INSTITUTE OF RAILWAY TECHNOLOGY

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TECHNICAL NOTE

REVIEW OF VICTORIAN NORTH EAST RAIL LINE UPGRADE PROJECT TO ACHIEVE V/LINE PASSENGER CLASS 2 TRACK GEOMETRY

Report No: Monash/RT/2018/1361

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EXECUTIVE SUMMARY

The Institute of Railway Technology was engaged by ARTC to undertake an independent review of the methodology applied and the prioritised scope defined for the upgrade to the North East Rail Line in Victoria, and to form a view if the scope would achieve V/Line Passenger Class 2 track geometry. A funding commitment of $235M was targeted to provide V/Line Passenger Class 2 track geometry with the associated upgrade works being delivered as an ARTC Major Project. The following are the key outcomes of the review:

- The upgrade plan targets punctuality, ride quality and resilience (relating to operations).
- ARTC have undertaken an in-depth assessment of the NERL and developed significant supporting data to derive the proposed upgrade plan.
- ARTC continue to outperform the majority of agreed track performance metrics, as reported in the Interstate Infrastructure Lease for the North East Line [1], for both super-freight and passenger services.
- The upgrade plan principally addresses the removal of mud holes, upgrades to level crossings and bridges, drainage, tamping and lining and ballast refreshment. These activities appear reasonable and targeted against the objectives.
- Delivery of the defined Project scope will achieve V/Line Passenger Class 2 track geometry at the completion of the project. In this report the ongoing requirements post upgrade for maintaining the track to V/Line Passenger Class 2 track geometry have not been addressed.
- ARTC have conducted detailed site inspections and associated surveys since providing the initial upgrade plans. These updates have not been assessed in the current review.

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- It is considered that the proposed plan targets the key criteria outlined and should provide a much-improved and more maintainable permanent way at the completion of the works within the current budget of $235M.

1 INTRODUCTION

As a result of a $235M funding commitment from the Commonwealth Government to upgrade the North East Rail Line (NERL), ARTC have developed a detailed project plan. Based on the information supplied by ARTC, the planned works for this upgrade are oriented to address and improve the following principal attributes:

- Punctuality;
- Ride quality; and
- Resilience.

ARTC has engaged the Institute of Railway Technology (IRT) at Monash University to carry out an independent desktop review of the proposed upgrade plan. This report focusses on the defined project scope in terms of the delivery of V/Line Passenger Class 2 track at the end of the upgrade project, and not the ongoing maintenance to sustain the performance at V/Line Passenger Class 2 standard post upgrade.

ARTC have provided the following documents to IRT to support the analysis:

- *32018_03_VIC_NERL_class2_dr04_summary_Monash.xlsx* which contains a summary of the key priorities, the detailed scope of work, together with track locations identified for upgrading, the analysis methodology (including performance and condition data used) as well as assumptions used for work types prioritisation, the unit rate of the proposed works and an estimation of budget required for each category of work together with total budget for the entire upgrade plan;
- *tms_vicne_spencerst_albury_aug2017_feb2018.pdf* which shows various track condition reports over 5 km segments in a graphical format (raw data files in DPlot format were also provided);
- *Memo_Explanation of Top Moving Sum (TMS).pdf* which provides an explanation of the Top Moving Sum (TMS) calculations which is one of the analysis methodologies for assessing track condition based on track geometry car data; and
- *2018_06_13_NERL_WAE_history.xlsx* which lists the maintenance history of NERL from 2003 to 2018.

Additional information in email format was also provided by the ARTC Track Performance Manager (28th May, 2018). This information included a response to questions raised by IRT regarding the upgrade methodology, which included:

- The objective of the upgrade;
- The approach by which ARTC plan to evaluate the success of the Project;
- Track standards to be achieved at the completion of the project; and
- The allocation of funding to different work categories following the work activity priorities as per Table 1.

To help clarify enquires raised by IRT, the ARTC Track Performance Manager visited IRT on the 18th June 2018, to discuss the details of this upgrade plan. The following aspects were addressed:

- The limitations and constraints encountered during planning;
- The balance between cost-benefit and limitations/constraints; and
- The prioritisation methodology (compromises) used to cap the cost within the $235M committed funding.

Based on the information provided above, the review of the proposed upgrade plan focussed on the rationale used in its derivation, and included the following aspects:

- Review of all assumptions and prioritisation methodology;
- Desktop review of relevant documentation and supporting data related to the upgrade plan provided by ARTC; and
- Provide recommended changes (if any) to the upgrade plan.

It is important to note that the current condition of the NERL continues to outperform the majority of agreed track performance metrics, as defined in the Interstate Infrastructure Lease, for both super-freight and passenger services [1].

As a general comment, the level of detail provided by ARTC was excellent and demonstrated that significant effort had been expended in developing an understanding of the condition of the North East Rail Line. The following section details the outcomes of the review.

2 DOCUMENT REVIEW

OVERVIEW OF ARTC UPGRADE PLAN

2.1.1 THE OBJECTIVE OF THE UPGRADE PLAN

The main objective of the upgrade plan is to deliver V/Line Passenger Class 2 [2-3] track between Spencer Street and Albury. The provision of this track standard should allow V/Line to operate at the posted speeds (115 km/h) over the route, which is currently subjected to V/Line imposed speed restrictions (East track), as detailed below.

- Wodonga (299.1 km) to Chiltern (271.3 km) – 100 km/h
- Springhurst (257.3 km) to Wangaratta (233.9 km) – 100 km/h
- Benalla (195.1 km) to Violet Town (169.2 km) – 100 km/h
- Violet Town (169.2 km) to Euroa (150.9 km) – 80 km/h
- Avenel (115.9 km) to Broadmeadows (16.8 km) – 100 km/h

The overarching targets of the planned works, include:

1. The removal of all existing mud holes;
2. The adjustment of track geometry to achieve the V/Line Passenger Class 2 track standard;
3. The upgrading of assets (turnouts, bridges and level crossings) to achieve V/Line specification (e.g. ballast depth);
4. The replacement of aging assets; and
5. The improvement of drainage and signalling power supply.

A series of work activities and their prioritisation was originally proposed by ARTC to reflect the above targets, as detailed in Table 1. Whilst these priorities were initially based on the $100M funding commitment, the general principles outlined are still considered pertinent at the increased $235M funding commitment.

TABLE 1: WORK ACTIVITY PRIORITISATION [4]

Work activity priorities		Attribute being addressed		
		Punctuality	**Ride Quality**	**Resilience**
1	Mud hole removal: undercut and full width ballast cleaning	✓	✓	
	Resurfacing: tamping and lining		✓	
	Turnout reconditioning: including replacement of steelwork components where necessary, tamping and ballast cleaning	✓	✓	✓
	Signalling – Replacement of overhead line wire with underground cabling	✓		✓
	Signalling – Installation of backup power supplies to minimise signalling outages	✓		✓
2	Cess drain improvements			✓
	Rail grinding		✓	✓
3	Bridge works: Conversion of transom underbridges to ballast top deck and realign rails or re-transom transom underbridges which have gauge or line issues		✓	✓
4	Recondition bridge ends and level crossings		✓	✓
5	Ballast depth improvement: 50-100 mm ballast depth increase depending on track conditions		✓	✓

Under the original $100M upgrade project, ARTC proposed geographical locations to prioritise the upgrade activities in regions where V/Line imposed speed restrictions exist. However, based on feedback from ARTC, the need for geographical prioritisation is now irrelevant in the current upgrade plan due to the increased funding to $235M, which is considered sufficient to address required work activities to a reasonable level for all the track locations.

2.1.2 PRIORITISATION METHODOLOGY

The prioritisation methodology used to identify the type of works required for different track segments is the key to underpin the framework of the entire upgrade plan. Two sources of data were utilised for project planning:

- Performance data
  - Top Moving Sum (TMS) [5]
  - Vehicle Track Interaction system (VTI hits) [6]
- Field inspection data
  - Ellipse asset register (structural and defects details)
  - Outcome of detailed site inspection

The works activities priorities were developed by a Technical Working Group (TWG) comprising ARTC, V/Line, RPV and PTV representatives to create the boundaries of whether certain types of works are required for certain track segments and segregate track segments into work activity priorities listed in Table 1. The performance and field inspection data were assessed against the works planning rules to assign the track sections into the work activity prioritisation list. The methodology applied is briefly summarised below:

- All mud holes identified in the ARTC Ellipse asset register were planned to be removed; together with tamping and additional ballast placement across the entire NERL corridor (except locations with limited track length between fixed assets) to allow adjustment of the track geometry to V/Line Passenger Class 2 track standards.
- For track, both the average and maximum TMS values were used to identify rougher sections, which, together with VTI hits, Victorian Quality Index (VQI) and visual inspection,

influenced the extent of tamping and lining likely to be required to achieve the desired performance.

- Prioritisation of works for turnouts, level crossings and bridge ends were based on both TMS and VTI hits (typically >20).
- Bridge works were prioritised using the outcome of site inspections conducted by ARTC structural engineers with emphasis and prioritisations on aging timber and transom structures as well as transom deck bridges with alignment and/or gauge issues.
- Site inspection data were used to plan for drainage improvement works.

2.1.3 UNCERTAINTIES

ARTC has pointed out that the results of detailed site inspections, together with a review of historical maintenance records, are yet to be incorporated into the current ARTC upgrade plan to identify locations where extra drainage and track reconstruction are necessary. The current plan provided to IRT for this review will be finalised once the results of these site inspections and associated surveys have been completed. Geogrid reinforcement and/or geofabric will be used where necessary.

To capture the cost risk related to this uncertainty, some work activities were sensibly overestimated to allow a degree of flexibility when undertaking the actual remediation works. For example, it was assumed all cess drains require regrading and shaping, but the actual length of required cess drain works will almost certainly be significantly less following the detailed field assessments. This degree of conservatism is also applied to some of the bridge works.

Both ARTC and V/Line have their own specifications relating to track geometry standards. The track is currently maintained against the ARTC standards, which typically reflect freight operations. By comparison, V/Line have their own standards for track geometry which are defined in NIST-2706 [2] and NIST-2610 [3]. As noted previously, the intent of the upgrade works is to achieve track geometry to the V/Line Passenger Class 2 standards at the completion of the project.

It is noted that a decision still needs to be reached between V/Line and ARTC regarding the mechanism by which the NERL track geometry is to be measured and defects assessed. Although the options to measure the track geometry include the use of ARTC's AK car or V/Line's existing track geometry recording car (IEV100), it is important to note that one of the objectives of the upgrade is improve ride quality. It is therefore considered useful to identify and cross reference upgrade requirements using ride quality indices against the NERL track geometry standards. ARTC have recently advised that comparative assessments have recently been carried out using both the AK car and the IEV100, with the analysis of this data currently ongoing.

2.1.4 RAIL GRINDING AND SIGNALLING POWER SUPPLY

The ARTC Track Performance Manager indicated that the rail running surface condition is generally considered "acceptable", except for minor corrugations on the West track and some locations on the single line. As a minimum, single pass grinding is proposed across the entire network to provide a clean-up of the rail profile, with additional passes to be allocated to locations with corrugations as identified during more detailed track inspections. The principal outcomes expected of the grinding works include:

- Profile lug within 0.5 mm of gauge face, in accordance with current ARTC grinding standard requirements [9];
- Corrugations ground, with a view to manage over multiple cycles to ensure no rail softening occurs;
- Most curves expected to get 2-3 machine passes; and

- The oldest 47 kg/m rail, flagged by the AK car grind reports, will receive two passes, sufficient to provide full profile restoration.

Rolling contact fatigue (RCF) is not a focus of the upgrade as it does not substantively affect ride quality. However, it is noted that RCF affects the resilience of the track infrastructure and RCF should be removed through the grinding works (where practicable).

In terms of the grinding program, consideration also needs to be given to (i) areas where vehicle hunting is occurring due to metal flow (tight gauge) or (ii) locations with significant RCF to the point where it is affecting ultrasonic rail inspection. These locations will also require additional grinding effort.

Based on the information provided by ARTC, no endemic issues relating to broken rails or track buckling have been recorded after the track was upgraded to concrete sleepers, indicating that factors such as neutral rail temperature, rail welding and the wheel-rail interface are adequately managed.

Replacement of overhead line wire with underground cabling and installation of back-up power supplies to minimise signalling outages are planned as part of the signalling power supply upgrade. Details of this were not provided for this review; it was indicated by ARTC that this will be conducted with the budget assigned and does not influence the main objective (V/Line Passenger Class 2 track) of the upgrade plan.

2.1.5 CONSTRAINTS

Some short sections of track between fixed points are more challenging to upgrade to the higher geometry standards, due to the inability to modify track height through the addition of ballast. In order to achieve the required track geometry standard at these locations, ballast quality may need to be improved if currently not acceptable. This would most likely be achieved through ballast cleaning. Historical maintenance and recording car records could also be used to determine whether track condition can be maintained in these locations. ARTC has already undertaken targeted maintenance at several of these locations (e.g. replacement of fixed transom underbridges with ballast top decks) to minimise their impact.

2.1.6 FUNDING ALLOCATION[1]

ARTC have indicated that new ballast installation is considered to be the critical activity, as it is only through the placement of clean, angular ballast that the required V/Line Passenger Class 2 geometry standard can be achieved (in conjunction with tamping and lining). It is currently envisaged that ~100 mm of new ballast will be installed across almost the entire network. IRT did not directly review the rates used for the upgrades, with these being based on previous activities undertaken by ARTC. Some concern has been expressed with regards the use of current rates, due to the high number of road and rail projects in the pipeline, and the limited pool of contractors who can undertake such activities, putting upward pressure on pricing. ARTC have advised that this is a known risk (included in their risk register) and have engaged specialist consultancy support to address this issue.

[1] Commercial information from Section 2.1.6 (Funding Allocation) has been removed at ARTC's request from this revised final report. No other changes have been made compared with the original report.

IRT ASSESSMENT OF THE ARTC UPGRADE PLAN

2.1.7 THE SUITABILITY OF PRIORITISATION METHODOLOGY AND DATA USAGE

The planning details and data provided by ARTC targets the delivery of V/Line Passenger Class 2 track in the NERL corridor; this overall strategy appears reasonable as it is strongly linked to the removal of speed restrictions, adjustment of track geometry to V/Line standards and addressing the aging assets, hence reducing transit times and improving track resilience.

ARTC clearly note that any upgrade should be condition-based. Current information used by ARTC to feed into the analysis methodology include the TMS and VTI hits, complemented by field inspection data. It is noted that whilst these inspections are now complete, the plan provide to IRT for review did not include the most recent assessments. TMS was the main source of the information used to assess the condition of the track and the 'first pass' allocation of work activities; VTI hits were principally used to evaluate the condition of level crossings and bridge ends. Additional information, an example of which is shown in Figure 1, was used by ARTC to support/verify the final plan.

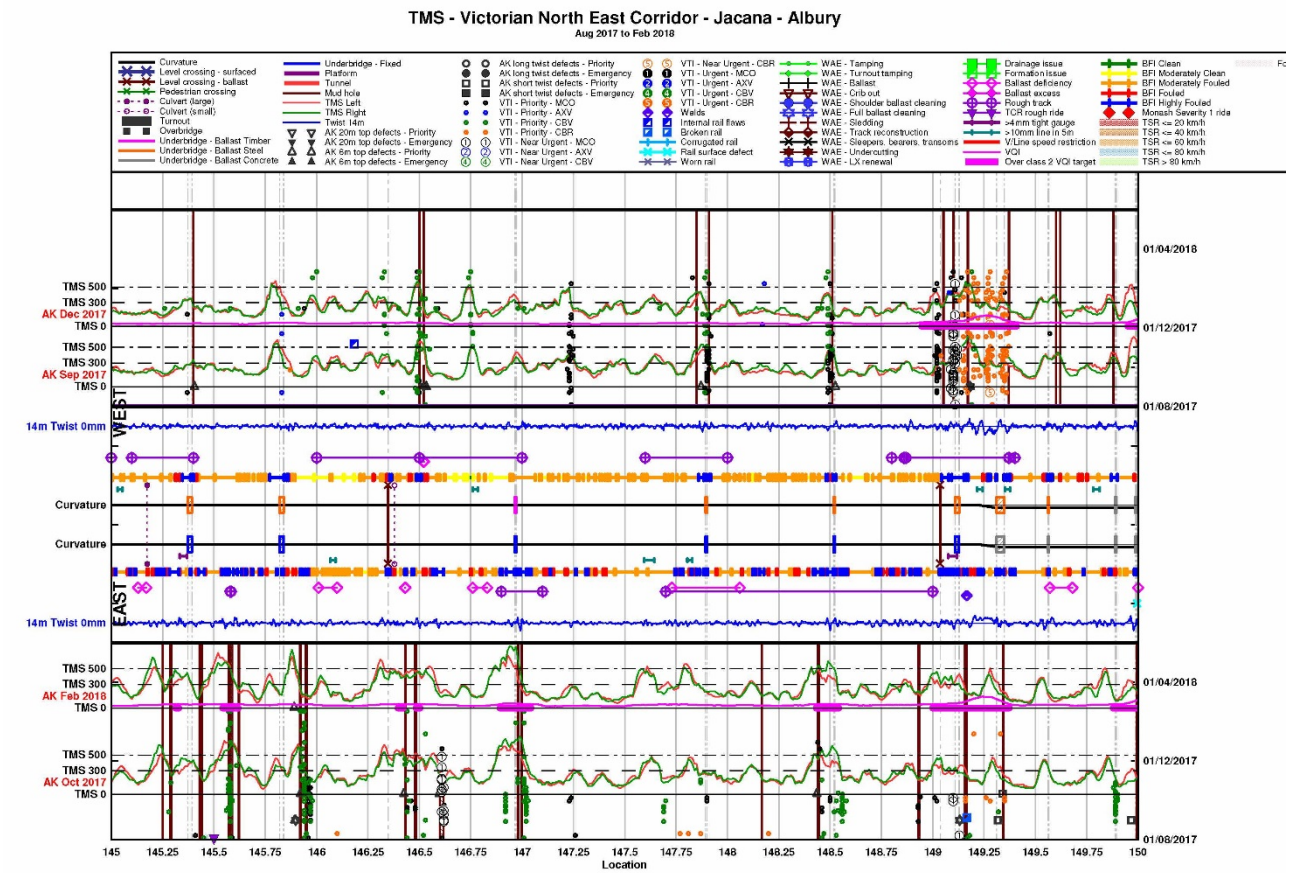


FIGURE 1: DETAILED CONDITION DATA UTILISED BY ARTC IN DEVELOPING THE NERL UPGRADE PLAN

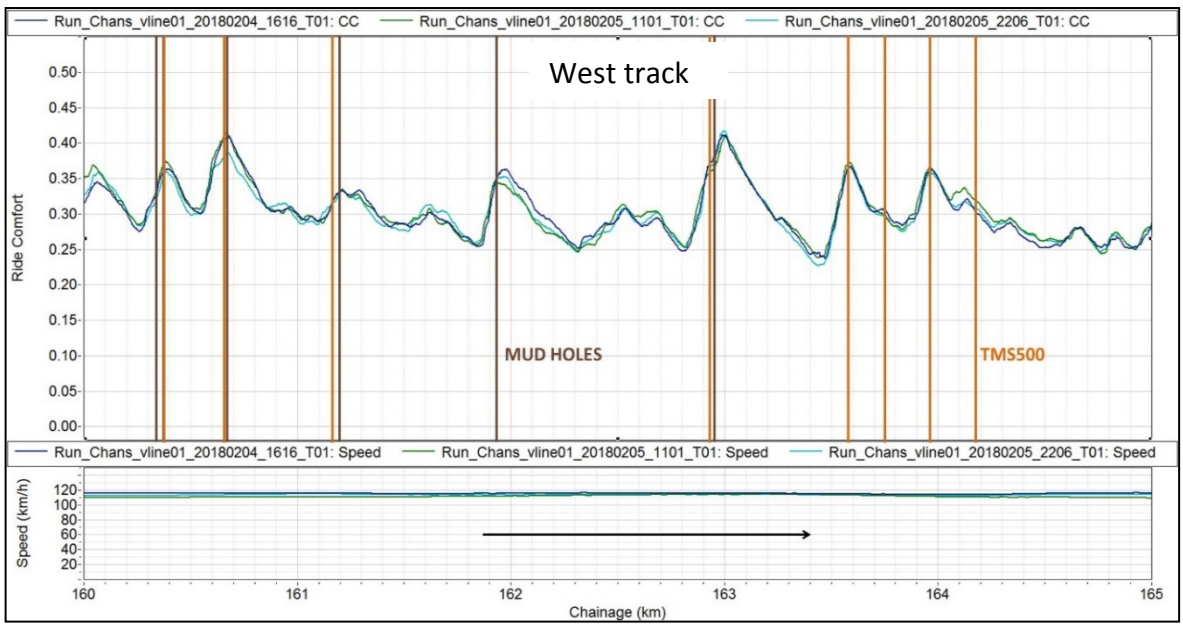
In addition to the data used by ARTC, V/Line also has additional information available relating to track condition through their Instrumented Revenue Vehicle – IRV [7]. The IRV provides information such as: passenger ride/comfort, passenger safety, vehicle stability, dynamic track loading (as measured at the vehicles suspension) and rail running surface condition (e.g. dipped rail welds, IRJ, turnout response, corrugations and other rail surface anomalies etc.). This information

should be obtained and utilised by ARTC since improving ride quality is one of the primary objectives of the upgrade program.

According to the information from ARTC, the main parameter to evaluate and highlight the success of the upgrade project will be the Victorian Quality Index (VQI) as defined in V/Line standards, NIST-2706 [2]. For V/Line Passenger Class 2 track, this requires a target VQI of 51 and a VQI limit of 61. Currently, based on information provided by ARTC (VQI estimates from AK car), approximately 38% (109 km) of the East track exceeds this limit and 21% (43 km) of the West track. It is clear that the priorities for upgrade activities must therefore target these locations.

As noted previously, in addition to the VQI, several additional recorded parameters are available regarding the track condition, including TMS, VTI hits and IRV data which can support the upgrade plan. In general there is a high correlation between these individual parameters, but it is important to note that at the end of the upgrade project, V/Line Passenger Class 2 track will be required to be delivered. As ARTC prefer to focus on the use of TMS, it is important that alternative metrics also be considered to ensure that the required track standard is achieved. Likewise, passenger ride metrics from the IRV should be assessed to ensure that all locations displaying poor ride characteristics are captured in the upgrade.

An example of the IRV response (3 runs overlayed) over a 5 km track section of both the East and West line between Violet Town and Euroa is shown in Figure 2. It is worth noting that there is currently a speed restriction of 80 km/h imposed on the East line, but no speed restriction has been applied to West line. For this section of track, ride comfort metrics are slightly lower (i.e. better ride) on the East line, most likely due to the imposition of the speed restriction (i.e. lower response due to lower speed). Also shown in Figure 2 are the locations of mud holes (vertical brown lines) taken from the ARTC Ellipse data base, as well as TMS500 exceedance locations (vertical orange lines) from the track geometry recording car. As can be seen, these results show relatively good correlation between the TMS exceedance versus mud hole locations and the high IRV ride comfort index locations, irrespective of the imposed speed restrictions.



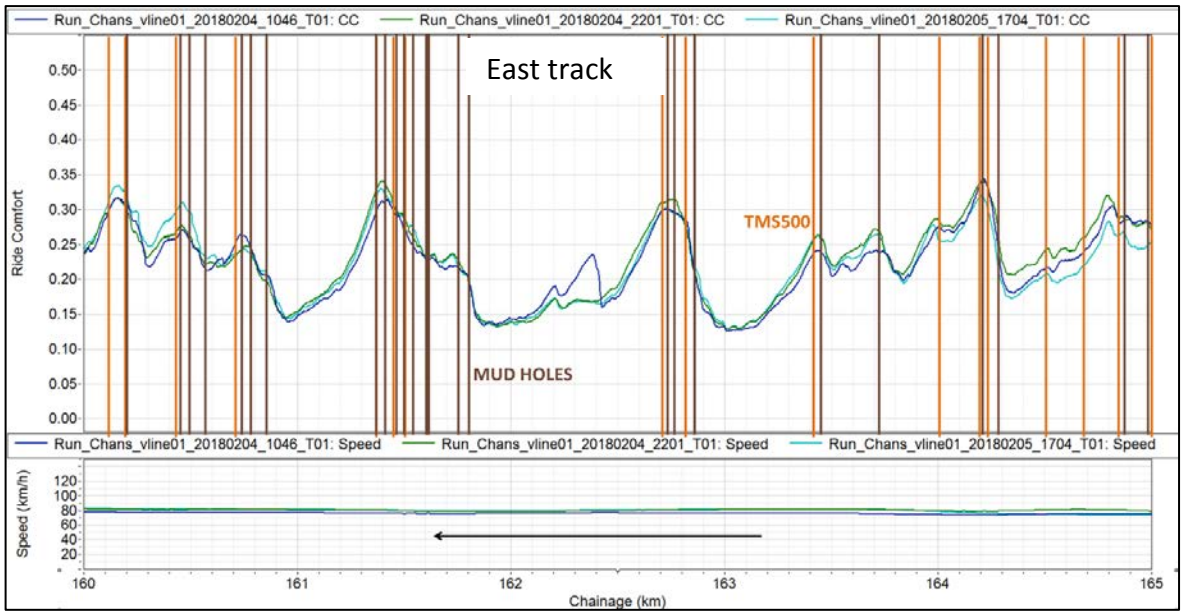


FIGURE 2: INSTRUMENTED REVENUE VEHICLE DATA (RIDE COMFORT) OVERLAYED AGAINST ARTC MUD HOLE LOCATIONS AND TMS500 PEAK LOCATIONS.

Figure 3 shows a sample of the TMS data provided by ARTC. This plot also includes additional details of the estimated VQI (preliminary results) and highlights locations where VQI values are over V/Line Passenger Class 2 limits. As was the case with the IRV data, from these preliminary results a reasonable match of VQI peaks with TMS maxima was apparent.

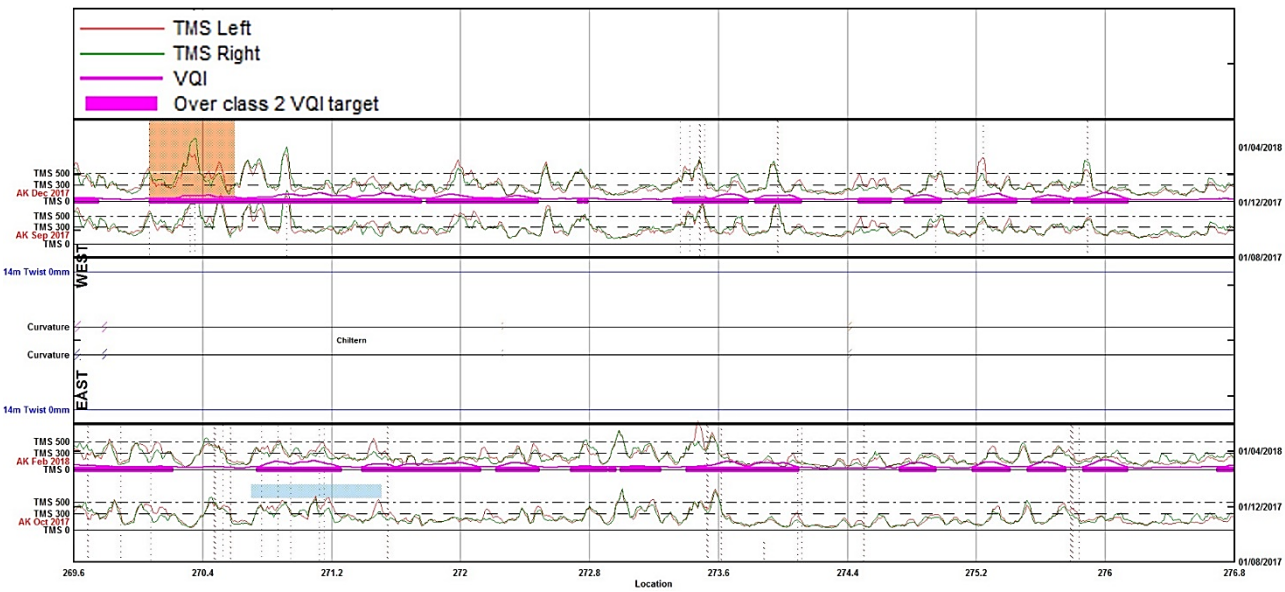


FIGURE 3: TMS VS. VQI.

Based on the various data sources available, a consistent story evolves, indicating that a focus on mud holes and regions of poor track quality (high VQI/TMS) resulting in poor ride quality is an appropriate upgrade strategy.

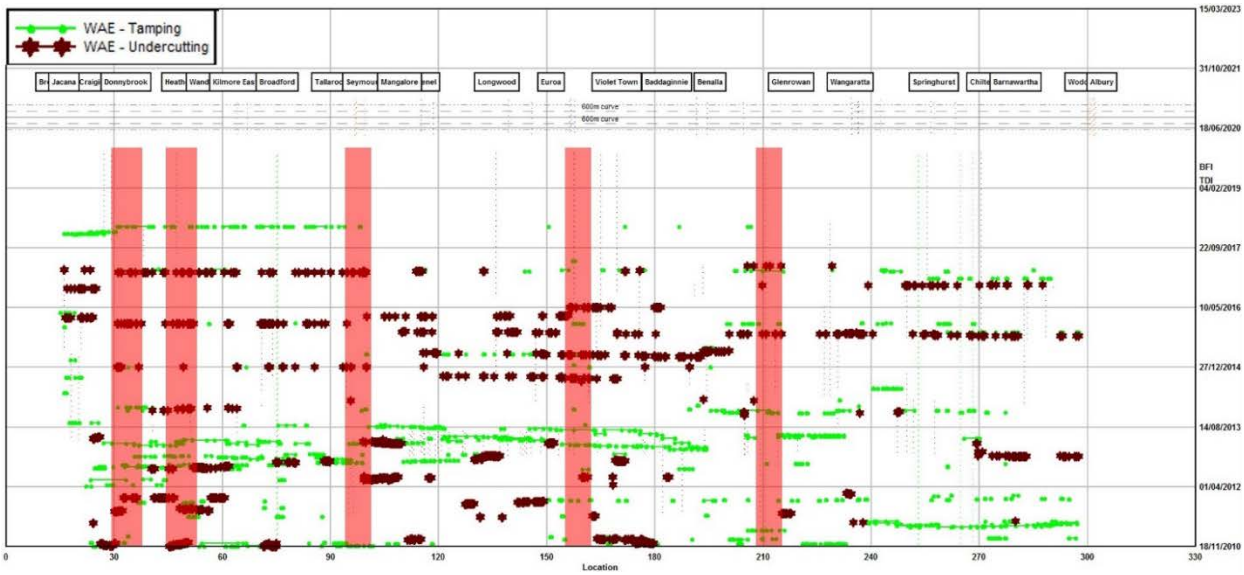
The proposed rail grinding works, as detailed in Section 2.1.4, will essentially provide a basic clean-up of the running surfaces and reinstate profile, in accordance with the current ARTC grinding standard [9]. While a minimum of single pass grinding for tangent track has been proposed, any

significant rail profile issues, particularly those affecting ride quality (hunting) and track integrity or resilience (RCF), are likely to require increased rail grinding effort to adequately rectify rail profile (multiple machine passes). It is important that the grinding works only be undertaken at the completion of other major works and the track is in a settled condition.

2.1.8 THE ADEQUACY OF PLANNED WORKS TO ADDRESS THE PROJECT OBJECTIVE

Overall, it would appear that the planned works in the ARTC upgrade plan address the main objectives of the project to a sufficient level within the funding commitment of $235M. The proposed mud hole removal and track resurfacing along with emphasis on turnout, bridge, level crossing and drainage conditions are believed to be reasonable to improve the track conditions to achieve the V/Line Passenger Class 2 track limits. However, this may only be possible if the uncertainties and constraints discussed above are overcome by careful fine tuning of the plan after the completion of the detailed site inspections and successful negotiation with V/Line personnel to achieve common agreement on a realistic acceptance level for V/Line Passenger Class 2 tracks.

Figure 4 shows the tamping and undercutting maintenance record provided by ARTC from 2011-2018 (y-axis on the right). It should be noted that the local maintenance activities performed by ARTC local gangs are not input into the ARTC database and not available to aid this review. Some typical locations (shaded red) required revisiting for tamping and lining as well as undercutting activities. If the records from the local teams were included, a more comprehensive picture of the network maintenance requirements would emerge. The detailed site inspections recently completed by ARTC (but not available for this review) should focus on similar such locations using the maintenance history as a basis. The locations which required extensive repetitive maintenance works would possibly indicate underlying formation or drainage issues which could not be fixed by the simple ballast depth improvement and subsequent tamping and lining proposed in the ARTC upgrade plan. It is important that these locations (i.e. high historical maintenance requirements or regions with continual poor geometry) be identified and corrected as part of the upgrade plan to ensure that these do not continue to be 'maintenance hot spots' locations into the future. Whilst all track will receive additional ballast together with tamping and lining, these locations may require more effort dependent upon the individual findings from the track inspections.



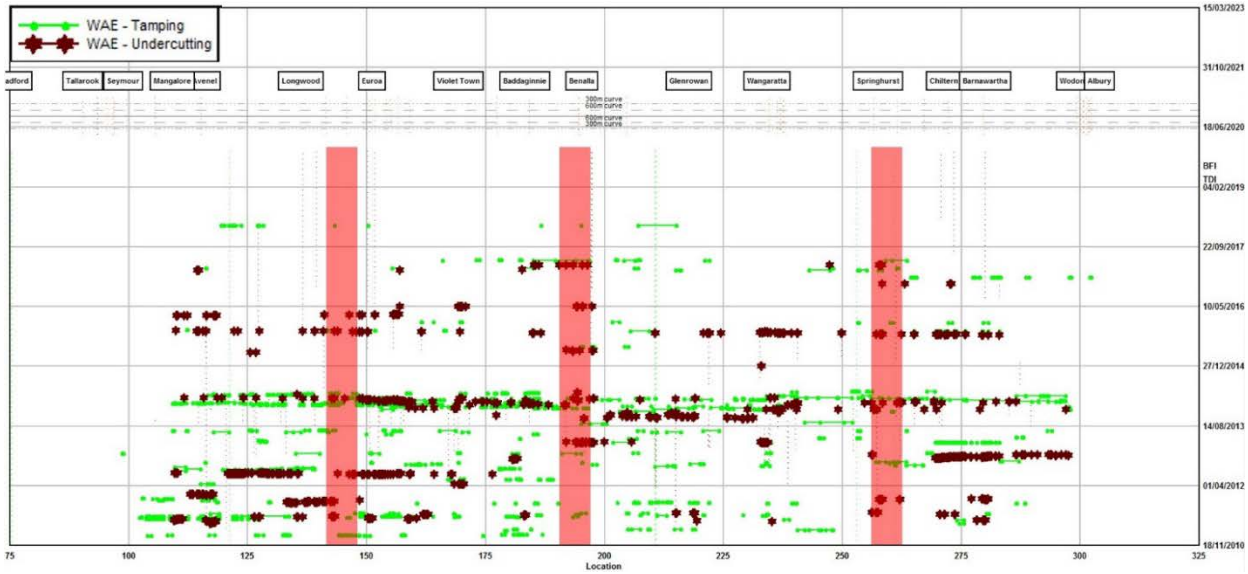


FIGURE 4: TAMPING AND UNDERCUTTING HISTORY ON EAST TRACK (TOP) AND WEST TRACK (BOTTOM) FROM ARTC.

As indicated by ARTC and agreed by IRT, the whole NERL corridor is prone to formation of mud holes and subsequent track condition deterioration; this is partially attributed to drainage problems, substandard ballast quality previously used and a generally fouled track structure. Within the current plan (based on the ARTC Ellipse asset register) some 234 locations have been identified on the East track and a further 137 locations on the West track which contain mud holes. Whilst a 20% allowance has been allowed in track length to correct these mud holes, the typical length of these mud holes is generally less than 10 metres. Based on ARTC advice, mud hole formation on this corridor is generally due to ballast fouling, rather than the formation failure which is only observed on a few isolated locations. Where the formation failures do occur, rectification works must include formation remediation, replacement of ballast capping layers, the potential use of geogrids/geotextiles and rectification of drainage. If these activities are not completed, the proposed undercutting/cleaning of ballast at these locations may only offer short term improvements.

The existing NERL tracks have seen extensive service over many years and will most likely have significant ballast fouling across much of the corridor. The best long-term solution is full-width ballast cleaning of the entire NERL corridor together with a detailed geotechnical inspection to identify locations requiring formation repair and rectification of drainage problems. However, the cost of full-width ballast cleaning along the whole line alone will likely exceed the funding allocation of $235M. The undercutting, limited ballast cleaning and limited formation and drainage improvement activities indeed become the practical solution given the level of funding commitment.

It should be emphasised that the priority 5 work activity (ballast addition) was responsible for the largest portion of available funding, surpassing priority 1 works. Since the primary objective is to achieve V/Line Passenger Class 2 track and ballast condition is a prerequisite/precursor for the adjustment of track geometry to V/Line standards, it appears reasonable that a larger proportion of the budget be focussed on this activity (in conjunction with tamping and lining). However, it is felt that this heavy investment in ballast alone will provide a medium-term solution, as there is a risk that the additional new ballast will become fouled and lose its stabilising capacity, particularly in areas containing highly fouled ballast and/or developing mud holes (formation failure). Any regions which suffer such deterioration will need to be managed into the future with localised works. Again, this

highlights the fact that there is insufficient budget to undertake a complete upgrade of the NERL and that compromises need to be made.

ARTC have also flagged several short lengths of track between fixed points where targeted works will be required to achieve the V/Line Passenger Class 2 standard. Given the potential impact that these may have on the ability to operate at mainline speeds (115 km/h), alternative treatments have been considered in these locations to mitigate their effect. Ballast cleaning, replacement of transom top bridges and where possible the addition of new ballast are all strategies included in the upgrade plan to minimise the impact of these locations.

3 SUMMARY

This report provides a desktop review of the proposed upgrading activities to be carried out by ARTC on the North East Rail Line (Melbourne to Albury). Comprehensive plans have been developed by ARTC which provide (i) a detailed understanding of the current condition of the asset and (ii) proposed upgrading activities to meet the following overall objectives:

- Allow operation of V/Line passenger services at posted speed limits (115 km/h) as well as 130 km/h DMU operations;
- Upgrade assets which are currently below those required by V/Line Passenger Class 2 track standards allowing the removal of V/Line imposed temporary speed restrictions; and
- Replace aging assets.

The upgrade strategy put forward by ARTC appears to address the key driver in that it targets the delivery of V/Line Passenger Class 2 track, allowing the removal of speed restrictions which currently affect the V/Line operation. Based on discussions with ARTC, it is felt that the plan provided for this review was approximately 70% complete, with refinements to take place following further track inspections (now complete) together with specific information which will become available during the upgrade works (e.g. targeted formation failures requiring repair).

As a general comment, ARTC have put together a very detailed plan, supported by an extensive and complete set of data. ARTC should be commended on the level of detail applied to the development of the plan. Likewise, track maintenance history data was also very comprehensive, spanning the last 10-15 years. It is further noted that the current condition of the North East Rail Line well exceeds the KPIs of the Victorian Interstate Infrastructure Lease requirements.

Apart from structures works, the main track rehabilitation activities to be undertaken include ballast depth improvements, mud hole removal, drainage improvements and complete tamping and lining across the network. Whilst various measures are available to assess the condition of the track (TMS, VQI, VTI, IRV etc) it was generally found that all these measures quantified track condition similarly. Given that upgrades works are planned across the NERL (at a minimum the addition of ballast supported by tamping and lining), the need to prioritise upgrade locations based on a preferred condition measure is generally not required (apart from the extent of tamping and lining that may be required to provide the required geometry standard).

The current upgrade plan aims to achieve V/Line Passenger Class 2 track standards across the NERL. However, the ongoing requirements to maintain the V/Line Passenger Class 2 track geometry post upgrade has not been addressed in this report.

A majority of the upgrade cost is targeting the introduction of either 50 mm or 100 mm of clean ballast into the existing track structure. Whilst this is expected to produce some short to medium-term improvement in track maintainability, given the underlying track structures are likely to be

heavily fouled, the long term efficacy of this activity is uncertain, particularly in areas where mud holes are likely to develop over the next few years. Targeted ballast cleaning, together with formation and drainage remediation works would be the preferred option, but constraints in the funding commitment preclude such activities being undertaken on a large scale.

Prior to finalising the upgrade plan, the following aspect should be considered:

- ARTC have indicated that a detailed study has already completed looking at the effectiveness of historical upgrades on the NERL corridor (e.g. mud hole removal, ballast addition), with these results being utilised in the upgrade plan development. This has included a review of the maintenance activities undertaken pre- and post-upgrades to determine whether the activity has (i) reduced subsequent maintenance requirements and (ii) reduced the rate of track geometry deterioration (e.g. TMS, VQI). The relevant data and outcome (regarding maintenance effectiveness and track deterioration rate) of these studies should be used to derive an understanding of the likely effectiveness of the proposed upgrade strategy. The results of these assessments were not made available to IRT as part of the current review.

In summary, it is considered that the proposed upgrade plan targets the key criteria outlined (in particular the delivery of V/Line Passenger Class 2 track) and should provide a much-improved and more maintainable permanent way at the completion of the works within the current funding commitment of $235M.

4 REFERENCES

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