RAIL SAFETY INVESTIGATION REPORT

MAIN LINE RAIL DEFECT

BORONIA NO. 3 TUNNEL

10 OCTOBER 2014

Cover photograph: digitally altered (lightened) image of Boronia No. 3 Tunnel (Source OTSI)

Released under the provisions of
Section 45C (2) of the Transport Administration Act 1988 and
Section 46BBA (1) of the Passenger Transport Act 1990

Investigation Reference 04657
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EXECUTIVE SUMMARY

On 10 October 2014, Sydney Trains maintenance staff discovered that five consecutive track fasteners had failed on the Up Main line within Boronia No.3 Tunnel located between Cowan and Hawkesbury River. In the vicinity of 54.387 kilometres, long term water ingress had corroded the track and track fastenings to a point where the fasteners failed. The unrestrained track had the potential to displace laterally to the extent that a derailment could have occurred.

OTSI's investigation found that the corrosion related defects to the track fastenings had progressed over time and went undetected by Sydney Trains’ maintenance regime. A rail corrosion defect had been identified at this location (first recorded 7 March 2011). However, the inspection regime from 2011 to the incident date had not adequately identified the deterioration of the track fastenings at this location.

OTSI reviewed other similar incidents and Sydney Trains’ internal audits, and found that inadequate track inspection and inadequate maintenance were systemic. For example, an investigation by Sydney Trains into the derailment of a freight train at Sefton on 18 October 2015 found that there had been significant failings in the lead up to the incident in the way the track defect had been assessed and managed.

In many cases, Sydney Trains’ maintenance staff did not use the technical guidance material available for each type of inspection and consequently did not address all inspection criteria. There were deficiencies in the training and competence of inspectors and in the assurance of track maintenance activities. OTSI found there was insufficient management oversight to give assurance that track inspections were performed to the required standard across the Sydney Trains network.

OTSI has made a number of recommendations to Sydney Trains in the areas of infrastructure inspections and staff training and competency assurance. Refer to Part 3 Findings and Part 4 Recommendations for further detail.
1.1 The incident location was within Boronia No. 3 Tunnel. This is one of four tunnels between Cowan and Hawkesbury River stations on the Main North line which takes all rail traffic travelling north of Sydney.

1.2 The tunnel is approximately 140 metres (m) long, between (track locations) 54.340 and 54.480 kilometres (km). The defect location was within the tunnel around 54.387 km, approximately 45 m into the tunnel from its southern portal.
Track information

1.3 The Main North line has an Up and Down track\(^1\), both provided with signalling infrastructure to allow trains to run in either direction. The line had a weekly traffic load of over 350 trains in each direction with a mix of passenger and freight traffic. Maximum allowable train speed through the tunnel was 55 kilometres per hour (km/h) in either direction.

1.4 The track through the tunnel is continuous welded rail, 60 kg/m, with a hardened railhead. The track through Boronia No. 3 Tunnel uses a “direct fixation track system” whereby the track assemblies (Up and Down rails) are bolted onto a concrete slab. This was achieved by securing each rail using

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\(^1\) The Up line is primarily for trains travelling towards Sydney. Conversely, the Down line is primarily for trains travelling away from Sydney.
Pandrol clips to a double shoulder sleeper plate (see Figure 3). The plate in turn was bolted, through a mortar pad, to a concrete slab.

![Figure 3: Rail section and fastening details](Source: Sydney Trains, modified by OTSI)

1.5 The radius of the curve at the defect location (54.387 km) was 217 m with a rising grade of 2.5105% (approximately 1:40). The track had a cant\(^2\) of 90 mm. The concrete slab extended for the width and length of the tunnel and was designed in 1987 and constructed soon thereafter. The gauge\(^3\) was designed to be 'standard', that is 1435 mm. However, the 'as built' gauge of the Up Main line through Boronia No. 3 Tunnel was 24 mm wider than standard.

**Environmental conditions**

1.6 The incident defect occurred within a tunnel which was not equipped with artificial lighting. The tunnel was relatively short, at about 140 m, and useful amounts of daylight could penetrate a short way into the tunnel. Depending on natural lighting conditions, about 120 m of the tunnel remained in darkness. Hand held torches were, in most cases, used to inspect and maintain infrastructure in the tunnel. While this was no different to a number of other

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\(^2\) Cant, or Superelevation: The difference in height between the low rail on the inside of the curve and the outer rail.

\(^3\) Gauge: The distance between the inside running faces of the rails, measured 16 mm down from the top of the rail, nominally 1435 mm.
tunnels around the Sydney Trains Network, it did add a level of difficulty when carrying out the various inspections through the tunnel.

Post occurrence

1.7 Once the defect at 54.387 km was detected, the Acting Maintenance Services Manager categorised the defect as emergency level 1 (E1) and arranged for the installation of an improvised temporary repair to allow rail traffic to resume on the Up Main line pending a permanent repair. A number of wooden sleepers were cut to size and used to brace the unrestrained rail against the tunnel wall (see Photograph 1) to maintain rail gauge to within an acceptable tolerance. While freight trains continued to operate on the other track, passenger trains were permitted to travel over the stabilised defect area at a reduced speed of 10 km/h. After the passage of each train, the location was reinspected to ensure that the track was safe for the next train.

Photograph 1: Wooden sleepers and wedges used to brace the unrestrained rail against the tunnel wall (Source: Sydney Trains)
1.8 A permanent repair of the E1 defect at 54.387 km was made the day after its discovery. The five corroded and ineffective fastenings, including sleeper plates, were replaced. Resilient baseplates\(^4\) were used, secured by two hold down bolts, one on each side of the rail.

**Network management and access**

1.9 Sydney Trains is a vertically integrated railway organisation. As well as maintaining the track, they operate passenger services and provide network operations management.

1.10 Maintenance personnel organise access to inspect the running line with network controllers. Work is carried out during suitable opportunities between train movements. Maintenance personnel organised track access to conduct maintenance inspections and repairs.

1.11 The *Sydney Trains Hazardous Locations Register* stated that Lookout Working could not be used on the Up Main line between 54.213 km and 54.591 km, which includes Boronia No. 3 Tunnel. This was due to “Inadequate Minimum Warning Time available for Lookout Working within Danger Zone.”\(^5\) This safety related requirement put further restrictions on track access in this area as longer time periods between trains were needed to implement suitable workplace safety arrangements.

**Proactive Safety Actions by Sydney Trains**

1.12 Sydney Trains issued an *Engineering Instruction CIVIL (EI C 14/04 V1.1)* on 27 November 2014. This instruction highlighted the incident in Boronia No.3 Tunnel to relevant civil staff and instructed them to carry out the following actions:

1. “*Detailed examination of direct fixed track slabs and track components in tunnels in accordance with TMC 301 and MN T 20203 (successor to TMC 203), and the additional requirements in this engineering instruction.*”

\(^4\) Resilient fastenings: An alternative fitting design which can be used to reduce the noise and vibration generated by rail traffic.

\(^5\) Excerpt from Sydney Trains’ safeworking document “*Hazardous Locations Register*.”
2. Identification of defects and actions as described in the following table” (comprising photographs of various defects with required actions and timeframes).

The above Engineering Instruction was implemented by Sydney Trains across their network.

1.13 A number of other documents were also produced by Sydney Trains including an internal memorandum to the responsible General Manager (dated 12 November 2014) and a Network Maintenance, Maintenance Engineering Inspection Report, Boronia Tunnels 3 & 4 (dated 11 January 2015). These documents highlighted a number of defects within the tunnel and near the portal. Of note, the report stated that “pumping track at the interface with the tunnel portal (track slab) creating a fulcrum placing increased stress on the rail and fastenings” (see Photograph 2).

Photograph 2: Track with poor drainage and pumping evident at Boronia No. 3 Tunnel portal (Source: Sydney Trains)
1.14 Sydney Trains also undertook a Level 5 investigation. It was completed in March 2015. OTSI sought further detail to the Level 5 investigation report and Sydney Trains then initiated a Level 4 investigation, their next investigation level.

1.15 The Sydney Trains Level 4 investigation report was finalised 31 August 2015. This report identified a number of safety actions and also referenced recommendations from other Sydney Trains reports. These are listed in full at Appendix 1.

1.16 Sydney Trains has informed OTSI that it has initiated the following since the incident:

- Improved the functionality of the MTP vehicles and that hi-rail vehicle inspections are no longer required through Boronia No.3 Tunnel. Full MTP functionality is programmed to be finalised by July 2017,
- created a central review facility of MTP vehicle data, including additional staff for reviewing data (2016),
- increased the number of track and structure inspection staff (2015),
- increased the number of civil and track engineering positions (2015),
- reviewed track examiner capabilities and provided additional training and assessment of track examiners and engineers (2015).
- the development of a Certificate II and III in Track Maintenance (2016),
- split track and civil engineering to create a dedicated track group (2016),
- adopting a data driven asset management regime (2017),
- designing a Rail Track Training school to provide better ‘hands on’ facilities in the future, and
- creating a university course for track engineer development (2017).
PART 2 ANALYSIS

Introduction

2.1 OTSI became aware of the incident in Boronia No. 3 Tunnel through ONRSR’s NSW Daily Occurrence Report dated 14 October 2014. OTSI initially requested a copy of Sydney Trains’ investigation report in accordance with section 45A(2)(d) of the Transport Administration Act 1988. OTSI received a Level 5 report from Sydney Trains on 20 March 2015. Having reviewed this report, OTSI determined that the circumstances of the incident required further investigation and commenced its own independent investigation.

2.2 The investigation initially focussed on the single incident in Boronia No. 3 Tunnel. However, evidence of systemic maintenance issues was identified and OTSI’s investigation scope widened. The revised scope included other incidents and examples that demonstrated similar track infrastructure inspection and management issues across the Sydney Trains network.

2.3 The track, laid on a concrete slab, had been built 24 mm wider than standard track gauge. The relevant Sydney Trains engineering standard (ESC 210 Track Geometry and Stability) stated that gauge (when track was constructed on a slab) should be within 3 mm of the design gauge. Sydney Trains could offer no explanation for the existence of this wider gauge. According to Sydney Trains’ Base Operating Conditions, wide track gauge of up to 26 mm did not represent an actionable defect on track with a maximum speed of up to 60 km/h (Refer to Appendix 2: Track defect hierarchy). Boronia No. 3 Tunnel has a maximum speed of 55 km/h. The wide gauge was classified as ‘N’ (Normal) which required no action other than routine programmed maintenance inspections. This meant that a further gauge widening of 9 mm would produce an Emergency 2 (E2) defect. In comparison, track built to the standard 1435 mm gauge would need to widen by 33 mm before being categorised as an E2 defect.

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6 These incidents included Homebush (2013), Sydney Terminal (2014), Sefton (2015).
2.4 On 16 September 2014 AK car track recording train\textsuperscript{7} (AK car), on a routine inspection run, detected some track defects in the vicinity of Boronia No. 3 Tunnel. A length of track was examined the next day. Defects were found and recorded, but the defect within the tunnel at 54.387 km was not found by the civil employees.

References to defect locations used within this report

2.5 This report refers to defect locations detected from a variety of inspection methods. For clarity, the defect locations have been allocated with a reference number as presented in Figure 4. These references have been used throughout this report and will appear in square brackets following a reference to a defect or its reported kilometres (e.g., 54.387 km [7] refers to defect seven in Figure 4).

\textbf{Figure 4: Range of reported defects (OTSI)}

\textsuperscript{7} The AK car, so designated because it is made up carriages: AK2382, AK2383 and AK2384. These were formerly sleeping carriages that used to provide sleeping accommodation on the major inter-capital services of the NSW railways. They were converted into their present roles in 2001 and operate as a locomotive hauled train. The AK car measures various track geometry parameters including gauge.
The rail defect discovery

2.6 At approximately 1200 on 10 October 2014, a team from Gosford Network Base arrived to carry out an inspection of the defect identified on 17 September 2014 near the southerly portal of Boronia No. 3 Tunnel on the Up Main line. A Track Occupancy Authority (TOA) was issued at 1256 to allow access to the location.

2.7 A member of the Gosford Network Base team present on site on 10 October 2014 had reviewed Mechanised Track Patrol (MTP) imagery of Boronia No. 3 Tunnel in August 2014. The reviewed images indicated that there was something unusual at the same location as a length of corroded rail about 45 m into the tunnel. Evidence suggests that while this issue may have been reported within Gosford Network Base, no defect had been identified at the location in August. The team member stated at interview that they were interested to see the location for themselves. The team member took the opportunity to walk into the tunnel and observed that there was rail play and corroded track fastenings in the vicinity of 54.387 km [7]. Once confirmed, the defect was immediately reported to the team leader on site.

2.8 The team, having completed their inspection of the previously identified defect, determined that no significant deterioration had occurred since the previous inspection and shifted their attention to the defect within the tunnel at 54.387 km [7]. The TOA was extended from 1300 to 1500 to allow the defect [7] to be assessed. The inspection revealed that there was significant corrosion of the track fastenings and that the rail was no longer adequately restrained.

2.9 The workgroup informed Network Control of the situation and an Incident Rail Commander was dispatched to the site to assist with the management of operational aspects of the incident.

2.10 The Acting Workgroup Leader called their Acting Civil Engineer. However, the Acting Civil Engineer was unavailable and the matter was referred to the

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8 Times used in this report are Australian Eastern Standard Time (AEST) and Australian Eastern Daylight Time (AEDT) as applicable. AEDT began on 5 October 2014.

9 Civil Engineer: the Team Manager Civil (Gosford) was acting in the position at this time.
Acting Gosford Network Base Civil Team Leader and the Acting Maintenance Services Manager\textsuperscript{10}. Both attended the incident site.

2.11 On their arrival, at approximately 1440, it was found that five consecutive fastenings on the inside curve (the rail nearest the tunnel wall) on the Up Main line had failed and the rail was unrestrained. While the static gauge\textsuperscript{11} was measured as being 28 mm wider than standard, there was potential for the unrestrained track to laterally displace further during the passage of a train\textsuperscript{12}. The defect met the criterion for an E1 defect which required remediation before further rail traffic could be permitted.

2.12 Figure 5 shows a representation of track mounted on a concrete slab. The measured (static) gauge is the distance between the rail faces (at $A$, measured 16 mm down from the top of the rail). The Total Potential Gauge is the sum of $A$ and the rail play, measured or assessed, at $B$ and $C$. In this case, the value of $C$ had no upper limit.

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure5.png}
\caption{Determination of total track gauge (Source: Assets Standards Authority NSW annotated by OTSI)}
\end{figure}

\textsuperscript{10} The Acting Maintenance Services Manager was also the local Senior Civil Engineer responsible for this area.

\textsuperscript{11} Static gauge is the gauge measured with no load. It does not take into account movement due to loose, worn or otherwise ineffective fittings under forces applied by a passing train.

\textsuperscript{12} Source: Interviews and Sydney Trains reports.
2.13 The condition of the track at that time is demonstrated in Photograph 3. This image was taken by the Mechanised Track Patrol vehicle on 01 September 2014. One of the ineffective hold down bolts removed from the track is shown in Photograph 4. The wet patch at the incident location was approximately 45 m into the tunnel from its southern portal and is shown in Photograph 5.

![Photograph 3: MTP image 01 September 2014 at of fastenings on the Up Main Line at 54.387 km [7] within Boronia No. 3 Tunnel (source Sydney Trains)]
Photograph 4: Example of a corroded and ineffective hold down bolt removed from the concrete slab on 11 October 2014 (Source: Sydney Trains)

Photograph 5: Showing incident location [7] on the Up Main line after repair and clean up. (Source: OTSI).
Inspection regime and defect history

2.14 On 22 June 2014, as part of a general Sydney Trains wide reorganisation of maintenance (including track, electrical overheads, structures and signalling maintenance) responsibility for Boronia No.3 Tunnel passed from Hornsby Network Base to Gosford Network Base. A new base had been built at Gosford to accommodate all civil disciplines. At the same time, the civil depot at Hamilton became a satellite sub-base to Gosford. The two locations together covered the ‘Central Coast Territory’ for the Sydney Trains network from Cowan northwards.

2.15 On 15 July 2014, an annual rail wear and condition examination was conducted through Boronia No. 3 Tunnel. The inspector did not have prior knowledge of the location and this was their first inspection of this type at this location. Existing defects recorded for the location were available in Teams3\textsuperscript{13}. However, the inspector was not aware they had access to this area’s information and had not checked to see if it was available. The inspector had not received a handover or briefing from Hornsby personnel. No rail corrosion was observed in Boronia No. 3 Tunnel by the inspector, nor did they identify the wet area that existed there.

2.16 A detailed walk (the first one conducted by Gosford Network Base) did note the corroded rail in Boronia No. 3 Tunnel on 10 August 2014. Similar to previous detailed walks (conducted by Hornsby Depot) there was no reference to the condition of the track fastenings. Meanwhile, Teams3 still showed a planned replacement date for the corroded rail of 6 September 2014. However, the corroded rail was not a high priority defect and the track replacement did not eventuate.

2.17 Sydney Trains, and its predecessor RailCorp, had a track and structures inspection regime that included a number of different periodic or triggered inspections (see Appendix 3). Defects identified during an inspection were recorded and entered into Sydney Trains’ Teams3 asset management database. The defects were then managed and repaired depending on the nature and severity of the defect.

\textsuperscript{13} Teams3: A Sydney Trains database that was used to record and manage civil (e.g., track) defects.
2.18 The inspections / examinations of particular relevance to the incident were:

1. Mechanised Track Patrol (MTP): The MTP vehicle ran fortnightly. These inspections were conducted through all tunnels such as Boronia No. 3 Tunnel. However, the review of photographic imagery taken in the tunnels by the MTP reviewer was not mandatory due to the system’s technical limitation to obtain suitable imagery in low-light conditions.

2. Hi-rail\textsuperscript{14} patrols: Hi-rail patrols were conducted on the Main North line, these were carried out up to twice a week. Hi-rail patrols were also utilised as a substitute for the limited MTP photographic imagery inspection.

3. Detailed Walking Examination (conducted every three months): This on-foot examination was a boundary fence to boundary fence inspection of the rail corridor including all track components such as rail fastenings.

4. AK cars: ran every four months and measured various track geometry parameters, including gauge. Note: when the MTP is fully commissioned (planned for later in 2017) the AK cars inspections will be discontinued.

5. Annual Rail Corrosion examination.

6. Two yearly interval (biennial) Detailed Examination of Track Slabs, which included the inspection of track fastenings into a concrete slab.

7. Four yearly interval (quadrennial) Detailed Examination of Tunnels.

2.19 A rail corrosion examination was scheduled annually for rail within tunnels. The first recorded issue identified, at the location on the Up Main line in Boronia No. 3 Tunnel, was on 7 March 2011 when the annual tunnel rail corrosion examination recorded rail corrosion from 54.380km to 54.386 km. The rectification of the defect required the replacement of a 6 m length of rail. However, the extent of the corrosion was such that replacement was deemed a low priority and categorised as a Priority 3 (P3) defect. P3 defects are managed by routine maintenance and did not require a scheduled repair date.

\textsuperscript{14} High-rail: a road vehicle adapted such that it can also run on track.
(refer Appendix 2). This meant that while the rail condition was recorded as a defect in Teams3 it did not have to be rectified within a given timeframe. The report did not comment on the condition of rail fastenings into the concrete slab.

2.20 Also in March 2011, the tunnel was identified as having a build-up of sand\textsuperscript{15} on its floor (see Photograph 6). A work order required the sand to be cleaned away and also the tightening of hold down bolts. This work was removed from Teams3 in June 2011 and may indicate the work had been completed. However, the investigation was unable to verify that the work was carried out.

\textbf{Photograph 6:} Mechanised Track Patrol (MTP) image from 6 July 2011 showing corroded rail (Source: Sydney Trains)

2.21 The annual rail corrosion examination was specifically for tunnels and other locations where a risk of corrosion had been identified. This inspection also required track fastenings to be inspected for corrosion wherever corroded rail was found. A rail corrosion examination was conducted on 11 January 2013

\textsuperscript{15} Build up of sand: This predominantly came from locomotives. Locomotives drop sand onto the head of the rail to improve adhesion on steep grades, particularly in damp conditions.
and its report confirmed the continued presence of rail corrosion and indicated that the defect should be managed as routine maintenance. This inspection report also identified that the “tunnel is leaking at 54+384 rail clips are getting corroded”. While subsequent rail corrosion inspection (and Detailed Walk) reports recorded the condition of the corroded rail, this was the only mention of corroded fastenings in any pre-incident inspection document or report supplied by Sydney Trains.

2.22 Track Service Schedule SSC 010 Detailed Walking Examination (see Appendix 4 [item 4]) states “Examine fastenings for general condition including loose, missing or ineffective fastenings, Rail play and evidence of backcanting, locations listed for wide gauge and where ballast prevents routine examination of fastenings”. None of the Detailed Walking Examinations conducted prior to 10 October 2014 had detected the defect [7].

2.23 A detailed walk conducted in May 2014 also recorded “corroded rail” and the extent of the corrosion was categorised as low priority for ‘routine maintenance’. Nonetheless, Sydney Trains had planned to repair the defect by replacing a 6 m length of rail on 6 September 2014. However, this did not occur.

2.24 The AK cars ran every four months. The AK car inspections continued to report the presence of wide gauge through Boronia No. 3 Tunnel. On 16 September 2014, the AK car identified three instances of wide gauge through the area. Sydney Trains’ Engineering Manual MNT20203 Track Inspection detailed how AK car inspections were to be managed and who should attend. In relation to Team Leaders, MNT20203 (section C2-2.1) stated, “Team Leaders should accompany the (AK) car of their track lengths when possible. Since they will normally be ‘on the ground’ during recording runs to assess any defects found, this may not always be possible.” However, it was not normal practice to have staff on standby during AK car runs. Sydney Trains’ Root Cause Analysis conducted after the incident on 10 October 2014 identified that the Team Manager Civil had “insufficient staff levels to inspect in line with standard.” Notwithstanding the above, section C6-1.1.1 of MNT20203 allows for a downgrade of a gauge defect category where “the track is secure against further widening” such as where it was on concrete sleepers or slab. In this
instance, the defects were categorised as E2 however, the Team Leader assessed them as suitable to be managed as P1 defects.

2.25 MTP imagery was capable of identifying the defect and MTP imagery was reviewed at Granville the day after each run. However, the viewing of tunnel imagery was not mandatory for reviewers due to the imagery quality not being reliable in all low-light conditions, such as in the case with Boronia No.3 Tunnel. A member of the Gosford network base travelled to Granville to undertake the imagery review task. This individual observed the imagery from multiple cameras for the entire section in both directions. While areas of interest can be highlighted to this observer (e.g. known defects or geometry exceeding the defined parameters), the detection of other new defects is reliant on their constant vigilance and attention to detail. Evidence from interviews, from observing the process and from Human Factors research,\(^\text{16}\) indicates that this review process can be unreliable. Relying on one individual to view large amounts of video data exposes the process to Human Factors issues such as distraction and fatigue.

2.26 At least one MTP reviewer did view the imagery and noticed a potential defect [7]. While evidence suggests that the potential defect was reported by that reviewer, this did not result in the location of the defect being recorded or inspected.

2.27 Hi-rail patrols were used in lieu of MTP coverage. However, these relied exclusively on inspectors viewing the track from the cab as the vehicle travelled along the line at up to 40 km/h. It was therefore unlikely that these patrols would pick up a defect such as this, and indeed they did not.

**Track inspection procedures undertaken**

2.28 Sydney Trains document *TMC 101*\(^\text{17}\): had individual service schedules for each class of inspection / examination: “The Service Schedules contained in this section form an important part of Rail Corporation’s (and then Sydney

\(^{\text{16}}\) http://www.flightsafetyaustralia.com/2015/06/monitoring-matters/

Trains) Track System. This system is intended to help maintain a safe railway infrastructure."

The various Service Schedules provided instructions for each routine maintenance examination task detailed in ESC 100 - Civil Technical Maintenance Plan for Track. They:

- "summarise the tasks to be undertaken"
- "include references to detailed explanation of the inspection process"
- "include references to maintenance limits and responses."

2.29 Track Service Schedule SSC 010 - Detailed Walking Examination gave detailed guidance for the Detailed Walks inspections (see Appendix 4). It is likely that the track fastenings defect would have been discovered if item 4 of SSC 010 had been effectively carried out during any of the detailed walks conducted in the period preceding the defect discovery on 10 October 2014.

2.30 From November 2012, the Detailed Walk Inspection reports consistently recorded the presence of corroded rail from 54.380km to 54.386km using the same wording: "Corroded in foot of rail from water dripping from tunnel roof need to be replaced by 6 meter closure rail." Some reports also had "SIT" (Still In Track) hand written in the Additional Comments box on Sydney Trains’ detailed walk Inspection report form.

2.31 Likewise, the annual rail corrosion examination’s Service Schedule (SSC 035) had instructions to check for corrosion in the fittings. However, only the inspection of 11 January 2013 made reference to corroded fastenings and no maintenance intervention was deemed to be necessary at that time.

2.32 The practice of track inspection personnel not referring to the relevant Service Schedules affected the effectiveness of the inspection (Gosford, Hornsby and elsewhere across Sydney Trains). Track inspection personnel relied on their training and experience to carry out the various inspections. The inspection reports produced did not demonstrate conformance with the items of inspection as specified in the various SSC documents. Had these Service Schedules been followed then it is likely that the defect would have been detected.
2.33 A requirement (of TMC 203) was that supervisors check a minimum of 5% of their team’s tasks. The investigation was unable to find evidence these took place or find reports related to supervisor checks. It was stated during interview that there was insufficient time in the work program to carry out these checking tasks.

**Structures Inspections**

2.34 Inspections of ‘structures’, e.g., tunnel walls, track slabs and overhead wiring fixtures, should have occurred within Boronia No.3 Tunnel according to Sydney Trains’ standards. These comprised of a biennial slab inspection and a quadrennial tunnel inspection. As per track inspections, detailed guidance was available for each class of structures inspection in the ‘SSC’ series of documents.

2.35 Structures Service Schedule SSC 227 is for a Detailed Examination of Track Slabs. It directed the inspector to examine “track slabs for general condition and structural integrity, condition of components including joints, security of track fastenings, movement between top and base of slabs, ponding of water…evidence of damage to slab components.”

2.36 A track slab examination of Boronia No.3 Tunnel was due in September 2011 and again in 2013. However, these inspections were not scheduled in Ellipse\(^\text{18}\) and hence were not flagged to maintenance staff via Teams3 and so not carried out. The track slab inspection was not performed in Boronia No.3 Tunnel. SSC 227 specifies the checking of ‘security of track fastenings’ for tunnel track slabs. The issues with track fastenings should have been detected and actioned had the inspections been performed in accordance with SSC227 in 2011 and in 2013. Other track slab examinations throughout Sydney Trains network may not have been carried out. Sydney Trains advised that they believed that track slab inspections were being carried out in other locations however, records were not easily recoverable.

2.37 Structures Service Schedule SSC 222 Detailed Examination of Tunnels detailed the requirements and scope of the four yearly inspection. The most

\(^{18}\text{Ellipse: A software management system. Ellipse generate work orders for maintenance tasks at a set frequency. These work orders are then managed through Teams3.}\)
recent four yearly ‘Detailed Examination of Tunnels’ inspection had been performed on Boronia No.3 Tunnel in September 2011. The four yearly report did conform to the relevant SSC (SSC 222) (see inspection report at Appendix 5). The report identified seepage of water through the fabric of the tunnel: “seepage in walls causing rust to (wall) anchor rock bolts.” However, the corrosion was not identified as being serious and no repair priority was allocated to this issue. SSC 222 does not require a detailed examination of the slab and track fastenings. The only requirement, relative to this investigation, was to check the “floor” (concrete slab) as a “component” of the tunnel. The inspection did not extend to detail such as track fastenings. The word “Good” was recorded against “floor” in the comments section.

Events leading up to the rail defect discovery

2.38 According to the AK car data at 1243 on 16 September 2014, the AK car detected three instances of emergency category defect of wide gauge during a scheduled inspection through Boronia No. 3 Tunnel on the Up Main line (see Appendix 6). Emergency level defects are displayed in real time in the AK car. The wide gauge locations, each recorded as being 33 mm wider than the standard gauge of 1435 mm, were categorised as E2 (Emergency level 2) defects. The mandated response to E2 defects was to inspect the track within two hours or before the next train, whichever is the greater. However, the Team Manager Civil from the Gosford Network Base, who was on the AK car train, determined that the defects would be treated as ‘priority 1’ (P1) defects (as explained in section 2.23). This defect categorisation extended the time limit for inspection to 24 hours.

2.39 At 1311 on 17 September 2014, a TOA was issued by Sydney Trains Network Control to provide authorisation for a team from Gosford Network Base to access the track and inspect the defect locations as reported by the AK car. The locations recorded by the AK car were precise (to the metre) and reported as 54.325 [4], 54.375 [5] and 54.378 km adjacent to [7]. However, the identified locations could be inaccurate due to factors described below (section 2.42).
2.40 The largest reported wide gauge was reported to be in the vicinity of the southern tunnel portal. It was 30 mm wider than standard, which meant that it was categorised as a priority 2 (P2) defect, required to be repaired or reassessed with 28 days.

2.41 The defect was recorded in the track maintenance database, Teams3. On 8 October 2014, the system generated a regular *Defects Due In Next 7 Days* report alerting staff that the defect was due for repair in this period.

2.42 The Gosford Team Leader Civil, who reviewed the report, determined that it would be more efficient to repair the defect during a planned shutdown of the line. The shutdown was scheduled to occur on the first weekend in November. An extension of this nature required that the defect be reinspected to ensure that it had not deteriorated beyond P2 parameters and allowed a further 28-day period before repair would be required.

**Identification and management of defect**

2.43 Locations given by the AK cars were given as 54.325 [4], 54.375 [5] and 54.378 km adjacent to [7]. However, a number of factors could make these locations inaccurate (typically up to +/- 20 m and potentially by up to 100 m in either direction). Primarily, this could be caused by errors introduced by the necessity to manually record the passing of line-side kilometre posts as the AK car passed each one. Therefore, the defects could have lain anywhere between 54.225 [1] and 54.478 km [10], a length of 253 m. Even taking the more usual, lesser error of +/- 20 m the defects could have been located within a track length bounded by 54.305 km [2] and 54.398 km [9], that is, 93 m of track. However, the civil team inspected the track over a length of 42 m, taking a gauge measurement every 2 m, and therefore, no certainty that all of the defects detected by the AK cars were located and assessed within the 42 m of track inspected by the civil team.

2.44 Evidence suggests the defect discovered at the tunnel portal on 10 October 2014 with a wide gauge of 30 mm was not the only defect recorded by the AK cars. The AK cars measured the gauge under the load of the train. The dynamic gauge recorded would have been wider than any static gauges
measured in the tunnel. When the defect was searched for it would appear that the worst static wide gauge was identified as the ‘defect’ while the actual defect (as identified by the passage of the AK cars on 16 September 2014) in the tunnel had a lesser (static) wide gauge. The potential for a wider dynamic gauge (under train loading) was not assessed or was assessed incorrectly. Also, it is possible that the actual location of the defect was not measured as only 42 m of track was inspected while, due to the variability of the AK cars locations, the defects could have been located over a wider area.

2.45 The identified defect at the tunnel portal was managed correctly as per the applicable standards. However, a worse defect inside the tunnel was not identified and was therefore neither recorded nor managed.

2.46 When a workgroup returned to the identified defect at the tunnel portal to reassess it, the track which contained the unrestrained E1 track defect in the tunnel was not part of the inspection scope as it was not known to exist. A civil employee who was curious about the location having earlier seen MTP images identified this defect at 54.387 km [7] in the tunnel. It was only then that the E1 defect was identified.

2.47 The E1 defect [7], as discovered on 10 October 2014, was initially managed correctly as per Sydney Trains’ standards. No rail traffic was allowed to run over the defect. Local specialist personnel attended and, with advice from engineering staff off-site, short-term repairs were implemented. The site was actively managed (closely observed as detailed in section 1.7) to ensure the safety of rail traffic.

2.48 The permanent repair replaced the five failed fittings. The original double shoulder sleeper plates were replaced with Delkor ALT 1 resilient baseplates. These plates were held down with bolts into the concrete slab, one on either side of the rail, similar to the previous arrangement.

2.49 Engineering Standard ESC 230 Sleepers and Track Support\(^{20}\) (section 4.9.5) specifies that on a curve with a radius of less than 300 m, such as that found within Boronia No. 3 Tunnel, the rail plates should have four hold down bolts. This fact was identified in the Sydney Trains’ investigation report Track Slab

Investigation in November 2014. However, no action had been taken to rectify the issue as of July 2015 (see Photograph 7).

2.50 In September 2015 work was completed which included installing an extra 276 plates. These plates were installed in between the existing plates as shown in Photograph 8.

Photograph 7: MTP image dated 20 July 2015, Boronia No. 3 Tunnel (Source: Sydney Trains)
2.51 A number of maintenance personnel from two civil depots, over an extended timeframe, were involved in the inspection and maintenance of the track through Boronia No. 3 Tunnel. In addition, ‘structures’ personnel carried out an inspection of the tunnel. There is no evidence that any of the maintenance personnel were anything other than correctly certified for the inspection tasks that were undertaken.

2.52 Training and recertification of maintenance personnel was previously (until the reorganisation in 2013) undertaken by RailCorp’s own training facility. After the reorganisation, this function was absorbed into Transport for NSW (TfNSW). The facility, at Petersham, then provided training for TfNSW as a whole and for all transport modes.
Regulatory environment

2.53 The operations of Sydney Trains fall under the *Rail Safety National Law (RSNL) Act 2012*. The regulator is the Office of the National Rail Safety Regulator (ONRSR).

2.54 The reporting of safety incidents is governed by the *Transport Safety Investigation Act (Commonwealth) 2003*. This Act refers to the *RSNL Regulations 2012* for reporting requirements. Reportable safety incidents are divided into two categories: Category ‘A’ incidents and Category ‘B’ incidents.

2.55 There are seven defined types of Category ‘A’ incident (*RSNL Regulations 2012*, s57(1)(a) see Appendix 7). Category ‘A’ incidents were immediately reportable to the Australian Transport Safety Bureau (ATSB). Five were defined by a particular outcome (e.g. (ii) “a running line derailment”) while only one included incident potential: (vi) “an accident or incident involving a significant failure of a safety management system that could have caused death, serious injury or significant property damage”. The wording of this subclause leaves scope for interpretation on the part of the reporter. However, an incident such as the subject of this investigation where an E1 defect with derailment potential on a main line in a tunnel could fit into this description.

2.56 Category ‘B’ incidents have to be reported to ONRSR within 72 hours. The definition of Category ‘B’ incidents is broad\(^\text{21}\): There are 23 Category ‘B’ incident types. The incident on 10 October 2014 was assessed and reported by Sydney Trains as a Category ‘B’ incident. This decision was probably guided by the incident matching Category ‘B’ incident (xvi) “the detection of an irregularity in any rail infrastructure (including electrical infrastructure) that could affect the safety of railway operations or the safety of people”. The incident was reported to the ONRSR on 13 October 2014 and OTSI became aware of it on the following day: 14 October 2014.

\(^{21}\) Category B incidents, for definitions see: Rail Safety National Law National Regulations 2012, s57(1)(b)
Assets Standards Authority

2.57 The Asset Standards Authority (ASA) is a division of TfNSW\(^{22}\). ASA’s charter\(^{23}\), dated August 2015, sets out its objectives and functions. One objective was to “assure system and network integrity.” With relation to Authorised Engineering Organisations (AEO), “(ASA) will have the rights and powers (including the powers of review, surveillance, audit and instruction) conferred on it by this charter...”. The ASA was to undertake surveillance audits: “Systems auditors or assessors will periodically perform surveillance audits of the artefacts of an AEO’s engineering assurance process over the service areas for which it has authorisation”. Sydney Trains was an AEO.

2.58 The ASA had an audit schedule and had commenced a track management audit in September 2016, scheduled to be completed in November 2016.

2.59 Due to largely undefined reporting requirements, ASA was unaware of incidents which may have indicated that Sydney Trains’ asset management was inadequate, such as the subject of this investigation.

Sydney Trains Safety Management System

2.60 Sydney Trains Safety Management System (SMS) included documents pertaining to incident reporting and investigation. The SMS document *Incident Reporting and Investigations* had guidance on the internal and external reporting of incidents. There was an Appendix with a table setting out the levels of investigation, the attributes of an occurrence commensurate with each level, a short explanation of what the report will address and investigator and approval details. It also stipulated a timeframe in which a given level of investigation must be completed.

2.61 According to the above document, a Level 5 investigation’s attributes were “An occurrence of minor consequence with either no damage or only superficial damage or injury. There is little or no evidence that a more serious consequence was narrowly averted”. The attributes of an incident that warrants a Level 4 investigation are “A single incident that shows the potential


to have been a serious accident had circumstances been slightly different.” A Level 5 report has no requirement for analysis but a Level 4 “Requires an analysis of the evidence and a systemic investigation to provide organisational learning outcomes.” Sydney Trains determined that this incident was suitable for a Level 5 investigation.

The SMS document provides a timescale for Level 5 investigations of 5 days and twenty days for the completion of Level 4 investigations.

**Sydney Trains response to incident and OTSI’s interest**

2.62 When OTSI became aware of the incident immediate enquiries were made with Sydney Trains. It was established that Sydney Trains were to undertake a Level 5 investigation (their lowest level) and also a root cause analysis. Sydney Trains stated that a “detailed specialist examination of the site” would be conducted and they also undertook to provide the output of a root cause analysis workshop that was to be held into the incident. OTSI made a request to Sydney Trains under section 45A(2)(d) of the Transport Administration Act 1988 for a copy of the Sydney Trains’ Level 5 investigation report and the root cause analysis.

2.63 Sydney Trains produced a Level 5 investigation report into the incident and the report was finalised (approved by management) on 20 March 2015. The report did not canvass the reason(s) for the defect going undetected for an extended period of time. OTSI was informed by Sydney Trains that “there was no suitable root cause analysis workshop conducted following the incident”.

2.64 In parallel with the original Level 5 investigation, Sydney Trains undertook a review of the incident resulting in a memorandum to the responsible Sydney Trains General Manager and a further slab investigation was carried out. The memorandum and slab investigation report were not initially provided to OTSI. The slab investigation report described a number of issues. Many of these issues were not directly related to the track defect but exposed long-standing issues with the construction and maintenance of the slab and its track. The memorandum contained the passage “It was not possible to determine the cause of a lack of action for such a prolonged time due to the loss of key staff in the area of concern.”
2.65 After OTSI launched an independent investigation in April 2015, Sydney Trains initiated a Level 4 investigation. The Level 4 investigation report revealed a number of significant issues and led to a number of safety recommendations being made. Recommendations from other incident related documents (Boronia Tunnel Numbers 3 & 4 Main Northern Line 54.332km Track Slab Inspection November 2014 Report Number: S-128 and Network Maintenance Maintenance Engineering Inspection report Boronia Tunnels 3 & 4) were also included into the recommendations of this Level 4 investigation. Sydney Trains included this information into their Safety Action Management system. Prior to their inclusion in the Level 4 investigation the recommendations from the earlier documents, referenced above, had not been subject to any form of action management. As of September 2016, the majority of actions were listed as ‘closed’ with the remainder ‘on-target’.

2.66 However, not all of the significant issues identified in Sydney Trains’ Level 4 investigation were addressed in the report’s recommendations. These issues were:

a) The observation that track inspections, notably detailed walks, either were not being carried out or were being carried out under incorrect protection arrangements, and

b) The related issue of the difficulty of arranging suitable track access to allow maintenance staff sufficient windows to complete the necessary inspections.

Organisational change

2.67 The move to amalgamate the various maintenance disciplines into regional centres and the closing of a large number of smaller single discipline depots was designed to improve efficiency and to improve communication and cooperation between the disciplines.

2.68 To achieve the above a number of positions were abolished and there were changes to both the number and reporting structure of supervisory and management personnel.
Sydney Trains internal assurance audits and inspections

2.69 As part of the transition from RailCorp to Sydney Trains and ASA, an Engineering and System Integrity (ESI) unit was set up within Sydney Trains. ESI had, amongst its functions, the responsibility to enable Sydney Trains to maintain Authorised Engineering Organisation (AEO) accreditation with regard to the integrity of Sydney Trains’ assets e.g., track. ESI carried out assurance inspections and audits as part of these assurance activities.

2.70 A number of Sydney Trains audit and inspection reports of civil disciplines’ maintenance activities and processes were reviewed. The reports were conducted between March 2014 and August 2015. Many aspects were found to be ‘satisfactory’ and in one case ‘commendable’. However, a number of reports highlighted a recurring theme of systemic issues with civil maintenance at Sydney Trains as detailed in the following extracts:

- “Rail wear measurements were being measured incorrectly.”  
- “Rail wear was being measured using the incorrect tools.”
- “The examination DID NOT meet the requirement parameters for work order scheduling and DID NOT meet fully the requirements of the service schedules and the instructions to carry out the examination.”
- “Defect management process is inconsistently applied... for example temporary repairs were not being entered into Teams3.”
- “Staff have poor understanding of the importance of relationship between Technical Maintenance Plans (TMP’s) and service Schedules.”
- “A re-awareness education program is needed to reinforce what was learned, unlearn bad habits over the years and continually learn from positive and negative events.”
- “There is inconsistency, as low priority defects are not entered into Teams3. Having defects in Teams3 encourages monitoring; transparency;”

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24 Sydney Trains ESI Inspection Report, Gosford, 18 March 2014
25 Ibid
26 Sydney Trains ESI Inspection Report, Glenfield, 21 August 2014
27 Sydney Trains ESI Assurance Audit Report, City East, June 2015
28 Sydney Trains ESI Assurance Audit Report, City East, June 2015
29 Ibid
analysis and application ensures defects don’t deteriorate further or forgotten about."30

- “A process is lacking to formally record all findings, produced by E&SI Asset Assurance Inspectors, which identify risks to the integrity of an asset.”31

- “Training plans for each discipline requires review to ensure that these are not only kept up to date but also need to establish a Training Needs Analysis (TNA) to identify a complete skills and competency inventory…Additionally the certification and re-certification of staff competency levels is not performed in a controlled manner.”32

- “This highlights a systemic issue with differing roles and responsibilities and expectations required of each position across each base.”33

- “Line management and staff knowledge and understanding based on current Engineering Criteria (e.g. TMPs, SS, procedures and instructions criteria) are inconsistent i.e., the importance and relationships of TMPs and SS; the concern that SS are not taken out during inspections, SS are not really referred to as per Civil TMP’s and generally staffs are not greatly familiar with SS. It is evident that gaps have existed, do exist and require an amount of effort to turn the situation around for better future outcomes. This was found to be a systemic issue.”34

2.71 In addition to the above, the following is taken from one Asset Assurance Engineering System Integrity Inspection Summary after observing a track inspector undertake a Detailed Walk. The text in the original document was red to highlight its importance:

'It must be noted that the track certifier who carried out this examination demonstrated a lack of experience and understanding to fully identify track issues related to this examination.
It should be noted this employee is newly qualified with this examination qualification and carried out the examination as he has been taught.
It should also be noted that this employee found and recorded in excess of 10 new track related defects over a 2.5km section of track which was very good however

30 Sydney Trains ESI Assurance Audit Report, Central Coast Territory, May 2015
33 Sydney Trains ESI Assurance Audit Report, Clyde, May 2015
34 Sydney Trains ESI Assurance Audit Report, Central Coast Territory, May 2015
missed identifying many other defects and this would indicate a failure in the onsite training from more experienced staff.
The volume of newly found defects would indicate that the weekly “Track Patrol” review to identify new defects is very poorly performed. This may also be reflected in the condition of some of the current track component defects, their ratings and the accelerated deterioration concerns once identified to a condition affecting the network.

Based on the condition of some reviewed track components and the incorrectly assigned defect severity rating, this inspection practice must have been the normal accepted examination process for some time.

It would be desirable for any newly trained employee to work with a more experienced staff member to carry out and understand the requirements of any future detailed examination.\textsuperscript{35}

The inspections and reports from which the above extracts were made were not provided by ESI to ASA.

Other incidents

2.72 A number of contemporary incidents have been selected that have particular resonance to the incident at Boronia. The sample selected is far from exhaustive. There are many incidents where defective track and, more importantly, breakdowns in the inspection and maintenance of track, has led to safety incidents and accidents. A synopsis of these incidents, as relevant to this investigation, follows:

2.73 Homebush, NSW (2013):

An empty passenger train derailed on 690B points on the Up Homebush Bay (Lidcombe to Olympic Park line) on 26 November 2013. In the direction of travel, 690B points were the leading set of points making up 690 crossover between the Up and Down Homebush Bay lines. Most trains travelled in the opposite direction on this crossover. The derailment was caused by a combination of wear in the track and a thin wheel flange.

Due to their particular geometry, these points should have been subject to additional six monthly inspections. However, these were not scheduled in Sydney Trains’ systems and therefore did not occur.

Notwithstanding the above, the defective track work had been identified during an inspection in January 2013. The defects were assessed as being of a P2 severity. P2 defects should be rectified or reassessed within one month.\textsuperscript{35}

\textsuperscript{35} Sydney Trains ESI Inspection Report, Sydney CBD, 11 June 2015
However, the defect was given a target date for repair of 02 February 2014, more than 12 months later.

2.74 Sydney Terminal, NSW (2014):
There was a derailment in Sydney Terminal Yard on 11 September 2014. The empty passenger train was departing from the Middle Road between platforms 7 and 8. One set of wheels dropped into the four foot between the two rails that made up the track. It was determined that the gauge had spread (was wide) by 50 mm. Track inspections through the area had been ineffective because the sleepers and fastenings had been obscured due to a build-up of earth and tar. No action had been taken to correct the issues which prevented effective track inspection.

2.75 Sefton, NSW (2015):
On Sunday 18th October 2015, a freight train derailed one bogie of a container wagon on the Down Sefton West Fork. This section of track also carried Sydney Trains suburban passenger trains travelling between Bankstown and Liverpool. While uneven loading of the container wagon may also have contributed to the incident, the track was found to be in a state of disrepair with known defects in the area of the derailment. Sydney Trains investigation stated that while issues at the location were identified earlier than June 2013 there was “little evidence…to indicate that existing defects were inspected or removed”. The report made five Findings:

“Excessive train speed for the train condition, resulting from the last speed board in the ARTC territory displayed (50 km/h) while the maintainer was utilising the TOC (Train Operating Manual) speed (35km/h to prioritise the long twist defect) had contributed to the initiation of the derailment event.

Track inspections, documentation that records track inspection activity and the appropriate analysis and recording of track defects into Teams3 was deficient.

Management and analysis of AK car data was deficient.

Internal assurance processes and accountabilities were insufficiently robust enough to detect deficiencies as described in findings (2) and (3).”
In Summary

2.76 The investigation has gathered sufficient evidence to demonstrate that Sydney Trains’ track inspection and maintenance functions were not operating effectively. This means that there was a lack of an appropriate level of assurance that track, throughout the network, was being inspected and maintained to the required standard.

2.77 The embedded problems with training, competency maintenance, inspection regimes, inspection efficacy, management oversight and the management of maintenance systems (Teams3) predate the reorganisation that occurred in 2013. A review of other Sydney Trains incidents has demonstrated that issues associated with track inspection and maintenance were systemic across the organisation.
PART 3 FINDINGS

3.1 The failure, over time, of the hold down bolts (track fastenings) of five consecutive rail plates caused the E1 defect [7]. The inspection regime (of Sydney Trains / RailCorp) did not adequately identify the deterioration or failure of the components until an unscheduled inspection on the incident date.

Contributing factors

3.2 Water seepage into tunnel created the conditions to promote rail and fastening corrosion.

3.3 The various mandated track and structures inspections did not identify the defect before it deteriorated to a state at which trains should not have been permitted to run over the defective track. The inspections carried out by civil maintenance staff were not correlated with nor referenced to the inspection requirements of the various Service Schedules (SSC document series).

3.4 A two yearly slab inspection was not carried out in Boronia No.3 Tunnel as it had not been included in Sydney Trains’ asset management system.

3.5 Available Motorised Track Patrol (MTP) imagery was not routinely reviewed through Boronia No. 3 Tunnel. Further, the hi-rail inspections, performed to compensate for the lack of reliable MTP imagery, were of questionable suitability to identify defects such as corroded track fastenings.

3.6 There was a lack of management oversight and system assurance. The required oversight of 5% of work was not being carried out effectively or consistently by maintenance supervisors.

Other findings

3.7 That the various deficiencies in inspection and maintenance of track and structures were systemic across the Sydney Trains network.

3.8 Sydney Trains internal audits and inspections had consistently, over time, reported significant systemic issues with the way track inspections and maintenance were being conducted and managed. Significant failings were also exposed in track inspector training and competencies. However, there is
no evidence that these reports translated into meaningful action. Findings and recommendations from these internal audits and inspections were not included in the central Sydney Trains Safety Action Management system.

3.9 The reliance on one employee to review the MTP imagery introduces a significant risk that defects may be missed due to concentration lapses over time.

3.10 The ASA had not commenced formal assurance activities, for Sydney Trains’ civil infrastructure (track) at the date of the incident. Sydney Trains had limited formal reporting lines to ASA with the result that ASA was unaware of some track maintenance related incidents and issues.
PART 4 RECOMMENDATIONS

The following recommendations are made in relation to matters identified in the course of this investigation.

Sydney Trains

4.1 Improve the capture and management of all issues that have a safety dimension to ensure when these issues are detected, whether through investigation, audit, inspection or other means, they are dealt with in an appropriate and timely manner.

4.2 Gain assurance all mandated track and structures inspections are being conducted, and are being conducted under the correct level of safeworking.

4.3 Ensure all track and structures inspections adhere to the minimum requirements of the various Service Schedules (SSC document series).

4.4 Ensure all mandated track and structures inspections, such as the bi-annual (biennial) slab inspection (SSC 227), are correctly entered into Ellipse.

4.5 Review MTP image inspection process with Human Factors input as required to ensure imagery is inspected in a manner such that all significant defects are likely to be detected. In particular, review the practice of requiring one individual to review the imagery from an entire MTP run.

4.6 Improve the standard of track inspector training and competency to ensure they are suitably proficient to carry out track inspection functions to the standards required.

Office of the National Rail Safety Regulator

4.7 To note the findings of this investigation and determine if further actions such as audit or inspection are required.
PART 5 APPENDICES

Appendix 1: Sydney Trains’ actions

The actions proposed in Sydney Trains’ internal Memo, Network Maintenance Maintenance Engineering Inspection report Boronia Tunnels 3 & 4, the Level 5 and Level 4 investigation produced a large number of safety recommendations. Sydney Trains informed OTSI in September 2016 that the majority of these actions had been completed with the remainder scheduled for completion. The actions are reproduced below (reproduced verbatim):

1. Complete the trial of the Infrared Cameras on the Mechanised Track Patrol Vehicle, and roll out for use in tunnels network wide

2. Implement tunnel cleaning in all tunnels network wide

3. Implement track slab inspections as per ESC100 on all track slabs network wide

4. Investigate method for protection of rail and fasteners from water leaking and implement solution

5. Clean drainage at mouth of Boronia Tunnel No.3 and ensure effective. If the drainage is not effective, then get the drainage upgraded

6. Briefing to all Network Maintenance Division staff regarding Track Geometry Vehicle defects and their management

7. Reinforce the existence of sleeper condition defects in MN T 20203

8. Conduct detailed review with Asset Management Division of the tunnel and scope up major periodic maintenance requirement to be considered are issues of rerailing, and fastener upgrading

9. Conduct detailed review of track and structures issues on site

10. Implement review of track geometry data by Civil Engineers

11. Root cause analysis RCA to be conducted

12. Lessons learnt

(a) Briefing to be issued by Maintenance Engineering
I. All Civil teams to be briefed

II. Staff to carry out detailed inspections to be carried out within standards for all priority AK car defects

III. Evidence to be collected to determine defect category

(b) Introduce trial for the use of Infra-Red (IR) cameras in all tunnels

I. Provide training for reviewers on the requirements for reviewing IR images in tunnels

13. MST’s to be created for removal of built-up sand and debris on 12 (twelve) months cycle

14. Replace all heavy Duty insulation pads (Biscuits) within 3 (three) months

15. Replace all Broken / Missing Clips (Pandrol) within 3 (three) months

16. Install missing sleeper at entrance to Tunnel 4 Up Main North within 3 (three) months

17. Remove all sand and debris within 6 (six) months

18. Design and Install Drip shields in area of water leaks (active and non-active locations) within 12 (twelve) months

19. Install missing sleeper at entrance to Tunnel 4 Up Main North within 3 (three) months

20. Recondition transition areas and re-establish drainage within 12 (twelve) months.

In addition, the Sydney Trains Level 4 report recommended that they:

- Align the requirements for checking of 5% of inspection sheets and actual jobs of Engineering Manual MN T 20203 Track Inspection with the volume of interactions set down by the Network Maintenance Management Team.

- Develop a process, with KPIs, for recording the checking of inspection sheets and actual jobs.

- Develop and implement a report template to record the results of track slab inspections
- **Identify improvements to the governance process for the completion of inspections and the subsequent checking by managers.**

- **Develop guidelines for civil staff participating in the review of MTP imagery, and give consideration to including a requirement to check existing defects listed in Teams3.**

- **Conduct a review of the current track access for tunnel inspections and identify if these inspections can be replaced by detailed examinations of MTP imagery.**
Appendix 2: Track defect hierarchy

A Table from Track Inspection manual MNT20203 showing mandated responses to some track defects is reproduced below. Wide gauge is listed in the left hand column.

<table>
<thead>
<tr>
<th>Wide Gauge</th>
<th>Tight Gauge</th>
<th>2.7m DO NOT USE</th>
<th>2m</th>
<th>20/20</th>
<th>40/40</th>
<th>60/60</th>
<th>80/90</th>
<th>100/115</th>
<th>115/160</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;21</td>
<td>&lt;10</td>
<td>&lt;16</td>
<td>&lt;12</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>21 – 22</td>
<td>10</td>
<td>16 – 18</td>
<td>12 – 13</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>P3</td>
<td>P2</td>
</tr>
<tr>
<td>23 – 28</td>
<td>11 – 12</td>
<td>19 – 21</td>
<td>14 – 15</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>P3</td>
<td>P2</td>
<td>P1</td>
</tr>
<tr>
<td>27 – 28</td>
<td>13 – 14</td>
<td>22 – 23</td>
<td>16</td>
<td>N</td>
<td>N</td>
<td>P3</td>
<td>P2</td>
<td>P1</td>
<td>E2</td>
</tr>
<tr>
<td>33 – 34</td>
<td>18</td>
<td>28 – 29</td>
<td>21 – 22</td>
<td>P1</td>
<td>P1</td>
<td>E2</td>
<td>E2</td>
<td>E2</td>
<td>E1</td>
</tr>
<tr>
<td>35 – 37</td>
<td>19 – 20</td>
<td>30 – 31</td>
<td>23</td>
<td>E2</td>
<td>E2</td>
<td>E2</td>
<td>E2</td>
<td>E1</td>
<td>E1</td>
</tr>
<tr>
<td>&gt;37</td>
<td>&gt;20</td>
<td>&gt;31</td>
<td>&gt;23</td>
<td>E1</td>
<td>E1</td>
<td>E1</td>
<td>E1</td>
<td>E1</td>
<td>E1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not in a Transition</th>
<th>In a Transition</th>
<th>Track Speed (Normal / Passenger) km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2m</td>
<td>14m</td>
<td>13.2m</td>
</tr>
<tr>
<td>DO NOT USE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;29</td>
<td>&lt;31</td>
<td>&lt;32</td>
</tr>
<tr>
<td>29 – 33</td>
<td>31 – 35</td>
<td>32 – 36</td>
</tr>
<tr>
<td>34 – 38</td>
<td>36 – 40</td>
<td>37 – 41</td>
</tr>
<tr>
<td>39 – 43</td>
<td>41 – 46</td>
<td>42 – 46</td>
</tr>
<tr>
<td>44 – 49</td>
<td>47 – 52</td>
<td>47 – 52</td>
</tr>
<tr>
<td>50 – 56</td>
<td>53 – 59</td>
<td>53 – 59</td>
</tr>
<tr>
<td>57 – 60</td>
<td>60 – 64</td>
<td>60 – 63</td>
</tr>
<tr>
<td>61 – 66</td>
<td>65 – 70</td>
<td>64 – 69</td>
</tr>
<tr>
<td>&gt;66</td>
<td>&gt;70</td>
<td>&gt;69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track Speed (Normal / Passenger) km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/20</td>
</tr>
</tbody>
</table>

Example

A Wide Gauge of 34 mm is found on a track which has a track speed of 55 km/h. The Mandatory Response is E2 not P1.

[Diagram showing track speed and wide gauge]
The response to each category of defect is laid out in the table reproduced below:

<table>
<thead>
<tr>
<th>Response Category</th>
<th>Inspect and verify response</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency 1 (E1)</td>
<td>Prior to passage of next train</td>
<td>Prior to passage of next train</td>
</tr>
<tr>
<td>Emergency 2 (E2)</td>
<td>Within 2 hrs or before the next train, whichever is the greater</td>
<td>Within 24 hrs</td>
</tr>
<tr>
<td>Priority 1 (P1)</td>
<td>Within 24 hrs</td>
<td>Within 7 days</td>
</tr>
<tr>
<td>Priority 2 (P2)</td>
<td>Within 7 days</td>
<td>Within 28 days</td>
</tr>
<tr>
<td>Priority 3 (P3)</td>
<td>Within 28 days</td>
<td>Program for repair</td>
</tr>
<tr>
<td>Normal (N)</td>
<td>Nil</td>
<td>Routine inspection</td>
</tr>
</tbody>
</table>
Appendix 3: Track and structures inspection regime

The track was subject to routine inspections, as per Sydney Trains document *ESC 100 – Civil Technical Maintenance Plan*, of varying scope and frequency as per Table below.

**Table: Track and Structures inspection regime**

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Frequency</th>
<th>Comments/description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Track Patrol</td>
<td>Two per week</td>
<td>This had replaced regular walking patrols on the Main North line. They had to be performed regularly with a maximum of ‘3 days clear between patrols’. May include: ‘Walking Patrol’ SSC 001, ‘Hi-Rail Patrol’ SSC 002, Engine Patrol, ‘Mechanised Track Patrol’ SSC 003 and, if necessary, Supplementary Patrol(s).</td>
</tr>
<tr>
<td>Front of train examination SSC 009</td>
<td>14 days</td>
<td>This patrol allowed the inspector to experience the ride in the cab of the ‘fastest train’ operating through the section. Its purpose is to feel the motion of the train over the track and to check items such as placement and visibility of signage.</td>
</tr>
<tr>
<td>Engine Patrol SSC 004</td>
<td>Varies</td>
<td>Used as part of Integrated Track Patrol: This patrol is used for the inspector to visually check of the track and its surrounds from the cab of a train.</td>
</tr>
<tr>
<td>Mechanised Track Patrol SSC 003</td>
<td>14 days</td>
<td>Mechanised Track Patrol forms part of Integrated Track Patrol regime. It incorporates both a ‘Track Patrol’ and ‘Engine Patrol’. In addition, the MTP vehicle records detailed images of the track which are reviewed later. Due to technical issues, this review was not mandated for images through tunnels such as Boronia No.3 Tunnel.</td>
</tr>
<tr>
<td>Detailed Walking Examination SSC 010</td>
<td>3 monthly</td>
<td>To be undertaken every three months with a latitude of 18 days allowed. Equipment required does not include a torch. “Contains a number of safety significant activities such as speed boards and sleeper condition.”</td>
</tr>
<tr>
<td>Track recording Car Examination (AK cars) SSC 021</td>
<td>4 month</td>
<td>14 days allowed. This inspection measures the track gauge. It is planned that the MTP patrols will replace the AK car.</td>
</tr>
</tbody>
</table>
### Rail Corrosion examination SSC 035

<table>
<thead>
<tr>
<th>Latency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>36 days latitude is allowed. This examination was specifically for tunnels and other locations were a risk of corrosion had been identified. Notwithstanding this, ‘equipment required’ did not include a torch. The inspection included a requirement, where corroded rail was found, to examine fastenings for corrosion.</td>
</tr>
</tbody>
</table>

### Detailed Examination of Track Slabs SSC 227

<table>
<thead>
<tr>
<th>Latency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 years</td>
<td>72 days latitude is allowed. This inspection included checking the &quot;security of track fastenings”. However, due to an omission, this inspection was not entered into Teams3 and was not being carried out (Network wide).</td>
</tr>
</tbody>
</table>

### Detailed Examination of Tunnels SSC 222

<table>
<thead>
<tr>
<th>Latency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 years</td>
<td>145 days latitude is allowed. This inspection focussed on the structure of the tunnel itself. It did not require a detailed examination of the track fixtures.</td>
</tr>
</tbody>
</table>

In addition, triggered inspections after the AK car or in response to other inspections or reports of issues can be undertaken.
# Appendix 4: Sydney Trains Service Schedule SSC 010

## SSC 010 Detailed Walking Examination

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detailed visual examination of track and right of way to assess the condition of all known defects, to provide the opportunity for close-up examination of critical components</td>
<td></td>
</tr>
<tr>
<td>Personnel: Examine Track Authorisation / TLIB3099A - Examine track infrastructure</td>
<td>Ellipse</td>
</tr>
<tr>
<td>Equipment: Tape measure, Switch tip gauge, rail wear gauge, White waterproof chalk, Data logger or Notebook plus Combination Board, Detonators, Flags as required</td>
<td>Standard Job P00016</td>
</tr>
</tbody>
</table>

### Start The Job

<table>
<thead>
<tr>
<th>Task</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Obtain Current Defect Listing</td>
<td>TMC 203 C9-2</td>
</tr>
<tr>
<td>2. Set up Mobile Worksite (On Track)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Task</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Examine ties for general condition including damage or breakage especially where ballast prevents routine examination of ties</td>
<td>TMC 203 C9-2</td>
</tr>
<tr>
<td>4. Examine fastenings for general condition including loose, missing or ineffective fastenings, Rail play and evidence of backcanting, locations listed for wide gauge and where ballast prevents routine examination of fastenings</td>
<td></td>
</tr>
<tr>
<td>5. Examine Turnouts for Condition and fit of geometry and components including switches, crossings, bearers, fastenings and manual levers (where fitted)</td>
<td></td>
</tr>
<tr>
<td>6. Examine Level crossings for geometry, fit and condition of ties, fastenings, flange ways and crossing surface</td>
<td></td>
</tr>
<tr>
<td>7. Examine Rails for fit, condition and adjustment of rail joints, insulated joints, lubricators, rail wear, wheel burns and other visible defects and condition of guard rails (where fitted)</td>
<td></td>
</tr>
<tr>
<td>8. Examine for visual indicators or VSH rail defects, including flattening out of the rail head and widening of the shiny portion of the rail (the contact band), or rust stains down the web</td>
<td></td>
</tr>
<tr>
<td>9. Examine Earthworks, drainage, cess drains (particularly in cuttings), tunnel drainage systems (where applicable) and waterways for condition and flooding</td>
<td></td>
</tr>
<tr>
<td>10. Examine Ballast for condition and profile including fouled ballast, pumping or unstable track and inadequate ballast profiles</td>
<td></td>
</tr>
<tr>
<td>11. Examine Right of Way for condition of fencing and gates, weed and vermin control, firebreak condition, fire hazard control, access roads, vegetation fouling or with the potential to foul the track, undermining of track or structures</td>
<td></td>
</tr>
<tr>
<td>12. Examine Permanent and Temporary Speed signs and other trackside safety signs for visibility, security and clearances, including:</td>
<td></td>
</tr>
<tr>
<td>- condition of painted surfaces or protective coatings, cleanliness and visibility of the sign and condition of indicator lamps and batteries (where fitted)</td>
<td></td>
</tr>
<tr>
<td>- integrity of the sign mountings, mechanical connections and fastenings or corrosion of metal components</td>
<td></td>
</tr>
<tr>
<td>13. Examine Permanent Speed signs for correctness of position, speed shown, track indicated etc at least once per year</td>
<td></td>
</tr>
<tr>
<td>14. Where RailCorp boundary signs exist, examine them for position, security and visibility</td>
<td></td>
</tr>
<tr>
<td>15. Examine Track geometry</td>
<td></td>
</tr>
<tr>
<td>16. Monitor welded track performance and note deficiencies in preparation for annual Track Stability Analysis</td>
<td></td>
</tr>
<tr>
<td>17. Examine Undertrack structures for conditions effecting track integrity (temporary supports, wedges etc)</td>
<td></td>
</tr>
<tr>
<td>18. Look for disused materials (and arrange removal)</td>
<td></td>
</tr>
<tr>
<td>Task</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>19</td>
<td>Monitor the quality of completed maintenance works</td>
</tr>
<tr>
<td>20</td>
<td>Examine matters noted during Track Patrol (and decide action)</td>
</tr>
<tr>
<td>21</td>
<td>Identify and record all defects and compare to Current Defect List noting new and deteriorating defects and defects that have been removed</td>
</tr>
<tr>
<td>22</td>
<td>Repair defect or PROTECT (or arrange protect ion of) site pending further corrective actions</td>
</tr>
</tbody>
</table>

**Finish The Job**

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Pack up Worksite (On Track)</td>
<td>TMC 203 C9-2</td>
</tr>
<tr>
<td>24</td>
<td>Update Defect List and program repairs required</td>
<td>TMC 203 C9-2</td>
</tr>
<tr>
<td>25</td>
<td>Complete Examination Certification</td>
<td>TMC 203 C9-2</td>
</tr>
</tbody>
</table>
Appendix 5: Boronia No 3 Tunnel Inspection 2011

![Tunnel Examination Report](image)

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>Defect Category</th>
<th>COMMENTS</th>
<th>Repair Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROOF</td>
<td>E</td>
<td>Slight seepage throughout.</td>
<td></td>
</tr>
<tr>
<td>WALLS</td>
<td>E</td>
<td>Seepage in walls causing rust to anchor rock bolts.</td>
<td></td>
</tr>
<tr>
<td>FLOOR</td>
<td></td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>PORTALS</td>
<td></td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>REFUGES</td>
<td></td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>REFUGE MARKERS</td>
<td>D</td>
<td>In need of cleaning.</td>
<td></td>
</tr>
<tr>
<td>DRAINS</td>
<td></td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>SIGNAGE</td>
<td></td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>GENERAL</td>
<td></td>
<td>Slight seepage throughout tunnel walls and roof.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 6: AK car graph, 16 September 2014
Appendix 7: RSNL National Regulations 2012, s57(1)(a) extract

_Rail Safety National Law National Regulations 2012, s57(1)(a) extract_

57—Reporting of notifiable occurrences
(1) For the purposes of this regulation—

(a) any of the following notifiable occurrences is a **Category A notifiable occurrence**:

(i) an accident or incident that has caused death, serious injury or significant property damage;
(ii) a running line derailment;
(iii) a running line collision between rolling stock;
(iv) a collision at a road or pedestrian level crossing between rolling stock and either a road vehicle or a person;
(v) a suspected terrorist attack;
(vi) an accident or incident involving a significant failure of a safety management system that could have caused death, serious injury or significant property damage;
(vii) any other accident or incident likely to generate immediate or intense public interest or concern;
Appendix 8 Sources and submissions

Sources of information

- Sydney Trains
- Office of the National Rail Safety Regulator
- Transport for New South Wales Asset Standards Authority

Submissions

The Chief investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- Sydney Trains
- Office of the National Rail Safety Regulator
- Transport for New South Wales Asset Standards Authority

Responses were received from all DIPs and these were taken into consideration in finalising the Report.