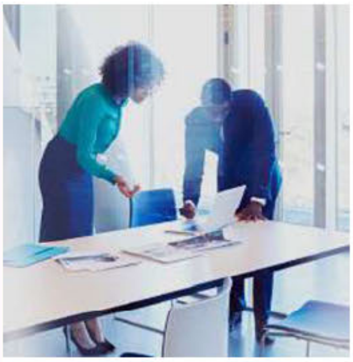
Attachment 6: GHD Peer Review of West Moreton System DAU2 Maintenance Costs 2020-21 to 2024-25

GHD Advisory



Peer review of Queensland Rail's proposed maintenance expenditure for DAU2

Queensland Rail

27 July 2018

GHD

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Executive summary

Queensland Rail engaged GHD (us) to undertake a peer review of its proposed maintenance costs for the West Moreton network during the Draft Access Undertaking 2 (DAU2) period, covering 2020-21 (FY2021) to FY2025. The West Moreton network is divided into two segments, namely: Rosewood to Jondaryan; and Jondaryan to Columboola; the network is approximately 407 km long (321 km route) and is an aged narrow gauge network from the 1860s with steep gradients, tight curves and non-engineered formations on key parts of the network.

Queensland Rail is proposing two throughput scenarios as part of our commission, namely:

- a [redacted] per annum (MTPA) scenario, where only Yancoal's mine at Cameby Downs operates
- [redacted] scenario, where Yancoal's mine and New Hope Group's New Acland mine expansion comes to fruition.

Queensland Rail has asked us to undertake our peer review on the basis of whether the prudency and efficiency of Queensland Rail's existing practices indicate whether proposed costs for the DAU2 period reflect outcomes that are prudent (is the maintenance activity needed?) and efficient (is the maintenance activity being delivered in the most efficient way?). Against this requirement, our analysis has been geared at identifying whether Queensland Rail's maintenance activities, including its planning practices and use of machinery/labour, are likely to lead to the aforementioned prudent and efficient outcomes.

In agreement with Queensland Rail, we undertook a review of eight maintenance activities, namely: mechanised resurfacing; top and line spot resurfacing; ballast undercutting (track lowering); rail renewal; rail joint management; sleeper management; maintenance ballasting; and rail stress adjustment. Based on FY2018 costs for the network, these eight activities account for more than 40% of total costs, which we consider a reasonable sample size to achieve given the timeframes for, and nature of, our peer review for Queensland Rail.

As part of our engagement, we undertook a two-day site visit to the West Moreton system, with a view to observing parts of the network that Queensland Rail considered a well-maintained standard had been achieved and parts of the network that Queensland Rail had scheduled for maintenance in the near future. This provided context and valuable insights for our predominantly desktop-based assessment of whether Queensland Rail's existing practices for maintenance are consistent with generating prudent and efficient outcomes.

Our findings are that, overall, Queensland Rail's maintenance activities and practices reflect prudent and efficient outcomes. Key observations from our site visit are that parts of the network that Queensland Rail had earmarked for maintenance in the near future do indeed require the maintenance work that Queensland Rail plans to undertake for them, hence fulfilling the prudency requirement. Our assessment of, where the data were available, machinery performance, use of shifts and unit rates for raw materials support the position that Queensland Rail is achieving efficient maintenance outcomes for its West Moreton network. In conclusion, we find that Queensland Rail's existing practices for maintaining its railway reflect prudent and efficient outcomes, and that this translates to its cost proposals for the [redacted] and [redacted] scenarios over the DAU2 period reflecting prudent and efficient outcomes.

As a final part of our peer review, Queensland Rail asked us to offer a view on the fixed/variable nature of maintenance costs, in the context of the fixed/variable split of 57.3%/42.7% that the Queensland Competition Authority has proposed in AU1. We find that an appropriate fixed/variable maintenance-cost split is 62%/38%, noting that our line-by-line review of maintenance activities is based on MAT codes rather than the previous classifications that Queensland Rail had used as part of AU1.

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This report, which is a peer review of Queensland Rail's proposed costs for the DAU2 period, has been prepared in the context that Queensland Rail's submission is being provided as a response to an economic-regulation process.

1 Introduction

Queensland Rail has engaged GHD (us) to undertake a peer review of its proposed maintenance expenditure for the DAU2 period, covering FY2020-21 (FY2021) to FY2025. The peer review includes:

- Identifying efficient costs for the forecast maintenance tasks, noting the throughput scenarios to be considered are for [redacted] per annum (Mtpa) and [redacted]
- Undertaking a comparative analysis, where relevant, of the proposed cost forecast with a suitable rail system and/or corridor to demonstrate that costs are appropriate.

Our peer review acknowledges that Queensland Rail's proposed maintenance expenditure for the DAU2 period will be subject to review by the Queensland Competition Authority (QCA) and its consultants in the QCA's draft decision on the DAU2. Hence, our assessment has been undertaken in the context of an economic-regulation expenditure review.

1.1 Queensland Rail's proposal

A summary of Queensland Rail's proposed maintenance expenditure, for each throughput scenario, is presented in Table 1.

Table 1: Queensland Rail's proposed maintenance expenditure ($M, $FY2021) over DAU2

Scenarios	FY2021	FY2022	FY2023	FY2024	FY2025	Total
[redacted]	20.700	20.533	20.374	20.202	20.015	**101.825**
[redacted]	28.483	28.321	28.177	28.048	27.891	**140.921**

Under the [redacted] scenario, total costs are $101.8 million ($FY2021). In comparison, costs are $140.9 million under the [redacted] scenario. Table 2 sets out Queensland Rail's maintenance categories for the DAU2 period, including an assessment of whether Queensland Rail considers them to be tonnage-dependent.

Table 2: Queensland Rail's proposed maintenance categories for DAU2 period

Categories	Queensland Rail assessment of tonnage dependence
Structures and civil	Yes
Ballast Undercutting	Yes
Earthworks—non-formation (including drainage).	No
Minor yard maintenance	No
Rail joint management	Yes
Rail renewal	Yes
Turnout maintenance	Yes
Signage	No
Maintenance ballast	Yes

Categories	Queensland Rail assessment of tonnage dependence
Sleeper management	Yes
Fire & vegetation management	No
Rail stress adjustment	No
Asset inspections	Partial
Rail lubrication	Yes
Top & line resurfacing	Yes
Rail repair	Yes
Resurfacing	Yes
Rail grinding	Yes
Facilities	No
Telecommunications	No
Signalling	No

1.2 Structure of GHD's report

We have adopted a prudency-and-efficiency approach to identify if Queensland Rail's proposed maintenance expenditure for DAU2 is appropriate. Our report is structured as follows:

- Approach for assessing prudency and efficiency (including limitations of our review)
- Sampling approach
- Observations from our site visit of the West Moreton system
- Analysis for the sampled maintenance activities
  Fixed/variable split of below-rail maintenance costs on the West Moreton system.

2 Approach for assessing prudency and efficiency

2.1 Prudency

Prudency relates to whether a maintenance activity is *needed*. What needs to be established is whether a maintenance activity is required for Queensland Rail to deliver the below-rail declared service and what regulatory driver supports that expenditure is related to, for example:

- Replacement and refurbishment of assets to maintain foreseeably required capacity and conformance with performance standards in customers' access agreements
- Compliance with applicable legislation (e.g. for rail, Transport (Rail Safety) Act 2010 (Qld) (TRSA Act) and Transport (Rail Safety) Regulation 2010 (Qld) (TRSA Regulation), the Professional Engineers Act 2002 (Qld) and mandatory standards and operating licences)
- Maintenance of regulated assets to achieve planned service life (typically on a least life-cycle-cost basis hence allowing for capital expenditure and maintenance expenditure trade-offs).

Our assessment considers whether Queensland Rail's proposal provides a clear link between the maintenance activities and the provision of the below-rail service.

2.2 Efficiency

An efficient expenditure is one that is the most cost effective for delivering the required standard of service. This could relate to the maintenance activity selected to meet the service requirement, the unit costs being assumed, the amount of materials used and/or labour forecasts for the relevant period. To assess whether a cost estimate for the maintenance activity is efficient, we would seek to consider whether the costs are:

a. in keeping with the appropriate scope for the required task

b. the least costs (taking into account asset lifecycle cost)

c. in keeping with market rates

d. comparable with industry benchmarks (taking into account locational and operating factors that may impact on costs)

e. in keeping with those costs that an operator would have incurred, if it were subject to competitive pressures to retain market share. We note that this is a subjective assessment that requires engineering and commercial judgement.

Where possible, trade-offs with capital expenditure are also considered.

2.3 Limitations of the review

In some cases, we were unable to extract useful maintenance scopes (e.g. distance of top and line resurfacing works) from the cost data and defect notification data that Queensland Rail provided us for the DAU 2 period. As part of our peer review, we undertook scope analysis independently of Queensland Rail, and Queensland Rail may or may not have the same information for the scope of works previously conducted. Hence, we were not in a position to assess the efficiency of unit rates that we were not able to derive from the data or find an appropriate measurement for benchmarking (e.g. the many maintenance activities in rail joint management).

Given this, our assessment has focussed on: prudency; from the perspective of whether a project is needed, rather than the quantum of works to support that need; and efficiency, on an exceptions basis, in that only if we observed anomalies in the data or our site visit that indicated we should review the efficiency associated with the relevant maintenance activity, then we would do so.

3 Sampling approach

We have adopted a sampling approach to undertake a targeted and in-depth review of major maintenance categories. The premise of this approach is that it allows a wide-ranging review of the efficiency and prudency of major maintenance cost categories, which ultimately represent the overall efficiency and prudency of the maintenance works being performed in the West Moreton system.

3.1 Principles for selecting sample

The principles that we have adopted for selecting the sample are as follows:

- At least 40% of total maintenance-expenditure costs are covered
- A broad mixture of tonnage-driven and tonnage-independent sub-categories have been selected
- Some of the selected maintenance cost categories should have a relationship with Queensland Rail's proposed capital-expenditure plans (e.g. if a timber bridge upgrade program is completed during DAU2, then we would expect a reduction in maintenance costs of 'repair timber bridges'.

3.2 Sample selected

The sample of maintenance projects that we selected to review is presented in Table 3. A total of eight categories were selected.

Table 3: Maintenance activities assessed as part of our peer review

Maintenance activity	MAT Code
Mechanised Resurfacing	N32
Top & Line Spot resurfacing	N53
Ballast undercutting (track lowering)	N06
Rail renewal	N63
Rail joint management	N41
Sleeper management	N51
Maintenance ballasting	N30
Rail stress adjustment	N42

Each maintenance activity is assessed below in the context of our site visit of the West Moreton system.

4 Site visit

This section sets out the key observations we made from our site visit in the West Moreton network on 5-6 June 2018. We undertook the site visit to validate the context of Queensland Rail's position that the West Moreton network is an aged system that was built when limited track technology (e.g. un-engineered formation options only) was available. Hence, we kept in mind that the condition of the asset would reflect the age and topography of the network and the engineering-practice norms in the 1860s.

We visited locations between Rosewood to Toowoomba on 5 June and locations between Toowoomba to Miles (Columboola) on 6 June.

We visited eight locations during the site visit:

- Rosewood/Lanefield (-27.654763,152.559239)
- Laidley (-27.629573, 152.395023)
- Forest Hill (-27.589068,152.357624)
- Forest Hill (-27.585077,152.351730)
- Ringwood (-27.548893,152.243048)
- Lockyer (-27.520685,152.093959)
- Murphy's Creek (-27.450844,152.029583)
- Blue Mountain Heights/Ballard (-27.492947, 151.965048).

Figure 1 shows the locations that we inspected. Locations 1 to 7 were within Rosewood to Toowoomba, and location 8 was from Toowoomba to Miles.

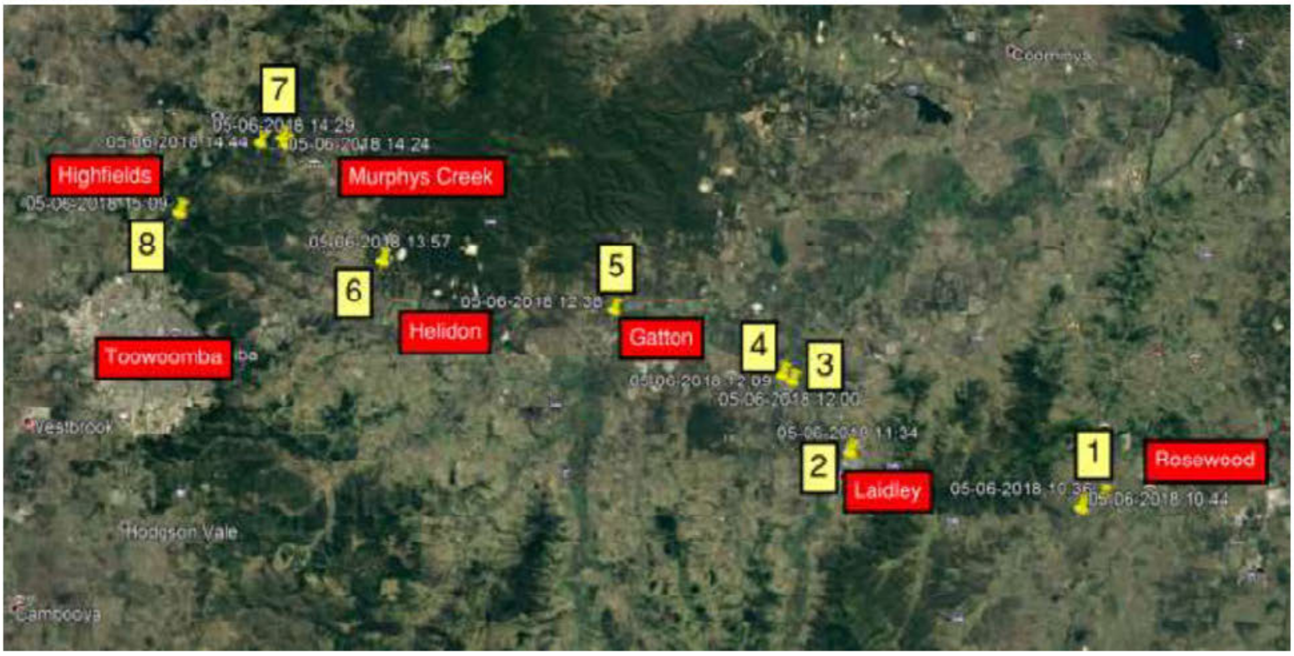

Figure 1: Map of locations that we inspected in the West Moreton system during our site visit of 5-6 June 2018

Seven of the locations were within Rosewood to Toowoomba, with one of the locations just beyond the west of Toowoomba.

4.1 Resurfacing and top & line (spot) resurfacing

Resurfacing is required when the track is uneven, either longitudinally or laterally, resulting in poor line and level. The cause is often due to the ballast and/or subgrade formation being in poor condition e.g. worn or unstable ballast, mud holes etc.

Mechanical (or Top & Line Spot) Resurfacing is required to lift and compact the ballast while aligning the rail line to the required design level. The site team identified that the Jondaryan to Miles section of the track had several locations that require mechanised resurfacing.

4.2 Ballast undercutting (track lowering)

Track lowering works are required in the West Moreton System where repetitive passes of mechanised resurfacing (or Top & Line spot resurfacing) have raised the top of the ballast structure to the point where it exacerbates ballast deterioration and creates track instability. These numerous passes of mechanised resurfacing are required in certain parts of the West Moreton System where the sub-ballast has merged into the subgrade formation (non-engineered black soil), causing the loss of top and line in the track geometry.

Site 8 had issues with the above described formation as evidenced by the vegetation coming through the sleeper bays, as shown in Figure 3 and Figure 4 below. Figure 2 below shows an example of recent track lowering works performed near Laidley, with the difference in track height clearly noticeable (although this is not suggestion that the down-road track is excessively high, this is shown to demonstrate the actual work).

Figure 2: Recent track lowering works near Laidley on the up-road track

Figure 3: Poor formation conditions evidenced by the vegetation in the sleeper bays

Figure 4: Dense vegetation growth through the track bed in parts of the track between Toowoomba and Miles, a symptom of the non-engineered formation characteristic of the West Moreton System

Figure 5 below demonstrates an area in need formation repairs

The vegetation growth suggests that fine particles have been pumped from the formation subgrade and interspersed with the ballast. If left untreated this can cause waterlogging/mud holes and will impede the integrety of the track structure.

Figure 5: Poor formation issues and vegetation growing from track-bed

The formation between Jondaryan to Bowenville is generally in poor condition noting the historical nature of the tracks, with pumping issues in some locations. Formation upgrade maintenance was conducted on some portions of track between Jondaryan and Bowenville approximately four years ago, and these parts are in good condition. The formation in the Dalby to Miles section is also in poor condition, with changes in soil conditions causing formation problems including ballast depth issues.

These issues arise a consequence of the West Moreton Network's historical construction.

4.3 Rail renewal

The track is upgraded based on condition and priority, for example; the Down road (loaded traffic) has more tonnage and more associated deterioration and is therefore upgraded before the Up road which has predominantly unloaded traffic.

The Jondaryan to Bowenville track section had wearing issues and will need replacement. Likewise, Bowenville to Koomi had higher than average wear due to high tonnage rates and will subsequently need frequent re-railing as part of capital expenditure. Legacy issues exist between Jondaryan to Miles, where the original track was laid prior to the use of heavy machinery and mechanical compaction (this is what we refer to as the 'legacy issues'). In the Toowoomba range track section, significantly more wear was noticed on the outside rail head in the tight radius curves, caused by the large lateral forces exerted from passing rolling stock on the outside rail. These tight radius curves and their outside rails will subsequently require regular rail renewal (as opposed to re-railing).

4.4 Rail joint management

The longitudinal rail movement resulting from thermal initiated expansion and contraction, need to be allowed for at the time of track construction set up and monitored during maintenance works and subsequent inspections. Poor joint management can result in rail buckling, caused through compression and excessive gaps caused through contraction.

Figure 6 below shows a frozen joint, which does not allow for adequate expansion and contraction to accommodate thermal induced longitudinal movement, resulting in the ends of each rail being damaged (slightly battered).

Figure 6: Frozen joint

4.5 Sleeper management

In Site 1, concrete sleepers were used on the down track, while the up track used an even mix of timber and steel sleepers instead (Figure 7).

Figure 7: Use of a mix of steel and timber sleepers on parts of the West Moreton system

Site 2 demonstrated the need for regular and consistent sleeper management (Figure 8). Steel sleepers are lighter than concrete sleepers and are not as secure and more readily move when subject to above-rail movement. This sleeper movement is especially prevalent in the up track, due to the tight radius of the curves and additional associated stresses.

Figure 8: Mix of timber and steel sleepers

Figure 9: Skewed sleepers caused by excessive longitudinal forces

Figure 10: Missing dog spike

Figure 11: Missing sleeper clips and nylon

Site 8 was a similarly curved section, and experienced comparable sleeper damage and excessive lateral movement resulting in damage to the sleepers, fittings and associated alignment issues. Timber sleeper damage can be seen in Figure 12 below, which is likely a result of excessive radial loading compounded by constricted lateral movement.

Figure 12: Skewed timber sleeper splintering

The Jondaryan to Bowenville section has issues with sleepers under joints and sleeper spacing issues from 51 km to 55 km, due to rail creep. Rail creep is the longitudinal movement of rail that is mainly caused through train accelerating or decelerating, causing movement to the adjoining sleepers and resulting in sleeper spacing issues. Sleepers laid under rail joints can cause difficulties for Queensland Rail's rail-joint-management practices.

4.6 Maintenance ballast

The level crossing located at Site 3 shows the impact of poor track drainage (see Figure 13).

The transition between track stiffness at the level crossing and off the end of the level crossing has resulted in pumping and development of a mud hole. This ballast was last maintained over a decade ago; possibly due to the constraints which the tamper machines have in lifting the rail (the rail is firmly held by the surrounding asphalt).

These mudholes have been creeping into the asphalt, contaminating the pavement and resulting in structural failure of the subgrade below. This increases the likelihood of surface asphalt failure. Furthermore, these mudholes can cause waterlogging issues in the ballast, allow for vegetation to grow in and around the rail tracks.

Figure 13: Impact of poor drainage on the condition of ballast

4.7 Rail stress adjustment

A tight radius curve leads into Site 2, adjacent to the Laidley yard (see Figure 14 and Figure 15). The track is laid on a combination of steel and timber sleepers and traverses under a low bridge (an 'overbridge'). During warmer months, the track buckles from the heat, resulting in track stability problems. We understand that Queensland Rail often cools the track with water from a water-spraying track car, with the objective of minimising track buckling.

Since our site visit, Queensland Rail has reconditioned the track structure and replaced the interspersed steel and timber sleepers with concrete sleepers and 50 kg/m rail (as can be seen in the background of Figure 14), and used low profile concrete sleepers under the overbridge as part of its capital expenditure program.

Figure 14: Tight radius curves (1)

Figure 15: Tight radius curves (2)

A tight radius curve leads into Site 6. This area has been known to succumb to rail buckling due to the stress arising from temperature effects on the tight curves. These curves also pull the sleepers to one side (see Figure 12 again), creating voids in the ballast on the outer edge side of the track. Rail stress management is required to minimise the likelihood of buckling.

Several tight curves in the Toowoomba range lead into Site 7. Kings Bridge is also situated here and is scheduled to receive stress monitoring through on-site detectors. Further along this section of track, a tight radius curve occurs. This curve receives extra support from a check rail on the inner track. It was also noticed that the track section between Jondaryan to Bowenville had issues with rail creep. As noted above, rail creep is the longitudinal movement of rail that is mainly caused through train accelerating or decelerating, causing movement to the adjoining sleepers and resulting in sleeper spacing issues.

4.8 Summary

Whilst we observed several defects in the West Moreton System, particularly with respect to missing fastenings, frozen joints, fouled ballast and pumping, it is important to note that the purpose of the site visit was to identify the prudency of the maintenance activities, not to highlight track sections in good condition. As such the site report is not intended to provide commentary on the overall condition of the West Moreton System or Queensland Rail's overall maintenance strategy and we are cognisant that the ongoing maintenance requirements continue to be influenced by the rail network's history. We recognise where Queensland Rail has performed either capital or maintenance works, the quality of the product is to a high standard.

5 Mechanised Resurfacing

5.1 Background

The geometry of the rail line facilitates the interface between the track and the above-rail operators. It represents the final element of the track structure extending from the subgrade through to the rail. The integrity of the track geometry is a critical component for operational safety and efficiency. Poor geometry results in increased risk of derailment and the implementation of speed restrictions. As a result, geometry is susceptible to misalignment from two primary avenues: changes to each component in the track system that arise from deterioration and wear, and from general wear and tear due to standard operation of the line.

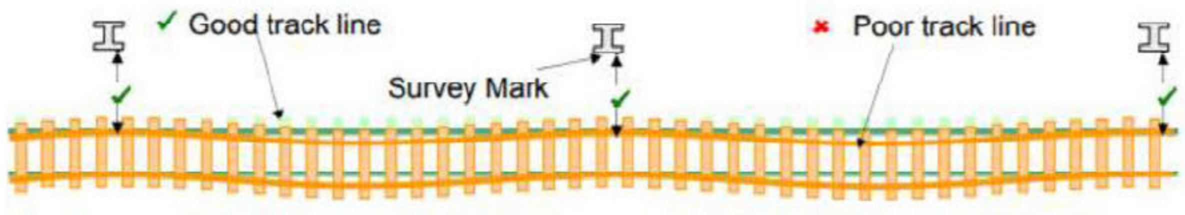

Figure 16: Rail line deviation superimposed on original track line design. Re-alignment is necessary to achieve the good track line from the deviated poor track line[1].

[1] Engineering Manual (Track): TMC 202 Track Fundamentals, Transport Rail Corp 2012.

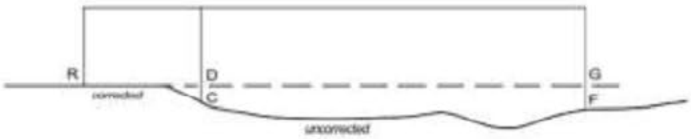

Figure 17: Resurfacing levelling (lifting) process. The uncorrected track is lifted to the pre-determined track line (line RG) and cross-fall[2].

As the track geometry deteriorates from the specifications set out in the maintenance standards, it is necessary to resurface the track. The purpose of the mechanised-resurfacing activity is to reinstate the designed track geometry top and line, as is diagrammatically explained in Figure 16 and Figure 17. To achieve this, the resurfacing activity aims to ensure integrity of the ballast component through tamping, and to adjust the geometry by aligning the track line to pre-determined coordinates and also the track top via track lifting.

Mechanised resurfacing is undertaken via on-track equipment such as tampers and regulators. The characteristics of this resurfacing activity surround production line work and are generally deployed for significant resurfacing distances.

5.2 Prudency

The need for resurfacing coincides with the need to maintain line safety and the desire for network capacity. Consequences of improper resurfacing maintenance involve speed restrictions and increased risk of derailments. The geometry changes arise through several factors such as network usage, formation condition, and weather events.

General track usage causes wear and tear on the geometry as a result of the forces exerted through the train wheel interface with the rail. This stress wears members of the track structure system such as the sleeper alignment (particularly around curves), ballast and formation.

Another contributing factor identified arises from the formation. As the Queensland Rail West Moreton network was developed in the nineteenth century, the formation has offered challenges of late due to factors such as:

- Cumulative tonnage
- Out-dated formation design
- General formation age and deterioration

The impact of these factors were evident in various sample sections of the line visited during the site visit (as is expected from an operational railway). Given normal wear and tear, and the formation condition, it is clear that for Queensland Rail to maintain the West Moreton System safety and network capacity from a geometry stand point that the resurfacing activity is a necessity.

5.3 Efficiency

Resurfacing may be conducted via several methods of varying efficiencies and costs. The major determinant in selecting the appropriate method relates to the distance of resurfacing required, occupation window and resource allocation requirements. Key factors are:

[2] Mechanised Track Surfacing, Track and Civil ARTC Page 11

- Manual/ Localised capacity: Excavator with tamper head and rail threader or manual methods.
- Production capacity: On-Track tamper machine

To conduct this resurfacing activity in a production capacity, On-Track machines are a necessity due to the time restriction of occupation windows, and higher efficiency of working on a face with a machine. These machines will have inherent performance characteristics relating to their size and capabilities.

The track occupation opportunities, particularly on a coal freight network, present challenges in windows of time to complete work. If the necessary work meets the length criteria of this resurfacing activity, the need for higher production resurfacing equipment commonly arises. This favours the higher production On-Track units. We recognise the following measures that Queensland Rail takes to increase the efficiency of its mechanised resurfacing activities:

- The West Moreton maintenance planning team works with the above-rail-operator team to adjust train paths to create larger possession windows, to maximise use of machinery and to increase plant operating time during possessions; and
- During planned track closure possessions, the mechanised resurfacing team will work night shifts from 6:30 pm to 4:00 am where needed to ensure completion of maintenance work following reinstated track, as opposed to completing work outside of track closure.

Furthermore, analysis of the 291 km of mechanised resurfacing[3] (71.4% of the total track distance in the West Moreton System) that occurred FY2017 showed that Queensland Rail exceeded its planned plant usage, with [redacted] plant utility for every [redacted] crew hour[4], as opposed to typical planned usage of [redacted] in a [redacted] [redacted], [redacted]).

We also note that in our review for the same financial year, we found that Queensland Rail achieved an [redacted] which is lower than Aurizon Network's proposed UT5 unit rate of [redacted][5] for FY2018. Noting the modern condition of the Aurizon Network rail system, including its far superior mechanised resurfacing plant and its relative advantage with respect to economies of scale, the evidence is testament to the efficiency and organisation of Queensland Rail's mechanised resurfacing activities.

6 Top & line (spot) resurfacing

6.1 Background

As with mechanised resurfacing, Top and Line (spot) resurfacing is a maintenance activity conducted to prevent the rail top and line geometry from misaligning from the track standards, or to correct existing defective geometry. The Top and Line correction process is presented in Section 6.1 Figure 16 and Figure 17.The need for this process arises from the discussed factors such as wear and tear from use, impact from the formation condition and weather.

[3] Queensland Rail Access Undertaking 1 – 2016-2017 Annual Performance Report

[4] 6 Mechanised resurfacing team members between a regulator and a tamping machine.

[5] Aurizon Network's UT5 Maintenance Allowance Presentation

6.2 Prudency

As with Resurfacing, Top and Line (Spot) resurfacing is a necessary activity arising from the need to maintain the safety of the line by minimising the risk of derailment (from geometry contribution) in addition to maintaining the track speed rating for the line capacity. Top and Line (Spot) resurfacing specifically establishes its own need over the alternative mechanised resurfacing through several advantages offered in relation to compatibility for a given work scenario.

Top and Line (Spot) resurfacing offers several benefits over alternative resurfacing methods that establish a need for this particular activity, over the application of mechanised resurfacing. The reason for this, is that Mechanised units are (in relation to manual resources) less compatible for certain work scenarios if the correct operating environment is not presented. Examples of this include:

- The length and distribution of work. Mechanised units favour long production work on a face (Due to efficiency). In comparison, for low production and highly distributed work, manual work groups are at times more efficient due to accessibility (ie, level crossings, other On-Track machines or discontinuous track due to other work, potential for On-Track machine derailment).
- Availability of mechanised resources – mechanised resurfacing machines are not always to the West Moreton system
- Disturbance from other work groups (flexibility). As mechanised units are On-Track and present great risk to other work groups, this reduces their flexibility compatibility for certain work sites. In comparison, manual resources are more flexible to work around other work groups during maintenance activities.

The variety of advantages and disadvantages owing to each activity will drive a difference between the two resurfacing strategies employed. These differences establish a specific need for the Top and Line (Spot) resurfacing activity. When coupled with the principal drivers for maintaining track geometry from a safety and line capacity stand-point, it is evident that Top and Line (Spot) resurfacing is an essential, and necessary activity as a part of Queensland Rail's maintenance program.

6.3 Efficiency

The employment of Top and Line resurfacing over mechanised resurfacing offers potential for efficiency improvements, due to the numerous differences observed and explained in Section 7.2. As a result, it is important for a dynamic blend of each activity to be implemented through the maintenance plan. As is evident in the data presented from Queensland Rail regarding the West Moreton network, these two activities have been applied in a joint effort to achieve greater efficiency and production. This is evident in the FY2016 to FY2018 work scopes.

Analysis of the resurfacing work scopes presents insight into the strategy driving the application of Top and Line Resurfacing. Over the past three years, Queensland Rail's scope of Top and Line Resurfacing has presented significant variability. From the FY2016 scope of 983 km, peaking at 1,342 km in FY2017 and decreasing to 507 km in FY2018. A different trend was observed in mechanised resurfacing, where a steady decline in scope has been evident over FY2016 to FY2018 with a 47% decrease in production. Several observations can be made from this data:

1. A possible catch up of baseline resurfacing activity evident in the mechanised scope declination. A component of this result may arise from the reduced train paths observed from FY2014 to FY2016 of 14.6%.
2. Optimisation of resourcing for higher priority works, evident in the 62% drop-off of top and line scope in 2018. This may coincide with the completion of the major sleeper replacement project in 2016 which

included significant resurfacing requirements. This is in addition to 94% less ballast undercutting and (track lowering) scope from FY2016 to FY2018 and the increased focus on rail-renewal scope in FY2018.

We note that Queensland Rail has taken the approach to dynamically apply Top and Line Resurfacing, particularly surrounding works that present compatibility such as the sleeper renewal project, and receives the benefits from this activity over mechanised resurfacing. This strategy represents an efficient approach to application of this method. As such, we consider that Queensland Rail's current Top and Line Resurfacing practices and expenditure to be efficient.

7 Ballast undercutting (track lowering)

7.1 Background

Decay (and in some cases failure) of the formation subgrade is a common operational issue faced by rail networks, particularly when developed in certain geographical areas such as over black soil, like the West Moreton system. Over time, regular track use and other factors such as weather events, initial formation construction and freight material (coal dust contamination), naturally enhances the rate of decay of this formation.

Subgrade deflection and/or failure causes a systematic change in the formation extending up to the track line impacting geometry. Not addressing these issues increases the risk of rail derailments, which compromises the safety of above-rail operators on the track. There are two primary methods employed to rectify such track deficiencies:

- Resurfacing of top and line – the addition of ballast to allow a tamper to lift the track to re-instate the geometry. Eventually, this triggers the need for track lowering. Resurfacing of top and line and track lowering are considered to be maintenance activities.
- Formation repairs – the full excavation and re-laying of formation to ideal compactness and moisture content to reinstate the original capacity of the formation. Formation repairs are considered to be a capital activity.

As with the resurfacing option, track lowering is needed to trim the excess top ballast that grows due to lift during tamping and track alignment operations to prevent the ballast reaching the point of instability. Track lift (explained in Figure 17) is a component of the resurfacing activities and is required to achieve the desired top (level). Track lift is often desirable up to a limit of 50 mm[6]. The resurfacing and track lowering method, in comparison to formation repair, is a quick fix to the track geometry deterioration. Whereas the formation repair method can be described as a more invasive and lengthy process. As a part of maintaining the West Moreton system, Queensland Rail is required by the QCA to demonstrate the prudency and efficiency of each maintenance method employed.

7.2 Prudency

Track geometry requires monitoring and maintenance to prevent an increase to the risk of derailment due to deterioration of the top and line. The track geometry is monitored to identify deviance from geometry criteria to a maximum limit (up to 7mm tolerance in certain networks)[7]. The work necessary to maintain this

[6] Mechanised Track Surfacing, Track and Civil ARTC Page 11

[7] Mechanised Track Surfacing, Track and Civil ARTC Page 14

geometry is achieved through mechanised resurfacing, and depending on the state of the formation under the track, repair work through to the subgrade may be necessary as a comprehensive alternative to prevent ongoing elevated rates of deterioration. This comes as a direct result of the historical formation construction that the West Moreton line was built on since 1865, which in comparison to the present time is not structured nor filled with appropriate material.

The need for this maintenance work also comes about as a result of both the location and natural characteristics of the network, being laid on black soil, and other factors such as the: high tonnage rates (Class H loading in excess of 6 mtpa)[8,9], numerous curves and gradients observed throughout the line, particularly extending from the Toowoomba ranges; weather events; and the remaining ash deposits from steam trains[10]. Given the expected increase in tonnage over the next 3 – 5 years as outlined in the 17/18 AMP, it is likely that the network will see an associated rise in formation deterioration as this has been correlated to the tonnage rate, and will also be subsequently reflected in the top & line resurfacing, mechanised resurfacing and track lowering costs.

The track lowering work arises as a result of the decision to maintain the geometry through several rounds of resurfacing (over time) despite poor formation condition. For open haul track the level should not exceed +75 mm of approved grade level, provided minimum ballast level is achieved[11]. Alternatively, formation repair may be undertaken for significantly deteriorated locations, provided appropriate occupation windows are met. The benefit of this work being that the deterioration rate will significant slow as a result of renewed formation[12]. Numerous factors influence the decision as to what method should be employed; these are taken into consideration upon assessing the prudency of the proposed work.

As a rail line approaches the end of its useful life expectancy and operational capacity, then it is unlikely that it would be efficient to conduct full formation repair. The costs of this work will simply not be recovered before reaching the end of line usefulness. A preliminary analysis of the length of life extension and associated cost of each method are recommended (significantly depending on many factors).

Queensland Rail has identified factors that would dictate the asset management strategy surrounding the useful life of certain track sections in the West Moreton system. These factors are: competition from the Inland Rail, affecting Rosewood to Gowrie; and uncertainty in the future of freight market, affecting Gowrie to Miles. Queensland Rail's 2017-18 AMP[13] proposes that as it currently stands, there is no alteration to the existing strategy regarding these two key factors. Therefore, from Queensland Rail's current perspective, the formation repair strategy should maintain as is.

From our capex analysis and the data provided by Queensland Rail, we have identified a ratio of mechanised resurfacing/track lowering/ formation repairs of approximately 29/1/1 (ratio of km). When considering the cost of formation repair (approximately [redacted]), mechanised resurfacing (approximately [redacted]) and track lowering (approximately [redacted]) in addition to the required frequency of work, we consider that the ratio identified is prudent.

[8] Where < 2MGT is considered 'Low' by ARTC standards – Engineering (Track & Civil) Code of Practice 2012.

[9] Class H loading as described by AS 2758.7 - 2009

[10] Identified in the West Moreton Maintenance Submission 2020 – 2025, Queensland Rail 2018. & the Queensland Rail Asset Management Plan (AMP) 2017-2018.

[11] ARTC track and Civil: Track Geometry Standards for Construction, Upgrading and Maintenance Works, Page 10 ARTC, 2013.

[12] Design Life Prediction of a Heavy Haul Track Formation, Grabe & Shaw 2009.

[13] Page 126 of the Queensland Rail Asset Management Plan 2017/2018

7.3 Efficiency

The duration of track occupation is a determining factor that will influence the decision made to perform resurfacing, track lowering and formation repairs. The average length of works performed is approximately: 1.5-2 km per day for mechanised resurfacing; 0.5 km per day for track lowering; and 0.5 km per day for formation repairs. The labour cost of track possession should be taken into consideration (and so can the opportunity costs of longer track possessions, but this is not discussed here, as the focus is on direct, rather than indirect, costs).

Queensland Rail's line data for the West Moreton system indicates typical occupations of 11.5 hours for mechanised resurfacing. Due to the inability to create significant windows of track occupation, the formation repair efficiency would be significantly affected as it would require much more mobilisation to and from site and less production per day. However, on the odd occasion that there is a lengthy occupation (such as during the Commonwealth Games), it would be advantageous to undertake formation repairs.

Another significant factor influencing the maintenance method relates to the current available resources, the Enterprise Asset Management System (EAMS) defect notification priority system and Queensland Rail's overall maintenance strategy for the West Moreton System. If there is insufficient opportunity for Queensland Rail to undertake formation repair works, either due to a lack of available track possessions of suitable length or a lack of on-the-ground resources, then it is efficient for Queensland Rail to undertake the more expedient resurfacing option. This is required by Queensland Rail to maintain its strategic maintenance goal, which is to maintain the network to the standard required by users whilst balancing expenditure to achieve this objective. This outcome is likely more favourable than hiring external resources to address the track-geometry defects at a greater expense via conducting formation repairs.

Overall, the evidence provided by Queensland Rail on its maintenance-cost proposal for ballast undercutting (track lowering) to be consistent with achieving efficient outcomes.

7.4 Maintenance or capital in nature?

Queensland Rail sought our advice on the appropriateness of treating Ballast Undercutting (Track Lowering) as maintenance expenditure as opposed to capital expenditure. Track Lowering relates to a removal of ballast, followed by grading and the addition of minimal ballast to the track to maintain top and line; it does not involve any substantive replacement of ballast.

Queensland Rail's request for our advice was triggered by Queensland Rail's need to address the following position of B&H in its May 2016 *Supplementary Report Part 1 – Discussion Relating to Maintenance and Capital Estimates*. This is in relation to Submissions by Stakeholders in response to the *QCA's Draft Decision Of the Queensland Rail DAU 2015*. B&H's position (pp. 2 & 6) was as follows:

> *In Queensland Rail's December 2015 submission it is asserted that this activity is (only) track lowering to remove excessive ballast. It involves, according to Queensland Rail's 2015DAU "carried out in large section and is done by removing the track and grading ballast away…", a highly invasive activity involving the cutting of rail, removal of sleepers, grading the ballast and replacement of same. It appears to be a reconstruction of the track.*
>
> *This activity is not Ballast Undercutting as would normally be termed in the Australian rail industry: it is track reconstruction.*

Queensland Rail's December 2015 submission does not indicate whether any "district….excavator mounted" activity is involved in the program.

As Track Reconstruction the activity is definitely capital works and also for the large single portion of expenditure at an average of approximately $1.5m per year, this is not maintenance activity.

It is also astounding that so much "excessive ballast depth" has been created during maintenance (or Capex) activity and changes to maintenance methods are required. Therefore there is no change to our estimate.

The "Ballast Undercutting" described by Queensland Rail in its December 2015 submission is highly invasive and reconfigures the ballast layer. In addition it involves reconstruction of the track structure where the track is firstly totally demolished and then rebuilt with recycled ballast of lesser quantity and therefore involving premature life expiry of the surplus ballast.

We therefore remain satisfied that this is a capital expenditure. We also suggest a renaming of the activity because it is Track Reconstruction, not Undercutting. Undercutting is so called because it does not disturb the rail and sleepers. Undercutting is also subject to the classification of capital expenditure if it is highly invasive and effectively repairing the capping or the formation. Some undercutting is localised and minor in nature, but this is not shown here. Therefore there is no change to our estimates.

In short, B&H advised the QCA that, in its opinion, ballast undercutting was capital expenditure not operating expenditure. This section focuses on the cost treatment of the maintenance activity, and does not seek to comment on whether it is prudent or efficient for the maintenance activity to be performed *in-lieu* of capital expenditure to address the underlying root cause of the problem (formation failure). This aspect is covered in the maintenance cost review of the proposed Ballast Undercutting (Track Lowering) expenditure in Queensland Rail's draft DAU2 submission.

7.4.1 Capital expenditure

We consider that for an expense to be treated as capital expenditure with respect to Queensland Rail's West Moreton System, it is subject to Queensland Rail's *Capitalisation of expenditure – MD-12-376 and AASB 116,137,138*, and the following criteria must be fulfilled:

i. That the expense relates to new construction or replacement of an existing capital asset; or

ii. That the expense will extend an existing asset component's life beyond its remaining maximum useful life; or

iii. That the expense will increase the performance of an existing asset component above its original as-installed performance.

We consider these criteria appropriate because, in terms of maintenance cost treatment, they define whether an asset is being 'maintained', that is an expense which 'continues' the asset's useful purpose, as opposed to a direct replacement or renewal or refurbishment.

7.4.1.1 New construction or asset replacement

The Track Lowering activity does not relate to the construction or replacement of new track, subgrade formation or other assets. Hence, the activity does not fulfil the criterion of relating to 'new construction'.

7.4.1.2 Remaining maximum useful life

We consider that the remaining maximum useful life of an asset component is that of its constituents with the least remaining useful life providing an indication of overall useful life of the asset. We define an asset component as a unique medium or a set of related parts that form a functional asset component for the below-rail network (such as a sleeper cluster, dual rail lines, top ballast, etc.). For example, the rail asset component consisting of two parallel rails would not have its useful life extended if only one rail is replaced, as its overall useful life is limited to that of the rail that has not been replaced).This is in alignment with the first principles argument that the asset component would not be 'renewed' until the oldest constituent was replaced in its entirety.

Our proposed definition aligns with Queensland Rail's *Capitalisation of Expenditure* specification, for example under which rail line replacement is only capitalised if dual rail lines are replaced and at least for the length of a standard track piece (110 metres of Continuously Welded Rail) in the West Moreton System. This would extend the life of the asset to that of the useful life of the rail (50 years, the maximum useful life of any component as per Queensland Rail's *Specification MD-12-376 Capitalisation of Expenditure*), as both rails comprising the track would be renewed.

7.4.1.3 Original as-installed performance

Original as-installed performance refers to the performance of the asset component as when it was first installed/constructed or the point immediately after construction where peak performance is achieved through a short wear in phase (as would be the case in fresh ballast) or through tuning. For example, the track modulus and the granularity of ballast would deform and decline in performance over time from the point it was first 'installed' as part of the railway track asset, leading to rough track over time.

Resurfacing activities would restore the ballast's performance close to that of its original as-installed performance, to the extent that the ballast maintains its useful properties (e.g. angularity and size). This fits in concisely with Queensland Rail's position that resurfacing activities are clearly defined as maintenance activities as has been accepted by the Queensland Completion Authority in DAU1.

7.4.2 Appropriate cost treatment

Track Lowering is reflected in Queensland Rail's DAU2 submission as ballast undercutting in the absence of a specific MAT code (cost code) for this function (as occurred in DAU1). The activity relates to a removal of ballast, followed by grading and the addition of minimal ballast to the track to maintain top and line; it does not involve any substantive replacement of ballast. It is evident from B&H's comments "*We also suggest a renaming of the activity because it is Track Reconstruction, not Undercutting",* that the fact that the Ballast Undercutting MAT code was being used for the activity resulted in it not being appreciating that the activity was in fact 'Track Lowering'. This is albeit that the activity describes 'track lowering', in the product title and there is no mention of the defined activities which would constitute 'Track Reconstruction' in the description.

Track lowering is required in the West Moreton System due to the poor subgrade 'formation' inherent with a rail system over 150 years old that has been built on fertile black soil with no engineered formation. The presence of poor subgrade causes the sub-ballast to amalgamate unevenly with subgrade formation over time, causing the loss of top and line. This culminates in the 'pumping' of trains as they traverse the infrastructure. This is known as 'pumping failure'.

Due to the resurfacing activities required to maintain the track's top and line and to prevent failure, over time, these activities have raised the top of the trackbed to the point where it is now outside of maintenance tolerance and these symptoms occur more frequently. We reject the B&H's comment that *"it is also astounding that so much "excessive ballast depth" has been created during maintenance (or Capex) activity* *and changes to maintenance methods are required"*, as B&H fails to recognize the characteristics of the subgrade foundation. That is non-engineered porous black soil, characteristics that are not comparable to other regulated rail systems. B&H's position as set out in its comment is also inappropriate as B&H makes no acknowledgement to that fact that only 10 km of track lowering occurs for every 290 km of mechanized resurfacing, a corrective ratio of 1:29 for 'excessive ballast'. We do not consider this activity excessive for a 150 year old track foundation on black soil with no engineered formation.

In addressing B&H's comment that track lowering is "a highly invasive activity involving the cutting of rail, removal of sleepers, grading the ballast and replacement of same. It appears to be a reconstruction of the track", we observe that the individual removal of sleepers does not occur, and that this activity is done by lifting the track structure (in track panels) off the top ballast and placing it to the side (with rails still attached to sleepers, which is sometimes known as track 'slewing'). Inherently, the track structure (as opposed to track foundation), which consists of the rail, track fastenings and sleepers are not 'reconstructed', as no replacement or reconfiguration of parts has occurred in the track structure through this activity (with the exception of incidental damage repair associated with lifting and removing the track panels). Furthermore the removal of sleepers from the track foundation would not necessarily indicate track 'deconstruction'. As such B&H's assertion that this is a defining feature of track reconstruction is inaccurate.

During ballast undercutting (or track lowering) the replacement of the ballast that forms the trackbed does not occur, and new ballast is only added above this existing ballast to maintain top and line, an accepted maintenance cost activity as per the QCA's decision on Queensland Rail's DAU1 submission (Top and Line Sport Resurfacing). As such, Track Lowering cannot be considered capital expenditure under "relation to new construction", nor does the addition of fresh ballast change the asset components' remaining maximum useful life (as the asset component is limited by the life of the shortest remaining maximum useful life of any of its constituents, e.g. the existing ballast is not replaced).

The minimal ballast that is added during a maintenance activity to restore most of the original as-installed performance of the ballast component, would, by definition, not increase the performance of the existing asset component beyond its original as-installed performance. Indeed, if B&H considered that the addition of ballast to the track is capital in nature, than the maintenance activity of 'maintenance ballast' should also be deemed by B&H to be capital expenditure.

In summary, track lowering does not:

- involve new construction or replacement of either track structure or formation; or
- extend the life of the existing asset component (top ballast) beyond the overall asset's remaining maximum useful life; or
- increase the performance of the existing asset component (top ballast) above its original as-installed performance.

We therefore consider that Track Lowering should not be treated as capital expenditure, and consistent with Queensland Rail's *Capitalisation of expenditure* specification, should be treated as maintenance expenditure.

8 Rail renewal

8.1 Background

Rail renewal is the process of replacing rail, provided that less than 2,000 metres of rail (is being replaced or (we have inferred this) if only one side of the rail is being replaced.[14]

Rail renewal can be required for a number of reasons, including:

- Upgrading rail to a higher standard(41kg/m to 50kg/m)
- Damaged rail from wear, fatigue, derailment and wheel burns
- Rail failure due to fracture.

Rail wear, when properly, controlled maximises rail life. Rail wear predominantly occurs as table wear (top of rail), side wear, or a combination of both. Rail profile, wheel profile, rail size, rail manufacturing deformations, track structure and track geometry are some of the factors affect the rate and degree of rail wear. Queensland Rail renews rail when the limits of wear exceed the specifications listed in the Civil Engineering Track Standard. Re-railing, by comparison with rail renewal, is a capital activity that is undertaken when the rail standard is to be upgraded, due to rail failure or when the rail is past its design life.

8.2 Prudency

Given the observations from our site visit, we consider there is a need to undertake rail renewal on the West Moreton network. What might be useful in a future version of Queensland Rail's documentation is the inclusion of decision rules for preferring the use of rail renewals (maintenance) over re-railing (capex).

8.3 Efficiency

In our capex report, we observed that Queensland Rail's proposed re-railing rates for the DAU2 period were [redacted]e.[15] We consider this rate should extend to the rail renewal program, noting that rail renewal is for re-railing activities that are less than 2,000 metres or for one side of the rail. In the case of rail renewal for one side of the rail, it would be expected the rate should be less than [redacted]. Without knowing what the proposed scopes are for rail renewal during the DAU2 period, we cannot infer what unit rate for rail renewal has been applied. However, we did not observe anything during the site visit or sight any information during our peer review that would indicate that Queensland Rail is undertaking the rail renewal activity inefficiently.

9 Rail joint management

9.1 Background

Rail joint management encompasses several maintenance activities related to the maintenance of rail joints. This includes thermite welding of joints, bolt and fishplate maintenance (including fishplate greasing), glue joint maintenance, joint lifting, top & lining joints and arc welding chipped joints. This product also includes

[14] FY2019 *Capitalisation of expenditure* specification, pp. 36 and 58

[15] GHD peer review of Queensland Rail's proposed capital expenditure for DAU2, p. 20

the thermite welding of 110m continuously welded rail (CWR) lengths into 220-metre lengths through the timber and steel sleeper sections, as part of joint reduction works.

The management of rail joints is required to allow for effective thermal movement between jointed track sections and CWR to reduce rail buckling and rail breaks (particularly in temperature extremes). It is also required for the minimising of joint fatigue and reduction of metal wear on the fishing surfaces at the interface of the fishplate and rail.

Failure to adequately maintain joints results in greater vertical impact loads from wheel loadings at the interface of the fishplate and rail causing dipped joints, frozen joints (bolt holes in the rails out of alignment, preventing the joint opening and closing in response to thermal stress), battered joints and exacerbates deterioration of the immediate track structure and foundation.

9.2 Prudency

Regular 15.75 tonne axle loads and the inherent nature of the West Moreton track foundation will result in regular maintenance being required to address dipped joints and/or frozen joints. This work would be required in addition to spot joint top & lining and joint lifting to correct for localised pumping, which is caused by a combination of the greater impact loadings from increasing joint deflection and poor supporting formation. Noting our observations from the site visit (Figure 6 and Figure 18), including observing several dipped, battered and frozen joints, in addition to joint related pumping, the need for regular joint maintenance is evident.

Figure 18 Battered and frozen joint

9.3 Efficiency

From our analysis of Queensland Rail's settlement data (actual cost data) and defect notification data, we recognise that Queensland Rail has reduced its rail joint management scope and cost per activity hour over the last three financial years' data that we reviewed. The scope of works has reduced from approximately [redacted] activity hours in FY2016 to approximately [redacted] hours in FY2017, followed by a further reduction in FY2018 to approximately [redacted] activity hours. Assuming fixed scopes of work for rail joint management, there is clearly a year-on-year improvement in the efficiency of what is delivering during each activity hours. In addition, we note that the cost per activity hour has reduced from approximately [redacted] in FY2016 to [redacted] in FY2017, and then dipping slightly to [redacted] per activity hour in 2018[16]. Given these observations, we consider Queensland Rail's proposed scopes and costs for rail joint management to be efficient.

10 Sleeper management

10.1 Background

Sleeper management incorporates several maintenance activities, depending on the type of sleeper (interspersed timber and steel, timber only, steel only, concrete only) being used and the characteristic of the track section (gradient, radius and track foundation condition).

[16] These numbers are approximate based on the raw settlement data provided by Queensland Rail to GHD and GHD's interpretation of settlement data.

For the interspersed timber and steel sleeper sections of track predominantly present in straights and wide radius curves, the sleeper-management activities include spot replacement of defective sleepers, reboring, regauging, plating, respacing and defective or missing fastener replacement. Sleeper cluster management (alignment and spacing of sleepers) is the most significant task as part of sleeper management, and requires track closures in order to carry out the works.

In the concrete-only sections of track, particularly in the Toowoomba range section where tight radius curves and steep gradients exist, maintenance activities include replacing worn and rail seat pads, gauge foot spacers and clip fastenings (predominantly PANDROL e-clips) to maintain gauge and toe load. Due to high levels of lateral forces experienced on the outside rail in tight radius curves, rail pads are being replaced at relatively short intervals to maintain toe load and track gauge.

10.2 Prudency

Sleeper management is required to ensure that sleepers are effectively spreading axle loads over a large enough area of ballast to ensure that the sub-ballast and the subgrade are not overstressed. The sleepers need to hold the correct gauge and inclination within specified Civil Engineering Track Standard (CETS) limits, as they restrain the track laterally under either centrifugal or thermal forces, and do not move longitudinally (or skew) under traction or braking forces exerted by rolling stock. Hence, sleeper management is an important maintenance activity for operating the network safely.

As observed in the site visit, the need for sleeper management is clearly present, with several sleepers observed missing fastenings (in all sleeper types present) across the system, damaged pads and biscuits visible throughout the Toowoomba range section, and sleeper skewing in tight radius curves. Queensland Rail's current sleeper management strategy (covering approximately 635,000 sleepers) appears to be prudent, with effective use of its EAMS notification system to prioritise sleeper management maintenance activities, minimising track deterioration related to defective sleepers and reducing the risk of derailments due to wide gauge outside of CETS limits.

10.3 Efficiency

Our review found that expenditure on sleeper management amounts to approximately [redacted] to [redacted] of the minimum sleeper component asset value (the value of all 635,000 sleepers at minimum replacement cost, approximately [redacted] per replacement consisting of a timber sleeper, 4 screw spikes and 2 timber sleeper plates based on Queensland Rail's procurement prices).

Noting [redacted] to [redacted] is the conservative upper bound, and that exact like-for-like sleeper replacement cost would be significantly higher due to the presence of concrete and steel sleepers in the system, relative expenditure in reality would be approaching approximately [redacted] of the sleeper component asset value. Observing that the asset life of a concrete sleeper is 50 years for example, this would suggest that over the long term, the wearing of the asset is at equilibrium with the maintenance expenditure incurred to 'maintain' the asset. This suggests that Queensland Rail's sleeper management strategy is optimal, as an equivalent amount of maintenance is being spent relative to the depreciation of the sleeper component asset each year. Hence, we consider Queensland Rail's sleeper-management practices to be efficient.

11 Maintenance ballast

11.1 Background

Maintenance ballasting includes the purchase, freight and installation of ballast to re-establish the design properties of the track. Specialised machines, known as ballast trains, are used to freight and distribute the maintenance ballast over the track structure.

11.2 Prudency

Regular track use, poor ballast strength, loss of ballast angularity and loss of ballast voids result in loss of vertical geometry and poor ballast drainage. This negatively affects the geometry and stability of track, causing track foundation defects, increasing the risk of derailment and requiring track speed restrictions in order to maintain track safety. We observed some of these issues during our site visit.

Given the observations from our site visit, we consider there is clearly a need to undertake the process of applying maintenance ballast to the track. It is required where ballast is low (sleepers riding above the ballast, reducing longitudinal track stability), ballast shoulders are narrower then CETS limits and/or when or when sleeper ends are exposed through the ballast shoulders (sleepers not secured within the top ballast laterally, reducing the tracks lateral stability). Maintenance ballast is also required where resurfacing activities are planned, to ensure that there is enough ballast of sufficient quality to effectively lift and pack sleepers to bring track geometry back to top & line.

11.3 Efficiency

Queensland Rail uses a ballast train to lay the maintenance ballast on the track; according to Queensland Rail, the use of the ballast train is the largest cost for the maintenance-ballast activity. As noted in our capex report, Queensland Rail secures very competitive rates for the raw cost of ballast (i.e. [redacted] to [redacted] from the firms Boral, Mount Marrow and Quarry Products, compared with [redacted] that our in-house benchmarking process revealed); hence, we consider the cost of ballast to reflect highly efficient procurement outcomes.

As for the efficiency associated with the use of the ballast train, we understand that Queensland Rail achieves more than [redacted] of productive movement when deploying ballast trains to distribute maintenance ballast. We recognise that for mechanised plant in the West Moreton System, [redacted] is related to safety requirements involving PO activities securing the work site, and travel to and from site, with the remaining time spent on track. This high rate of productive movement suggests that it is highly likely that Queensland Rail's maintenance-ballasting costs reflect efficient outcomes.

12 Rail stress adjustment

12.1 Background

Rail stress adjustment relates to any maintenance activities associated with the "standalone product" of rail stress testing and adjustment. Works include rail stress testing, creep marker monitoring, rails stress

[17] [redacted].

adjustment including anchoring and rail length adjustment). Rail stress needs to also be managed at the interface between existing CWR track and jointed track sections.

We understand that, due to the nature of the task, track closure is necessary to carry out the works. The costs included in this product include restressing of sections where track works and modifications have occurred.

12.2 Prudency

Based on our observations from the site visit, we consider that rail stress adjustment work will indeed be required on the network during the DAU2 period. The temperature extremes experienced in the West Moreton System cause significant longitudinal expansion of the rail, causing creep and potential buckling from the compression forces between the ends of the rail (resulting in lateral movement). The main need for rail stress adjustment is driven by the tight curves along the network and the need to manage track-buckling risks and incidents during the summer months. These tight curves have been shown to skew sleepers towards the inside of the track, creating ballast voids on the outer track edge. Major rail stresses are conducive to buckling, and continuous and effective rail stress adjustment minimises this risk.

12.3 Efficiency

As no unit rates have been provided for rail stress adjustment, we cannot assess the efficiency associated with this maintenance activity, also noting that it occurs in response to maintenance activities and capital works. We did not make any observations or sight any information during our peer review that would suggest that Queensland Rail is undertaking the rail stress adjustment activity inefficiently.

13 Fixed/variable split of West Moreton network maintenance costs

Table 4 below sets out the findings of GHD's (our) assessment of the split of fixed and variable costs for Queensland Rail's maintenance MAT codes. The values we present in the assessment have been established with reference to the B&H Review of Queensland Rail's DAU 2015 (B&H,2015), which was undertaken on a maintenance-subcategory rather than MAT-code basis.

In addition, certain MAT codes have also been cross referenced with Wik-Consult's 2015 fixed-variable split assessment of the ARTC Hunter Valley Coal Network (HVCN), so we can provide comparisons with a high haulage line, where such comparisons make sense to draw out. Guidance has also been extracted from the 2000 *QCA Working Paper 2: Usage-related infrastructure maintenance costs in railways*.

13.1 GHD's analysis

Our assessment reveals that the fixed/variable split for maintenance costs is **62%/38%**, in comparison with Queensland Rail's proposed 54.4%/45.6% split. We seek Queensland Rail's feedback on the last two columns of Table 4.

Table 4: GHD's analysis of the fixed/variable split of West Moreton network maintenance costs

MAT code	Tonnage dependent	GHD's recommended fixed-proportion value	GHD's explanations and justifications
Structures and civil	Yes	75%	The driving force behind rail structures and civil maintenance, particularly on a low-tonnage line, is considered to relate to asset aging and exposure to the environment. Examples of this include timber bridges, which have to be repaired as time elapses regardless of throughput levels. Therefore the fixed cost component can be expected to dominate. However, a small component will relate to network usage, which has the effect of stressing the structures. We agree with the fixed-proportion value of 75% presented by B&H and Queensland Rail, which we note aligns with the value presented by Wik-Consult for the HVCN.
Ballast Undercutting (Track Lowering only)	Yes	35%	This activity primarily relates to removing ballast due to re-surfacing lift. This need arises from deteriorated track geometry. The root cause of this is twofold: formation; and wear (usage-related). Considering that the West Moreton network is a light-tonnage line situated on poor formation the fixed component of these works will be higher than a typical line with an engineered formation. This value should reflect the same value used by resurfacing (35%, see below), as that activity is the direct driver for this track lowering.
Earthworks—non-formation (including drainage)	No	100%	As the West Moreton network passes through the Toowoomba ranges, there are challenges faced with access, drainage and miscellaneous civil works. This is exacerbated by weather and local environment (e.g. gradient and tight curves). Therefore, the fixed component of these works will dominate this maintenance category completely and that is we consider all costs will be fixed.
Minor Yard Maintenance (component of Repairs)	No	100%	The minor yard maintenance code does not include activities typically associated with tonnage-related track wear as identified by Queensland Rail. The yard maintenance code will include miscellaneous yard-specific activities which we do not anticipate will have any relationship with network volumes. Hence, we consider it appropriate for all costs to be fixed for this maintenance activity.
Rail Joint Management	Yes	80%	The rail joint maintenance involves fixing battered, frozen and dipped joints, ensuring bolts and fishplates are adequately assembled to specification. This includes also the lubrication of the fishplates (note that rail lubrication is for the rail itself rather than fishplates). A component of rail joint management can be coupled with other maintenance works, decreasing the proportion of influence from usage. We consider that the proposed fixed-proportion value of 80% by B&H is adequate.
Rail Renewal	Yes	50%	Rail maintenance is typically a mix of wear and tear from use and other factors such as manufacturing defects, environment and age. In comparison with a heavier haulage line such as the ARTC HVCN, a fixed-proportion value of 25% and 10% was proposed by ARTC and Wik-Consult respectively representing a network of high haulage. Due to the low haulage of the West Moreton network, we consider a 50% fixed-proportion value would be reasonable and consistent with the track characteristics of the infrastructure.

MAT code	Tonnage dependent	GHD's recommended fixed-proportion value	GHD's explanations and justifications
Turnout maintenance (component of Repairs)	Yes	50%	We consider that a component of turnouts will wear corresponding to line volume, particularly the curve rail and other turnout components. However, as resurfacing is not a component of these works, the fixed-cost component will be driven up, likely more significantly than the wear component due to the low haulage. Typical values for turnout observed on the ARTC HVCN indicate a range of 25 to 50% fixed. We consider that the West Moreton system would sit on the upper end of this range due to the formation condition and low-haulage volumes of the system. Accordingly, we consider a fixed-proportion value of 50% to be appropriate.
Signage Management	No	100%	Tonnage will not affect the management and maintenance of signage, as signage assets are implemented to facilitate operation of the line and is independent of the line volume. The creep markers serve purely as a reference to manage rail creep, and are assumed not to incur a variable cost with tonnage. Hence, we consider that all costs for this MAT code are fixed.
Maintenance ballasting	Yes	40%	Ballast degrades over time with tonnage forces, induces ground to be forced downwards and causes formation material to migrate up into the ballast layer. Ballast is also contaminated by coal fines, and this is sometimes referred to as coal fouling. These factors drive a component of variable cost. On the other hand, unrelated to usage, the formation condition will also impact the extent to which ballast is contaminated. Poor formation can impact drainage, thereby resulting in the ballast holding water and triggering the creation of 'wet spots'. This process contaminates and degrades the ballast, coupled with environmental contamination over time. These factors drive the share of the fixed component. We consider that due to the significant condition of the formation coupled with low haulage, that the rate should be relatively higher than proposed in other networks. The ARTC HVCN a high haulage line has ascribed to it a fixed-proportion value a rate of 25% via a recommendation by Wik-Consult. Given this, we consider a fixed-proportion value of 40% for the West Moreton network to be appropriate.
Sleeper Management	Yes	50%	The West Moreton network is characterised by a blend of timber steel and concrete sleepers. Typically concrete is more resilient to degradation than timber. Concrete sleepers do not rot, withstand fire and exhibit more UV resistance. This inclusion of concrete sleepers will increase the fixed-cost component of the line, as higher tonnages does not necessarily translate to more frequent replacement of concrete sleepers. However the curvature of some segments of the West Moreton network is likely to also impact the deterioration (correlating with volume) of all sleeper types. On balance, we consider a fixed-proportion value of 50% to be appropriate.
Fire & Vegetation Management	No	95%	Fire and vegetation management is required typically due to factors such as the environment and age of the network. As the West Moreton network passes through a significant amount of country and access is challenging, it can be expected that the fixed costs of this work are inherently high. In some instances, we note that the clearing of vegetation may be from the trackbed (caused by volume use and ballast seepage into the formation) rather than the part of the rail corridor outside the rail. To address this, we assume that 5% of costs are variable and that 95% are fixed.

MAT code	Tonnage dependent	GHD's recommended fixed-proportion value	GHD's explanations and justifications
Rail Stress Adjustment	Yes	90%	Rail stress adjustment works include stress tests, creep monitoring, anchor and anchor block installation. These activities are all typically considered independent of tonnage because for the purpose of a low haulage line, stress testing and creep monitoring would be considered consistent fixed rate activities. In comparison, anchor block installation varies with the development of adjustment modules, which is not related to tonnage. The same can be said about the effects of weather on track-buckling risks. The rail stress adjustment process, however, is also implemented as a result of other work that impacts the rail stress. Such work includes the cutting of the rail, and, as such, will have a small variable component that will be influenced by tonnage values. Given this, we consider a 90% fixed-cost component to be appropriate.
Asset Compliance Inspection / Asset Inspections Non Compliance	Yes	80%	Rail defects are generally caused by a spectrum of triggers, including manufacturing defects, defective welds, aging and weathering. These drive a fixed component of compliance-related inspections. However a small variable component is driven by wear and tear. The influence from wear and tear, correlated with tonnage, permeates through to the frequency of compliance inspections. The QCA value of 80% fixed costs is consistent with this view. Hence, we consider an 80% fixed-proportion value to be appropriate.
Lubrication	Yes	50%	The rail lubrication process coincides with the volume of trains – as more trains traverse the network, the lubrication on the line is dissipated. This will result in more consumption of the lubricating agent triggering the need for further lubrication to be applied. A component of the applicator maintenance will also be related to this variable rate of use. On balance, and in the absence of further information, we consider a 50% fixed-cost component to reflect the cost structure of this MAT code.
Top & Line Spot Resurfacing	Yes	35%	Top and line resurfacing is essential for maintaining the geometry of the track, which is affected by the extent of use of the track. As the geometry is influenced by the volume of track use, we can expect that the resurfacing task is also related to the volume. The track geometry also deteriorates due to the formation. As the West Moreton network is built on aged, lack of structure formation, we can expect that the non-tonnage related component will be 'high' for this network. We anticipate that a reasonable fixed-proportion value would be 35%.
Rail Repair	Yes	50%	Rail repair is typically a result of defects that comes about through the stresses put on the rail. Some of this will be due to environmental factors such as temperature, whilst others due to the quantity of tonnage run on the network. On balance and in the absence of further information we consider a 50% fixed-cost component to be reasonable.
Mechanised Resurfacing	Yes	35%	As with top and line resurfacing, the mechanised-resurfacing activity is primarily influenced by network use. However, a significant fixed component of this work will be contributed to by weather and formation age factors that trigger track misalignment. For the ARTC HVCN, a mechanised resurfacing fixed-cost component of 25% was applied. We consider this to be the lower limit of the fixed rate due to factors of low line haulage and formation condition. Given this, we consider a fixed-proportion value of 35% to be appropriate.
Rail Grinding	Yes	35%	Rail grinding is required to correct rail defects caused by the use of the network. This component of work will be significantly dominated by a variable rate with tonnage. In the case of the ARTC HVCN, Wik-Consult considered a

MAT code	Tonnage dependent	GHD's recommended fixed-proportion value	GHD's explanations and justifications
			fixed-cost component of 25% to be appropriate. When considering the much lower traffic volume of and formation condition on the West Moreton network, it is reasonable to assume the fixed-proportion value might be closer to 35%-40%. We have chosen the lower bound this range to be conservative.
Construction (N11)	No	100%	This category predominantly covers the cost of water, power and lighting facilities in below rail yards and the maintenance of infrastructure depots. Tonnage will not affect these costs (with the exception of a larger work force increasing utility costs which would be negligible).
Telecommunications	No	100%	The driving force behind telecommunications-systems maintenance is dominated by the age of assets and the nature of the environment in which the assets are located. We anticipate that the fixed component of these works will dominate entirely and, accordingly, we have ascribed a 100% fixed-cost component to this MAT code.
Signalling	No	100%	As with telecommunications, the driving force behind signalling-systems maintenance is dominated by the age of assets and the nature of the environment in which the assets are located. We anticipate that the fixed component of these works will dominate entirely and, accordingly, we have ascribed a 100% fixed-cost component to this MAT code.

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