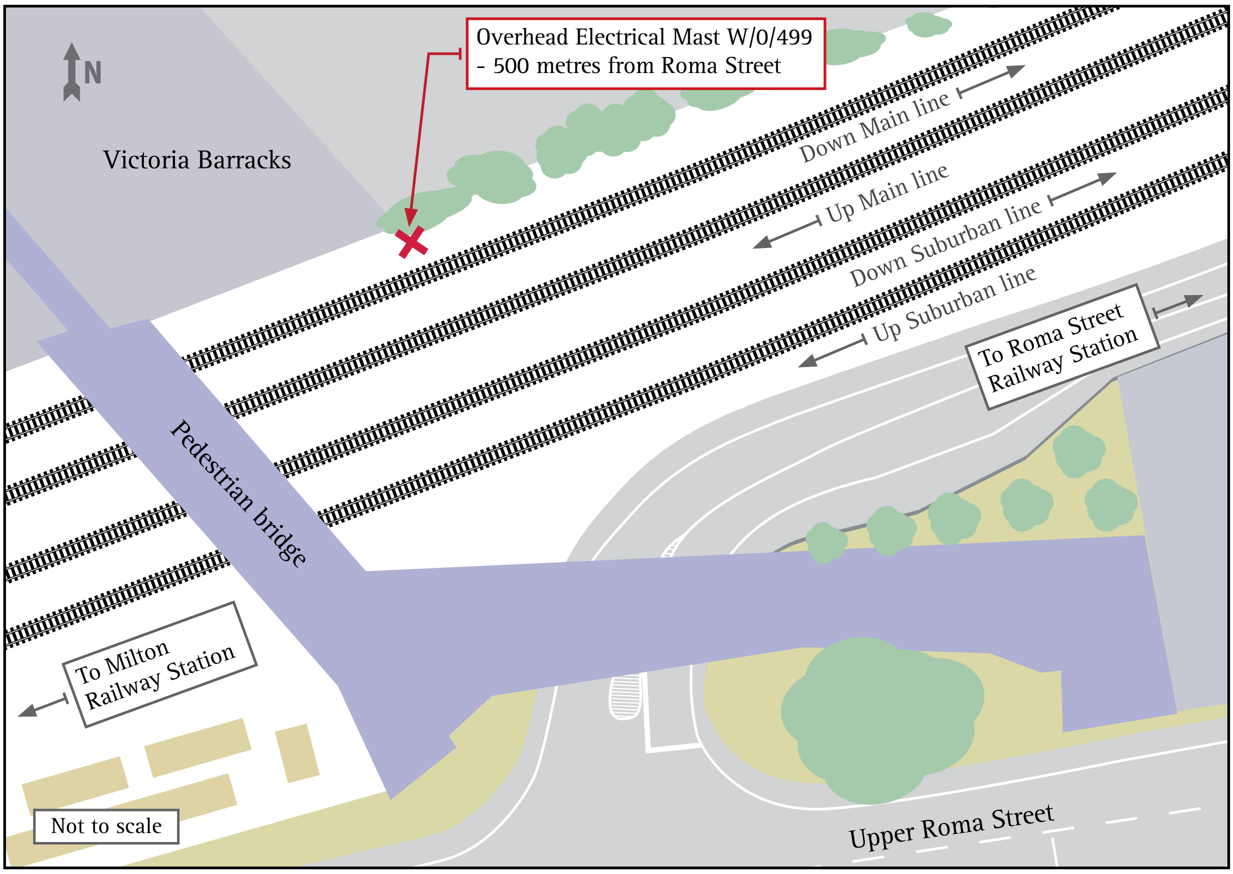

Figure 5 - Dewirement location near Roma Street.

The fractured contact wire was secured by a wedge clamp prior to the incident. This wedge clamp was installed approximately five metres above rail level in the vicinity of the Down Main Line near OHLE mast number W/0/499 (refer Figure 6).

Figure 6 – Dislodged OHLE.

4.1.6 Contact wire wedge clamp

The failed contact wire in the wedge clamp was used to secure the end of a section of tensioned OHLE above the Down Main Line approximately 500 metres west of Roma Street station on the western line corridor.

There are more than 2000 such wedge clamps in operation on the south-east Queensland network. This design of wedge clamp has been installed on the south-east Queensland network from the early 1990s. These wedge clamps are used to connect the end of the contact wire with various components of the OHLE. The wedge clamp is made of two major components, wedge clamp housing and wire keeper (wedge) (Figure 7). The contact wire is passed through the mouth of the wedge clamp housing and is kept secured in the clamp by firm contact of the serrated teeth of the wedge (Figure 8).

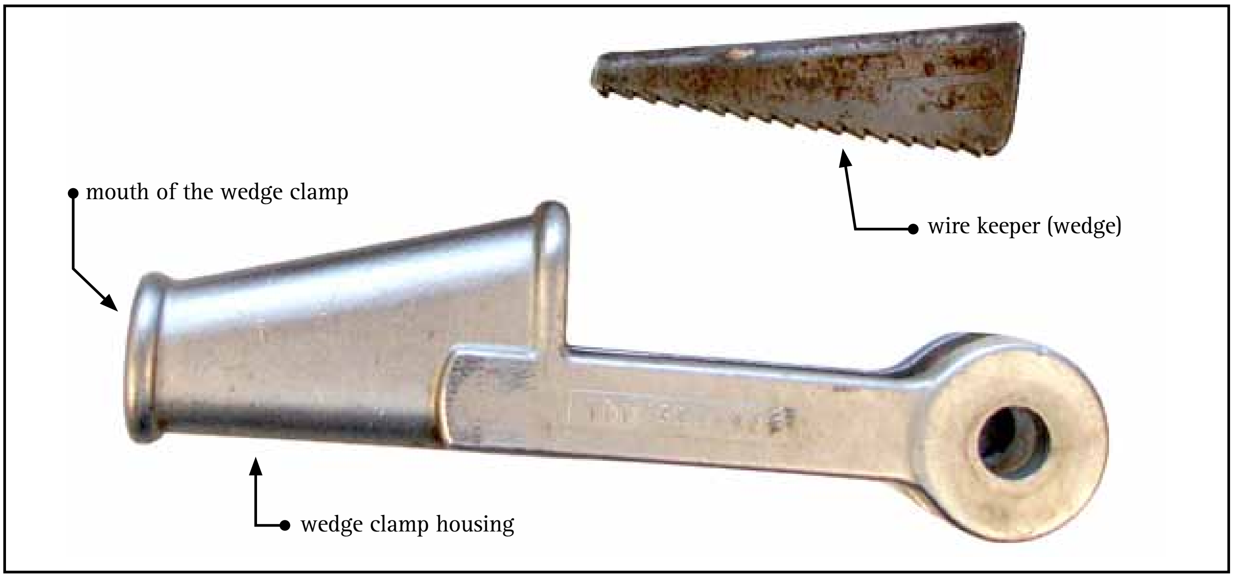

Figure 7 – Wedge clamp assembly.

Following the dewirement, the wedge clamp was found to be in good condition; however, the contact wire had not been installed in accordance with the approved construction drawing (Figure 8).

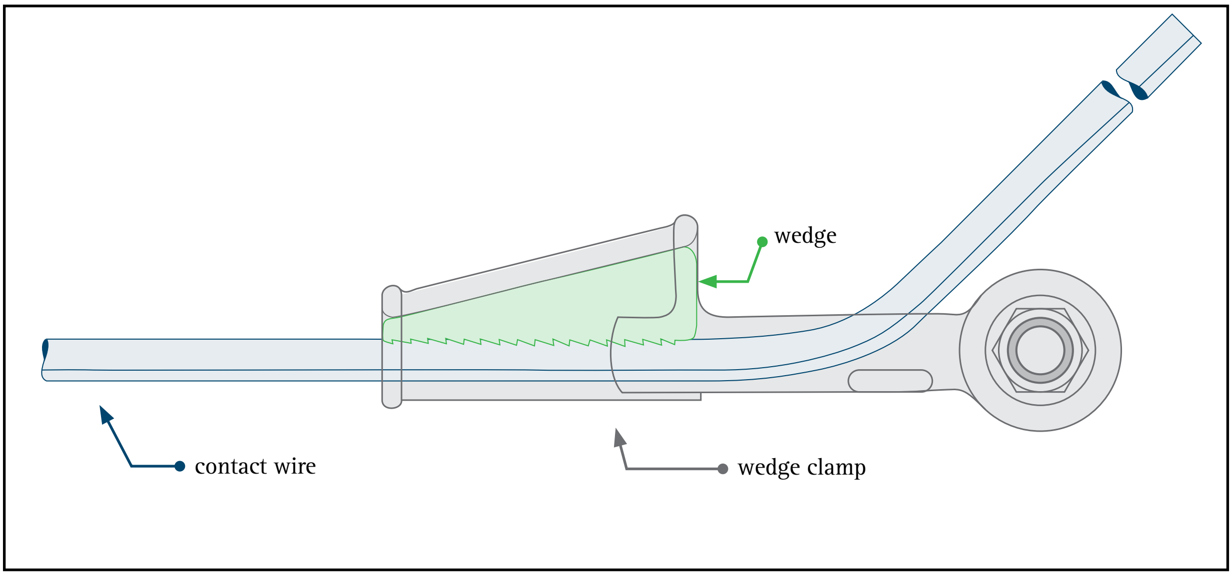

Figure 8 – Correct wedge clamp assembly.

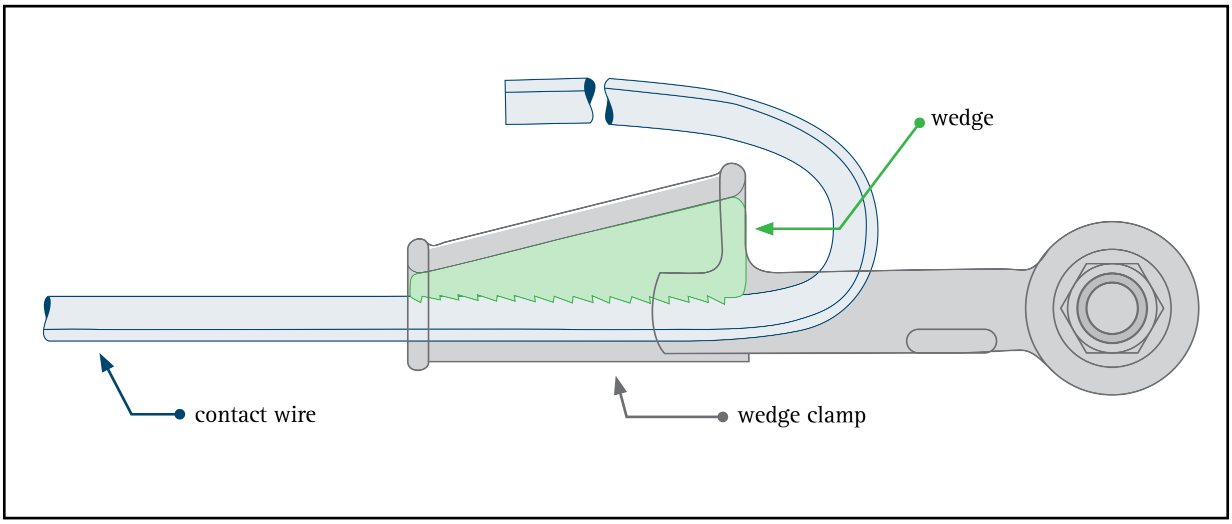

Figure 9 – Incorrect wedge clamp assembly.

It is understood that all other wedge clamps of this type across the network are installed with their contact wire end looped (Figures 9 and 10).

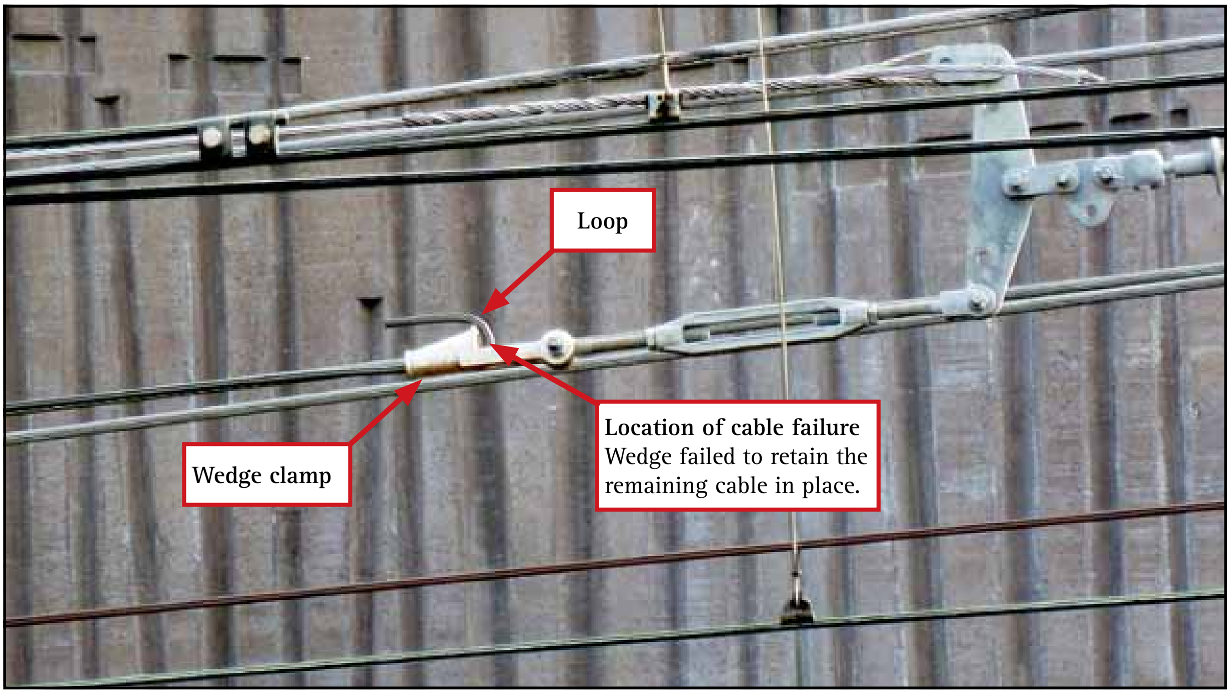

Figure 10 – Wedge clamp installation across south-east Queensland network.

The incorrectly installed wedge clamp had been in service for approximately five years and was installed by Queensland Rail personnel.

The failure is the only known failure by incorrect installation among the 2000 or so clamps installed since the early 1990s.

In 2009, Queensland Rail introduced a new design of clamp (Figure 11) which is vastly different in design from the incorrectly installed wedge clamp. The selection and introduction of the new design was made on the basis of simplicity and ease of installation. Queensland Rail has not used wedge clamps of the type which caused the failure on 28 February 2012 in new constructions since the introduction of the new type of clamp. However, the wedge type of clamp involved in 28 February 2012 incident is still used during OHLE repair and modification work.

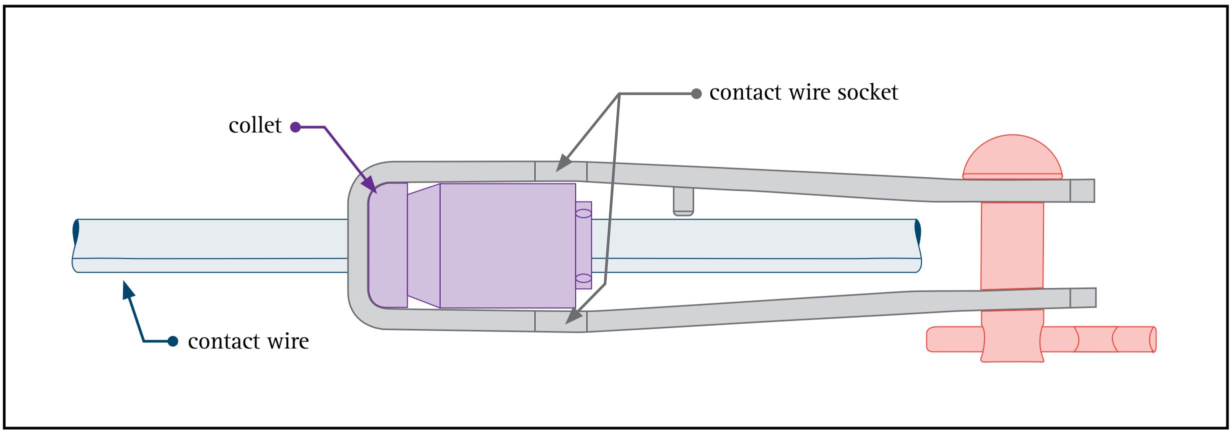

Figure 11 – New design clamps.

4.1.7 Signalling equipment

The signalling system at this location is known as automatic block signalling which is an electronically controlled remote signalling system using trackside coloured lens signals and track vacancy detection (electrical currents through the signal rail) to automatically control train access. Associated signal cabling is located in surface troughing at the site of this incident.

4.1.8 Recovery

A review of the work undertaken by Queensland Rail to recover from the incident and to return the network to a normal operational state was undertaken. The duration of time from the incident occurring to when the first train operated over the restored section was approximately 11 hours. During that time, while maintaining safe work practices, Queensland Rail:

- mobilised staff to investigate the cause
- made the affected area electrically safe
- investigated the extent of the damage caused
- mobilised repair staff, materials and plant
- carried out repairs
- conducted functional testing after the repairs had been completed
- cleared the repair site
- reopened the lines to traffic.

4.2 Analysis

4.2.1 Wedge clamp

4.2.1.1 Wedge clamp examination

Following the incident, an examination of the incorrectly installed wedge clamp revealed that the installation of the wedge did not provide sufficient grip on the contact wire. This was evidenced through minimal visible marks on the contact wire from the wedge teeth, suggesting wire tension was carried by the loop of the contact wire rather than the wedge. This resulted in a gradual weakening of the contact wire over a small contact area of the loop eventually fracturing the contact wire.

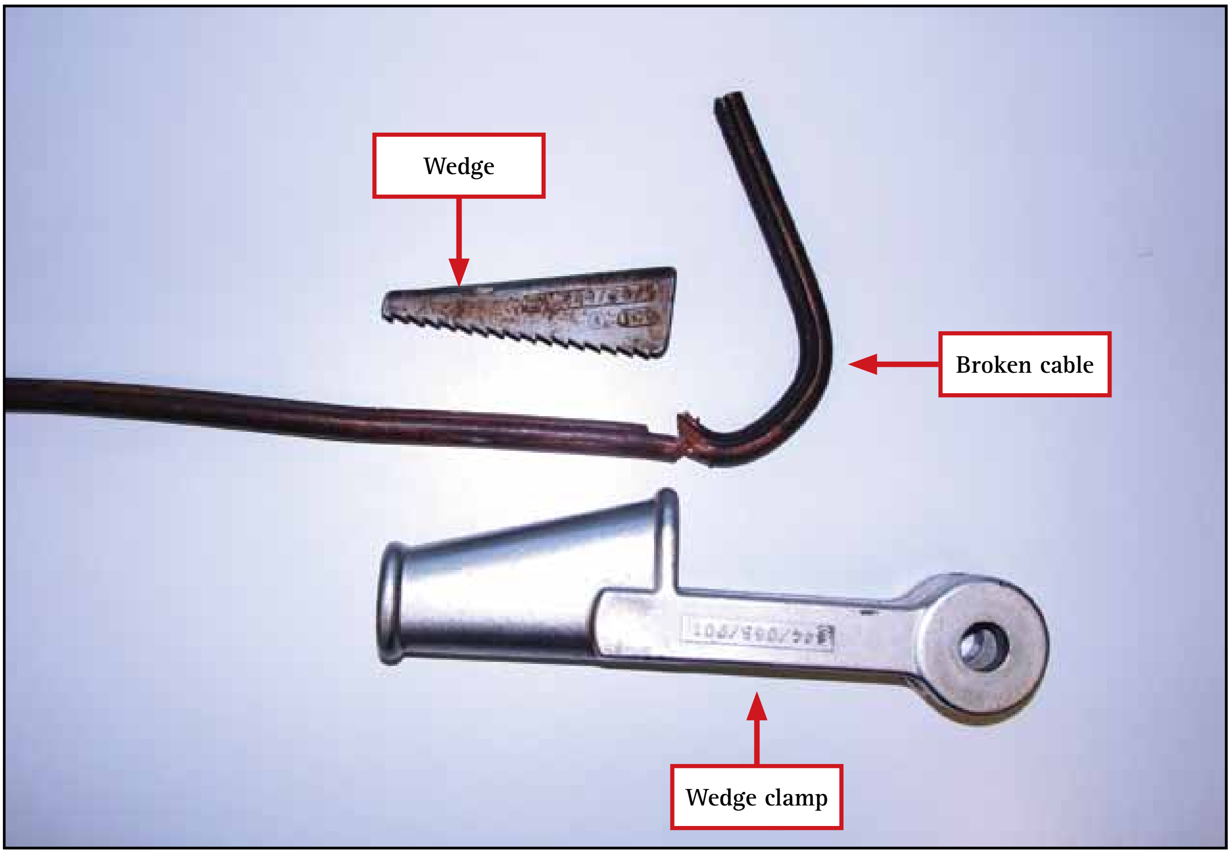

Figure 12 – Incorrectly installed wedge clamp.

Appropriate installation of the wedge clamp requires that the contact wire has only a slight bend beyond the end of the wedge clamp (Figure 8). At the time of installation, the installation practice on this type of wedge clamp was to bend (loop) the contact wire around the back of the wedge clamp (Figure 9 and 10). Engineering tests, following the incident, confirmed that it is immaterial whether the contact wire is looped or not as long as the wedge has been installed properly to provide sufficient grip on the contact wire. In this instance it appears that the act of bending the contact wire prior to placing the clamp under tension has prevented it from properly engaging the wedge. The most likely failure mechanism is illustrated in Figure 13.

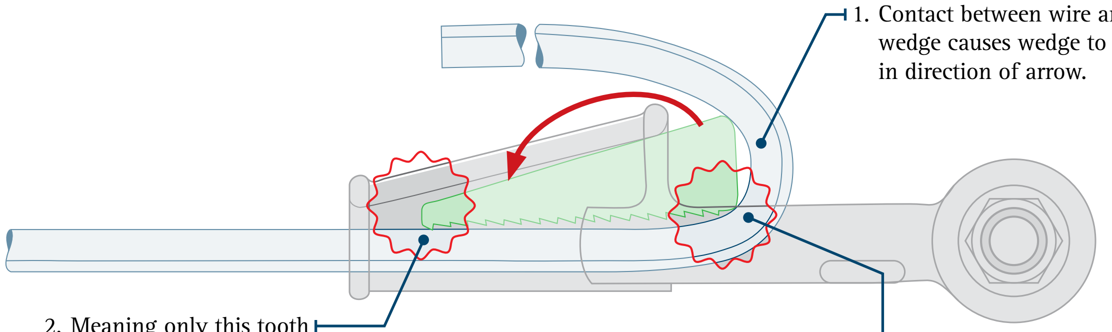

Figure 13 – Failure mechanism.

Finding:

The dewirement was caused by the insufficient gripping of the contact wire due to incorrect installation of the wedge clamp.

4.2.1.2 Test results

Following the dewirement, Queensland Rail engineering tests confirmed:

1. the contact wire quality had not contributed to the fracture
2. orientation of the contact wire installation in the wedge clamp had no bearing on its function or performance
3. it is immaterial whether the contact wire is looped or not if the wedge has first been installed properly to provide sufficient grip on the contact wire.

4.2.1.3 Installation procedure and training

The incorrectly installed wedge clamp had been in service for approximately five years and had been installed by Queensland Rail personnel. Overhead Linesmen are formally trained at 'linesman training' on installing wedge clamps. There is no specific work instruction, standard or procedure available to OHLE staff to use as a reference for the assembly of contact wire wedge clamps. Prior to this incident, the 'linesman training' did not emphasise the requirement for not having to loop the contact wire around the wedge clamp. Further, looping the contact wire around the wedge clamp appears to be an historic practice and has not been formally reviewed.

Findings:

There is no specific work instruction available for the assembly of contact wire wedge clamps.

Linesman training does not emphasise the requirement for not having to loop the contact wire around wedge clamp.

Linesman training has not been formally reviewed.

4.2.1.4 Installation supervision

All OHLE repairs, modifications and renewals on the south-east Queensland network are subject to final sign off by the Construction Engineer and independent checks are made by the Reliability Engineer. As there are over 2000 wedge clamps of similar design installed across the south-east Queensland network with the contact wire end looped, it is apparent that responsible OHLE supervisors were unaware of the appropriate installation requirement of the wedge clamp.

Finding:
OHLE supervisors were unaware of the appropriate installation requirement of the wedge clamp.

4.2.1.5 Scheduled inspections

According to routine inspection requirements, the OHLE staff carry out visual inspections of the OHLE at four weekly intervals. As the location of the wedge clamp was approximately five metres above the rail level any weakening or fraying of the cable would not have been visible during these inspections.

In the Audit team's opinion, no other inspection and maintenance regime routinely used by other railway administrations would have been able to detect the impending failure of the type suffered at Roma Street.

4.2.1.6 Corrective action

There are over 2000 similar contact wire wedge clamps in service on the south-east Queensland network. A close physical inspection of each wedge clamp would necessitate the electrical isolation of the OHLE and be very time consuming (two to four hours per clamp). A wedge clamp inspection program using a pole mounted video camera for the inner city has commenced with the aim of completing the inner city clamp inspections by the end of July 2012. Since the incident, Queensland Rail:

1. has inspected 34 wedge clamps within the Roma Street to Bowen Hill precinct. No suspect clamps were identified (as of 18 June 2012)
2. continues to inspect wedge clamps as and when track access is available
3. issued a Traction Maintenance Alert to both Maintenance and Construction Overhead depots instructing staff to cease usage of this style of wedge clamp pending technical investigation, and to visually inspect any that they are working near and remove from service any suspect ones
4. recommended (following the technical investigation) that instructions be issued to overhead depots that it is approved for wedge clamps to be used on contact wire terminations, however they must be installed precisely as per the construction drawings and the practice of the looping of the contact wire must cease
5. initiated reviewing its 'linesman training' modules with a view to incorporate instruction for the correct installation of wedge clamps on contact wire.

4.2.1.7 Review of Queensland Rail corrective actions

As Interfleet were the technical expertise providers to the Audit team, they reviewed the corrective actions taken and proposed by Queensland Rail. They were requested to provide an independent assurance that the actions being undertaken will, as far as reasonably practicable, prevent the re-occurrence of a similar incident.

The review concluded that Queensland Rail initiated and suggested corrective actions must continue and be fully implemented. Further, a clear set of installation instructions for all types of OHLE fittings in use should be developed and briefed to staff. Provided these actions are completed, Interfleet is of the opinion that these actions should be sufficient to identify any current issues and prevent further potential incidents of this nature occurring.

Findings:

Queensland Rail initiated and suggested corrective actions must continue and be fully implemented.

Queensland Rail should develop a clear set of installation instructions for all types of OHLE fittings in use and brief OHLE staff.

4.2.2 Signalling irregularity

Cables associated with the signalling system are housed within covered troughs located beside the Down Main Line. The flow of fault current to earth in close proximity to the troughs, as experienced following the dewirement, increases the potential for the current to enter and travel to the ends of the signalling equipment circuits. In this case, the current caused the failure of the protection equipment fitted to trackside signalling circuits at Roma Street.

Subsequently, when the energised contact wire came in contact with the signal rail, the flow of high currents caused a number of faults in the signalling system, including:

- operation of signalling equipment circuit breakers that could not be reset while the signalling equipment damage remained unrepaired (refer section 4.1.3 at 0456 hours)
- failure of 12 track circuit surge arrestors
- destruction of various bonding cables
- damage to an insulated rail joint
- intermittent failure of 12 data line arrestors over multiple locations which caused failures to signalling equipment for a period of time after 0640 hours (refer section 4.1.3).

The trackside circuit protection modules at signal equipment facilities at Roma Street have a limited electrical energy dissipation rating, above which the devices are destroyed (while still protecting the equipment connected to them). Beyond a certain upper electrical energy limit, the protection modules cannot protect the connected equipment and consequently both the protection device and the connected equipment will be damaged and/or destroyed.

The design of single rail track circuits used on the 25,000 volts AC electrified network means that some degree of damage to signalling equipment is to be expected should a live contact wire come into contact with the rail used for train detection. The nature and extent of the damage relating to this incident is not considered unusual for a fault of this type.

The surge protection equipment fitted to the track circuit equipment and other trackside signalling circuits is intended to protect the equipment against surges arising from train operations and distant traction faults or lightning strikes. The protective equipment is not capable of absorbing the currents and voltages associated with direct contact of the 25,000 volts AC line and, according to Interfleet engineering experts, it cannot be economically designed and arranged to do so.

Adoption of later designs of train detection such as double rail track circuits[9] and axle counters[10] overcomes the traction current return issues that are inherent with single rail track circuits. Queensland Rail engineers are aware of these technologies but, according to Interfleet engineering experts, wide scale adoption is unlikely to be economically viable unless combined as part of a wider re-signalling upgrade program.

Replacement of existing copper cabling with optic fibre bearers for signalling data links within critical rail traffic areas such as Roma Street, South Brisbane and Central Station would eliminate induced currents reaching sensitive signalling circuits. However, such modifications need to be carefully considered as it may introduce previously unknown risks to the reliability and maintainability of the network.

9. Double rail track circuit – A track circuit which uses both rails for signalling purposes and as traction return rails.
10. Axle counter – A trackside device for detecting the presence of a train or verifying that the signal section is clear by counting the number of axles passing a given point in either direction.

Findings:

Adoption of alternative train direction technology would overcome traction current return issues.

Replacement of existing copper cabling with optic fibre bearers for signalling data links would eliminate induced currents reaching sensitive signalling circuits.

4.2.3 Disruption severity

The location and criticality of the site to the operation of the whole network meant that severe disruption to the normal rail traffic could not have been reasonably avoided (refer to section 8.1).

Queensland Rail initially elected to close all four lines in order to conduct repairs so the network could recover from the disruption as soon as possible. The Suburban Lines were reopened at 0806 hours to allow limited traffic to flow. Further, the location of the dewirement (Down Main Line) could only be accessed from one side of the rail corridor (refer Figure 5). The restriction meant the repair crews and associated equipment had to cross all adjacent tracks in order to reach the dewirement location. This caused frequent interruptions to train services on the Suburban Lines, however it was necessary to ensure the safety of the repair crews.

Finding:

The location and criticality of the site to the operation of the whole network meant severe disruption to the normal rail traffic could not have been reasonably avoided.

5 14 March 2012 incident at Milton

5.1 Factual information

5.1.1 Background

At approximately 0545 hours on 14 March 2012 an alarm was received at Train Control Centre. Initially, the system fault was classified as non-critical and indicated that there was a signal interlocking fault. At around the same time, the OHLE electrical line section on the western rail corridor between Taringa and Roma Street stations on the Down Main Line tripped, indicating an electrical irregularity in the system.

As a result of these failures, the Train Controller made an emergency radio call to all trains in the vicinity of the Roma Street precinct to stop. This resulted in a diesel locomotive hauled freight train stopping at signal RS37 (Milton-Roma Street section) and three Queensland Rail passenger trains stopping at Milton, Auchenflower and Toowong stations.

The affected OHLE section was left de-energised until it could be safely inspected by an Overhead Linesman.

Subsequent to the initial interlocking fault alarm, major intermittent signalling faults and points failures began occurring on all tracks between Roma Street, Milton and South Brisbane stations. These faults were the result of failed track circuits and damaged protection modules associated with signalling data links in the Station Equipment Room at Roma Street station.

The diesel locomotive hauled freight train travelling on the affected line section was held at signal RS37 on the Milton-Roma Street section pending inspection for any obstruction or load irregularity. The inspection did not identify any obstruction or loading irregularity on the train.

On later inspection of the surrounding area, Overhead Linesmen located a severe burn on the ceramic strut insulator on OHLE mast W/1/25A and on a Bougainvillea cane growing in close proximity to the mast.

Following these inspections of and repairs to damaged components, the western rail corridor (except for the Down Main Line) was restored at 0638 hours allowing resumption of train services at 0645 hours. The Down Main line was released by the Overhead Linesmen for train services to resume at 0710 hours. As a result of the incident, a total of 52 trains were affected, of which 14 train services were cancelled.

5.1.2 Location

The location of the damaged ceramic strut insulator on overhead line mast W/1/25A where the electrical irregularity occurred is approximately 300 metres west of Milton station on the Down Main Line between Milton and Auchenflower (Figures 14 and 15).

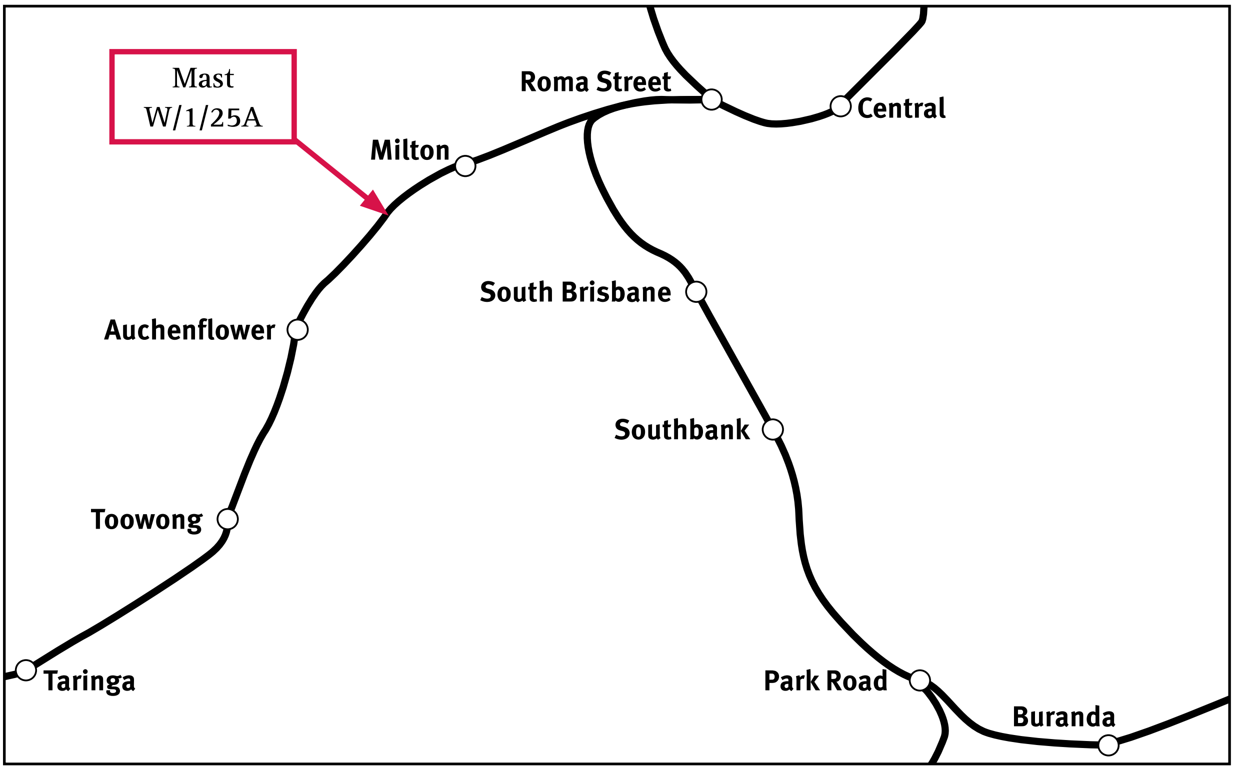

Figure 14 – 14 March 2012 Milton incident location.

The incident location is within the inner city network, in a railway corridor comprising a total of four lines consisting of Up and Down Suburban Lines and Up and Down Main Lines. All four lines are electrified with 25,000 volts AC overhead traction power.

The rail corridor provides access primarily for passenger trains. Diesel locomotive hauled freight trains also operate on the Up and Down Main Lines located on the northern side of the rail corridor. This is one of the main freight routes to the North Coast Line.

The corridor is fenced on both sides with 1.8 metre high security chain wire fencing attached to round steel fence posts embedded in concrete bases. The fence posts have a further 600 millimetres of height to which two strands of barbed wire are attached.

The horizontal alignment of the Down Main Line at the location of mast W/1/25A is a left hand curve (looking towards Auchenflower) of approximately 400 metre radius and with a vertical falling gradient towards Auchenflower of 1 in 79. The maximum allowable speed for electric passenger trains and freight trains is 60km/h and 50km/h, respectively.

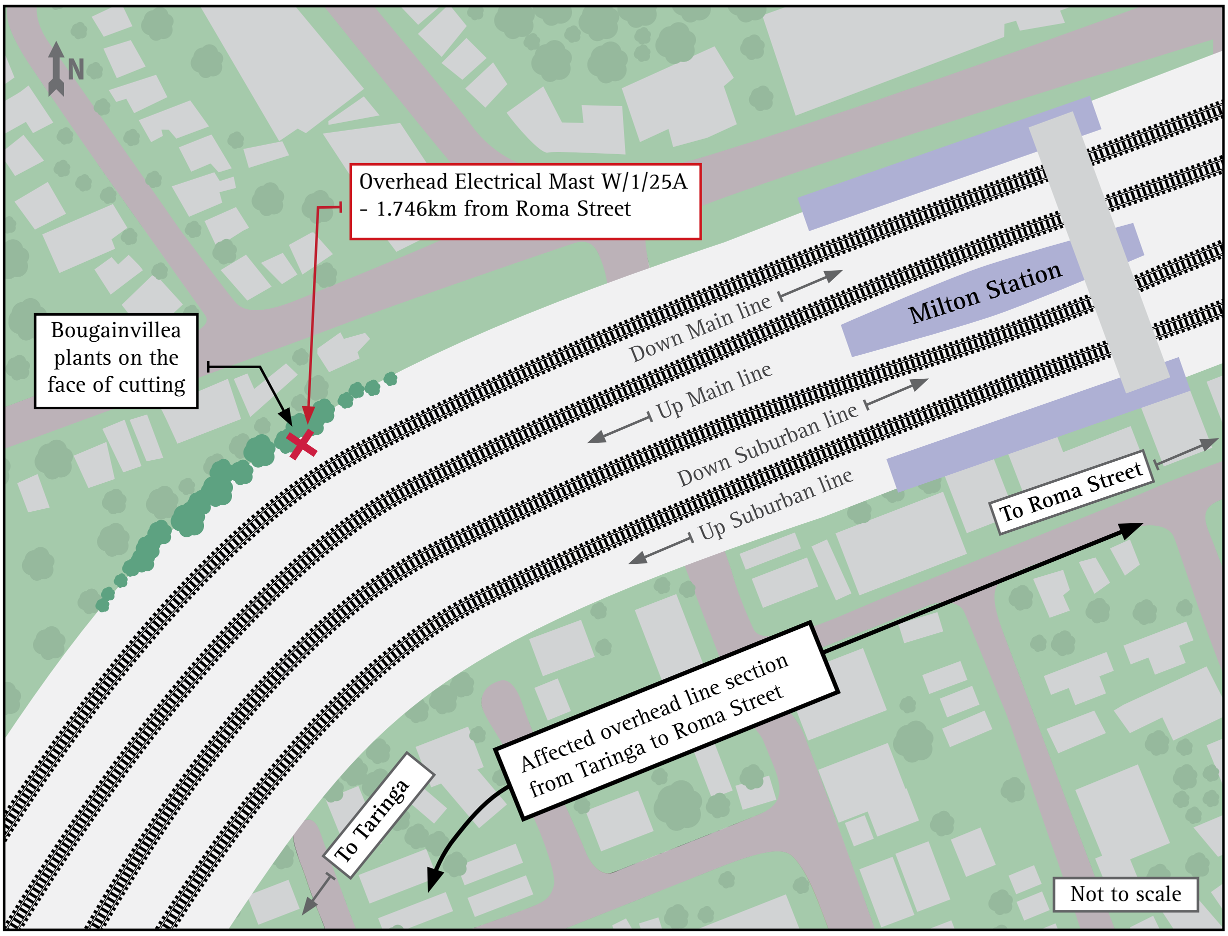

Figure 15 – Location of incident – Milton-Auchenflower Down Main Line on the Western Corridor.

5.1.3 Sequence of events

A chronology of events prior to and following the OHLE electrical trip was collated using information gathered from sources including:

- data collected from the Train Control Centre
- interviews with Queensland Rail personnel
- incident reports prepared by Queensland Rail personnel.

Prior to the electrical trip on the Down Main Line between Taringa and Milton, a northbound diesel locomotive hauled freight train entered this section of track at about 0543 hours and travelled past OHLE mast W/1/25A between about 0544 hours and 0545 hours. The train path for this train was set for the North Coast Line through Normanby on the Exhibition Line.

At about 0545 hours the Electric Control Operator (ECO) at the Train Control Centre received a trip alarm on the Taringa to Roma Street electrical section on the Down Main Line. The ECO then advised the Overhead Linesman on duty about the trip alarm.

At the same time, the Train Controller received signalling fault related alarms on all tracks between Roma Street and Milton and South Brisbane (Figure 16).

Given the extent of the signalling faults that were occurring, the Train Controller broadcast an emergency radio call informing all trains in the vicinity of Roma Street to stop. The trains that came to a stop were:

- a diesel locomotive hauled freight train at signal RS37 west of Roma Street station near the approach to the Exhibition Line.
- a passenger train at Milton Station on the Down Suburban Line
- a passenger train at Auchenflower Station on the Down Suburban Line
- a passenger train at Toowong Station on the Down Suburban Line.

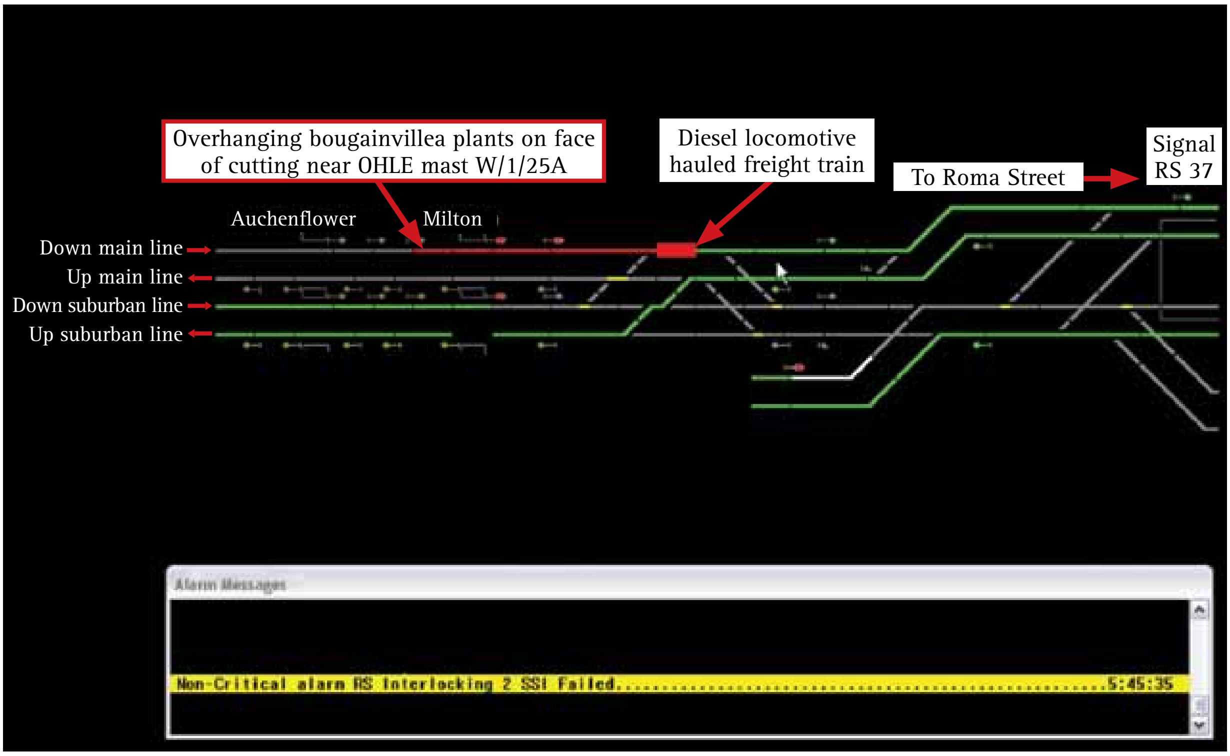

Figure 16 – Train Controller's screen at the time of signalling fault alarm (unrelated screen information removed).

The Train Controller also contacted the driver of the diesel locomotive hauled freight train enquiring whether he had observed any irregularities. In response, the driver advised he had not observed any irregularity.

At 0555 hours the ECO arranged for Overhead Linesmen from the Albion depot to inspect the affected overhead line section. Signal Electricians also had been called to attend and arrived on site at approximately 0610 hours.

After confirming there was no dewirement in the area, the overhead power was re-energised at 0615 hours.

Even though the overhead power had been re-energised, no movement of trains on the Down Main Line between Taringa and Roma Street could occur until Overhead Linesmen had examined the overhead lines above the diesel locomotive hauled freight train for any obstructions or load irregularities. None were found.

After the damaged signal protection components were repaired in the signal box at Roma Street the Signal Electricians restored the operations of the signals and points in the Roma Street-Milton-South Brisbane area at 0625 hours.

This allowed a resumption of train services at approximately 0645 hours from Roma Street to South Brisbane on all tracks and from Roma Street to Milton on the Up and Down Suburban Lines and the Up Main Line. The Down Main Line was not available for resumption of train services until 0710 hours when the Overhead Linesmen had advised that there was no overhead line damage.

At approximately 0658 hours the held diesel locomotive hauled freight train was allowed to depart signal RS37 enroute to the North Coast Line after receiving clearance from Train Control Centre.

At 0710 hours the ECO was advised by an Overhead Linesman that the overhead trip was likely caused by a vine (vegetation) coming into contact with the live OHLE about 300 metres west of Milton station. Upon completion of the overhead line inspection and trimming some of the vegetation, the Down Main Line Auchenflower to Milton section was then released by the Overhead Linesmen to allow the resumption of services.

5.1.4 Weather conditions

At the time of the incident the temperature was recorded as about 21 degrees C with average wind speed of about 2km/h. Bureau of Meteorology records indicate that Brisbane city, the closest recording station to the incident site, received about 1.6mm of rain in the 10 hours prior to the incident, however no rain was recorded between 0130 hours and the time of the incident.

Local time	Wind direction	Wind speed	Tempreature (degree celsius)	Rainfall from 10 hours prior (mm)
0545 hours	South West	2	21	1.6

Table 2 – Weather details for Brisbane city on 14 March 2012 (Source Bureau of Meteorology).

5.1.5 Overhead line equipment

The overhead traction power installation at OHLE mast number W/1/25A on the Milton-Taringa section of the Down Main Line consists of a 25,000 volts AC energised contact wire supported by insulated hangers and cantilevers attached to trackside support masts. A visual inspection indicated the mast structure and OHLE components at the incident location appeared sound. It was noted that the OHLE mast is located close to the face of the steep earth cutting as shown in Figure 17.

5.1.6 Routine inspection

Routine inspections in the vicinity of the incident location were conducted by Queensland Rail staff in October 2011 and on the weekend of 10 and 11 March 2012. The inspection on 10 and 11 March 2012 identified vegetation on the face of the cutting as a potential hazard which could cause interference with the OHLE. As the location of vegetation was on the steep face of the cutting, for safety reasons, it was decided to arrange an electrical isolation of the OHLE before attempting the removal of the vegetation.

An electrical isolation of the section was planned to occur the following weekend of 17 and 18 March 2012. On 18 March 2012 the planned electrical isolation of the section was undertaken. This allowed for the safe removal of the vegetation.

The inspection in October 2011 did not identify vegetation at the location as a potential hazard. Other inspections such as the four weekly OHLE inspections also did not identify vegetation at this location as a potential hazard.

Finding:

Four weekly routine inspections in the area of the cutting prior to the 10/11 March 2012 should have identified vegetation at the location as potential hazard.

5.1.7 Signalling equipment

The signalling system at this location is known as automatic block signalling and is an electronically controlled remote signalling system using trackside coloured lens signals and track vacancy detection (through electrical currents on signal rail) to automatically control train access.

At the incident site, signalling cables are located underground.

5.1.8 Corridor trespass activity

From the initial Queensland Rail incident investigations, the act of a trespasser throwing a foreign object onto the overhead wire at this location was considered as one of the possible causes. The Auditors observed several graffiti markings in the vicinity of mast W/1/25A, suggesting the area has a history of trespassing activity. A mast carrying a transformer near the incident site was observed to have graffiti close to the energised OHLE which suggests high risk trespass behaviour in this area.

5.1.9 Recovery

A review of the work undertaken by Queensland Rail to recover from the incident and to return the network to normal operational state was undertaken. From the time of the incident occurring to the time when the first train operated over the restored section was approximately one hour. During that time, Queensland Rail:

- mobilised staff
- investigated the damage
- mobilised repair staff
- carried out repairs to the damaged signal equipment protection modules at the Roma Street Signal Equipment Room
- conducted functional testing after the repairs had been completed.

5.1.10 Post incident

A review of the work undertaken by Queensland Rail to recover from the incident and to return the network to normal operational state was undertaken by the Audit team. From the time of the incident Queensland Rail has taken or initiated the following actions:

- overgrown vegetation (Bougainvillea) on the face of the cutting has been removed
- replaced damaged strut insulator on mast W/1/25A
- reviewing current vegetation management practices with the view to increasing the frequency and effectiveness of the current vegetation inspection regime
- examining feasibility of eliminating vegetation at selected locations through engineering solutions such as the provision of concrete or heavy duty matting covering on earth cutting.
- examining the feasibility of screening at selected overhead line equipment masts from the incursion of vegetation to minimise the likelihood of vegetation coming into contact with the overhead line equipment. An example of a type of screening could be sheets of fine mesh providing a barrier between OHLE masts and any adjacent vegetation to prevent the vegetation from growing past the screen and touching any part of the live OHLE.

5.2 Analysis

5.2.1 Likely cause for the trip

The Down Main Line at this location is adjacent to a steep cutting on the northern side of the rail corridor which at the time of the incident was covered with vegetation in close proximity to the OHLE trackside mast W/1/25A.

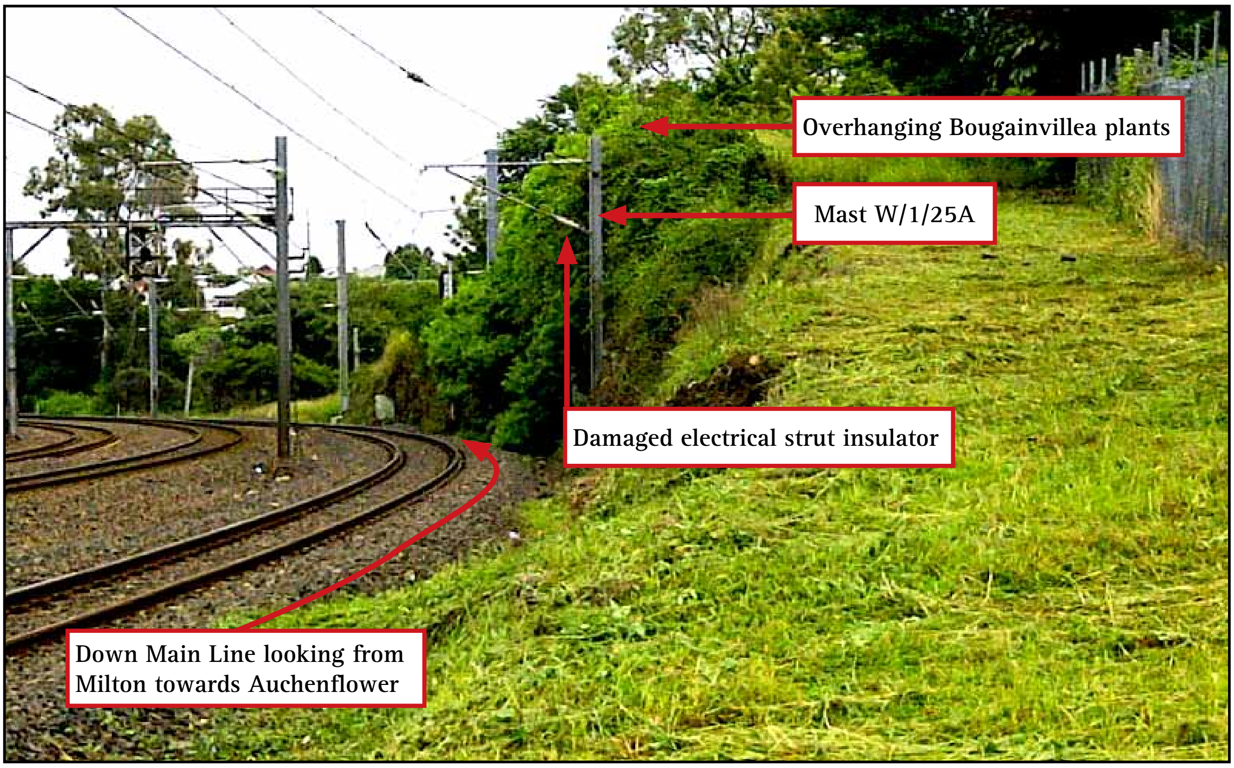

Figure 17 – Photograph of the incident site looking towards Auchenflower from Milton on the Down Main Line Western Corridor (photo taken 14 March 2012).

Following the incident OHLE staff located a severe burn mark on the ceramic strut insulator and on a Bougainvillea cane. The face of the cutting had overgrown vegetation including several Bougainvillea plants. Evidence suggests that some Bougainvillea canes were over three metres in length.

Considering the fact that the electrical trip occurred at the time when the diesel locomotive hauled freight train was travelling past the cutting, it is reasonable to believe that a draught generated by the passing train past the cutting brought a Bougainvillea cane into contact with the live OHLE.

Although there is evidence that the incident site has a history of trespass activity and presence of fauna (such as possums), in this case neither trespassing nor fauna is likely to have contributed to the trip.

Finding:

The most likely cause of the OHLE trip and subsequent signalling faults was vegetation coming in contact with the OHLE.

5.2.2 Vegetation management

Discussion on vegetation management is included in section (6.2.2.6) of this report.

5.2.3 Signalling irregularity

At the incident location, signalling cables are run underground. Any flow of fault current to earth in the vicinity of the cables increases the potential for the current to enter and travel to the ends of the signalling equipment circuits. As a result of the Bougainvillea cane contacting the OHLE, the current caused the failure of the protection equipment fitted to trackside signalling circuits at Roma Street.

The trackside circuit protection modules at signal equipment facilities at Roma Street have a limited electrical energy dissipation rating, above which the devices are destroyed (while still protecting the equipment connected to them).

The failure of trackside circuit protection modules under high earth fault current and/or high rises of remote earth potentials is expected in railways using the signal technologies currently existing in the south-east Queensland network. The existing protective equipment at these signal installations is not capable of absorbing the currents and voltages associated with high levels of earth fault current.

Further, it is not possible to economically design and arrange for this type of protective equipment to provide a level of protection that will absorb the currents and voltages associated with high levels of earth fault current such as those that would have resulted during the OHLE electrical trip at mast W/1/25A.

The surge protection equipment fitted to the track circuit equipment and other trackside signalling circuits is intended to protect the equipment against surges arising from train operations and distant traction faults or lightning strikes.

Replacement of existing copper cabling with optic fibre bearers for signalling data links within critical rail traffic areas such as Roma Street, South Brisbane and Central Station would eliminate induced currents reaching sensitive signalling circuits, however such modification needs to be carefully considered as it may introduce previously unknown risks to the reliability and maintainability of the network.

Finding:

Replacement of existing copper cabling with optic fibre bearers for signalling data links would eliminate induced currents reaching sensitive signalling

5.2.4 Disruption severity

As the diesel locomotive hauled freight train was travelling over the affected section of track at the time of the trip, procedure directed that the integrity of the train and its load be checked before the tripped section of track was re-energised.

The location of the trip and associated signalling system failures were in the inner city network which meant trains between South Brisbane and Roma Street were also affected. Therefore, large scale disruptions to the normal rail traffic could not have been reasonably avoided.

Response time for repairing the signalling system is considered by the Audit team to be adequate.

In summary, the management of the recovery of the rail network compares well with similar faults that have occurred in other rail networks.

6 Reliability and asset management

The investigation of these major disruptions indicates that a minor asset failure at a critical location can result in widespread disruption across the south-east Queensland network.

This impact is graphically illustrated in the figure below.

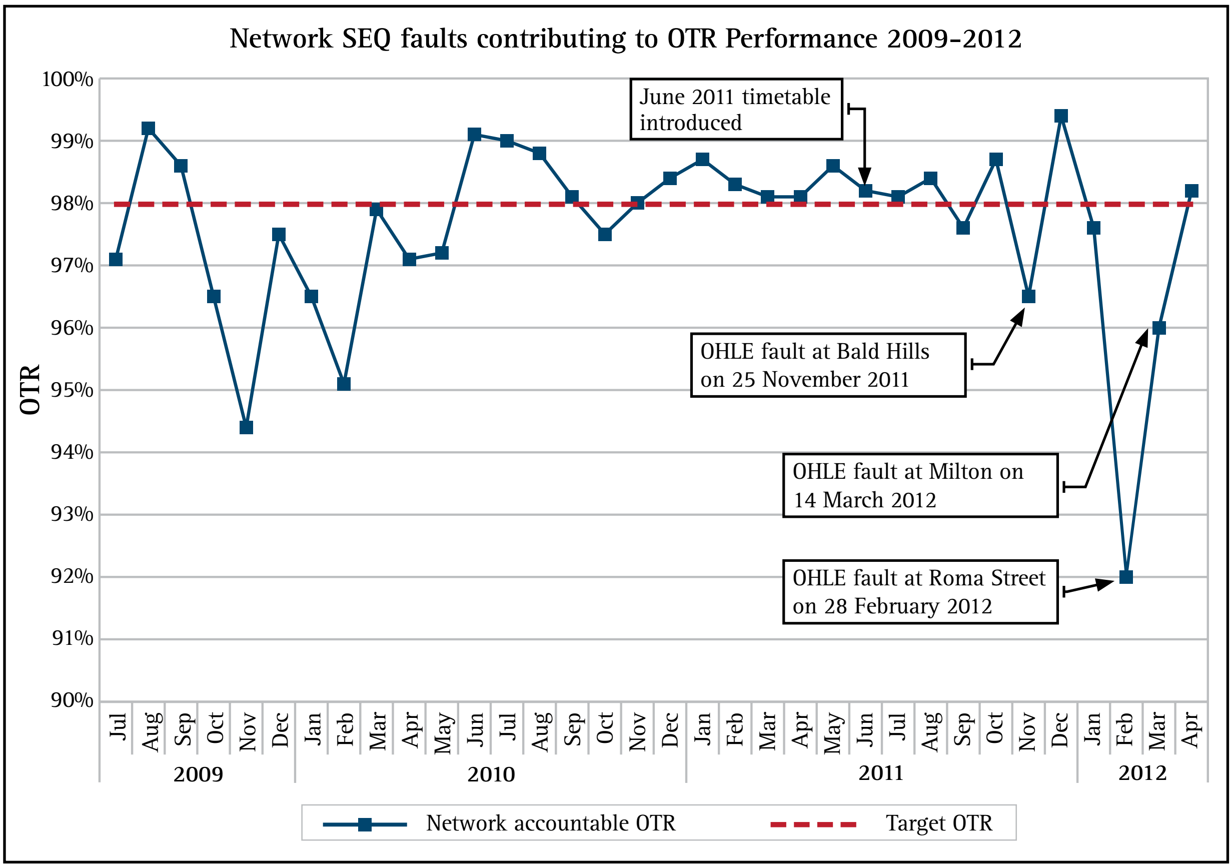

Figure 18 – Network SEQ faults contributing to OTR performance 2009-2012.

The Audit team concluded that to further understand the impact of network related incidents on reliability, a more detailed analysis of the faults or other contributing factors attributed to the network OTR performance was required.

In particular, asset management, roles and responsibilities, competencies and training and asset renewal were investigated.

The Audit team was supported by technical experts from Interfleet. Discipline experts from track, civil, signalling, telecommunication, OHLE and rolling stock reviewed the 2010 and 2011 Independent Asset Condition Reports and prepared audit checklists. A series of meetings were then held with key Queensland Rail staff. Field inspections and visits to maintenance depots (Appendix A) were also then conducted in order to complete sample asset condition audits.

This section of the report contains findings from meetings, inspections and the subsequent review of documents and records supplied by Queensland Rail.

6.1 Asset management strategy

Asset management for railway infrastructure is fundamentally about delivering the outputs valued by customers, funders and other key stakeholders, in a sustainable way, for the lowest whole life cost. It may be considered to be an evolution of traditional approaches to managing large scale infrastructure. There are three distinguishing features:

1. It focuses maintenance, renewal and enhancement activities on delivering sustainable outputs valued by customers and funding providers at the lowest whole-life cost.
2. It provides a means of providing a link between organisational management functions and asset engineering disciplines.
3. It places a greater emphasis on evidence-based decision making, using knowledge of how assets degrade and fail to optimise maintenance and renewal interventions.

A carefully crafted asset management strategy will include a 'line of sight' between strategy and implementation, the capability to deliver the same level of sustainable performance with reduced volumes of work and demonstration to external stakeholders that activities are being undertaken at the lowest whole life cost.

In July 2010, Queensland Rail recognised the need for contemporary asset management. To facilitate this change Queensland Rail has a policy titled *Asset Lifecycle and Project Management Policy*. This policy is intended to ensure that Queensland Rail has an effective, organisation-wide approach to managing the lifecycle of its assets, so that those assets help achieve, in a sustainable and cost effective manner, the objectives of the Government Owned Corporation.

For the south-east Queensland infrastructure network discipline strategies for overhead traction, signalling, telecommunications and civil assets have been developed. However, an overarching Queensland Rail asset management strategy in line with the *Asset Lifecycle and Project Management Policy* is currently not available.

Finding:
An overarching Queensland Rail asset management strategy is not currently available.

6.2 Below rail assets

Below rail assets are those which are generally situated within or adjacent to the rail corridor. These are:

- track infrastructure
- civil infrastructure
- signalling infrastructure
- OHLE infrastructure
- telecommunication infrastructure.

6.2.1 Below rail roles and responsibilities

The audit assessed roles and responsibilities of the following Queensland Rail teams:

- Reliability Engineering teams
- Below Rail Assets teams.

These teams are responsible for delivering day to day asset management related initiatives and activities on the south-east Queensland network.

6.2.1.1 Reliability Engineering teams

The Traction Power Reliability Engineering team consists of seven engineers and specialist staff managed by the Traction Power Reliability Engineer. The team is responsible for the short and long term development of the traction power system as well as supporting the maintenance staff on technical issues as and when they arise. The Traction Power Reliability Engineer oversees the development of standards and processes and the overall development of the traction power system.

The team will shortly commence training in the use of a complex power supply simulation software which will allow the loadings and ratings of the traction power system to be evaluated for various operational and system development scenarios. A member of this team is responsible for the ongoing testing of electrical protection equipment fitted at traction power sites and the upgrading of this specialist equipment. This role also trains the Electric Control Officers (ECO) and is the first line of support for the ECOs on a 24 hour seven days a week basis. Another team member is the sole relay testing and protection specialist. This role is critical and there is no backup replacement should this member not be available for duties.

The staffing complement for this team is considered inadequate to undertake the wide variety of responsibilities that this section is required to perform. The availability of these staff to support the maintenance function has been identified as a potential cause for concern as the workload of this team will increase for a number of reasons, including the introduction of simulation software considered as vital to support the future network planning.

The Signalling Reliability team consists of eight engineers managed by the Signalling Reliability Engineering Manager. The team is responsible for the short and long term development of the signalling system as well as supporting the maintenance staff with technical issues as and when they arise. The Signalling Reliability Engineer oversees the development of standards and processes and the overall development of the signalling system.

The structure of the team is divided into an operational focus, a strategic focus and a regional focus. At the time of the audit the regional focus engineer position was vacant. The Audit team considers the staffing complement for this team is inadequate when compared to the wide variety of responsibilities that this section is required to undertake.

Some of these responsibilities include the review of work procedures, setting work programmes, and quality control verifications of new or replacement signal equipment. The availability of these staff to support the maintenance function has been identified as a potential cause for concern by the Signalling Reliability Engineering Manager due to the workload of the team.

Finding:
The staffing complement of the Reliability Engineering teams is considered inadequate.

6.2.1.2 Below Rail Assets teams

The Track Operations Coordinator manages the entire south-east Queensland network area including 108 staff and six depots at Cooroy, Redbank, Sunshine, Mayne, Cannon Hill and Banoon. Each depot has a defined geographical track area, with a dedicated Track Maintenance Supervisor. Track patrol inspections are undertaken by each depot area. The track patrol inspections at 96 hour maximum intervals are generally walked in the city suburban areas and undertaken on Hi-Rails[11] in the outer suburban areas. Day to day routine maintenance and repairs on track infrastructure are undertaken by the depot staff. These tasks include rail defect removal, routine repairs to points and crossings, insulated joints maintenance, fastening maintenance and localised track geometry repairs (including faults identified by track recording machines).

11. Hi-Rail - A vehicle that is capable of running on both road and rail.

The Track Operations Coordinator's geographic area across the south-east Queensland network is large and complex with a high density of rail traffic, particularly on the inner city lines. The south-east Queensland network comprises almost 400km of two, three, four and six track corridors, five major freight and carriage yards, six storage yards and numerous operational sidings.

While the upper management for Below Rail Assets teams has strength in depth and provides support in compliance and performance monitoring, the front line operations under the Track Operations Coordinator appear to be stretched due to the current quantity of outstanding RIMS track repair tasks which were presented during the Audit interviews at the Track Operations Coordinator's depot.

In addition, constrained by limited track access (refer section 6.2.2.3) and stringent track safety criteria, the Auditors observed a lack of attention to detail in the identification of track defects (refer section 6.2.5).

The maintenance of the traction power assets is managed by the Traction Power Supervisor who supervises OHLE maintenance staff. At the time of the audit there were 34 OHLE maintenance staff at the Albion depot and four maintenance staff at the Beenleigh sub depot. At the time of the audit there were eight vacant positions within these two depots.

The maintenance of the signalling assets is managed by the Signalling Asset Management Supervisor. At the time of the audit there were a number of vacancies in the Signalling Maintenance area. As signalling incidents are identified as a significant contributor in peak period south-east Queensland OTR (network) delays, these vacancies may have an impact on the ability of signal maintainers to undertake basic signal preventative maintenance to minimise signalling related incidents.

Finding:
The staffing complement of the Below Rail Assets teams is considered inadequate.

6.2.2 Asset maintenance

6.2.2.1 Planned maintenance

Planned maintenance is carried out during scheduled corridor closures (refer section 6.2.2.3), at night, weekends or between peak periods. Maintenance activities are planned well in advance of closures and/or shut downs. Each engineering discipline coordinator formulates a plan taking into account the needs of their own activities and the requirements of other disciplines. From this, flow the resource requirements including staff, plant and materials. The favoured planning method involves the creation of a geographical plan of the area, with highlighted entries showing the work to be completed, at which location, by whom and at which time.

In the case of OHLE, signalling and telecommunications preventive maintenance tasks occur on a cyclical basis and these cycles are stored within the Trackside Systems Management System (TSMS) database. The coordinators at each depot review the upcoming maintenance activities that are contained within the TSMS database and schedule them accordingly.

In the case of track infrastructure, the Auditors consider the planning process relating to corrective maintenance activities is adequate. However, planning of routine maintenance activities is subject to continuous changes due to limited track access and the large volume of non-safety critical defects.

Due to the limited track access, the non-safety critical defects require constant re-prioritisation. Although these defects are categorised as non-safety critical they may impact the network reliability. For example, a poorly maintained insulated joint on the track may result in a track detection fault. Track condition inspections (refer section 6.2.5) revealed that welding repairs to points and crossings, insulated joints and fastening insulations were common items found to be in need of attention.

In case of civil structures, the annual structures maintenance plan for the south-east Queensland network provides an overall strategic plan based on the priorities of structures requiring routine or preventative maintenance. The annual structures maintenance plan also includes a provision for the installation of bridge impact detection systems or bridge impact protection components such as bridge protection beams on bridges which have a known history of road vehicle strikes. Currently, two bridges each year in the south-east Queensland network are being provided with strike detection or protection systems.

Finding:

Due to limited track access, the non-safety critical track defects require constant re-prioritisation. Although these defects are categorised as non-safety critical they may impact the network reliability.

6.2.2.2 Corrective actions

All defects identified during scheduled inspections are either recorded on a spreadsheet, hand held electronic devices such as PDA equipment or on paper based forms. The identified defects relate to a specific geographical area (or electrical section). The urgency with which the corrective actions need to be implemented is determined by the coordinator. This may range from immediate attention to awaiting a future Scheduled Corridor Access System (SCAS) closure or scheduled maintenance period.

A high level of reliance is placed on the knowledge and experience of the coordinators in assigning priority to each identified defect.

Once the defect is initially logged, a corrective maintenance request is raised within the TSMS or Rail Infrastructure Management System (RIMS) database, which in turn generates a “work order” for the activity to be performed. On completion of the activity, the then completed work order is passed to the coordinator to close out the activity in the database.

The creation of corrective maintenance tasks requires several steps within the databases. These databases allow for multiple entries at various stages of the process, which makes the process slightly less repetitive. The need to populate various parallel systems as well as the TSMS or RIMS requires a high degree of vigilance when operating the data management systems to avoid introducing errors. These databases are reasonably well developed, however they lack functionality and features when compared to more modern systems. Queensland Rail recognises this and is currently in the process of implementing Enterprise Asset Management System (EAMS) (refer section 6.2.3.1).

Formalised detailed processes for prioritising corrective actions for various defects is not available to responsible staff. Further, there is no evidence of a formal review process for asset defect prioritisation. In the absence of such reviews, outstanding defects that may exist beyond a specified timeframe may get re-prioritised without a documented reason to do so. The re-prioritisation of defects may be appropriate based on safety criticality however they may impact reliability of the network.

Findings:

Formal guidance on assigning priority on various defects is not available to responsible staff.

There was no evidence of a formal review process of defect prioritisation. In the absence of such reviews, outstanding defects that exist beyond a certain timeframe may get reprioritised without documented reason to do so.

6.2.2.3 Track closures

The asset management programs require a significant amount of regular extended track closures on the south-east Queensland network. Historically, the maintenance and construction of assets in the network had been carried out in between train services and at ad hoc times when access was available. As more passenger and freight trains travel over the network, gaining access to the tracks to conduct construction and maintenance activities has become increasingly more difficult.

In response to this, in 2010 Queensland Rail introduced pre-planned corridor closures. These closures are administered through the SCAS and, therefore, are generally known as SCAS closures. These closures facilitate access to the assets to enable staff to carry out construction and maintenance activities in a safe and organised manner.

The SCAS is used to plan and execute all scheduled closures for track, civil, signalling, telecommunication, OHLE and facilities (platform and station) related assets within the south-east Queensland network. A SCAS closure is undertaken within an agreed schedule and provides an optimal planned works program to accommodate the required asset management plans, corrective maintenance actions and/or construction activities. Multiple work parties from different disciplines are deployed during SCAS closures.

SCAS closures include:

- minor daytime closures of approximately 30 minutes to four hours duration for the regular inspection and servicing of critical assets
- night time closures during non operational periods for planned and corrective works on all asset types within the south-east Queensland network
- scheduled weekend zonal closures for major asset management and construction works.

During the Audit a common theme was raised regarding the constrained access to undertake maintenance and repairs arising from routine inspections. While SCAS closures have been successful in addressing medium and heavier maintenance and renewals, the more minor maintenance work is often not addressed until the priority for corrective action is raised to a more critical level. This was evident for activities such as insulated joint maintenance, viewed during the audit track condition inspections.

Finding:
Due to limited track access, minor maintenance work is often not addressed until the priority for corrective action is raised to a higher level.

Further, during asset condition inspections, Queensland Rail field staff raised concerns about the availability of adequately qualified Track Protection Officers (TPO) during SCAS closures. Obtaining a TPO can be difficult at times and can reduce the time available for maintenance activities.

Finding:
Staffing complement of the TPO team is considered inadequate.

The Audit team conducted a number of physical track condition inspections which are listed in Appendix A. On at least three occasions the Audit team experienced difficulty in accessing track for pre-planned inspections.

While this was an inconvenience to the Audit team if these cancellations and delays are systemic there will be an impact on the efficiency and cost of the maintenance program, through lost time on tools resulting in increased staff cost to both Queensland Rail and the Queensland Government through the Transport Service Contract (Rail Infrastructure) (TSC(RI)).

Finding:
Access to track for maintenance activities within pre-planned closures is impacted by the management of operating services during the agreed closure times.

The movement of trains to and from stabling yards at the beginning or end of a service is known as dead running. In the case of passenger trains these are non revenue services with no passengers on board that utilise train paths, while adding to the congestion and wear and tear on the network.

The introduction of the June 2011 City Network timetable resulted in an increase in dead running kilometres of approximately 40 per cent compared to the previous year. The dead running equates to nearly 4000km each day (refer Figure 19). This averages to an annual total of over 1.4 million kilometres.

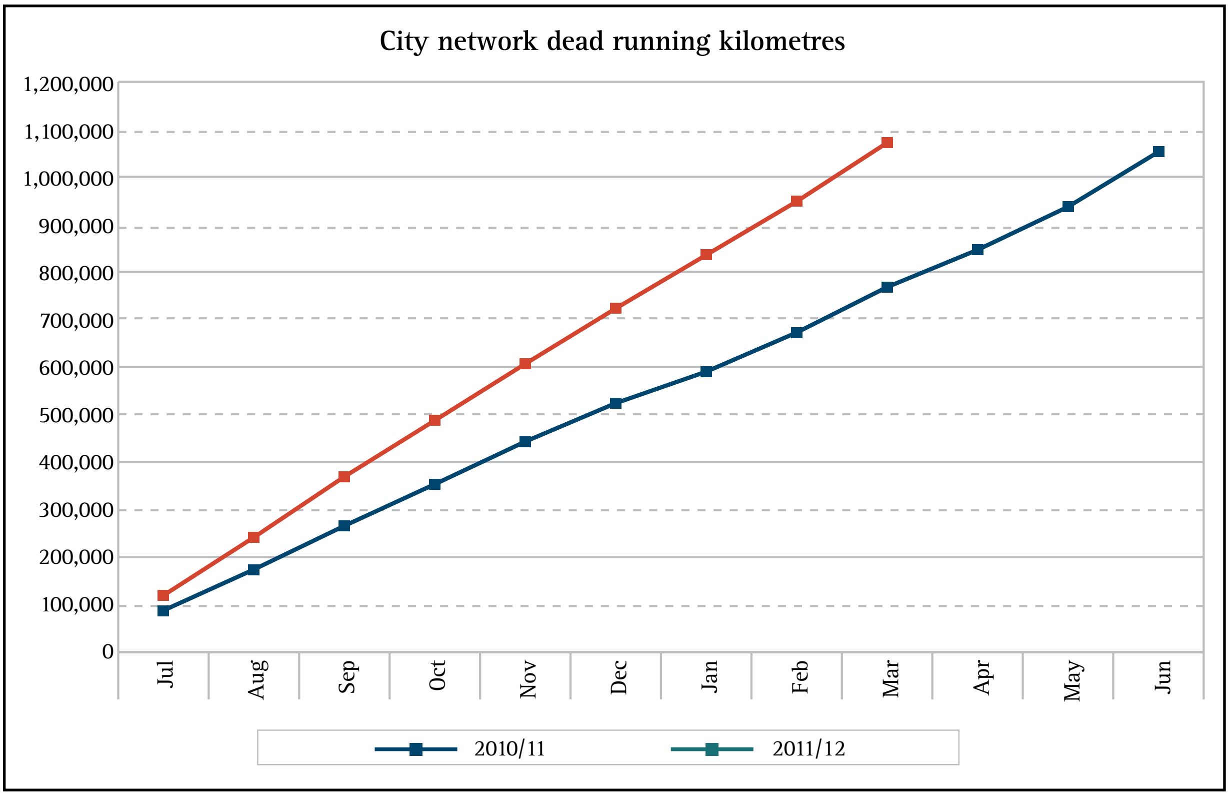

Figure 19 – City network dead running kilometres 2010-11 and 2011-12.
Source: City Network Transport Service Contract – Queensland Rail Monthly Report to TransLink March 2012.

Finding:
Increase in dead running may have an impact on available access to track for maintenance activities.

6.2.2.4 Reviews and monitoring

As maintenance requirements and wear patterns of a given system accumulates the maintenance practices and periodicities should be reviewed to ensure that:

- adequate maintenance is being delivered to retain the asset in the desired condition
- an asset is not subjected to excessive (and therefore wasteful) maintenance
- the assets which pose the highest risk to train service reliability are prioritised
- adequate resources in staff, material and plant are available.

The Auditors observed that elements of a formalised maintenance management system are being used by the maintenance and engineering staff in an ad hoc manner. The adoption of a formalised process to manage the maintenance planning would ensure that a consistent approach is applied and that all asset management initiatives are finalised.

A process to review the quality of maintenance appeared to be lacking. Due to staff shortages, no internal audits on the quality of work being performed are conducted. Formalised processes or standards for undertaking internal audits are not in place.

Findings:

Due to Reliability Engineering staff shortages no audits on the quality of work are being performed.

Formalised process and internal audit protocol or standards to govern internal quality audit task, are not available.

6.2.2.5 Documentation

To efficiently deliver its asset management function, Queensland Rail maintains various documents to lead, guide and instruct staff on activities. Documentation includes asset management strategies, standards, work instructions and check sheets which govern, define and record activities in each discipline.

During the audit, it was observed that work instructions for wedge clamp installation (refer section 4.2.1.3) and Power Systems activities did not exist.

Further, it was observed that some standards, work instructions and task forms were reviewed on an ad hoc basis. This review is undertaken by staff when they identify the need for a change to be made, for example, when the installation of a new asset type occurs or by their accumulated maintenance experience. While no evidence of poor management of this informal process was found, it is possible that necessary changes can be overlooked, deferred or reduced in importance. A formalised review process would overcome this limitation.

Findings:

Work instructions for Power Systems activities do not exist.

A formal review process for standards, work instructions and task forms would streamline the ad hoc reviews conducted currently.

6.2.2.6 Vegetation management

As an 'electricity entity' under the *Electrical Safety Act 2002*, Queensland Rail has an obligation to operate its OHLE in an electrically safe way. This includes managing vegetation so that it does not pose an unacceptable risk to the OHLE.

Queensland Rail has developed a document titled *Managing vegetation near electrified overhead line equipment - guide and action plan*, which includes guidelines relating to managing vegetation risks to the OHLE.

The document provides a general overview of the principles to be used for the overall management of vegetation growing in the vicinity of live overhead power lines on the rail corridor. The document highlights the threat to the OHLE of close branches facilitating the discharge of electricity from OHLE to the ground as well as allowing animals to climb onto the OHLE.

The document contains an 'action plan' for the development of vegetation management strategies to be implemented during 2006-2007. One of the initiatives to be undertaken was for rail corridor maintainers to 'prioritise vegetated areas/trees for management activities'.

The document highlights that:

- the OHLE itself and the space within three metres of the OHLE should be kept clear of vegetation at all times,
- all climbing vegetation such as vegetation on, or posing a threat to, OHLE should be removed
- the time between visits to a site for the purpose of vegetation management (return period) will be site or area specific and will be determined by regrowth rates
- considerations include wildfire risk, climate, type of vegetation, recurrent costs, conservation considerations and so on.

Currently, there is no specific hazard register for trackside vegetation growing near OHLE. Instead, if a vegetation hazard is found during line inspections Queensland Rail maintainers make arrangements for it to be removed.

Finding:
Currently there is no specific hazard register for trackside vegetation management near OHLE.

6.2.2.7 Rail stress management

During routine track patrols and inspections ballast[12] deficient track profiles are recorded. These records enable the track maintainers to identify where there maybe the potential for track buckling to occur. The track maintainers then arrange for ballast distribution trains to be programmed to correct ballast deficiencies.

Areas of suspected incorrect Stress Free Temperature (SFT) are currently programmed for rail stress testing to establish the actual rail SFT. A program of restressing is then established. The audit highlighted that there is no formalised rail stress register for the south-east Queensland network. That is, there are no continuous stress records for all south-east Queensland network open track rails or rail contained in points and crossings.

Finding:
A formal rail stress register for the south-east Queensland network recording rail stress history is not in place.

12. Ballast - Material, usually rock or aggregate, selected for placement on the trackbed for the purpose of holding the track in line both laterally and longitudinally at a determined level and to provide drainage of the track structure.

6.2.3 Asset knowledge

Queensland Rail presently has a variety of database and asset management tools. All major signalling, traction and telecommunication related assets and associated corrective actions are contained within the TSMS database while track and civil structures related assets and associated corrective actions are contained in the RIMS database.

The level of granularity possessed by these databases is considered to be coarse when judged by the standards of more modern systems. For example, a traction transformer is listed on the TSMS system, but ancillary equipment that is carried on and critical to the operation of the transformer (such as pumps, fans and so on) is not contained within TSMS as a subset of the transformer. The consequence of the use of coarse asset knowledge granularity is the need to maintain and use a number of parallel systems to track and trace assets that are not considered major – that is, at the 'sub TSMS/RIMS level'.

A number of such systems were observed and judged to be well managed and used, but at the expense of the (often considerable) time taken to update and use them. Unlike more modern systems, TSMS and RIMS as presently configured, do not have the ability to link to Geographic Information Systems (GIS) or other data repositories and as a consequence all drawings, original equipment manuals and other supporting information are held in paper or electronic soft copy formats at depots or on a shared network drive.

A review of the content and storage of this information at depots showed that the data is accessible to those who need it, is tidily stored, referenced and up to date.

Maintaining such a repository takes time and dedication, however such paper based systems can never match the functionality and speed of a software based system. Modern software based systems, if designed appropriately, would provide access to detailed required information (such as drawings and work instructions) in a timely manner.

Finding:

Current databases (TSMS/RIMS), data repositories and other conventional means for capturing and retaining asset knowledge are well managed, however they are time consuming to maintain and use.

6.2.3.1 Enterprise asset management system

A key factor of an effective maintenance regime is the ability of an organisation to maintain and retrieve asset knowledge. In the case of Queensland Rail this is important as it will assist in the planning and management of maintenance which in turn should lead to improved reliability. This can be taken to encompass not only formalised asset registers and databases, but also the accumulated experience of the technical staff. As described in section 6.1, Queensland Rail has changed its focus from asset maintenance to asset management and, as a result, is in the process of implementing EAMS across the organisation including both below and above rail assets.

EAMS is an internationally recognised asset management system, with a single asset register and repository of asset condition data and history. If used effectively, EAMS would provide a tool for tracking compliance, performance and automated scheduling of inspection and maintenance for prioritised activities, and facilitate timely execution of remedial actions. EAMS can facilitate management of assets through its life cycle.

In general, development of an integrated asset management system that assists key business decisions and that supports a whole life cost approach to railway asset management is seen as a key enabler towards the development of an asset management system based around PAS 55[13] principles.

13. PAS 55 - A Publicly Available Specification published by the British Standards Institution (BSI) for the optimised management of physical assets and is an internationally recognised standard.

While the Auditors can not comment on the details of the system being proposed for Queensland Rail, the Auditors are aware of significant benefits from implementation of an EAMS or similar system have brought to other organisations. In particular, such systems have greatly assisted decision-making for key business decisions at the tactical level of infrastructure management.

6.2.4 Competence and training

In order to comply with the *Transport (Rail Safety) Act 2010*, railways accredited in Queensland are required to have all safety training delivered in line with the available Australian Qualifications Framework. Queensland Rail is currently taking steps to partner with appropriately accredited training organisations to tailor suitable courses to the railway's requirements or to have internal training courses accredited in their own right.

Queensland Rail has well developed apprentice training programs for signalling and OHLE. Training programs are based upon training needs identification. Maintenance staff competencies are maintained and records are kept in databases.

Investigation into the 28 February 2012 incident at Roma Street indicated that:

- training content is not adequately reviewed to ascertain it meets installation and maintenance specifications (section 4.2.1.3)
- following initial training no refresher training is conducted.

Finding:

Some training content is not formally reviewed to ascertain it meets installation and maintenance specifications and no refresher training is conducted.

6.2.5 Asset condition review

As part of the Audit terms of reference, physical asset condition inspections of selected locations were carried out. Due to limited time, a small portion of the south-east Queensland network including Roma Street to Bowen Hills and Corinda to Indooroopilly were selected (refer Appendix A for full list).

Appendix B contains photographs of some of the defects identified during these asset condition inspections.

During asset condition inspections a number of pumping sleepers[14] and mud holes[15] were identified. Mud holes and pumping sleepers formed as a result of ineffective drainage. In some instances overgrown vegetation was observed to be affecting drainage in the vicinity of these defects. If not repaired in a timely manner, these defects may impact adversely on the reliability and possible safety of the network. Queensland Rail has recognised this issue and has advertised positions for a dedicated drainage team to improve drainage on the south-east Queensland network.

Findings:

Non-safety critical track defects require constant re-prioritisation. Although these defects are categorised as non-safety critical, they may impact the network reliability if not addressed in time.

Several defects in relation to rail fastening insulators and insulated joints are not identified for repairs on the RIMS database. These defects are not considered to be safety critical but they have a potential to impact on network reliability.

14. Pumping sleepers - Railway sleepers that are lacking support due to a mudhole or track bed anomaly.

15. Mud hole - Fouled railway track ballast to the extent that one or more sleepers are surrounded by a mixture of mud and degraded ballast rather than clean free draining ballast. The weakened track formation below the ballast can lead to a loss of track geometry both vertically and horizontally.

Various defects on the rail infrastructure relating to insulated joints, rail fastening insulators, weld repairs to points and crossings have potential to cause track circuit failures or points failures resulting in potential network delays. Some of these defects were identified for repair on the RIMS database, however in some instances defects in relation to rail fastening insulators and insulated joints were not identified.

In order to test for defects in steel rail, Non Destructive Testing (NDT) or ultrasonic testing is conducted on the south-east Queensland network infrastructure at regular intervals. These NDT test runs are considered to be an effective tool to identify any rail defects generated by rail traffic travelling over mud holes and pumping sleepers. However, there is a concern regarding the current twice yearly frequency of the NDT runs in view of the recent increase in network usage and observed track defects.

Finding:

The frequency of the NDT test runs in view of the recent increase in network usage and observed rail defects is considered insufficient.

6.3 Above rail asset

6.3.1 Rolling stock

Queensland Rail's Mayne Electric Train Depot maintains a fleet of 207 three-car passenger train sets consisting of three types:

- the original Electric Multiple Units (EMU) which were progressively introduced to service as the network was electrified
- the Suburban Multiple Units (SMU) which first entered service in 1994 and has three models in the series
- the Interurban Multiple Units (IMU) which first entered service in 1995 and also has three models.

The SMU and IMU trains differ in that the IMU are fitted with luggage racks and mobility-access toilets and are generally used on the Gold and Sunshine Coast services.

Type	Year Delivered	Number
EMU	1979 - 1986	87
SMU	1994	12
IMU	1995 - 1997	10
SMU	1999 - 2001	30
IMU	2001	4
SMU	2008 - 2011	36
IMU	2008 - 2011	28
	Total	**207**

Table 3 – Rolling stock fleet age.

In addition to the main fleet above, the Intercity Express (ICE) fleet entered service in 1988 as the long distance passenger service Spirit of Capricorn between Brisbane and Rockhampton. These units were progressively removed from long distance service from 1998 to 2003 with the introduction of the tilt train fleet. Since 2003, ICE fleet is used for interurban services on the Nambour and Gympie North Lines.

The ICE cannot be effectively used for normal City Network services due to its long distance design including non-powered single doors and low seating capacity. Its effective service capacity is the equivalent of four three car sets. However, the stabling requirement is the equivalent of eight three-car sets.

6.3.1.1 Data analysis

Queensland Rail maintains its City Network fleet with the objective of meeting a set of defined performance indicators used for both internal and external stakeholders. All comments in this section are based on data presented in the Queensland Rail monthly reports to TransLink except as nominated.

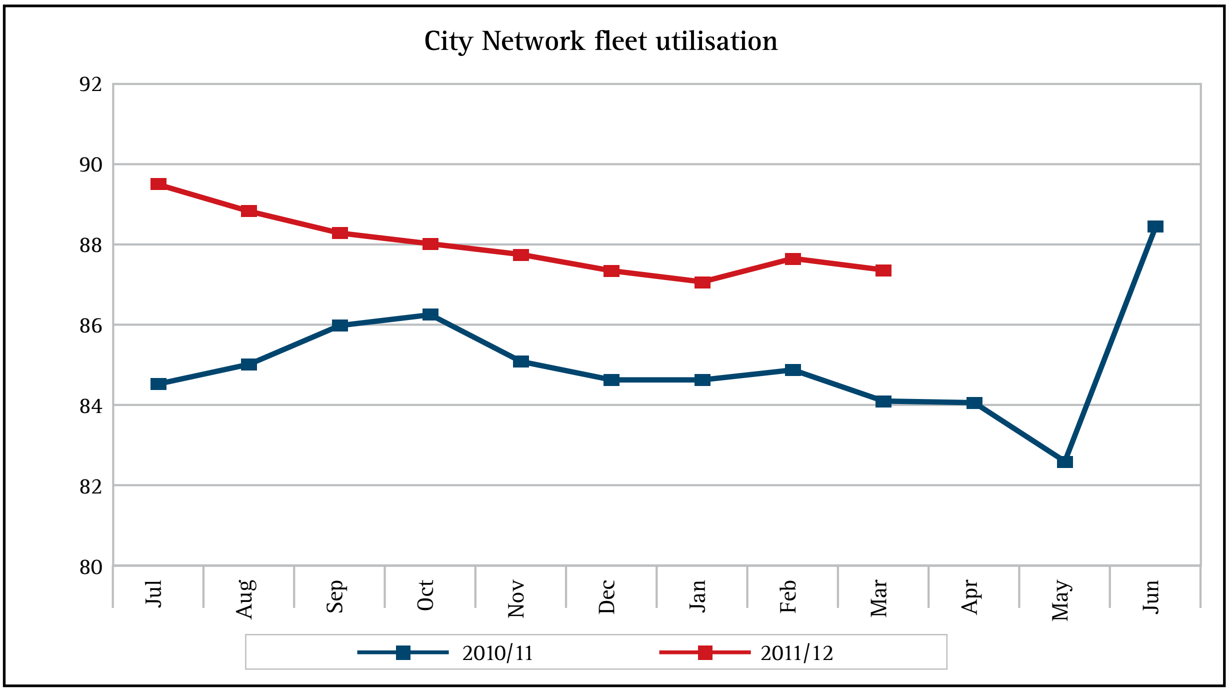

Figure 20 – City Network fleet utilisation 2010-11 and 2011-12 to March 0212
Source: City Network Transport Service Contract – Monthly Report to TransLink March 2012

Figure 20 indicates that rolling stock has not met the minimum target utilisation in the current financial year.

Fleet availability over the combined morning and evening peak periods is described in the Queensland Rail monthly reports to TransLink as the percentage of fleet used for revenue services in the combined peak periods and has a target of a minimum of 90 per cent.

For a fleet size of 207 Suburban and Interurban sets not including the ICE fleet, the minimum target of 90 per cent for fleet availability represents 187 suburban sets available for use.

For the first five months of this year, an average of eight three-car sets were lost from the morning peak for overhaul and warranty repair work at RACS Redbank and EDI Rail Maryborough. In addition, an average of two, three car sets were lost for installation of CCTV, communications system, disability compliance standards, signage and corporate rebranding.

On a typical weekday the availability of rolling stock is as follows:

3	Inspection
8	Major Overhaul
10	Repairs
1	Rebranding
1	Modifications (CCTV, Communications etc)
184	Available for service
207	**Total**

This represents a shortfall against the target of three three-car sets in the morning peak.

Findings:

Rolling stock has not met the minimum target utilisation in the current financial year.

As a result of current levels of service and current fleet numbers it is unlikely that Queensland Rail can meet its contractual fleet availability requirements.

6.3.1.2 Rolling stock maintenance

Due to the complex nature of rolling stock and the limited time available for the Audit, only train doors and pantographs were selected as the focus of the Audit. Pantographs are one of the two key contact points with the below rail infrastructure, and train door malfunctions can prevent passenger loading and unloading reducing OTR (overall) performance.

As part of the asset maintenance audit the following aspects of rolling stock maintenance were subject to audit:

- maintenance plans
- corrective maintenance
- planned maintenance
- reviews and monitoring
- documentation
- asset knowledge
- competency and training
- physical condition review

This section records findings by exception.

Train doors

Maintenance staff are required to maintain seven different types of doors on seven types of trains with some variations between the door types. The correct set up of the different types of door systems requires a consistent and effective approach. In response to this a specialist team has been established to work exclusively on the train door systems. As a result of this approach the frequency of delays due to reported door faults has decreased each year since 2009.

However, due to the diversity and number of door types, the availability of spare parts and components reduces with fleet age.

It is considered possible that door reliability can be increased by greater emphasis on the standardisation of components throughout the different fleet types and the use of only components that have been trialled and proved in operation. Due to issues with the availability of spare parts and components a train may be required to be out of service, impacting rolling stock availability, or operate with locked doors impacting passenger loading and, as a result, reliability.

Finding:

Maintenance staff are required to maintain seven different types of rolling stock doors on seven types of trains.

Pantographs

A pantograph is the train roof mounted equipment that connects to the OHLE enabling the train to draw traction power for its operation.

Queensland Rail has developed a standard design for pantographs which is progressively replacing other designs. The current practice is for Queensland Rail staff to undertake routine maintenance and audits of pantographs. All overhaul work of pantographs is undertaken off site by a specialist supplier.

The standards for pantograph maintenance, engineering practices and documentation were reviewed for currency, relevance and content. No significant issues were identified.

6.3.1.3 Asset knowledge

High levels of staff competence, motivation and experience were observed by the Audit team. This is reflected in the quality of work being delivered and level of overall asset condition. It is further noted that the overall condition is better than similar aged rolling stock in other comparable railways.

Since 2010, considerable changes have been made to the manner in which the maintenance is delivered and the way the long term plan for the traction power assets is being developed. As a general comment, the management of the rolling stock maintenance section have established a system with high quality technical and administrative practices. The technical condition of the ageing fleet is being well managed.

It is considered this will be further enhanced once the EAMS is fully implemented.

6.4 Asset renewal

As described in section 6.1, Queensland Rail has changed its focus from asset maintenance to asset management by working from the initial asset installation phase to the end of asset life replacement phase. This shift in focus not only required Queensland Rail to maintain business as usual while meeting performance improvement expectations, but also to undertake an accelerated program of replacing life expired assets.

Asset Renewal Planning

As a continuation of the asset management process Queensland Rail is also transitioning its asset renewal practices to align with its recent 'Asset Lifecycle and Project Management Policy'. The development of any infrastructure renewal plan should be aligned with the asset policy developed for each engineering discipline. However, time is required for the full implementation and for the benefits to be realised.

This in turn should form the basis of, and be directly linked to, the TSC(RI) or relevant TSC, its ongoing management and the Queensland Government's forward estimates processes through Transport and Main Roads. Long term planning should not be limited by the life of the TSC or government funding processes.

Rail infrastructure traditionally has a relatively long life, in the range of 30 to 50 years. Much of the infrastructure comes at a considerable cost and involves long lead times for manufacture and delivery. As such, asset renewals require careful and considered planning to avoid:

- premature replacement
- replacement of assets with inadequate future capacity
- insufficient integration with future projects.

Due to the longevity of numerous assets, the capital cost of replacement is significant. It is critical that these are planned and documented well in advance of the end of life to ensure funding availability at both the corporate and government level.

A number of below rail assets are of a significant age and do not currently have a renewal strategy. Consideration needs to be given to renewal strategies of these assets for the next twenty years. These include: overhead and electrical systems, signalling systems, bridges, points, telecommunications systems. Given the volume of required asset renewals and replacement, early planning and forecasting of funding requirements will be critical in ensuring funding availability to meet the emerging needs.

While renewal strategies and plans are in place, and work is progressing to develop the plans for the longer term, at present most are limited by current time frames of the TSC(RI). This will require significant changes to existing TSC(RI) modelling to meet the international best practice (such as PAS 55 or UIC guideline[16]) requirements. Significant ongoing capital expenditure is required over the next twenty years. This expenditure should be planned and forecast as early as possible.

From the above rail rolling stock perspective, Auditors were advised that the renewal of rolling stock is managed through acquisition projects at the corporate level, as is the case with the new generation rolling stock project.

Findings:

Currently, most asset renewal plans are linked to the existing TSC(RI) which expires in June 2013.

A number of network assets are of a significant age and do not currently have a renewal strategy.

It is critical that asset renewal plans are documented well in advance of the end of asset life to ensure appropriate investment decisions at both the corporate and government levels.

16. *Guideline for the Application of Asset Management in Railway Infrastructure Organisations* published by International Union of Railways (UIC) in 2010.

7 Contracts and capital investments

The Queensland Government purchases a range of rail services from Queensland Rail under the provisions the three major Transport Service Contracts, providing funding of over $1.5b annually. The Transport Service Contracts are funded as Community Service Obligations.

Transport Service Contracts are Queensland Rail's main source of revenue. Two of the three contracts are within the scope of this Audit, however, unless specified otherwise, recommendations should apply to all three contracts.

The three contracts are:

- Transport Service Contract (Rail Infrastructure) (TSC(RI))
- City Network Transport Service Contract (CNTSC)
- Long distance passenger Rail Transport Service Contract (Traveltrain), which is out of scope of this Audit.

7.1 Existing Transport Service Contract (Rail Infrastructure)

The TSC(RI) is entered into under the provisions of the *Transport Infrastructure Act 1994*. The current contract came into effect on 1 July 2006 and will expire on 30 June 2013.

The objective of the TSC(RI) is to:

- maintain a 'fit for purpose' capability for the state's non-commercial rail network, including the south-east Queensland network
- address Government's rail transport outcomes including the provision of infrastructure services and management of the track, including the implementation of capital projects to upgrade renovate and replace network assets
- provide network access to accredited operators of passenger and freight services.

The total budget for the TSC(RI) in 2011-12 is $500m. Of this $279.5m is allocated to the south-east Queensland network, with $144.1m being payments for return on asset and depreciation for major rail projects delivered since 2006.

There has been significant additional expenditure during the life of the current TSC(RI) under the provisions of the South East Queensland Infrastructure Program and Plan (SEQIPP). This has included the duplication and triplication of tracks and extensions to the network such as Robina to Varsity Lakes and Darra to Richlands and Springfield.

The TSC(RI) reporting framework requires Queensland Rail to supply quarterly and annual Infrastructure and System Performance and Project Progress Reports to Transport and Main Roads. Queensland Rail is also required to submit annual project proposals for review and approval, as well as seeking Transport and Main Roads approval for variation to approved projects.

The TSC(RI) specifies infrastructure standards and outcomes for a set of four Base Service Levels (BSL). The BSLs are monitored to ensure that network infrastructure is maintained to an agreed standard, in particular 'fit for purpose' network capability. BSLs are reported on a quarterly and annual basis to Transport and Main Roads. The BSLs include, an Overall Track Condition Index, Temporary Speed Restriction Threshold, Below Rail Train Cancellation and the Average Below Rail Delay per 100km.

7.2 Existing City Network Transport Service Contract

The CNTSC is entered into under the provisions of the *Transport Operations (Translink Transit Authority) Act 2008* under the delegation of the Chief Executive of Transport and Main Roads. The current contract came into effect on 1 July 2010 and will expire on 30 June 2013.

The total budget for the CNTSC in 2011-12 is $845.3m increasing to $924.1m in 2012-13.

The CNTSC is considered a relationship based contract which specifies the service outcomes for services, stations, on board trains, communications and marketing activities, revenue assurance, base level kilometres and growth kilometres, among other things. However, it does not specify the actual services purchased. It has a total of 36 KPIs and other indicators, with target trajectories across the term, including balanced indicators on financial performance.

Queensland Rail provides monthly and annual reports to TransLink for consideration, in addition to a number of groups which meet on a regular basis for consideration of elements of the business. The reporting includes, but is not limited to, On Time Running, Services Delivered, Customer Satisfaction, Fleet Utilisation and Delay Minutes.

In the 2011-12 financial year, the OTR (overall) target is 93.77 per cent, rising to 94.55 per cent for the 2012-13 financial year on 1 July 2012. When the OTR (overall) falls below this figure for three consecutive months the TSC requires the issuing of a performance improvement notice from TransLink to Queensland Rail.

7.3 Capital investment

Within the provisions of the Audit, discussions were held with Queensland Rail managers and executives on capital investment and prioritisation across several business groups. The Auditors were advised that Queensland Rail is replacing and modernising the process that has been in place for some years. With the different business groups at different stages of development and maturity, it is generally accepted that while processes are being improved, further time is needed to fully develop, implement and review the investment and prioritisation processes.

The general concept is built on the development from projects through sub programs to program levels with specified outcomes and linkages to agreed KPIs. Prioritisation is outcome based and requires a clear understanding of and relationship to the KPIs and business objectives.

While Queensland Rail is working towards an improved capital program methodology, it is noted that it does not give consideration to Government's broader transport objectives and investment strategies. In addition, tools such as the EAMS are being implemented across the organisation to better understand the life cycle of assets. The south-east Queensland Network and Rail Operations Groups are progressing with the development of a five year rolling management and replacement strategy.

The mutiple state purchase agreements for the TSCs and segregated nature of the capital funds available limits the flexibility to meet changing needs and priorities and achieve best value for money of capital investments from a whole of state perspective.

Finding:

The mutiple state purchase agreements for the TSCs and segregated nature of the capital funds available limits the flexibility to meet changing needs and priorities and achieve best value for money of capital investments from a whole of state perspective.

7.4 Future transport service contracts

All three major TSCs between the State of Queensland and Queensland Rail expire on 30 June 2013. Work is currently underway to reconsider the function of the contracts, their individual costing/funding models and the services and service levels Government wants to purchase, with a view to bringing them into line with current funding policy.

The term of the TSCs is one area that is being considered. Legislation currently allows for a maximum of seven years for a Transport Service Contract. In the case of the TSC(RI), the seven year contract has limited both Transport and Main Roads and Queensland Rail in having sufficient flexibility to manage the contract to meet emerging reliability needs and requirements.

There is no commonality in KPIs and reporting between the TSCs, which results in multiple reports and data sets which may lead to differing interpretation. Consideration should be being given to common or headline KPIs to sit and be reported across all three major contracts.

Additionally, the existing structure of the TSCs is that major infrastructure is prioritised, bid for and subsequently funded along the lines of the businesses and business objectives. Major infrastructure, including upgrade and replacement of existing below rail infrastructure such as signalling systems, could be better considered along the lines of Government transport objectives, funded and managed outside of the TSC until it becomes operational. This will provide a more holistic and balanced approach to funding major projects. Prioritisation of emerging needs and projects should be considered first within the capacity of existing program expenditure before new or additional funding is sought.

Since July 2010, station infrastructure within Queensland Rail is managed by the Network business group but funded through the above rail contracts, which convolutes the reporting and management lines. Consideration could be given to moving station infrastructure and maintenance funding from the above rail contracts to the below rail contract. This will ensure that all fixed infrastructure is funded and managed holistically under the one contract.

Findings:

Current TSCs are not aligned to Government objectives, and KPIs and reporting across the TSCs are not consistent.

Major infrastructure, including upgrade and replacement of existing below rail infrastructure, such as signalling systems, could be better considered within the broader context of Government transport objectives.

8 South-east Queensland network demand

On 6 June 2011, Queensland Rail introduced a new timetable for City Network passenger services. The new timetable saw a substantial increase in passenger services. Freight services through the network have also grown, with increasing demand.

Table 4 shows a snapshot of the increase in train movements across the south-east Queensland network (City Network, long distance passenger and freight services) on a typical Friday, which is the busiest day of the week.

	2007	2008	2009	2010	2011
Train movements per day (Friday)	746	790	800	820	921
% increase on previous year		6%	1%	2%	12%
% increase since 2007		6%	7%	10%	**23%**

Table 4 – Snapshot of train movements on Fridays – 2007 to 2011.

Between 2007 and 2011 there has been a 23 per cent increase in train movements.

8.1 Impact of service demand on fault recovery

To evaluate the impact on passenger delays Queensland Rail's south-east Queensland Operations Group were requested to undertake a quantitative analysis of the operational impact of unplanned track closures. The analysis took into consideration the current timetable and current south-east Queensland network layout. The analysis was based on the scope and objectives agreed upon by Transport and Main Roads and Queensland Rail. The outcome of this analysis provided quantitative metrics relating to the sensitivity of the current timetable and the south-east Queensland network to a range of fault scenarios in the rail system (unplanned track closures).

Due to time limitations to undertake the analysis, various assumptions were made for simplifying the modelling exercise. These assumptions, associated scope and methodology are included in Appendix C.

As part of the analysis, five fault scenarios (unplanned track closures) were selected. These were:

- closure at Roma Street (location of 28 February 2012 incident)
- closure at Milton (location of 14 March 2012 incident)
- track circuit failure at Petrie
- South Brisbane Platform 3 closure
- Ipswich Platform 3 and 4 closure.

All the above scenarios were modelled for unplanned track closure at 0730 hours on a week day.

Analysis results

The analysis suggested that to avoid a major disruption[17] the incident (or fault) needs to be recovered within the timeframes shown in Table 5.

Scenario	Time available to recover the fault to avoid a 'major disruption'	Network impact
Closure at Roma Street (location of 28 February 2012 incident)	40 – 50 Minutes	Significant widespread disruption (across the network).
Closure at Milton (location of 14 March 2012 incident)	60 – 70 Minutes	Widespread disruption (across the network).
Track circuit failure at Petrie	50 – 60 Minutes	Disruption on some lines.
South Brisbane Platform 3 closure	60 – 70 Minutes	Disruption on some lines.
Ipswich Platform 3 & 4 closure	60 – 75 Minutes	Disruption on some lines.

Table 5 – Time to avoid a major disruption.

Finding:
The current morning peak timetable leaves limited time for recovery and therefore disruption at critical locations, such as Roma Street or Milton, will result in significant impact across the network.

Rolling stock fault analysis

The Audit team examined component fault categories in the period from 2007 to 2012 on an historical trend basis. The trend lines each month generally show a downward trend.

Further investigation suggests that although the initiating technical faults[18] have not increased over the last five years, the effect of increased services on the south-east Queensland network mean that consequent delays following an initiating technical fault have significantly increased.

Data indicates that due to an increase in services (congestion in the rail system) the total effect on a delay due to a rolling stock technical fault is almost double in 2012 in comparison to 2007.

Finding:
Due to increasing demand on the south-east Queensland network the total effect on a delay due to a rolling stock technical fault is almost double in 2012 in comparison to 2007.

8.2 Other operators

The Audit team conducted interviews with major non passenger operators and customers to gauge their opinions on the reliability of the south-east Queensland network. General opinion is that the south-east Queensland network is meeting their requirements, but upgrades such as an additional Brisbane River crossing and track duplications would aid their businesses. Freight travelling through the south-east Queensland network and in particular on the North Coast Line includes general and bulk industrial, construction, cattle and bulk fresh food supplies for north and far north Queensland.

The particular area of concern to freight operators is the impact of SCAS closures on freight services.

17. Major disruption – when at least one peak service train is delayed for one hour or more.
18. Technical rolling stock fault which is responsible for initiating delay.

There are a number of areas of particular concern in relation to weekend SCAS closures on the North Coast Line including:

- programming closures during the wet season November to March, as this is the peak freight service period to enable the provisioning of commercial customers in the lead up to Christmas and additional bulk commodities, building materials, non perishable food and household goods, in advance of wet season closures
- regardless of the time of year, just-in-time fresh food has to be transported by road. For each freight train not able to operate, a minimum of 10 trucks are required to haul just-in-time commodities and food to north and far north Queensland
- all tracks closed for 40 to 50 hours and reopening immediately prior to Monday morning peak. This practice effectively extends the closure to non commuter trains by four to five hours as freight trains are held until after the peak period. Freight operators have suggested that in most North Coast Line SCAS closures making a single track available to freight operators during the overnight hours when Queensland Rail staff are not working on the line would assist them in meeting their business needs. As freight trains use diesel hauled locomotives the OHLE is not required and progressing through the works areas under speed restrictions is preferable to not being able to operate at all
- consideration also needs to be given to freight operators in the shorter term non SCAS regular closures as these also have a detrimental impact to OTR, consequential impacts as they travel the rest of the network and delivery penalties.

The Rail Corporation of New South Wales, operator of the daily passenger service to and from Sydney was not consulted in this Audit.

Finding:

SCAS closures impact on freight services on the North Coast Line.

9 Recommendations

#	Recommendation	Section
Queensland Rail:		
1.	Develop and submit to the Minister for Transport and Main Roads by 15 August 2012, an implementation plan. This plan is required to address the recommendations identified in this report relevant to Queensland Rail.	
2.	Report to the Minister for Transport and Main Roads on a quarterly basis commencing 15 October 2012 the progress of the implementation of the recommendations.	
3.	Continue with the wedge clamp inspection program.	4.2.1.7
4.	Develop a clear set of installation instructions for all types of wedge clamps in use by the organisation and brief OHLE staff on the installation and maintenance for all types of fittings in use.	4.2.1.3 4.2.1.7
5.	Formally review 'linesman training' and incorporate the correct installation procedure for all OHLE fittings into this training.	4.2.1.3
6.	As part of future resignalling upgrade projects, consideration should be given to the adoption of double rail track circuits and axle counters.	4.2.2
7.	Conduct a feasibility study of the signalling data links for replacing the existing copper cables with optic fibre bearers for signalling data links in critical areas.	4.2.2 5.2.3
8.	Examine the feasibility of eliminating vegetation at selected high risk locations using engineering solutions such as the provision of concrete or heavy duty matting to cover earth cuttings.	5.2.1
9.	Review the vegetation management system to ensure effective control on line-side vegetation.	5.1.6 5.2.1 6.2.2.6
10.	Re-evaluate the roles, responsibilities, individual workloads, and staffing numbers of its Reliability, Below Rail and Track Protection Officer teams.	6.2.1.1 6.2.1.2 6.2.2.3 6.2.2.4
11.	In relation to maintenance teams in Network SEQ, prepare protocols governing internal quality audits and implement internal quality audits of work being performed by its staff.	6.2.2.4
12.	Identify and implement strategies to bring a cultural change in the way infrastructure defects/hazards are identified, prioritised and re-prioritised.	6.2.2.1 6.2.2.2 6.2.2.3 6.2.5
13.	Identify and implement strategies to improve 'time-on-tools' for maintenance teams during SCAS closures.	6.2.2.3
14.	Formalise maintenance and review processes to align with the asset management strategies.	6.2.2.4 6.2.2.5
15.	Develop and communicate work instructions for power systems activities.	6.2.2.5

#	Recommendation	Section
16.	During the implementation of the Enterprise Asset Management System, ensure: a. EAMS is structured with a sufficient level of granularity to ensure that all traceable minor assets can be effectively managed b. EAMS offers effective asset data repository and GIS functionality to eradicate the current local asset data information systems c. the development and adoption of processes used to manage data held in TSMS and RIMS in parallel with EAMS d. EAMS has the ability to readily enter and interrogate outstanding actions and fault information.	6.2.3 6.2.3.1
17.	Implement a formal rail stress register for SEQ network to manage the Stress Free Temperature effectively.	6.2.2.7
18.	Review its NDT (ultrasonic test) run frequency in the SEQ network.	6.2.2.7
19.	Implement a formal review process for select training and refresher courses.	4.2.1.3 4.2.1.4 6.2.4
20.	Review the scheduling of rolling stock overhauls, frequency of warranty repairs and other corporate requirements to determine a limit on the number of units unavailable.	6.3.1.1
21.	Develop asset renewal plans based upon long term asset renewal needs.	6.4
22.	Review SCAS and other short term closures particularly on the North Coast, Ipswich and Cleveland Lines to ensure limited but equitable access for freight operators where possible to improve the reliability of rail freight operations.	8.2
23.	Evaluate possibility of standardising door components throughout its fleet including proposed new fleet.	6.3.1.2
Department of Transport and Main Roads:		
24.	Develop and submit to the Minister for Transport and Main Roads by 15 August 2012, an implementation plan. This plan is required to address the recommendations identified in this report relevant to the Department of Transport and Main Roads.	
25.	Report to the Minister for Transport and Main Roads on a quarterly basis commencing 15 October 2012 the progress of the implementation of the recommendations	
26.	By 30 June 2013, review, develop and negotiate new Transport Service Contracts with Queensland Rail to support and deliver the Government's transport objectives.	7.4

Glossary of terms

BSL	Base Service Levels
CNTSC	City Network Transport Service Contract
EAMS	Enterprise Asset Management System
ECO	Electric Control Operator
EMU	Electric Multiple Unit
GIS	Geographical Information System
ICE	Intercity Express
IMU	Interurban Multiple Unit
KPI	Key Performance Indicator
NDT	Non Destructive Testing (ultrasonic)
OHLE	Over Head Line Equipment
OTR	On Time Running
RIMS	Railway Infrastructure Maintenance System
SCAS	Scheduled Corridor Access System
SFT	Stress Free Temperature
SMU	Suburban Multiple Unit
TPO	Track Protection Officer
TSC(RI)	Transport Service Contract (Rail Infrastructure)
TSMS	Trackside Systems Management System

Appendix A

Physical condition inspections

Date	Site Inspected
09/05/12	Milton section, re 14 March incident (street side only)
10/05/12	Mayne Train Control Centre
11/05/12	Telecommunications - Fault Coordination Centre (FCC), Rail Centre 1
13/05/12	Yeronga to Yeerongpilly (inspection cancelled due to access not being provided by Queensland Rail)
14/05/12	Roma St to Bowen Hills Line: Mains
14/05/12	Mayne - Signalling
15/05/12	Mayne Depot
15/05/12	Corinda to IndooroopillyLine: Mains
15/05/12	Sunshine - Signalling
15/05/12	Albion OHLE depot
15/05/12	Mayne Power Systems depot
16/05/12	Corinda Feeder Station
16/05/12	Redbank lineworks training centre
16/05/12	Beenleigh Feeder Station
16/05/12	Wulkaraka Feeder Station
16/05/12	Caboolture Feeder Station
17/05/ 12	Milton to Auchenflower

Appendix B

Figure B1 – Pumping sleepers (down main line between Fortitude Valley and Bowen Hills).

Figure B2 – Pumping sleepers and mud hole (down main line between Fortitude Valley and Bowen Hills).

Figure B3 – Pumping sleepers and mud hole (down main line between Milton and Auchenflower).

Figure B4 – Blocked drain at northern entrance to number 1 tunnel Fortitude Valley.

Figure B5 – Rail head damage on an insulated joint (down main line between Corinda and Sherwood). Photograph was taken on 15 May 2012 and the damage was repaired on 20 May 2012.

Figure B6 – Damaged rail fastening insulator (down main line between Corinda to Sherwood).

Figure B7 – Park Road Bridge from Park Road, Milton.

Appendix C - Unplanned track closure modelling study

1 Scope

1.1 In scope

<table>
<tr><th>Ref</th><th>Item</th><th colspan="2">Main Actions</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Development unplanned track closure scenarios</td><td>a) Historical scenarios
Develop simplified incident scenarios relating to the following dates:
28/02/2012 – Roma Street de-wirement
14/03/2012 – Western Mains overhead trip
17/04/2012 – Petrie track circuit failure.</td><td rowspan="2">Perform rational simplification of actual incidents.
Specify track elements affected.
Specify time of day incident occurrence.
Developing a range of duration of incidents to be evaluated.</td></tr>
<tr><td>b) Theoretical scenarios
Develop two additional incident scenarios.</td></tr>
<tr><td>2</td><td>Quantitative analysis</td><td colspan="2">Implement and evaluate the relative performance of the current timetable and network with and without track closure scenarios using Railsys (RMCon) simulation software.
Determine the track closure duration trigger point of a severity level 3 incident based of modelled outputs.</td></tr>
<tr><td>3</td><td>Reporting</td><td colspan="2">Produce documentation summarising the modelling task and outcomes.</td></tr>
</table>

Table C1.1 – Scope lists in scope items.

2.2 Out of scope

The modelling task feasible within the study period is a simplification of the complexity of real operations. The items outlined in Table 2.2 – Out of Scope are out of scope of the modelling exercise. This is due to:

- purposeful scope narrowing simplifications to facilitate expedited modelling
- unavailability of analytical tools suitable for modelling the phenomena within the study period
- low feasibility of implementing a suitable modelling solution within the study period.

Ref	Category	Description
1	Expedited Incident Recovery	Investigations relating to factors influencing the duration of track closures.
2	Restricted Utilisation	Scenarios resulting in reduced performance of a track section as opposed to complete closure to rail traffic (P-90s etc).
3	Train Crew	Modelling the impact of the robustness of the crew schedule on timetable recovery.
4	Train Control	Service cancellations / fresh turnouts. Explicit replication of Queensland Rail dispatching/rerouting rules. Altered service details such as unscheduled express running or early termination to alleviate delays.
5	Crowding	The impacts of crowding on customer comfort. Flow-on operational impacts such as dwelling extensions due to redistributed passenger boardings/alightings.
6	Third Party Operators	Produce documentation summarising the modelling task and outcomes.

Table C1.2 – Scope lists out of scope items.

Several of these factors affect the timely recovery of the timetable from unplanned track closures. This is noted as a modelling limitation.

2 Methodology

Establish and evaluate baseline model	• Establishing simulating current timetable. • Refine infrastructure and control rules. • Measure any delays inherent in baseline timetable via simulation.
Establish and evaluate incident scenarios	• Design and implement track closures. • Superimpose incidents on baseline model and measure incident delays via simulation.
Calculate difference in performance metrics between baseline and scenario	• Perform post processing of simulation outputs. • Produce key performance measures.

Figure C2.1 – Methodology outline provides as overview of the methodology used.

2.2 Modelling assumptions

Table 2.2 – Modelling assumptions

Ref	Category	Description
1	**Track utilisation during incidents**	• All tracks in the evaluation area are in one of two states: 1. rendered completely unusable by rail traffic or 2. fully functional as per normal operations. • Other states involving diminished performance are not considered.
2	**Transitions between closure states**	• For the historically relevant incidents characterised by a sequence of different track sections rendered unusable at different points in time, the most limiting situation was selected as the sole closure to model.
3	**Time of incident occurrence**	• All incidents were initiated at 7:30am • At this time, the highest number of vehicles are in active use in the timetable. • It is acknowledged that the time of occurrence of an incident that results in the largest impact is different for each location in the network.

Table C2.2 – Modelling assumptions contain the major modelling assumptions required to define the simplified scenarios.

2.3 Modelling approach

2.3.1 Preferred method

When studying the complex interactions between vehicles, infrastructure, train crew, customers and other sources of variability affecting capacity over a large spatial and temporal scope, rail microsimulation is a suitable quantitative approach.

Perturbed simulation mimics the impact of daily variations on real operations by superimposing the impact of “soft” capacity factors (eg variance of dwell times due to passenger movements, variability in driver behaviour) on top of “hard” capacity factors (eg theoretical rolling stock, infrastructure capability, timetable structure).

Perturbed simulation was not feasible within the study period due to:

- large data and analytical resource requirements when conducted over a large study area
- large analytical effort required to calibrate a model of the current timetable against suitable historical performance data that will simulate sufficiently when subjected to both perturbations and an incident
- cumbersome and contentious issues surrounding cleaning secondary delays from perturbation data.

2.3.2 Adopted method

The adopted approach is unperturbed simulation including track closures to model the network incident. Railsys features track closure modelling functionality.

Unperturbed simulation captures the "hard capacity factors" of infrastructure capacity, rolling stock performance and timetable structure. Unperturbed simulation is relevant and descriptive in quantifying the impacts of incidents for the following reasons.

1. **The incident is the predominant source of delays:** On systems with high infrastructure utilisation on scheduled and alternative routes, large primary delays occurring in the proximity of an incident ricochet through the network potentially causing significant knock-on delays. The direct and indirect impacts of the incident overshadow the impacts of the small, frequently occurring daily variations. While smaller daily perturbations contribute to pushing the timetable in the direction of instability and consume the relatively small amount of recovery allocated to ameliorate small variations, the critical components of the system are the large primary and flow on impacts of the incident. The major disruption is the predominate source of delays.
2. **Comparative value:** By assessing the difference in delays between unperturbed scenarios with an incident in place, to scenarios without an incident in place, unperturbed simulation provides a comparison of an optimal day of running to a major incident with no other disruptions.
3. **Removal of other sources of delays:** Unperturbed simulation omits other sources of variance allowing the impacts of the incident to be studied in isolation from other sources of delays.

Information contained in Appendix C is an extract from Queensland Rail report ‘Unplanned Track Closure Modelling Study’ V1.0 dated 15 June 2012.

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