Inland Rail - Yelarbon to Gowrie

Australian Rail Track Corporation Limited

21-Apr-2017

Commercial-in-Confidence

Corridor Options Report

Corridor Options Report

Client: Australian Rail Track Corporation Limited

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Executive Summary

Background

In 2005 the Australian Government commissioned the ‘North-South Rail Corridor Study’ in order to assess future rail freight demand across the Melbourne-Sydney-Brisbane corridor. This study found that the most competitive route for rail was the Melbourne-Brisbane corridor, and that congestion issues in Sydney were a key constraint. Accordingly, a number of alternative inland routes were investigated that excluded a Sydney link. While no specific route was recommended, this laid the groundwork for future studies.

In 2008, the Inland Rail project was announced by the Australian Government, to be led by the Australian Rail Track Corporation (ARTC), a federally-owned corporation established in 1997. This resulted in the ‘Melbourne–Brisbane Inland Rail Alignment Study’, which identified the preferred corridor through central-west New South Wales and established the business case for the project. The preferred corridor alignment is referred to the Base Case alignment or corridor. Since this time, a number of additional route studies have been undertaken looking at changes, refinements, and alternatives to the preferred corridor.

In 2015 and 2016 an additional series of concept studies were commissioned by ARTC to further assess and refine an Inland Rail alignment including the Yelarbon to Gowrie section of alignment. These studies consisted of both desktop evaluation and site visit confirmation works.

Following the 2008 studies and prior to the 2016 study, Wellcamp Airport, which lies 15.6 km to the west of Toowoomba and is included in the Wellcamp-Charlton Industrial Precinct, was opened for passenger flights in November of 2014. This material change to the region was a key driver for the decision to revisit possible alternatives to the original Base Case corridor between Yelarbon and Gowrie.

The Australian Minister for Infrastructure and Transport, The Honourable Darren Chester MP, determined that the desire to have more certainty on the most appropriate route, along with the introduction of the opportunity to interface with Wellcamp-Charlton Industrial Precinct including Wellcamp Airport, compelled the commissioning of this options assessment study.

Objectives

This study has two overarching objectives:

- To perform a robust and like-for-like engineering and environmental comparative assessment of the three alternative investigation corridors against the Base Case Modified route, which is a modification to the 2010 Base Case route. The key changes being the bypass of Inglewood and refinement of the section from Yargullen to Kingsthorpe.
- To develop comparative cost estimates of the options against the Base Case Modified route.

A separate report concerning community stakeholders and impacts will be prepared by the Project Reference Group Chair, Mr Bruce Wilson (AM), to assist in the selection of a preferred Yelarbon to Gowrie investigation corridor. The processes to develop this report are discussed below in the Project Reference Group section.

Options

Four options have been selected for this corridor options assessment and shown in **Figure 1** and listed below:

1. The Base Case Modified
2. Wellcamp-Charlton
3. Karara-Leyburn
4. Warwick

These alignments have been developed through a series of studies over two decades by various federal and state organisations with differing objectives. Many options, sub-options and combinations of options have been previously considered. The four options detailed in this report have been nominated as they are consistent with common themes that have appeared throughout previous studies.

Each of the four corridors has been considered.

- The Base Case Modified corridor bypasses Inglewood to the north and then follows Millmerran-Inglewood Road until Millmerran. The corridor then follows the existing Millmerran Line before cutting north at Yarranlea towards Mt Tyson where it joins the disused Cecil Plains Branch Line. The corridor deviates from the Cecil Plains Branch Line north of Aubigny to cut north west across to join in with the West Moreton Railway near Kingsthorpe.
- The Wellcamp-Charlton corridor follows the Base Case Modified corridor to the north of Brookstead, then traverses along the Gore Highway via Pittsworth and Southbrook before heading towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport), and then joining the existing West Moreton Railway near Gowrie.
- The Karara-Leyburn corridor follows the existing South Western Railway corridor until Karara. It then heads north towards Leyburn following an existing transport corridor, before crossing the Condamine River near Felton, then heading towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport), and then follows the same route as the Wellcamp-Charlton route.
- The Warwick corridor generally follows the Karara-Leyburn route and the existing South Western Railway corridor from Yelarbon towards Warwick via Karara. The proposed route bypasses Warwick by approximately 20 km to the west before generally following the existing Southern Railway to Wyreema before turning north-west towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). The corridor then follows the same route as the Wellcamp-Charlton and Karara-Leyburn routes.

Existing transportation corridors and railways have traditionally led to development around these corridors. Any substantive change is likely to affect communities and stakeholders to varying degrees, either as an incremental change or as a significant material change.

Project Reference Group

To demonstrate a transparent assessment process and engagement with potentially affected communities and stakeholders, the Project Reference Group (PRG) was established. It is comprised of representatives from community organisations with both local and regional Darling Downs interests and was chaired by Mr Bruce Wilson (AM). The PRG had two main objectives:

- To provide input into the assessment
- To observe that a rigorous and like-for-like approach was being followed

The objective of the like-for-like analysis is to apply a consistent level of investigation for all four options, ensuring that the underlying data, level of detail for investigation and overall assessment was at the same level for all four options.

MCA Methodology

The methodology adopted to perform the like-for-like comparison was a Multi-Criteria Analysis (MCA) and comparative cost estimate. The three alternatives have been compared against the Base Case Modified investigation corridor. The assessment in this report was controlled by the requirements of the ARTC MCA Framework, criteria and weightings as provided by ARTC and used across the full extent of the Inland Rail programme.

Some environmental and social assessment aspects are qualitative by nature and therefore are more challenging to assess in a like-for-like manner. Where non-technical criteria (for example, community impacts, visual amenity etc.) which may be considered to be wholly or partly subjective were assessed, quantifiable metrics were adopted where appropriate. However, whilst quantified metrics provided assessment guidance in these instances, inevitably some subjectivity remained. Subjective assessment criteria were subject to post-scoring sensitivity testing to assess what impact, if any, alternative scoring may have on the overall result.

The underlying seven key criteria and the results of the MCA assessment are presented in **Table 1**.

Table 1 MCA scoring

Assessment Criteria	Weighting	Wellcamp-Charlton	Karara-Leyburn	Warwick
Technical viability	17%	-0.043	0.595	-0.298
Safety assessment of the proposed alignment	16.5%	0.041	-0.289	-0.784
Operational approach	16.5%	0	-0.817	-0.545
Constructability and schedule	12.5%	-0.125	0.094	-0.188
Technical Sub-Total		***-0.126***	***-0.417***	***-1.815***
Environmental and heritage Impacts	12.5%	0.094	0.281	-0.844
Community and property impacts	12.5%	-0.250	0.625	-0.375
Approvals and stakeholder risk	12.5%	0	0	0
Non-Technical Sub-Total		***-0.156***	***0.906***	***-1.22***
TOTAL	100%	**-0.283**	**0.490**	**-3.03**

The results of the MCA have indicated that two of the alternative options scored closely to the Base Case Modified option, these being the Wellcamp-Charlton route (-0.283) and the Karara-Leyburn route (0.490). The third alternative option, the Warwick route (-3.03), did not score as closely and scored negatively when compared to the Base Case Modified route. This negative score is a function of the extra length of the alignment, the interfaces with more local communities and sensitive receptors and the requirement to modify the existing alignment to meet the ARTC design standards and the ARTC Service Offering.

The criteria have been separated into what has been considered as Technical and Non-Technical Criteria. For the Technical criteria all of the options scored less favourably than the Base Case Modified route. For the Non-Technical criteria, the Karara-Leyburn route scored more favourably (+0.906) while the others scored less favourably.

Sensitivity testing was undertaken on the sub-criteria Local Stakeholder Buy-In, Community Impact and Response and Flooding/Hydrology. It demonstrated that there is no net comparative change in the MCA scoring outcome.

It should also be noted that the MCA and comparative cost estimate will be provided for consideration along with the PRG Chairman’s report. This report will provide additional social and community context to assist with the assessment of a preferred investigation corridor.

Cost

A summary of the construction cost estimates is presented in **Table 2**. The underlying Direct Job Costs and Construction Costs have been presented in **Table 3**. Owners Costs and risk ranging have been excluded from these costs to enable a direct base line construction comparison. The Owners Costs and upper bound risk contingency will be best determined by the proponent for the selected route based upon the project delivery method chosen. While the Owners Costs have been excluded it can be noted that they would likely be consistent across the four options and not be seen as a differentiator.

Table 2 Construction cost estimates

Alignment option	Construction estimate	Difference compared to Base Case Modified	% Difference
Base Case Modified	$ 1,232,743,893	$ -	0%
Wellcamp-Charlton	$ 1,334,949,841	$ 102,205,948	8%
Karara-Leyburn	$ 1,518,129,385	$ 285,385,493	23%
Warwick	$ 1,647,485,972	$ 414,742,079	34%

Notes:
- Base Case Modified is the control alignment
- Included in construction estimate: direct job costs, construction overheads, clients supply and property costs

The Construction estimate does not include design and clients cost, other owner’s costs, contingency and risk. The comparative cost estimate shows that the key material differentiators driving the cost are length of the track and resulting track structure, length of bridge structures required to cross creeks and rivers and most significantly, earthworks.

The key differentiators are presented in **Table 3** as both a dollar and comparative cost percentage.

Table 3 Cost estimate differentiators

Cost Description	Base Case Modified (BCM)	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Amount	Amount	% Diff.	Amount	% Diff.	Amount	% Diff.
Environmental	$ 22,245,138	$ 24,611,175		$ 28,502,198		$ 30,010,678	
Difference from BCM		$ 2,366,037	11%	$ 6,257,060	28%	$ 7,765,540	35%
Earthworks	$ 261,055,168	$ 373,052,643		$ 385,132,697		$ 377,621,309	
Difference from BCM		$ 111,997,475	43%	$ 124,077,529	48%	$ 116,566,141	45%
Capping	$ 51,619,495	$ 46,929,505		$ 47,123,720		$ 56,596,080	
Difference from BCM		-$ 4,689,990	-9%	-$ 4,495,775	-9%	$ 4,976,585	10%
Fencing	$ 14,124,411	$ 13,883,596		$ 13,622,180		$ 17,099,892	
Difference from BCM		-$ 240,815	-2%	-$ 502,231	-4%	$ 2,975,481	21%
Trackworks	$ 132,186,002	$ 123,016,068		$ 124,898,323		$ 152,599,531	
Difference from BCM		-$ 9,169,934	-7%	-$ 7,287,679	-6%	$ 20,413,529	15%
Culverts	$ 82,431,140	$ 83,115,058		$ 58,373,510		$ 23,621,102	
Difference from BCM		$ 683,918	1%	-$ 24,057,630	-29%	-$ 58,810,038	-71%
Viaducts/Bridges	$ 137,975,797	$ 119,338,854		$ 255,948,910		$ 312,916,719	
Difference from BCM		-$ 18,636,943	-14%	$ 117,973,113	86%	$ 174,940,922	127%
Grade Separations	$ 5,732,638	$ 5,732,638		$ 14,331,595		$ 11,465,276	
Difference from BCM		$ -	0%	$ 8,598,957	150%	$ 5,732,638	100%
Road Crossings	$ 32,351,148	$ 28,555,728		$ 20,712,937		$ 29,240,970	
Difference from BCM		-$ 3,795,420	-12%	-$ 11,638,211	-36%	-$ 3,110,178	-10%
PUP's	$ 1,783,630	$ 2,137,205		$ 1,427,188		$ 2,547,222	
Difference from BCM		$ 353,575	20%	-$ 356,442	-20%	$ 763,592	43%
Direct Job Costs	$ 741,504,567	$ 820,372,470		$ 950,073,258		$ 1,013,718,779	
Difference from BCM		$ 78,867,903	11%	$ 208,568,691	28%	$ 272,214,212	37%

Notes:

- Base Case Modified (BCM) is the control alignment
- Red fill indicates a cost value higher than the Base Case Modified
- Green fill indicates a cost value lower than the Base Case Modified

Summary

Table 4 provides a summary of the MCA and comparative cost estimate for the investigation corridors.

Table 4 MCA scoring and cost estimate summary

Element	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Corridor Length (km)	181.3	168.1	171.9	208.3
MCA Overall	0	-0.283	0.490	-3.03
MCA (Technical)	*0*	*-0.126*	*-0.417*	*-1.815*
MCA (Non-Technical)	*0*	*-0.156*	*0.906*	*-1.22*
Construction Cost	$1,232,743,893	$1,334,949,841	$1,518,129,385	$1,647,485,972
Construction Cost Difference to Base Case Modified	-	+ $102,205,948	+ $285,385,493	+ $414,742,079

Notes:
- Base Case Modified (BCM) is the control alignment
- Included in construction estimate: direct job costs, construction overheads, clients supply and property costs

The hydrological investigations have currently incorporated detailed modelling for nominated 10% and 1% AEP events for the Condamine River floodplains. The design of the infrastructure may vary according to a controlling event that is neither of these events and as such further investigation will be required during the more detailed design stages.

Detailed hydrological and hydraulic assessments supported by modelling and site survey (or LiDAR) are also required for other waterway crossings during further design development stages, to confirm cross drainage requirements.

Comparative costs estimated have indicated that the earthworks required for each alignment largely dictate the outcome of the comparative assessment. The earthworks design to date has been based on desktop analysis that has been supplemented with field observations from publically accessible areas. More detailed geotechnical investigations will be required to better refine the earthworks and mass-haul movements.

The PRG meetings and community engagements have assisted in clarifying impacts that the proposed railway would have on individuals, local communities and businesses from personal, operational and economic perspectives.

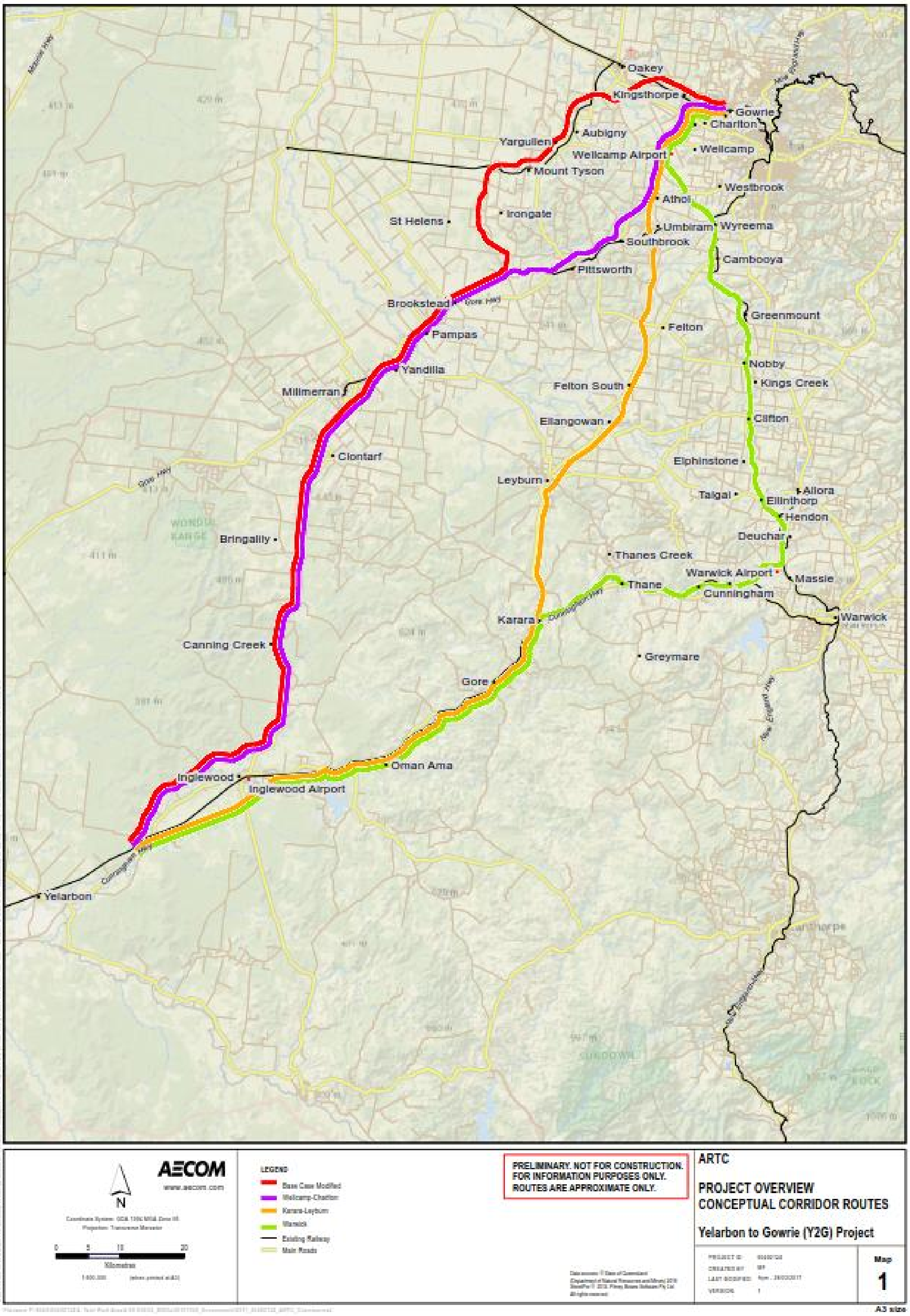
Early community engagement to discuss prospective impacts and requirements should be undertaken for the selected route. This includes an assessment of community, livestock and machinery movements in close proximity to the corridor and the local preference in planning for an alignment route that could minimise any prospective impacts.

1.0 Introduction

This study provides a comparative assessment of alternative route study investigation corridors and was established under the direction of the Honourable Darren Chester MP, Minister for Infrastructure and Transport.

The four options for assessment can be seen in **Figure 1**.

Figure 1 Corridor options



The four options are:

1. The Base Case Modified
2. Wellcamp-Charlton
3. Karara-Leyburn
4. Warwick

The four route study investigation corridors are detailed within **Section 3.0** of this report. This study is a comparative assessment whereby the alternative options are all compared and assessed against the Base Case Modified investigation corridor. The comparative assessment is to be like-for-like in nature, where the underlying data, the level of detail for investigation and the overall assessment will be to the same level for all four options.

1.1 Background

In 2005 the Australian Government commissioned the 'North-South Rail Corridor Study' in order to assess future rail freight demand across the Melbourne-Sydney-Brisbane corridor. This found that rail was most competitive on the Melbourne-Brisbane corridor, with congestion issues in Sydney a key constraint. As such, a number of inland routes were investigated. While no specific route was recommended, this laid the groundwork for future studies.

In 2008, the Inland Rail project was announced by the Australian Government, to be led by the Australian Rail Track Corporation (ARTC), a federally-owned corporation that had formally been established in 1997. This resulted in the 'Melbourne–Brisbane Inland Rail Alignment Study', which identified the preferred corridor through central-west New South Wales and established the business case. Since this time, a number of additional route studies have been undertaken looking at changes, refinements, and alternatives to the route. These are detailed in **Section 2.0**.

The nominally 1700 kilometre long Inland Rail project has been divided into a series of smaller segments to assist with delivery of the Inland Rail Programme of works. In 2016, ARTC awarded a number of separate Phase 1 concept level technical engineering and environmental services contracts, each looking at a separate segment of the corridor. One such section, as detailed below, involves the segment from Yelarbon, north of the QLD-NSW border, and Gowrie, to the west of Toowoomba. The study of this segment was awarded to AECOM.

The investigation corridor for this segment generally followed the 2010 Base Case alignment as defined in the Melbourne-Brisbane Inland Rail Alignment Study - Department of Infrastructure, Transport, Regional Development and Local Government, 2010 report. The route departs Yelarbon and travels via Inglewood, Millmerran, Brookstead, Mt Tyson, Yargullen and Kingsthorpe before linking with the adjoining West Moreton Railway at Gowrie Junction, to the west of Toowoomba.

Following the 2008 studies and prior to the 2016 study, Wellcamp Airport, which lies 15.6 km to the west of Toowoomba and is included in the Wellcamp-Charlton Industrial Precinct, was opened for passenger flights in November of 2014. This material change to the region was a key driver for the decision to revisit possible alternatives for an inland freight rail corridor between Yelarbon and Gowrie.

The four options for assessment can be seen in **Figure 1** and are detailed within **Section 3.0** of this report.

All four options start at the same geographic location and finish at the same geographic location. This allows for a fair comparison of options to achieve the same transportation task.

Four options have been selected for this corridor options assessment and shown in **Figure 1** and listed below:

1. The Base Case Modified
2. Wellcamp-Charlton
3. Karara-Leyburn
4. Warwick

These alignments have been developed through a series of studies over two decades by various federal and state organisations with differing objectives. Many options, sub-options and combinations of options have been previously considered. The four options detailed in this report have been nominated as they are consistent with common themes that have appeared throughout previous studies.

Each of the four corridors has been considered.

- The Base Case Modified corridor bypasses Inglewood to the north and then follows Millmerran-Inglewood Road until Millmerran. The corridor then follows the existing Millmerran Line before cutting north at Yarranlea towards Mt Tyson where it joins the disused Cecil Plains Branch Line. The corridor deviates from the Cecil Plains Branch Line north of Aubigny to cut north west across to join in with the West Moreton Railway near Kingsthorpe.
- The Wellcamp-Charlton corridor follows the Base Case Modified corridor to the north of Brookstead, then traverses along the Gore Highway via Pittsworth and Southbrook before heading towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport), and then joining the existing West Moreton Railway near Gowrie.
- The Karara-Leyburn corridor follows the existing South Western Railway corridor until Karara. It then heads north towards Leyburn following an existing transport corridor, before crossing the Condamine River near Felton, then heading towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport), and then follows the same route as the Wellcamp-Charlton route.
- The Warwick corridor generally follows the Karara-Leyburn route and the existing South Western Railway corridor from Yelarbon towards Warwick via Karara. The proposed route bypasses Warwick by approximately 20 km to the west before generally following the existing Southern Railway to Wyreema before turning north-west towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). The corridor then follows the same route as the Wellcamp-Charlton and Karara-Leyburn routes.

The four routes utilise differing amounts of existing railway corridor, follow varying amounts of existing road transport corridor, or alternatively crossing a differing number of currently unaffected properties. Existing road transportation corridors and railways have traditionally led to development around these network corridors. Any substantive change is likely to affect communities and stakeholders to varying degrees, either as an incremental change or as a material change.

Therefore, an additional driver for this study was to include the potentially affected communities and stakeholders with the purpose of ensuring that the process used in the assessment was rigorous and valid and to also provide local context and data input to assist with the assessment. The Project Reference Group (PRG) was established and comprises of community representation organisations including farming peak bodies and organisations; Chambers of Commerce and business groups; environmental and conservation organisations; and community and progress associations with both local and more regional Darling Downs interests.

The chairman for the PRG and Queensland Advisor, Mr Bruce Wilson (AM), was appointed by the federal Minister for Infrastructure and Transport, the Honourable Darren Chester MP. Mr Wilson was supported in a secretariat role by staff from the Department of Infrastructure and Regional Development.

The Terms of Reference for the PRG can be seen in **Appendix A**. ARTC are to provide specific policy, technical or operational input as required to assist in the assessment but are independent to the assessment process.

This study provides a comparative assessment of alternative route study investigation corridors and was established under the direction of the federal Minister for Infrastructure and Transport, the Honourable Darren Chester MP, and managed by the Department of Infrastructure and Regional Development (DIRD / the Department). The Department arranged for the commissioning of AECOM for this study through ARTC.

Each of the investigation corridors is 2 km wide based upon a nominal alignment. A 2 km wide corridor will also be taken forward into the Environmental Impact Statement (EIS) phase for the chosen option. A nominal alignment is used for this phase of the project so that detail around key metrics can be determined for the comparative assessment. As this is an investigation corridor study, impact on individual landowners cannot be confirmed until there is additional certainty around the preferred corridor.

1.2 Objectives

The Yelarbon to Gowrie segment of the Inland Rail corridor is the longest of the Queensland segments and contributes to approximately 11% of the overall Inland Rail alignment. This segment of track is a significant investment for the Inland Rail programme of works and therefore requires due consideration for the most appropriate route between Yelarbon and Gowrie. This corridor options assessment contributes to the wider objective of supporting a business case for the whole (Melbourne to Brisbane Inland Rail) MBIR project.

The key objective was to perform a comparative review in order to deliver the best possible outcome for this priority project through a robust and like-for-like engineering, environmental and cost comparative assessment of the three alternative investigation corridors against the Base Case Modified alignment. An additional aim was to identify key differentiators between the corridors.

The review was to include stakeholder input with the aim of enhancing the investigations and to provide transparency to the assessment process through regular updates to the PRG. To achieve this regular PRG meetings were arranged, which are detailed in **Section 6.0.**

The objective of the like-for-like analysis is to apply an equal level of investigation for all four options whereby the underlying data, the level of detail for investigation and the overall assessment will be to the same level for all four options. For example, the Phase 1 study in 2016 used Light Detection and Ranging (LiDAR) survey data to underpin its assessment. LiDAR survey data was not available for the full extent of all four investigation corridors, and as such, the next best level of survey data that was available across all four options was used. Due to the underlying accuracies of the available data set, the Base Case Modified alignment had to be re-designed to suit the revised survey data with an equivalent amount of design effort to that of the alternative route options. The survey data set adopted is considered to be suitable for this options assessment phase.

The Condamine River Flood Plain was identified as a significant topographic feature that all four alignment options interfaced with. A substantial amount of hydrological study was performed for the Base Case Modified alignment during the Phase 1 investigations in 2016. As such an equal amount of investigation would be performed on all of the alignments for the Condamine River. LiDAR data and hydrological models were sourced from local regional councils and used as a basis for this like-for-like assessment.

This options phase of the study will be followed by further more detailed investigation stages. The level of detail used in this investigation is suitable for a comparative options assessment, however more accurate and detailed data sets and an additional level of detail will be required to further refine the selected route corridor. For example, there have been no field geotechnical investigations or environmental assessment from areas other than publicly assessable areas, and there has also not been any invasive geotechnical assessment at this stage. As the focus of the assessment is at the corridor and not the alignment level, details such as impacts on individual property owners cannot be assessed at this stage.

The most suitable tool to perform like-for-like comparison is a Multi-Criteria Analysis (MCA) and comparative cost estimate. The three alternatives were compared against the Base Case Modified investigation corridor. The MCA framework is detailed in **Section 1.3.1** while the MCA process and results can be seen in **Section 8.0**.

The assessment in this report is controlled by the requirements of the ARTC MCA Framework, criteria and weightings. Where possible quantifiable data sources have been used to remove ambiguity and subjectivity of opinion. Some environmental criteria have a greater degree of subjectivity and as such are more difficult to make an assessment on. The approach used in the MCA assessment for these more subjective items has been to utilise sensitivity testing to assess what impact, if any, that there may be to the overall result.

1.3 Key project criteria

The ARTC Service Offering is central to Inland Rail and reflects the priorities of freight customers for a road competitive service based on

- Reliability
- Transit time
- Price
- Availability

This service offering was developed by ARTC in close consultation with customers, rail users and other key stakeholders. These key stakeholders were asked for their views during the 2010 Inland Rail Alignment Study, through a subsequent industry survey, extensive one-on-one interviews and, most recently, through two Stakeholder Reference Group Forums convened by the Department of Infrastructure and Regional Development in May and October 2014.

This feedback is reflected in the current service offering, with clear potential for faster and slower services to meet customer needs (while preserving the core offering of a 24 hour transit time from Melbourne to Brisbane), a clearly specified reliability target of 98 percent and clarity around the commitment to interoperability with connections to the New South Wales country rail network and Queensland narrow gauge network.

1.3.1 MCA framework

The assessment of options was undertaken using ARTC's MCA framework. This was used across all study areas of the MBIR Project, providing consistency across the programme of works. The options assessment is broken into three key aspects:

1. Compliance with MBIR service offering
2. MCA score, weighted by criteria
3. Comparative cost (CAPEX)

1.3.1.1 Compliance with MBIR project

Compliance with the Service Offering is a high level 'pass or fail' assessment, looking at whether the proposed alignment option satisfied the key service characteristics of the MBIR project. This included compliance with the Basis of Design, and aspects such as reliability, price-competitiveness, journey time, and availability.

All options were subject to a full evaluation irrespective of whether they were perceived to comply with the service offering, to fulfil a like-for-like assessment.

1.3.1.2 MCA criteria and scoring

The MCA criteria used in the assessment was a list of standard criteria and sub criteria produced by ARTC that is used to assess alignment options along the full MBIR corridor. This framework enabled an objective comparative assessment of each corridor option against a range of key criteria, with pre-defined weightings, providing consistency across the programme of works.

The MCA criteria and associated ratings used by ARTC for all sections of the MBIR project are listed in **Table 5**.

Table 5 MCA Framework

Criteria	Criteria Weighting	Sub-criteria	Sub Criteria Weighting
Technical viability	17%	Alignment	20%
		Impact on PUP and other assets	15%
		Geotechnical conditions	20%
		Impacts on existing road and rail networks	15%
		Flood immunity/ hydrology	20%
		Future proofing	10%
Safety assessment of the proposed alignment	16.5%	Operational safety	25%
		Public safety	10%
		Road safety interfaces	25%
		Emergency response	20%
		Construction safety	20%
Operational approach	16.5%	Effect / Impact on travel time	33%
		Effect on reliability and availability	33%
		Network interoperability and connectivity	33%
Constructability and schedule	12.5%	Construction duration	20%
		Construction access	15%
		Construction complexity	15%
		Resources / material sources	15%
		Interface with operational railway	20%
		Staging opportunities	15%
Environmental and heritage Impacts	12.5%	Ecological impacts (flora, fauna and habitats)	20%
		Visual impacts	15%
		Noise and vibration impacts	15%
		Flooding and waterway impacts	20%
		Effect on air quality	15%
		Effect on greenhouse gas emissions	15%
Community and property impacts	12.5%	Property impacts	20%
		Heritage	20%
		Impact on community e.g. road	20%
		Community response (community stakeholder risk)	20%
		Current and future land use impacts	20%
Approvals and stakeholder risk	12.5%	Planning and approval timescale	20%
		State/ Federal agency buy in	20%
		Local government buy in	20%
		Other statutory and regulatory approvals	20%
		Service authorities (utilities/ other)	20%

1.3.1.3 Comparative cost

The comparative cost is a key metric for the MCA framework and is used in conjunction with the MCA scoring and the PRG Chairman's report to determine a preferred option. The cost as built from a bill of quantities (BOQ) which was developed for each of the four options. This summarised estimated quantities at a concept level, focussing on key items such as earthworks, bridges, and drainage structures. The cost estimate was produced in parallel to the MCA process with the final costs delivered after the MCA scoring had been undertaken to ensure there was no preconceived bias on the scoring day.

1.3.2 Service offering criteria

The design criteria were developed by ARTC to meet the requirements of the service offering. The key characteristics are:

- 98 percent reliability
- A transit time from Melbourne to Brisbane in less than 24 hours
- Flexibility for faster and slower services
- Freight that is available when the market wants

For details on the design specification adopted refer to **Table 6** and **Table 7**.

Table 6 MBIR Operational Specification

Operation specification	
Freight train transit time (terminal to terminal)	Target driven by a range of customer preferences and less than 24 hours Melbourne-Brisbane for the intermodal reference train. Flexibility to provide for faster (higher power:weight ratio) and slower (lower power:weight ratio) services to meet market requirements
Gauge	Standard (1435 mm) with dual standard / narrow (1067 mm) gauge in appropriate Queensland sections
Maximum freight operating speed	115 km/h @ 21 tonne axle load
Maximum axle loads (initial)	21 tonnes @ 115 km/h 23 tonnes @ 90 km/h 25 tonnes @ 80 km/h
Clearance (terminal to terminal)	As per ARTC Plate F for double stacking (7.1 m above rail)
Maximum train length (initial)	1800 m
Braking Curve	G40 for intermodal reference train

Table 7 MBIR Minimum Design Standards

General alignment standards	
Design speed	115 km/h
Maximum grade	1:100 target, 1:80 maximum (compensated) 1:200 maximum at arrival or departure points at loops
Curve radius	1200m target, 800m minimum
Cant / cant deficiency	Set for intermodal reference train
Minimum speed alignment standards (mountainous terrain)	
Design speed	80 km/h minimum
Maximum grade	1:100 target, 1:80 maximum (compensated) 1:200 maximum at arrival or departure points at loops

General alignment standards	
Curve radius	800 m target, 400 m minimum
Cant	Set for coal reference train
Corridor width	40 m minimum
Rail	Minimum 53 kg/m on existing track; 60 kg/m on new or upgraded track
Concrete sleepers	Rated @ 30 tonne axle load
Sleeper spacing	667 mm spacing (1500/km) – existing track 600 mm (1666/km) – new corridors / track or re-sleepering existing track
Turnouts	Tangential, rated at track speed on the straight and 80 km/h entry / exit on the diverging track.
Crossing loops (initial)	1800 m (clearance point to clearance point) plus signalling overlap No level crossing across loops or within road vehicle sighting distance from loops
Future proofing	
Train length	To provide for future extension of maximum train length to 3600 m
New structures	Capable of 30 tonne axle load @ 80 km/h minimum
Formation	Formation on new track suitable for 30 tonne axle load @ 80 km/h
Crossing loops	Loops designed and located to allow future extension for 3600 m trains
Reliability and availability	Competitive with road

1.3.3 Hydrologic design standards

ARTC have provided high level design objectives for the entire MBIR project in relation to hydrology, including the Yelarbon to Gowrie section. These are:

- 1% AEP flood immunity for the rail.
- No change in flood inundation footprint.
- No redistribution of flood flows.
- Minimise changes in flood peak timing.
- Consider critical infrastructure.
- Minimise changes in flood levels with an aim of no net worsening.
- Minimise downstream erosion and minimise changes in flow velocities.

In future stages, the Project will have specific design criteria set during the Environmental Impact Statement (EIS) process. In the absence of these site specific design criteria, typical conditions for other recent freight rail projects in Queensland have been used to assess each alignment corridor option. This ensures areas of potential impact are similar for each alignment option, and therefore suitable for the comparative purposes of the cost estimate and MCA corridor option selection process.

1.4 Abbreviations

The following abbreviations have been used in the report.

Table 8 Abbreviations

Abbreviation	Description
AEP	Annual Exceedance Probability
ARA	Australasian Railway Association Inc.
ARR	Australian Rainfall and Runoff
ARTC	Australian Rail Track Corporation
ASRIS	Australian Soil Resource Information System
ATMS	Automated Train Management System
BOQ	Bill of Quantities
CAPEX	Capital Expenditure
DAF	Department of Agriculture and Fisheries
DATSIP	Department of Aboriginal and Torres Strait Islander Partnerships
DBYD	Dial Before You Dig
DEHP	Department of Environment and Heritage Protection
DIRD	Department of Infrastructure and Regional Development
DNRM	Department of Natural Resources and Mines
DOTARS	Department of Transport and Regional Services
DTM	Digital Terrain Model
EIS	Environmental Impact Statement
EP	Environmental Protection Act 1992
EPBC	Environmental Protection and Biodiversity Conservation 1999
EVNT	Endangered, Vulnerable and Near Threated
FHWA	Federal Highway Administration
GIS	Geographic Information System
GRC	Goondiwindi Regional Council
GSQ	Geological Survey of Queensland
HVR	High Value Regrowth
IRAS	Inland Rail Alignment Study
ISCA	Infrastructure Sustainability Council of Australia
LiDAR	Light Detection and Ranging
MBIR	Melbourne to Brisbane Inland Rail
MCA	Multi Criteria Analysis
MSES	Matters of State Environmental Significance
NC	Nature Conservation Act 1992
NSW RING	New South Wales Rail Infrastructure Noise Guideline
OPEX	Operational Expenditure

Abbreviation	Description
PMST	Protected Matters Search Tool
PRG	Project Reference Group
PUP	Public Utility Providers
QLUMP	Queensland Land Use Mapping Program
QR	Queensland Rail
QUDM	Queensland Urban Drainage Manual
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RE	Regional Ecosystem
RFFE	Regional Flood Frequency Estimation
SDPWO	State Development and Public Works Organisation
SRN	Stock Route Network
TEC	Threatened Ecological Communities
TMR	Department of Transport and Main Roads
TRC	Toowoomba Regional Council
TUFLOW	Two-dimensional Unsteady FLOW
URBS	Unified River Basin Simulator
VM	Vegetation Management Act 1999
WBS	Work Breakdown Structure

1.5 Assumptions and Limitations

All four of the investigation corridors will have equivalent investigation and analysis applied. All four investigation corridors will all progress through the MCA and cost estimate process even if they may have previously been perceived as not to be compliant with the requirements of the Service Offering.

The analysis contained in this study relates to the four nominated corridors. Only minor local corridor changes to the nominal alignments within these corridors have been assessed and consideration of alternative routes or corridors is outside the scope of this project.

The investigation corridors are defined by a 2km wide study area for each of the four options. For this project, only locally impacted properties and infrastructure have been assessed. The broader benefits and/or impacts to a community or region are outside the scope of this project.

Signalling not directly assessed in the MCA or the cost estimate as the Automated Train Management System (ATMS) is being managed by ARTC and is therefore excluded from this study.

The assessment in this report is controlled by the requirements of the MCA Framework, criteria and weightings, which have been supplied by ARTC and have been used across the whole of the MBIR programme. Where possible, quantifiable data sources have been used to remove ambiguity and subjectivity of opinion. Some environmental criteria have a greater degree of subjectivity and as such are more difficult to assess. The approach used in the MCA assessment for these more subjective items has been to utilise sensitivity testing to assess what impact, if any, there may be to the overall result.

This study is limited to the assessment between Yelarbon and Gowrie. The impact on adjoining sections and/or the overall MBIR Service Offering is not within the scope of this study.

1.6 Key References

ARTC: Melbourne-Brisbane Inland Rail - Basis of Design, September 2015.

Atlas of Living Australia database, 17 October 2016

Australian Rainfall and Runoff Project 11 - Blockage of Hydraulic Structures, 2016

Australian Soil Resource Information System, 2014

Basis of Design for Inland Rail, Parsons Brinkerhoff, 2015

Condamine River and Tributaries Flood Study, Southern Downs Regional Council, March 2012.

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DEHP's HVR mapping, DNRM, 2016

DEHP's Protected Plants Flora Survey Trigger Area mapping, DEHP, 2014b

DEHP's Wetland mapping, Queensland Herbarium, 2015b

Department of Agriculture and Fisheries' Queensland waterways for waterway barrier works data set

Department of Natural Resources and Mines' Ordered Drainage 100K for Queensland

Department of Natural Resources and Mines Baseline Roads and Tracks Database Queensland, 2016

Environment Protection and Biodiversity Conservation Act, 1999

EPBC Act Protected Matters Search Tool, 17 October 2016

Fisheries Act, 1994

Melbourne-Brisbane Inland Rail Alignment Study - Department of Infrastructure, Transport, Regional Development and Local Government, 2010

Melbourne-Brisbane Inland Rail Engineering and Technical Services Alignment Refinement Report - ARTC, 2015

Melbourne-Brisbane Inland Rail Options Analysis Project Department of Transport and Main Roads, 2015

Nature Conservation Act, 1992

New South Wales Rail Infrastructure Noise Guideline, 2013

North-South Rail Corridor Study - Department of Transport and Regional Services, 2006

Preliminary Environmental Assessment Report: Karara-Leyburn Route Option, AECOM, 2017

Preliminary Environmental Assessment Report: Warwick Route Option, AECOM, 2017

Queensland Globe watercourse layer

Queensland Government Department of Natural Resources and Mines, Detailed Regional Maps, 2008

Queensland MSES mapping, DSIP, 2015

Queensland Urban Drainage Manual, 2013

RE mapping, Queensland Herbarium, 2015a

State of Queensland Qspatial Catalogue, October 2016

Vegetation Management Act Stream order mapping, DNRM, 2015

Vegetation Management Act, 1999

Wildlife Online Database Search, 17 October 2016

2.0 Previous studies

A number of previous studies with varying level of analysis have considered differing routes within Queensland to provide a freight corridor between Melbourne and Brisbane. These are:

- 2005-2006 North–South Rail Corridor Study - Department of Transport and Regional Services
- 2008-2010 Melbourne–Brisbane Inland Rail Alignment Study – Department of Infrastructure, Transport, Regional Development and Local Government
- 2015 MBIR - Engineering and Technical Services Alignment Refinement Report – ARTC
- 2015 MBIR Options Analysis Project, Department of Transport and Main Roads.

This section provides a summary of these previous studies, the background to the study and their respective recommendations that have led to the current phase of study works analysing the four route options between Inglewood and Gowrie.

2.1 2005-2006 North–South Rail Corridor Study Executive Report - Department of Transport and Regional Services

The North-South Rail Corridor Study was announced by the Minister for Transport and Regional Services, the Honourable Warren Truss MP on 17 September 2005. The Study was commissioned by the Australian Government Department of Transport and Regional Services (DOTARS) and carried out by Ernst & Young, Hyder Consulting Pty Limited and ACILTasman Pty Limited. This report was developed in close consultation with the rail industry, including the Australasian Railway Association Inc. (ARA), major current rail freight operators and the Australian Rail Track Corporation (ARTC). Contributions were received from a broad representation of stakeholder organisations, including state governments, local councils and ACCs, current and potential freight users, rail operators and investors and interested parties.

The North-South Rail Corridor (the Corridor) study area comprised an elliptically-shaped area defined by the standard gauge rail line along the New South Wales coast, and a broad arc west of Shepparton, Jerilderie, Coonamble, Burren Junction, Goondiwindi and Toowoomba. This area embraces all sections of the existing rail network in Victoria, New South Wales and Queensland that currently forms, or could potentially form, part of a freight route between Melbourne and Brisbane. Four main corridors were identified for comparative analysis and the Far Western Sub-Corridor was adopted for further refinement in the Melbourne–Brisbane Inland Rail Alignment Study.

Although no recommendations were made in this report, the Far Western Sub-Corridor provides the shortest transit journey from north to south with the routes considered varying in length from 1,657 km to 1,926 km. This Sub-Corridor also avoids the impact of Sydney rail traffic congestion as it does not pass through the Sydney metropolitan area. This corridor forms the basis of the MBIR alignment study.

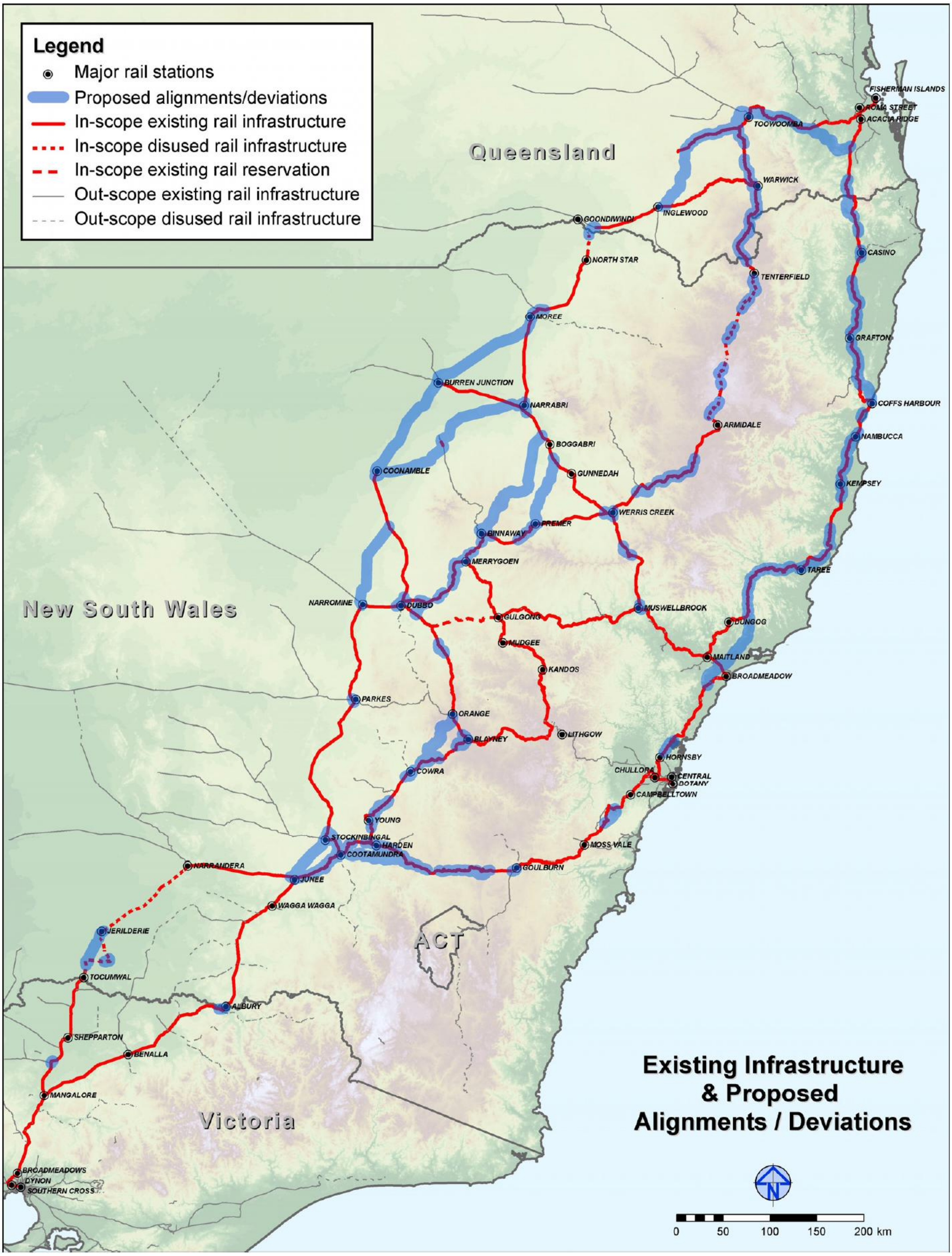

Figure 2 Route Options considered for the corridor

2.2 2008-2010 Melbourne–Brisbane Inland Rail Alignment Study – Department of Infrastructure, Transport, Regional Development and Local Government

The Melbourne–Brisbane Inland Rail Alignment Study (IRAS) was announced by the Minister for Infrastructure, Transport, Regional Development and Local Government, the Honourable Anthony Albanese MP on 28 March 2008. The study aims were to determine the optimum alignment as well as the economic benefits and likely commercial success of a new standard gauge inland railway between Melbourne and Brisbane. It was intended to provide both the Government and the private sector with information that would help guide future investment decisions, including likely demand and the estimated construction cost of the line, and a range of possible private financing options.

ARTC was asked to conduct the study, building on work undertaken earlier in the North-South Rail Corridor Study. The route to be developed would generally follow the far western sub-corridor identified in that study. As well as determining the route alignment, the Minister stated that ARTC study would provide both the Government and private sector with information that would help guide their future investment decisions, including likely demand and an estimated construction cost. The study would provide the Government with a basis for evaluating private financing options for part or the entire project. The Minister also requested that the study be customer-focused and consultative, involving discussions with state governments, industry, local government and major rail customers.

The IRAS study evaluation framework was based on three broad criteria: Cost (capex), Journey Time and High Level environmental impacts

The route defined in the 2010 Study determined the optimum broad corridor as the basis for progressing further investigations to resolve the fine-scale alignment and details. The IRAS route underpins the current Inland Rail program. ARTC is undertaking more detailed studies to support further approval and implementation of the program.

The Toowoomba and Little Liverpool ranges represent a considerable operational challenge to the inland railway project meeting its required performance criteria. The challenge in developing an optimal route for the Inglewood to Acacia Ridge section was to balance transit time with capital expenditure. Considerable design work and analysis was performed in this region which went beyond the depth of a range of prior studies. This analysis confirmed that almost 50% of the capital cost estimated for an inland railway would be incurred over this last 26% of the route distance, as the line descends from an elevation of 690 m at Toowoomba or 450 m at Warwick to 60–80 m over a horizontal distance of approximately 20–30 km. Rather than stopping at Toowoomba, which would have a negative impact on the viability of the line, the optimal route was confirmed to reach Brisbane.

Two distinct route options emerged, these being:

- The Warwick route – a new ‘greenfield’ route via Warwick to the existing standard gauge Sydney–Brisbane line. This had the potential to reduce distance by providing a more direct link to the south side of Brisbane. Such a line would cross the range to the east of Warwick and traverse parts of the Main Range National Park near the NSW/Queensland border.
- The Toowoomba route – a new corridor direct from Inglewood to Millmerran and Oakey, near Toowoomba, and then a new alignment down the Toowoomba range; thence using the proposed Southern Freight Rail Corridor from Rosewood to Kagaru.

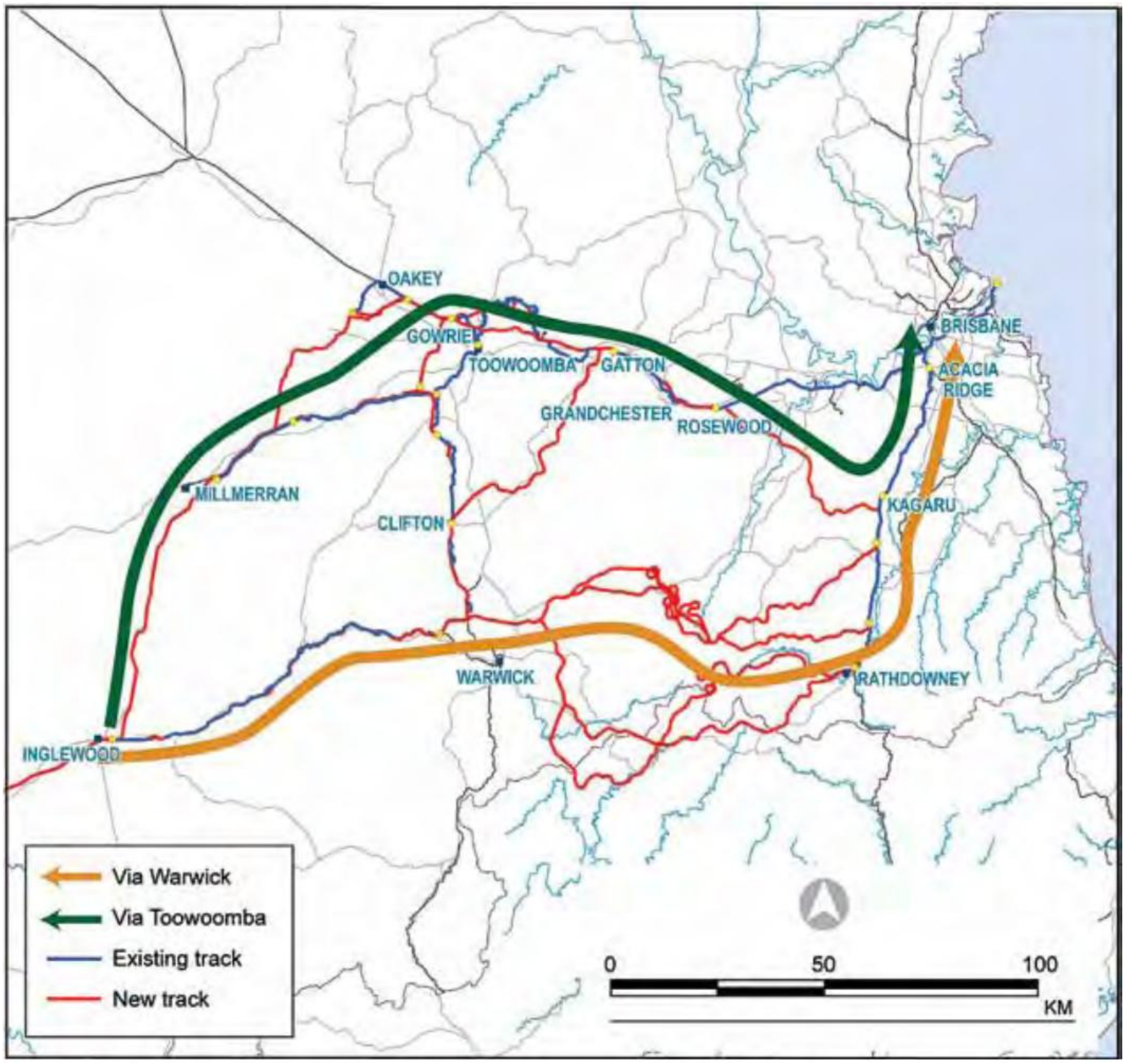

Figure 3 Primary route options to reach Brisbane

The report identified that increasingly high capital costs are required to achieve the shortest journey times. The most expensive options were therefore not analysed further – in particular, no options via Warwick or Shepparton were considered further.

There was not a sufficient demand change nor a sufficient impact on economic viability (brought about by a 45 minute reduction in the journey time) to justify additional capital expenditure of around $1 billion. If such a reduction in transit time was identified as significant, it could be achieved in a more cost effective manner by adding crossing loops to reduce crossing delays, rather than adopting a more expensive route via Warwick. In any event, demand on the route via Warwick would have been lower because it would not have carried coal from Toowoomba to Brisbane.

The results of the analysis indicated that the route via Toowoomba had stronger economic merit. Although the Warwick routes were faster than the Toowoomba options, they were also significantly more expensive. Although approximately 20 minutes would be saved, this would be at a cost of almost $450 million. As such the route identified Toowoomba was chosen in the 2010 IRAS study.

2.3 2015 MBIR - Engineering and Technical Services Alignment Refinement Report – ARTC

The key drivers for the review of the 2010 Base Case were changes to constraints over the elapsed period and the opportunity to optimise the alignment to better suit known constraints. The purpose of the Alignment Refinement Report was to document the Alignment Refinement task methodology, the review and assessment outcomes and the recommendations for the ARTC's Inland Rail Program. The reports intent is to build confidence in the Melbourne to Brisbane alignment.

This information provides a robust foundation for the next steps of site investigations, property negotiations, environmental assessment and approvals. This includes services briefs that support field investigations for geotechnical and environmental data and validation, stakeholder engagement, reference design preparation and ultimately detailed design and construction of Inland Rail.

The Alignment Refinement Report provided ARTC's internal stakeholders with a summary of the process, outcomes and recommendations of the review to establish certainty of the alignment and its impacts and support progression into the implementation phase and engagement with the program stakeholders.

Existing track sections forming part of the Inland Rail Base Case were not assessed as part of this study.

The Alignment Refinement task focused on reviewing changed legislation, constraints, risks and requirements and explored opportunities to enhance and improve the alignment, and with improved data to minimise and mitigate risks.

A refined Melbourne to Brisbane Inland Rail alignment was recommended as part of this report with the intent that this would form the basis for ongoing design development, scope definition and cost estimates.

An alternative alignment that deviated more than 100 m from the Base Case was defined as 'Corridor Change' and developed and assessed through a Multi-Criteria Assessment (MCA) process. The MCA framework was developed from processes implemented on similar large scale projects in Australia that met Federal Government and Infrastructure Australia requirements and resulting in transparent and auditable outcomes.

Minor changes to alignments within 100 m of the Base Case were considered normal design development and defined as Alignment Improvements. The concept assessment phase of alignment development provided sufficient information to allow the selection of the preferred Inland Rail alignment and inform targeted investigations and design development.

While a preferred alignment is recommended, it is at a preliminary concept level of design and valid alternatives still remain in a number of route sections. Following site investigations, further development of the designs, consideration of detailed costing and stakeholders and community engagements, the MCA process will be reviewed to finalise the alignment.

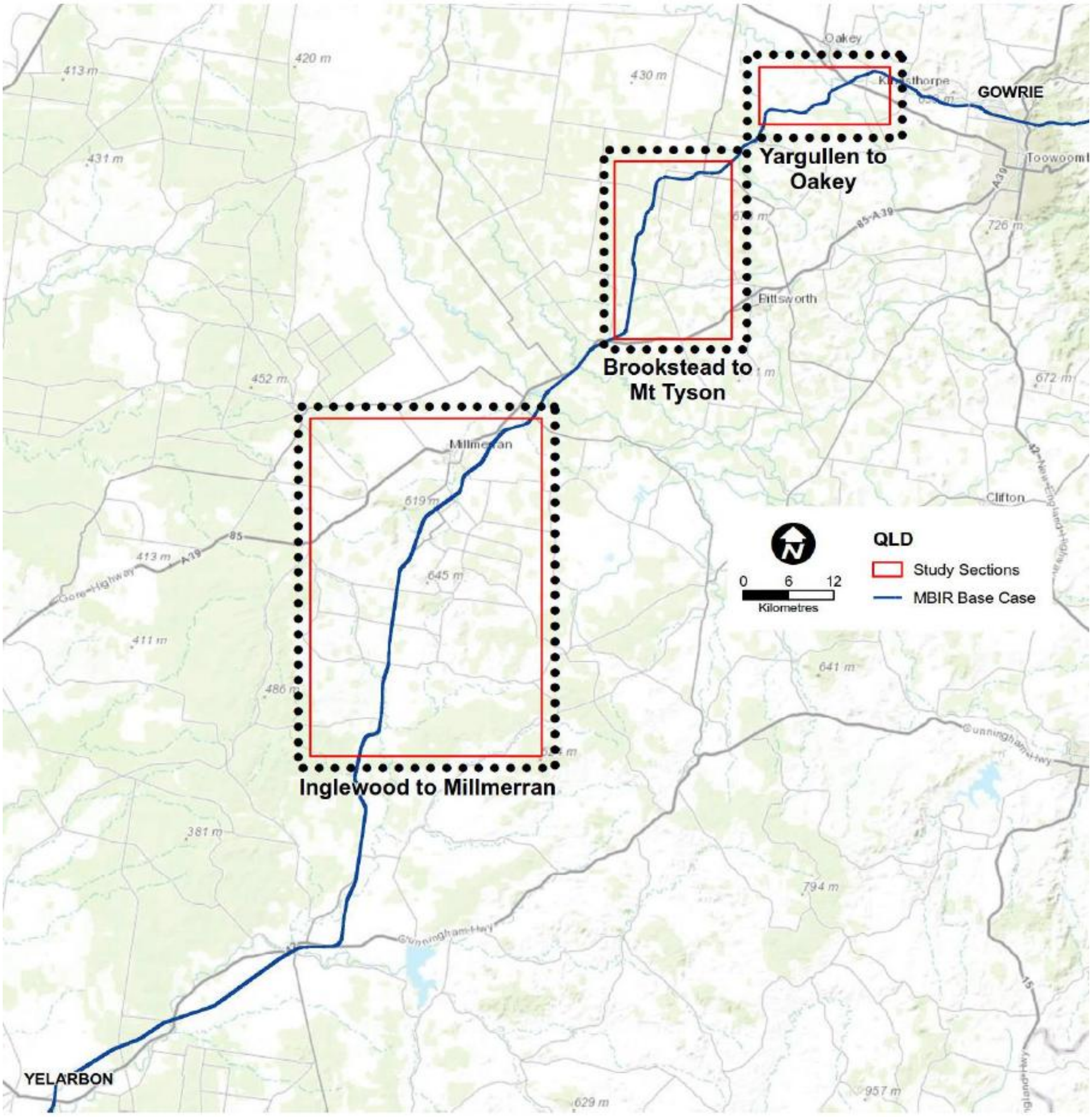

Figure 4 Yelarbon to Gowrie Route selection

The Inland Rail alignment between Yelarbon and Inglewood utilises Queensland Rail's existing South Western narrow gauge rail network. A review of the existing Queensland Rail alignment was not part of the scope of the alignment refinement task within the 2015 Alignment Refinement Report study. Therefore, alignment improvements and corridor revision had not been considered for the brownfield route section between Yelarbon and Inglewood. The Base Case alignment defined by the 2010 IRAS was reconfirmed from this report, with a number of refinements noted for future project phases.

2.4 2015 MBIR Options Analysis Project Department of Transport and Main Roads

The Department of Transport and Main Roads (TMR) commissioned SMEC to undertake a high level examination of feasible alternative route options not previously considered in the ARTC Melbourne to Brisbane Inland Rail freight route in 2010, that may offer better outcomes for both Queensland and the MBIR itself.

While ARTC recommended a preferred alignment in the 2010 IRAS report, a variety of alternative alignments and deviations were also considered within this report. These, together with deviations and refinements identified by TMR and Queensland Rail form the basis of the SMEC study.

The report initially considered and assessed a number of alignment options (including possible alternatives) against a list of known constraints and assembled as a "Long List" labelled Options A through to Option F. Environmental approval requirements and risks were identified at the strategic level, with a focus on the Queensland approvals pathway and processes. The long list was further refined to develop a "Short List". These options represent the most feasible rail alignments that the report identified between North Star and Gowrie.

The report examined a number of constraints at a strategic level. These included the alignment performance, potential flood plain impacts, geotechnical conditions, environmental and land use impacts, service utility impacts, land use and property impacts, community impacts, anticipated stakeholder sentiments, and current and future economic opportunities in developing the Short List. In addition, the study reviewed the need for supplementary infrastructure such as the need to replace existing bridge structures and build new bridges. The derived Short List of alignment options was taken forward as Options 1 through to Option 4 as shown below in **Table 9**.

A strategic comparative cost estimate was prepared for each of the Short Listed options within the MBIR Options Analysis report. The results of this are shown below in **Table 9**.

Table 9 Strategic Comparative Cost Estimates from TMR MBIR Options Analysis Report

Option	Description	Strategic Comparative Cost Estimate ($million)
1	North Star to Gowrie via Millmerran and Mt Tyson – ARTC 2010 alignment	3,070
2	North Star to Gowrie via Brookstead and Pittsworth	3,030
3	North Star to Gowrie via Karara and Umbiram	3,020
4	North Star to Gowrie via west Warwick and Wyreema	4,050

The report noted that from a cost estimate point of view, Option 4 is the most expensive. However, the cost estimates for Option 1, Option 2 and Option 3 were more closely aligned and could not be used as a means of ruling out any other options from further consideration. The report also noted the costs presented are intended to be strategic comparative estimates only and should not be interpreted as project costs.

The intent of the study was to identify the potential economic drivers and benefits that could be derived from an alternate alignment.

The study undertaken was at a strategic level with high level comparisons made between, distance, transit time, Capital Cost, Community / Stakeholder sentiments, Economic Opportunities, Agricultural Land Use, Environmental and Heritage Impact,

Terrain and Future Opportunities with the information available to the study team at the time the assessment was undertaken. Limited technical engineering was undertaken to validate the technical aspects of the routes against the ARTC Inland Rail Service Offering requirements.

The study recommended further analysis of the identified shortlisted. As such the report suggested a number of additional investigations that could be undertaken for further study into the development of alternative route options as part of the proposed MBIR including:

- *Development of feasible alignment(s) based on the preferred route option, supported by sufficient engineering detail to evaluate the land footprint required for a connection between North Star to Gowrie, and development of earthworks quantities and assessment of requirement for bridge structures, etc.;*
- *Further proofing of the Option 3-Alt alignment via Karara/Thane/Felton South including the preparation of a basic alignment model and earthwork quantities;*

- Concept design for Freight Terminal at Wellcamp-Charlton to future proof for 3,600m trains, and freight and passenger to Brisbane West Wellcamp Airport;
- Analysis of the alignment around the airport to Kingsthorpe (including the need to ensure a reasonable grade in the order of 1:100 desirable or 1:60 max) and alignment options for a Kingsthorpe rail bypass to match;
- Collection of additional LIDAR imagery for the Option 3 corridor so as to inform the development of a more detailed alignment and cost estimate for comparison with Option 1;
- *Further work on alignment options east and west of Brisbane West Wellcamp Airport;*
- *Further assessment of the agricultural impacts and hydrological issues of crossing the Condamine floodplain near Brookstead under Option 1 and Option 3 near Leyburn so that an appropriate engineering solution can be developed and costed for comparison. This will also allow the implications at agricultural holdings during flood events to be clearly considered in both option selection and design treatments, including consideration of upstream inundation (duration and depth), impacts to property access (to and within agricultural holdings), and implications for downstream areas (e.g. environmental flows, and soil conservation issues);*
- *Further assessment of the land and agricultural impacts is undertaken to determine the policy for partial or full resumption requirements;*
- *Undertake a more detailed assessment of the local road network with a view towards developing a more detailed understanding of the need for grade separation and in so far as possible the retention of at grade crossings of the lesser minor roads. This remains a key concern for communities, industry and agricultural operations.*
- *Relevant stakeholders are identified and engaged in accordance with applicable processes throughout the design process;*
- *Confirmation of any environmental and statutory approvals that is required to progress the proposal;*
- Additionally, consideration for undertaking works on or near the existing sections of the Queensland Rail network should be considered, and assessed for their impacts on existing operations. This includes consideration of contaminated land within the existing rail corridor.
- Impact of the MBIR alignment and gauge on the infrastructure and operations of the existing QR network including South Western and Western Systems.
- *A more formal multi criteria analysis is undertaken against an agreed set of weighted assessment criteria that considers the key objectives, of not only TMR, but ARTC and other stakeholders before confirming the preferred route option.*

The recommendations from this report in italics above have been considered as part of this corridor options assessment. The additional recommendations above were either not considered relevant or the information wasn't available for this study.

3.0 Corridor option origins

The four investigation corridors that have been nominated by Minister Chester for options analysis have evolved over a period of time, under differing levels of investigation and for varying purposes.

The four options are listed below:

1. The Base Case Modified
2. Wellcamp-Charlton
3. Karara-Leyburn
4. Warwick

The Base Case Modified alignment has evolved from the 2010 IRAS Base Case alignment. This alignment was further developed through the 2015 and 2016 Phase 1 Concept Studies by ARTC. The key changes include the bypass of Inglewood and the section from Yargullen to Kingsthorpe.

The three alternative alignments that have been nominated by Minister Chester were documented in a report by SMEC, the *MBIR Options Analysis Project, Issues Identification and Alignment Refinement of the ARTC Inland Rail Alignment between Toowoomba and the NSW Border –Final Report, 16th December 2015*. This report was tabled in the Queensland Parliament by the Member for Southern Downs, Lawrence Springborg in September 2016.

The aim of the report by SMEC was to examine feasible alternative route options between North Star and Gowrie Junction. This study took previously considered ARTC alignments along with deviations identified by TMR and Queensland Rail.

The report prepared an initial “Long List” of options which were further refined to a “Short List”, which consisted of four options with an additional sub-option between Karara and Felton East. The four options align with the Base Case Modified and three alternatives that are under comparative assessment in this report.

The report noted that a more formal multi criteria analysis be undertaken against a set of weighted assessment criteria, that considers stakeholder and project objectives, be performed before confirming the preferred investigation corridor. This proposed approach is being undertaken as part of this study.

4.0 Methodology

The aim of the corridor options assessment is to review and assess the four corridor options put forward. The following section describes at a high level, the methodology undertaken to produce this assessment with details on specific criteria expanded on in the following sections.

In order to ensure a like-for-like assessment between options each alignment was refined to conform to the ARTC Service Offering. This is detailed in **Section 5.0**.

In order to assist the MCA process and to provide clarity, regular PRG sessions were held. These were used to provide selected members of the community regular updates on the assessment process. It also enabled valuable feedback to the project team on key issues and criteria that should be incorporated into the assessment.

The PRG sessions also expanded to include site visits and community Drop-In sessions. The site visits were to detail existing flood heights and extents and visually assess the geotechnical conditions along the four alignments. The drop in sessions provided openness and clarity to the wider community not directly part of the PRG and provided an additional way for the project team to take on community concerns and additional issues that could be relevant to the assessment process. The PRG process is detailed in **Section 6.0**.

Once the alignments were refined, each was assessed by all disciplines to determine key metrics and values that would provide differentiators for the MCA process and the cost estimate. The specific metrics for assessment were chosen to align with the MCA criteria provided by ARTC, which is detailed in **Section 1.3.1.2**. Key values and information from the assessment were added into the MCA scoring sheet under the relevant section criteria.

In parallel to the options assessment, key values were input into a Bill of Quantities (BOQ) to enable a cost estimate to be undertaken for each option. As part of this estimate, risk ranging was also provided to the estimators to show the level of risk against each item in the BOQ as detailed in **Section 9.0**. Each alignment has differing attributes and hence differing risk profiles.

Once all relevant information was obtained and input into the MCA, an MCA scoring day was held. This involved technical representatives from each discipline who would know the key drivers for each assessment criteria in the MCA. In addition to the technical representatives a number of observes from the PRG were present to witness the scoring. Details of the scoring process are described in **Section 8.0**.

Following the MCA scoring day, the cost estimate was received from the quantity surveyors/estimators. Along with this report it will be issued to ARTC for inclusion in an assessment for the Minister of Infrastructure and Transport, the Honourable Darren Chester MP.

5.0 Refinement of alignments

The four options chosen for the corridor options assessment were refined so that they all comply with the Basis of Design. This section details the refinements for each option.

To ensure a like-for-like assessment, the nominal alignments were all based on the same source data. The most detailed ground topography available for all four options was the 5 m DTM supplied by The State of Queensland Qspatial Catalogue October 2016. Therefore, this was used as the ground surface for all four alignment designs.

All alignments start approximately 19 km south west of Inglewood on the QR South Western Line and finish approximately 0.5 km west of Gowrie Junction on the QR Western Line. Maps of all four alignments are shown in **Appendix B.**

ARTC has a preference to utilise existing railway corridors where feasible. The existing railway corridors that are proposed to be used for the four options are the:

- West Moreton line to the west of Toowoomba
- Southern Railway from Toowoomba to Warwick
- South Western Railway from Warwick to Yelarbon via Karara and Inglewood
- Millmerran Brach Line
- Cecil Plains Line.

The ability to use the existing railway corridors needed to be assessed against the ARTC design standards, which underpin the ARTC Service Offering.

In many instances the design standards used within the existing corridors do not comply with the ARTC geometric design standards or flood immunity requirements. For example, the minimum preferred gradient for the ARTC standard is 1 in 100 and 1 in 80 for mountainous terrain, while the existing South Western Line has grades as steep as 1 in 50. The ARTC design parameter for minimum horizontal curves is a radius of 800 m while the South Western Line has 200 m radius curves and back to back 300 m radii curves. Therefore, the ability to use the existing railway corridor is not guaranteed. In many instances the ultimate alignment will not be able to directly follow these existing corridors and may in fact only follow them from a relative direction perspective. This constraint has a direct impact on the route options assessment methodology.

5.1 Base Case Modified

The Base Case Modified alignment was based on the design produced by Aurecon / AECOM for the Yelarbon to Gowrie Phase 1 project. This alignment was designed using LiDAR data as it was available for the whole corridor.

The start of the alignment is now approximately 9 km north east of the original start point for the Phase 1 works, to provide a common start point with the three alternative alignments. To ensure the design was like-for-like with the alternative options the vertical alignment has been reviewed and amended to suit the 5 m DTM data. No change has been made to the horizontal alignment since the previous phase works.

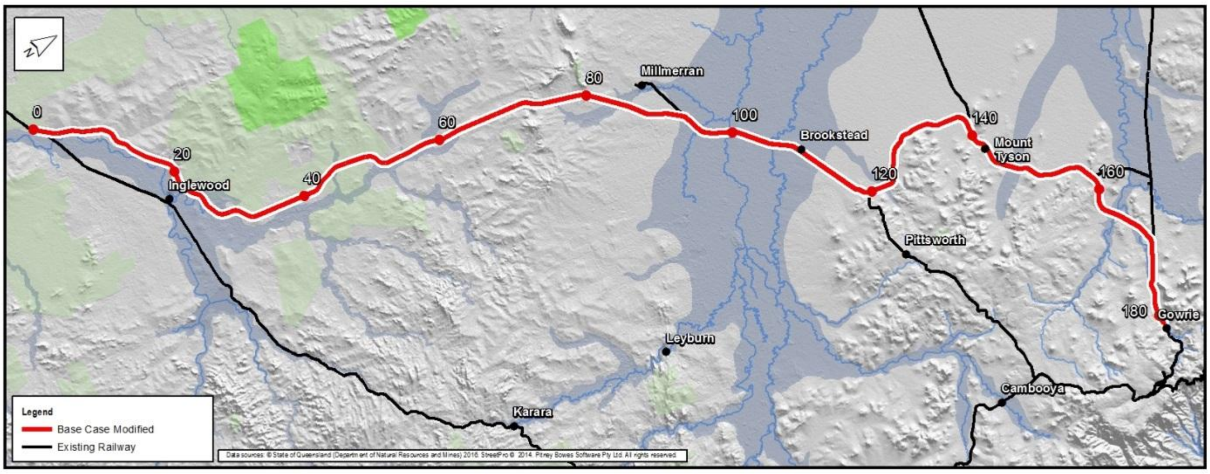

Figure 5 Base Case Modified alignment

5.2 Wellcamp-Charlton

The Wellcamp-Charlton option was originally investigated prior to the PRG as a modification to the Base Case Modified route, it passes to the west of Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). It was added to the options assessment to ensure all potentially viable options were assessed. Wellcamp Airport, part of the Wellcamp-Charlton Industrial Precinct, is also a significant change to the local infrastructure since the earlier studies. In addition, because Karara-Leyburn and Warwick options passed the Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) it provided a like-for-like assessment with the Base Case Modified alignment as a sub-option.

This section of alignment was chosen from previous phase works assessing options past Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). A GIS least-cost path assessment was initially carried out to provide a number of high level options that passed Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). These were then refined by the design team to enable an MCA to be undertaken. The preferred alignment from the MCA has been used for the Wellcamp-Charlton option. The alignment also follows a path as nominated in the MBIR Options Analysis Project report for TMR in December 2015.

This alignment follows the Base Case Modified until approximately CH 119 km halfway between Brookstead and Pittsworth. The alignment deviates at this point to pass on the western side of Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) before tying back into the Base Case Modified alignment at approximately CH 178 km. As with the Base Case Modified, the vertical alignment has been amended to suit the 5m DTM data. No change has been made to the horizontal alignment since the previous phase works.

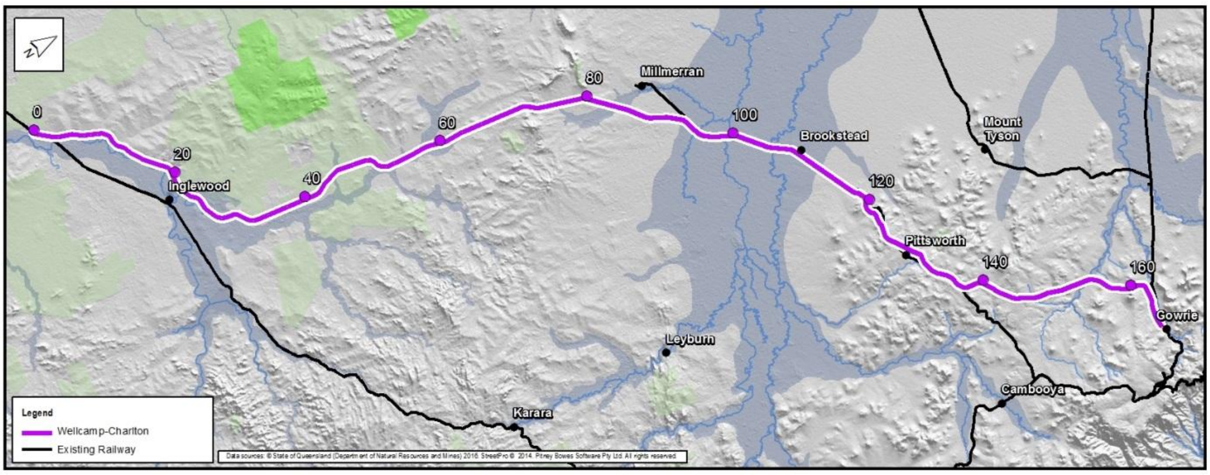

Figure 6 Wellcamp-Charlton alignment

5.3 Karara-Leyburn

The Karara-Leyburn option was the preferred alignment from the MBIR Options Analysis Project report for TMR in December 2015 and will be referred to as the TMR 2015 alignment or TMR 2015 report. This report assessed six alternative options against known constraints at the time to determine a preferred alignment.

For the current options assessment, a 2D horizontal alignment was provided. A vertical alignment was then designed using the 5m DTM data. In addition, the following horizontal alignment changes have been made from the original TMR 2015 alignment.

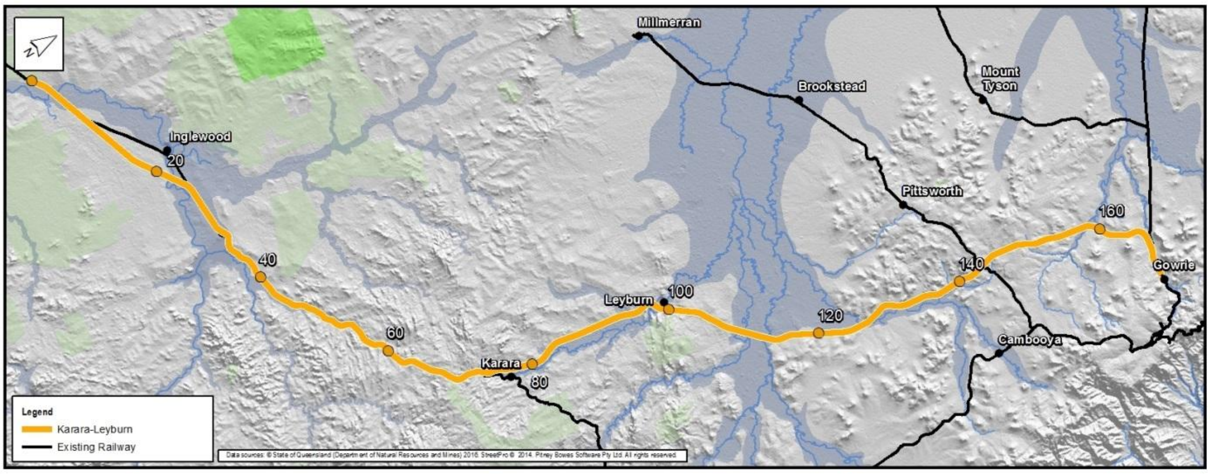

Figure 7 Karara-Leyburn alignment

5.3.1 Inglewood bypass

The Warwick and Karara-Leyburn corridors currently run through Inglewood following the existing Queensland Rail corridor. However, the Base Case Modified corridor had been realigned to bypass north of Inglewood as the result of the Yelarbon to Inglewood MCA undertaken on a previous phase of the project. The key drivers for this move as determined from the MCA were:

- **Roads.** Moving the Base Case corridor north reduced the number of road crossings and impacts to road users in Inglewood.
- **Flooding.** Impacts to the town would be reduced as the crossing would not impact the Macintyre Brook River running through Inglewood.
- **Community.** GRC stated they do not want the IR alignment running through Inglewood.
- **Environmental.** Visual, noise and air quality impacts would be removed by moving the corridor away from town.

In order to maintain a like-for-like assessment, and follow the methodology between corridors, a 'mini-MCA' was undertaken for the Warwick and Karara-Leyburn corridors to assess the option of moving the alignments for the Karara-Leyburn and Warwick options away from Inglewood to the south.

Only one alternative option was assessed due to the flat grades through the area. Alignment options further south were discounted due to the increased track length and steeper terrain. An option to the north following a similar alignment to the Base Case Modified was discounted as it would need to cross the Cunningham Highway and would result in a significantly longer alignment.

The original alignment along the existing South Western Line and Inglewood bypass option is detailed in **Figure 8.**

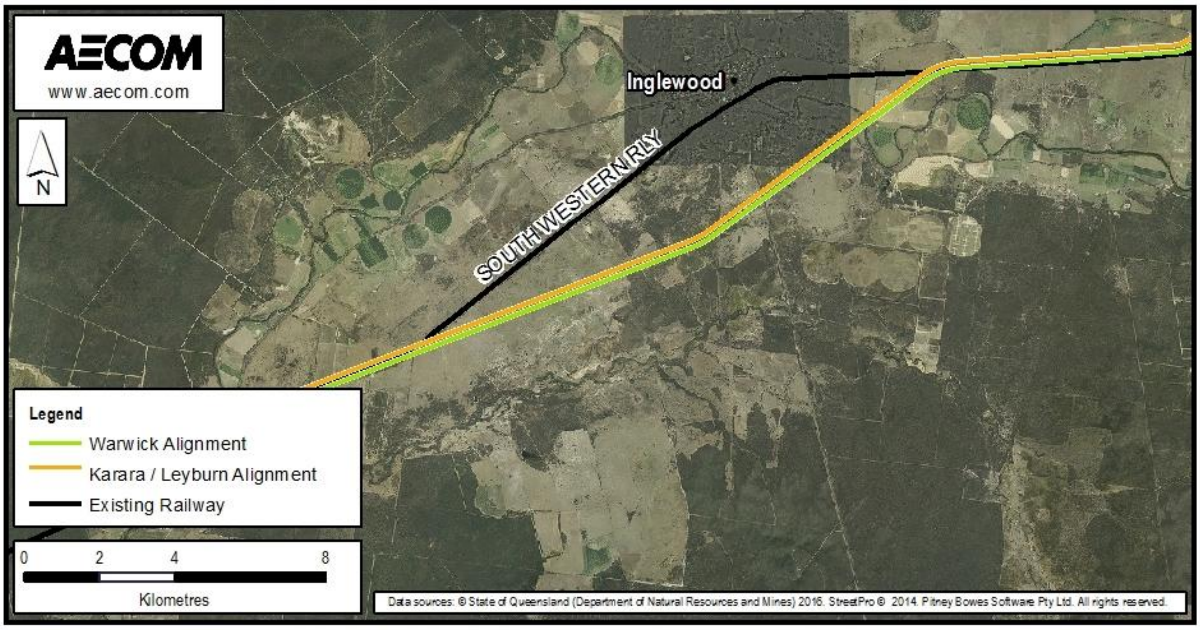

Figure 8 Inglewood bypass

The mini-MCA followed the same framework that is used across all study areas in this phase of the MBIR project, providing consistency across the programme of works. A summary of the key features assessed as part of the MCA is provided in **Table 10** with the category level MCA scores provided in **Table 11**.

Table 10 Inglewood bypass option summary

Option	Key Benefits	Key Constrains/Risks
4101 TMR 2015 alignment through Inglewood	· No property impacts as the alignment will be upgraded through existing corridor	· Interfaces with local roads in Inglewood · Possible flooding impacts to town from due to higher embankment required for flood immunity requirements · GRC stated the community does not want IR alignment running through town · Visual, noise and air quality impacts from · alignment running through town · Height of IR train will impact operation of airport as corridor is located at end of runway
4102 Inglewood bypass to the south	· Flooding impacts reduced as alignment located upstream away from Inglewood · Reduced road crossings with roads being of a more rural nature with less traffic away from town · Community wants alignment away from town · Reduces impacts for visual, noise and air quality	· 1.2km of route passes through endangered and of concern remnant vegetation · 20 free hold titles affected

Table 11 Inglewood bypass score summary

Criteria	Weighted Score	
	4101 Through Inglewood	4102 Bypass Inglewood
Technical viability	0	0.48
Safety assessment of the proposed alignment	0	0.30
Operational approach	0	0.58
Constructability and schedule	0	0
Environmental and heritage impacts	0	0.22
Community and property impacts	0	0.13
Approvals and stakeholder risk	0	0.25
Overall MCA Score:	0	1.96

A sensitivity analysis was undertaken on a number of sub-criteria where it was not obvious what scoring should be applied. Sub-criteria where a sensitivity analyses was performed were Impacts on PUP and Other Assets, Future Proofing and Emergency Response. Due to the strong scoring towards the bypass alignment the sensitivity assessment had no relevant impact on overall score.

The mini-MCA outcome was that the Inglewood bypass alignment to the south for the Warwick and Karara-Leyburn corridors is a significantly better option. This aligns with the Base Case Modified corridor which also moved away from Inglewood after a separate MCA was undertaken and ensures the corridors are like-for-like.

The Inglewood bypass alignment to the south for the Warwick and Karara-Leyburn options has therefore been adopted for the corridor assessment works.

5.3.2 Gore

From CH 63 km to CH 67 km the alignment has been modified in order to improve the vertical alignment and provide a better cut/fill balance. This has resulted in the horizontal alignment being realigned approximately 100 m north-west.

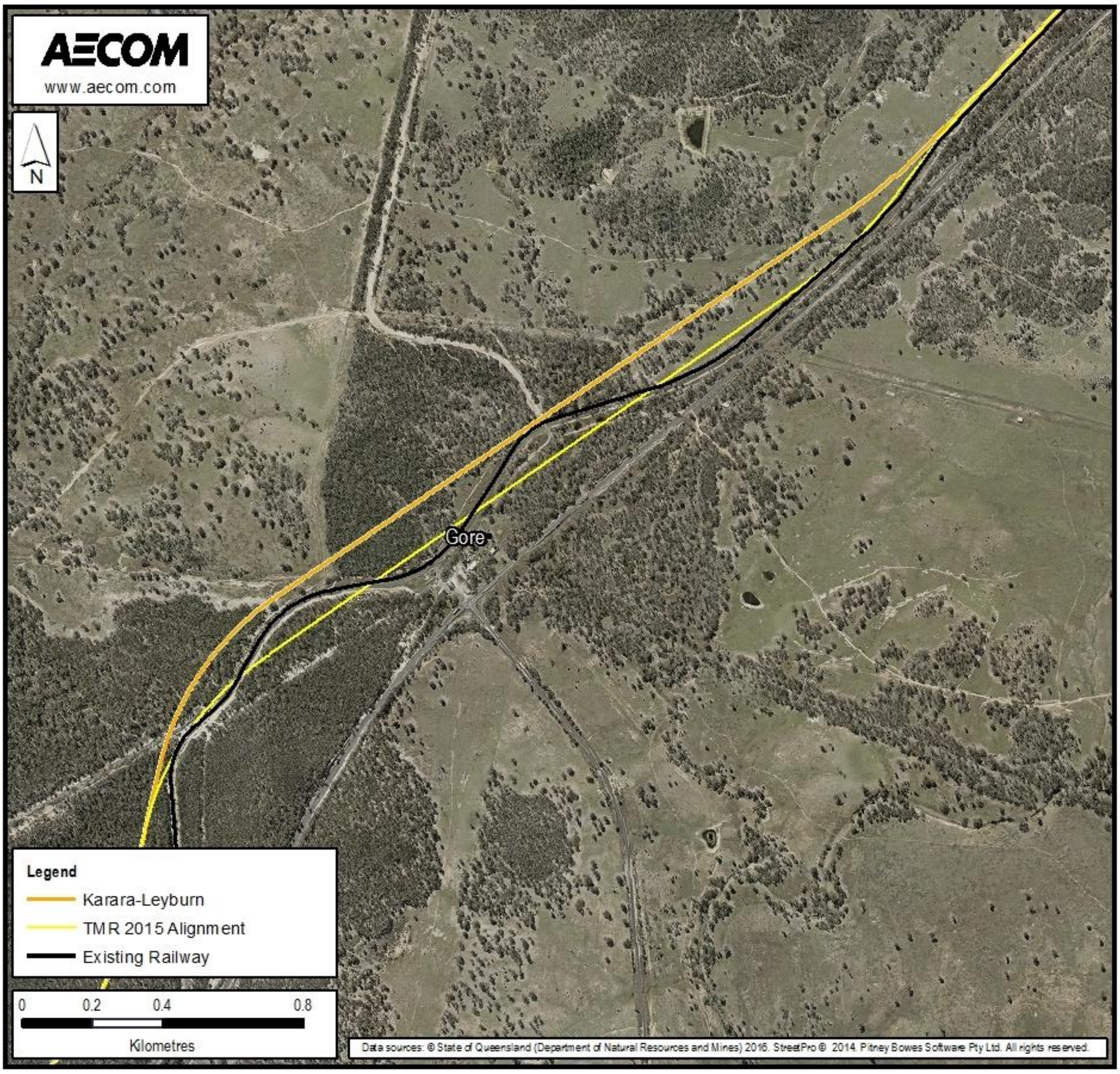

Figure 9 Gore realignment

5.3.2.1 South of Karara

From CH 69 km to CH 78 km the alignment has been modified in order to improve the vertical alignment and provide a better cut/fill balance. This has resulted in the horizontal alignment being realigned up to 150 m each side of original TMR 2015 alignment.

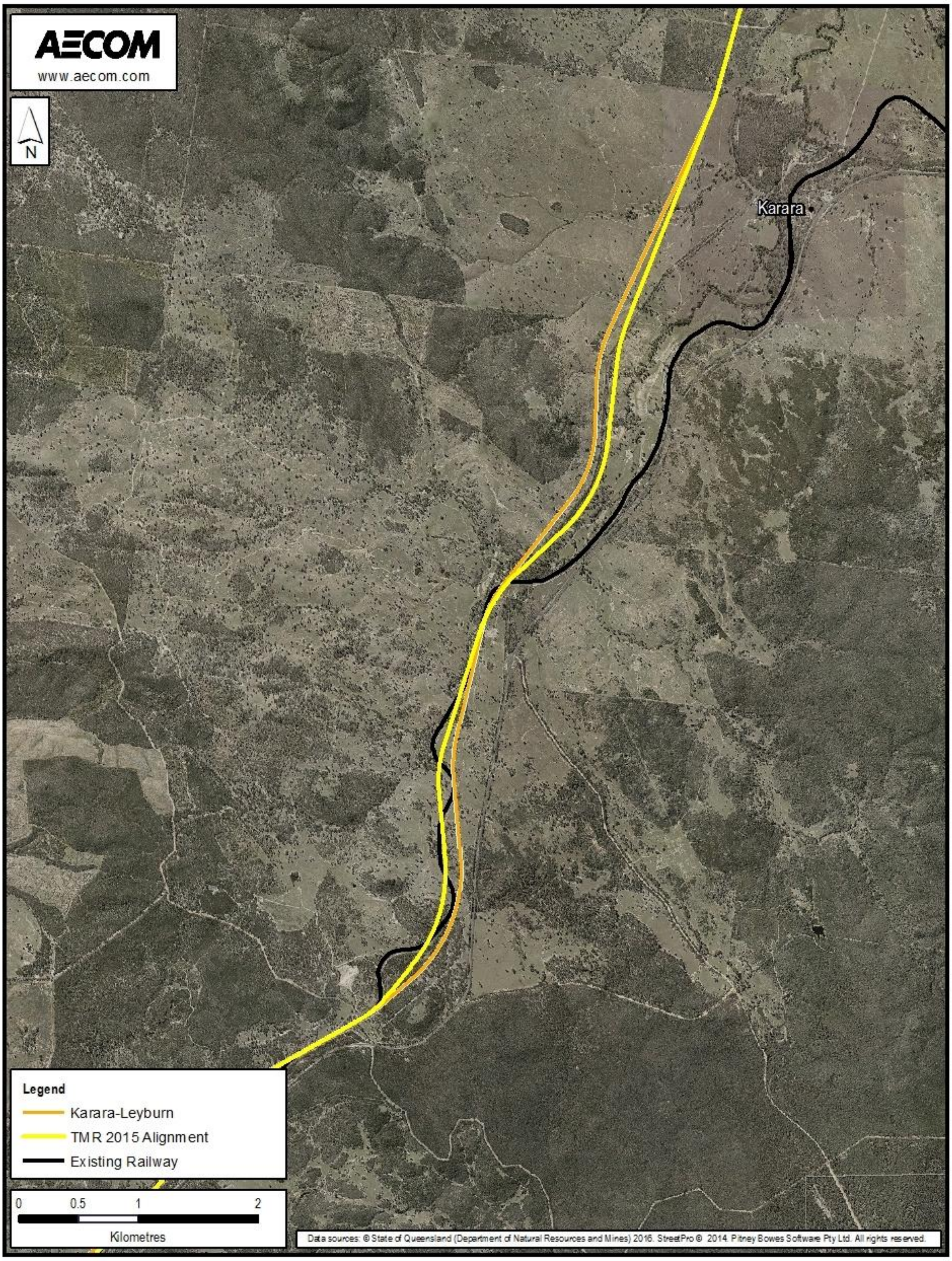

Figure 10 South of Karara realignment

5.3.3 North of Karara

From CH 81 km to CH 88 km the alignment has been modified in order to improve the vertical alignment and provide a better cut/fill balance. This has resulted in the horizontal alignment being realigned up to 160 m each side of original 2015 TMR alignment.

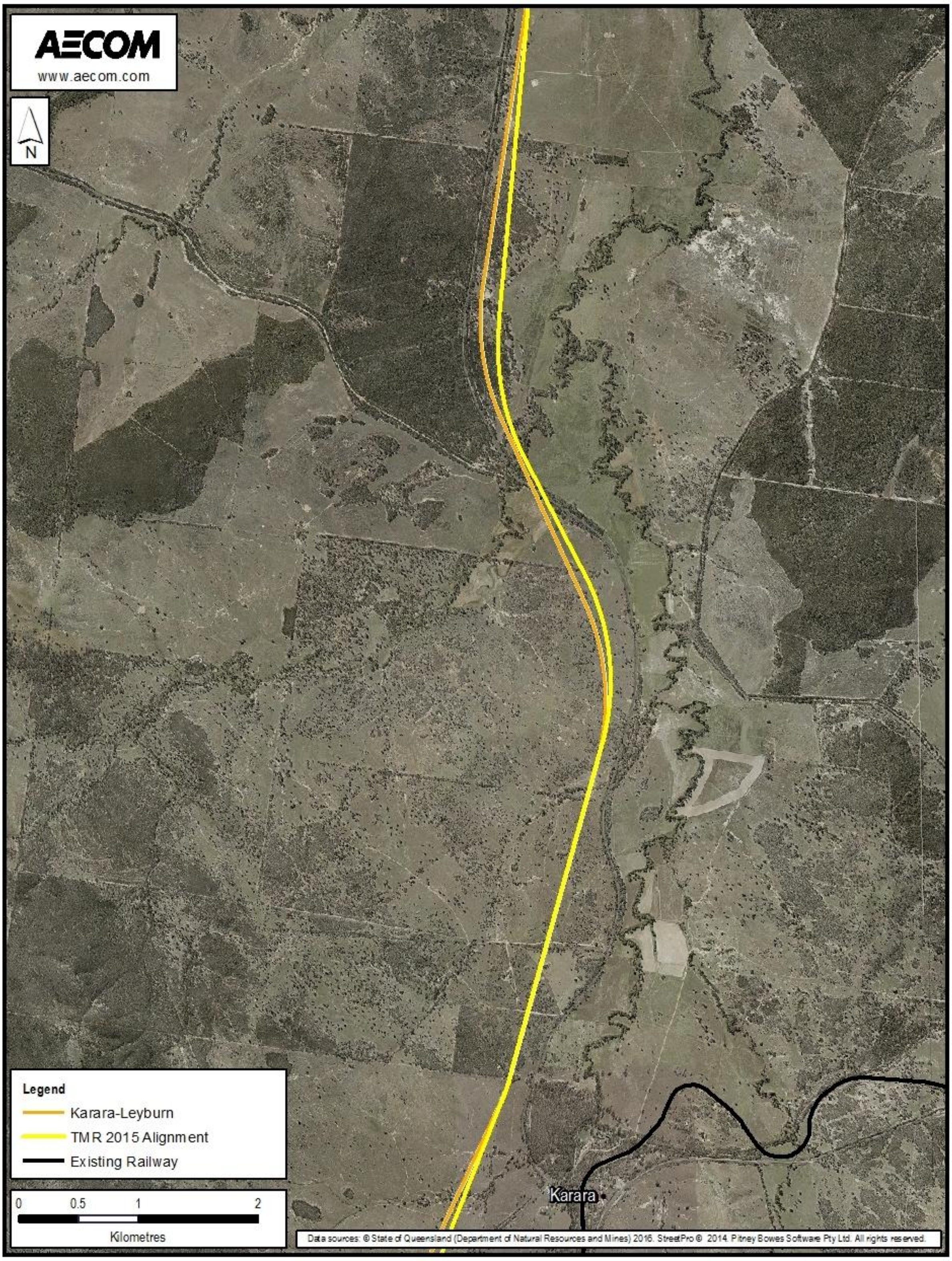

Figure 11 North of Karara realignment

5.3.4 Ellangowan

From CH 113 km to CH 117 km the alignment has been modified to miss a significant amount of farmyard infrastructure located on a property. This has resulted in the horizontal alignment being realigned up to 320 m to the east of original TMR 2015 alignment.

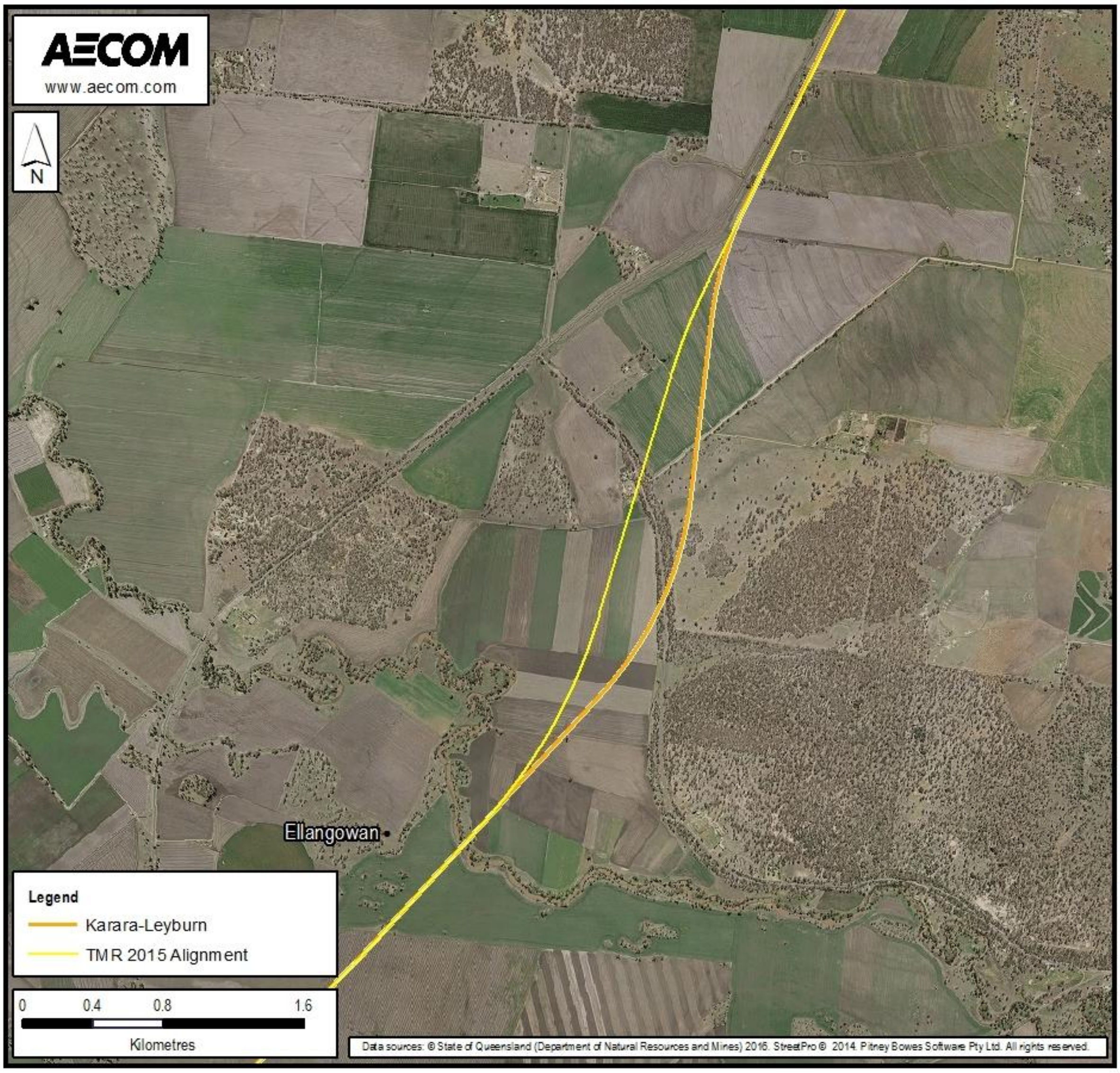

Figure 12 Ellangowan realignment

5.3.5 Felton

From CH 123 km to CH 138 km the alignment has been modified to minimise the impact to high value cropping land. This has resulted in the horizontal alignment being realigned up to 2.6 km to the west of original TMR 2015 alignment.

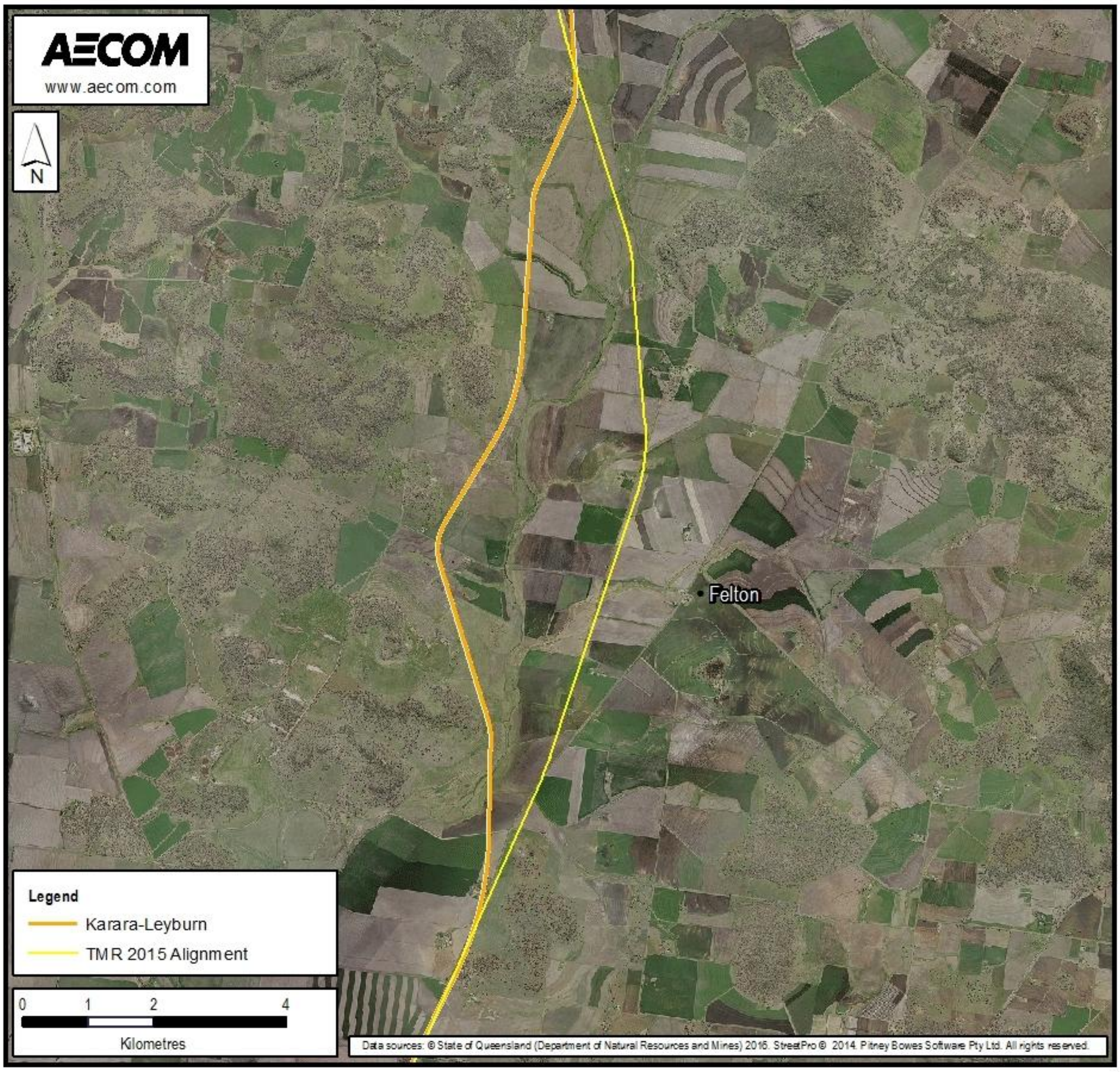

Figure 13 Felton realignment

5.3.6 Umbiram

From CH 138 km to CH 150 km the alignment has been modified to improve the vertical geometry to provide a better cut/fill balance and minimise the number of houses impacted and. This has resulted in the horizontal alignment being realigned up to 1.2 km to the west of original TMR 2015 alignment.

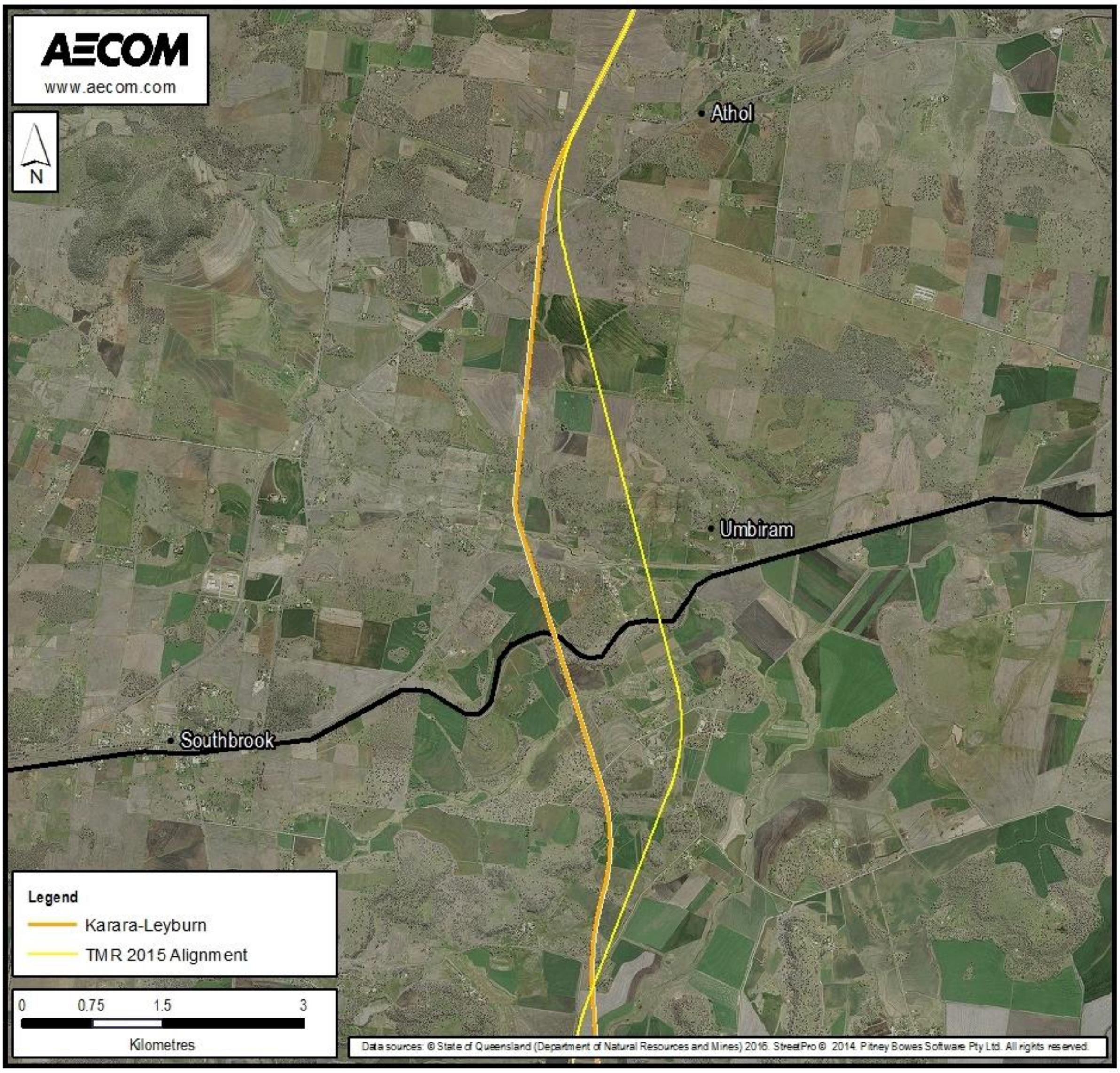

Figure 14 Umbiram realignment

5.3.7 Wellcamp

To ensure a like-for-like assessment between the Base Case Modified, Wellcamp-Charlton, Karara-Leyburn and Warwick options, all needed to follow the same corridor around the Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). The preferred alignment was determined in a previous phase as described in **Section 5.2**. This alignment has therefore been adopted for the Wellcamp section of the Karara-Leyburn corridor. This deviation from the original TMR 2015 alignment runs from CH 152 km to CH 169 km.

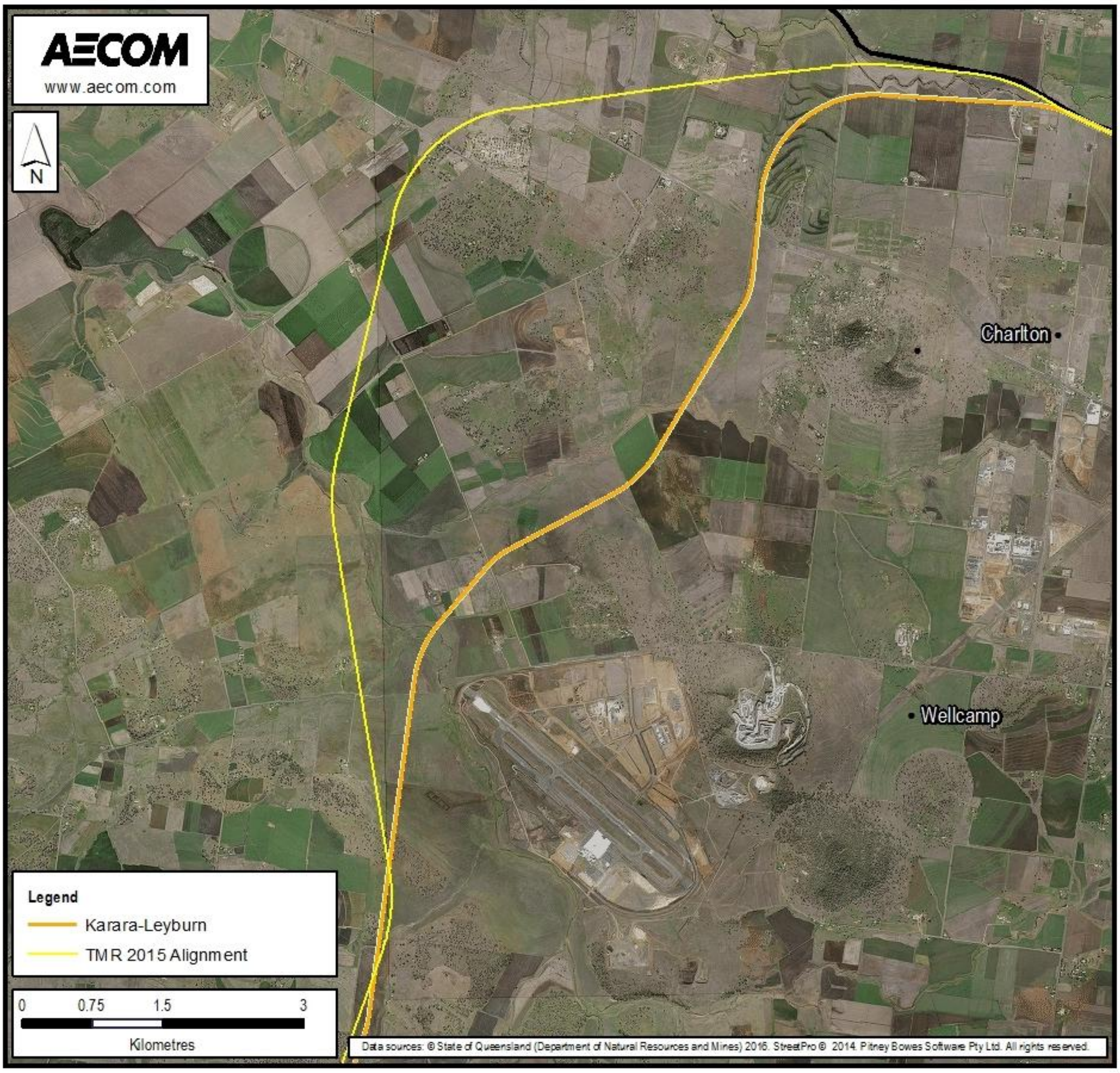

Figure 15 Wellcamp realignment

5.4 Warwick

The Warwick option is one of the shortlisted alignments from the TMR 2015 report.

The only information available on the alignment was the figures in the TMR 2015 report. Therefore, the aim was to design an alignment that followed the principles of the original alignment while conforming to the MBIR Service Offering. This involved following the South Western line towards Warwick with a deviation at the Warwick airport to connect to the Southern Line. From the airport it follows the Southern Line north towards Toowoomba before deviating north-west at Wyreema towards the Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) before connecting in to the Western Line at Gowrie.

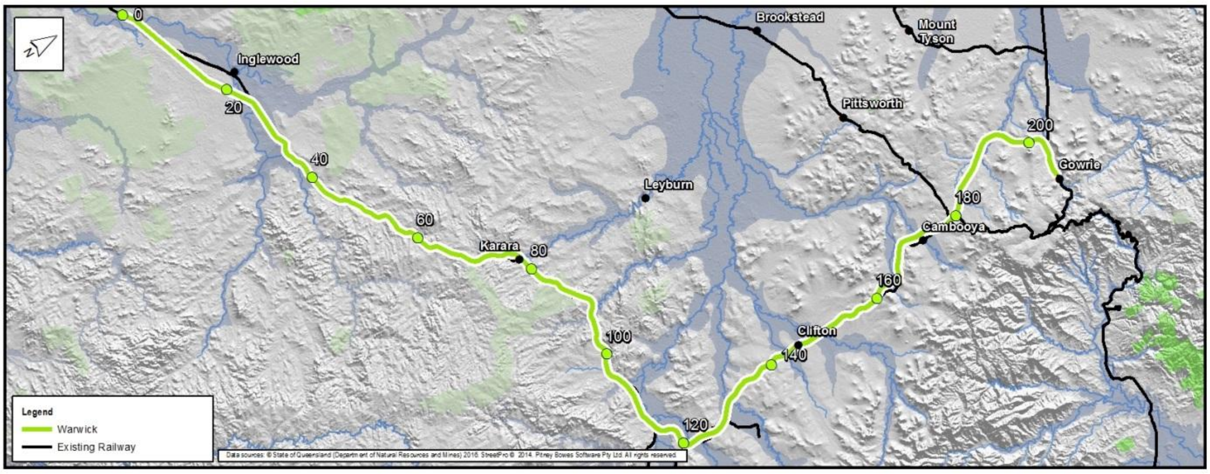

Figure 16 Warwick alignment

5.4.1 Inglewood bypass

To ensure a like-for-like alignment with the Karara-Leyburn alignment the Warwick option bypasses Inglewood. For details on the bypass refer to **Section 5.3.1**.

5.4.2 Inglewood to Karara

This section follows the Karara-Leyburn alignment along the South Western Line before deviating at CH 75km just south of Karara. For details on how this alignment varies to the original TMR 2015 alignment refer to **Sections 5.3.2** and **5.3.2.1**.

5.4.3 Karara to Warwick Airport

From CH 75 km to CH 114 km the alignment generally follows the South Western Line. However, the minimum horizontal and vertical curves and minimum grades for the MBIR are significantly different than that used on the QR line that was completed in 1913. The curves are larger and grades flatter which produces a straighter alignment that can only follow parts of the QR alignment in short sections. Noting that the alignment produced for the options assessment has been designed to follow the existing corridor as close as possible while conforming to the MBIR Service Offering.

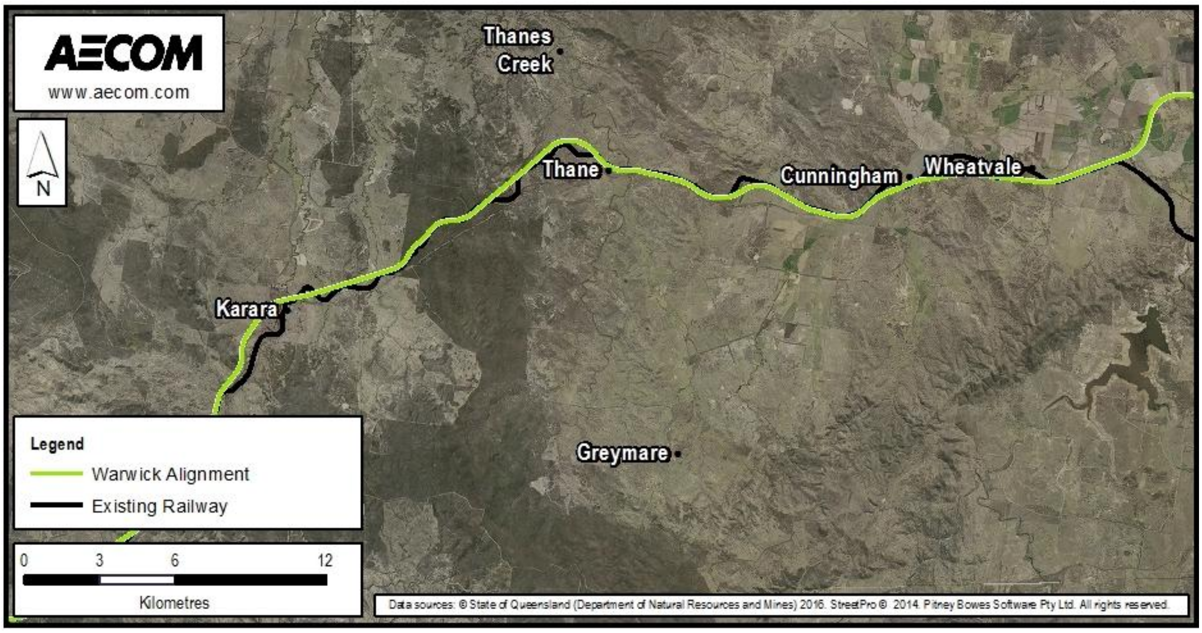

Figure 17 Karara to Warwick airport alignment

5.4.4 Warwick Airport

The TMR 2015 alignment cut across north of the airport to join the South Western Line to the Southern Line. The option of extending the alignment along the South Western Line towards Warwick was discounted in the TMR 2015 report as it would significantly impact the route length and travel time thus not meeting the MBIR Service Offering. Using the TMR 2015 alignment as a guide, two separate alignments were produced around the airport for the current assessment, one to the north and one to the south. Both were designed to minimise the length of the Condamine floodplain crossed.

The preferred alignment was initially to the south of the Warwick airport. However, after further investigation it was found the alignment passed through the North Toolburra Homestead heritage listed property and therefore would not be a viable option. Therefore, the northern option was taken forward for the options assessment.

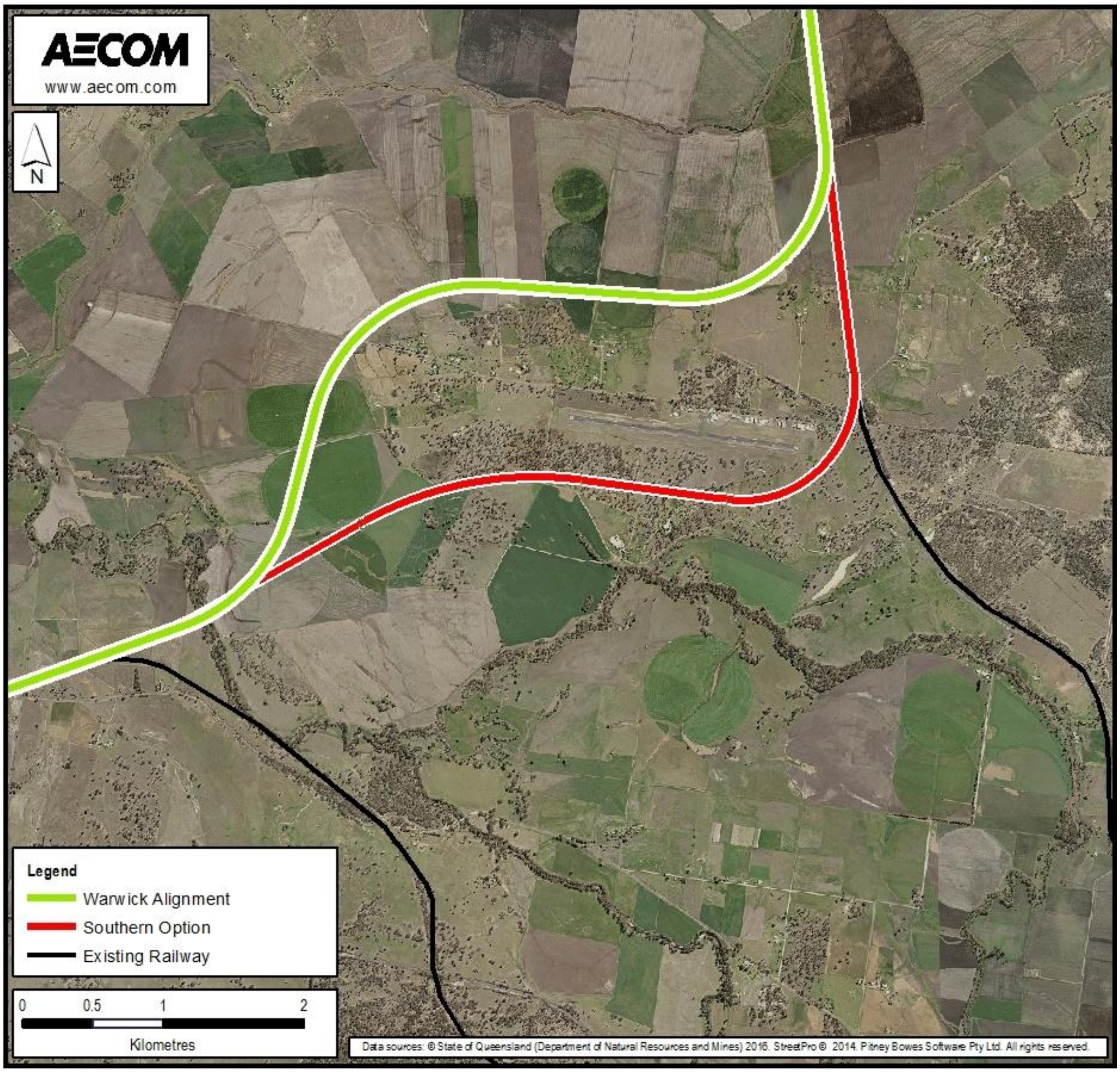

Figure 18 Warwick airport alignment options

5.4.5 Warwick Airport to Clifton

From CH 121 km to CH 146 km the alignment follows the existing Southern Line as close as possible while meeting the MBIR Service Offering. The deviations through this section are to meet the horizontal geometry requirements as the existing line has a number of very tight curves.

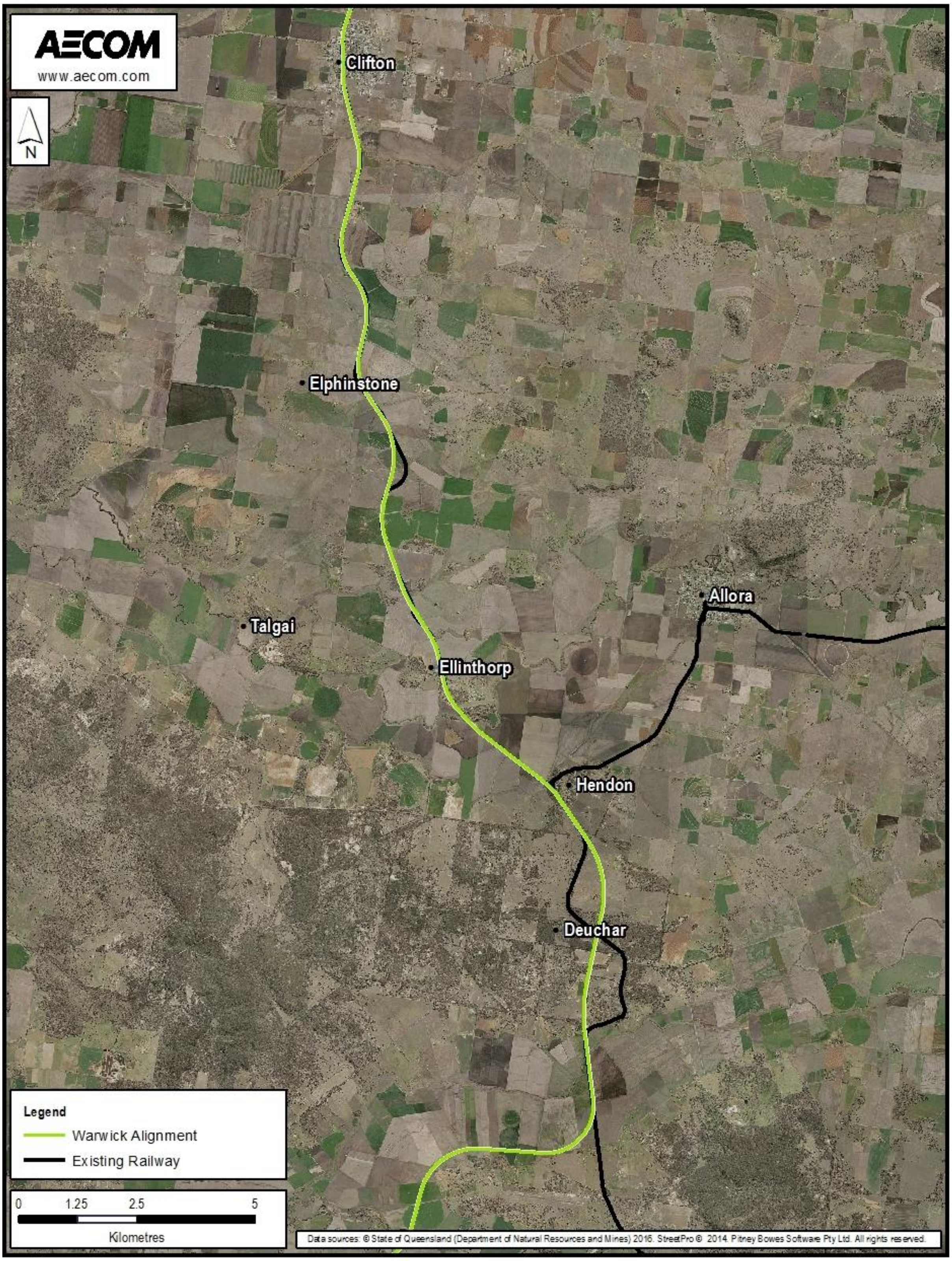

Figure 19 Warwick Airport to Clifton alignment

5.4.6 Clifton to Greenmount

From CH 146 km to CH 160 km the alignment follows the existing Southern Line as close as possible while meeting the MBIR Service Offering. The slight deviations through this section are to meet the horizontal geometry requirements as the existing line has a number of curves that are slightly tighter than Service Offering permits.

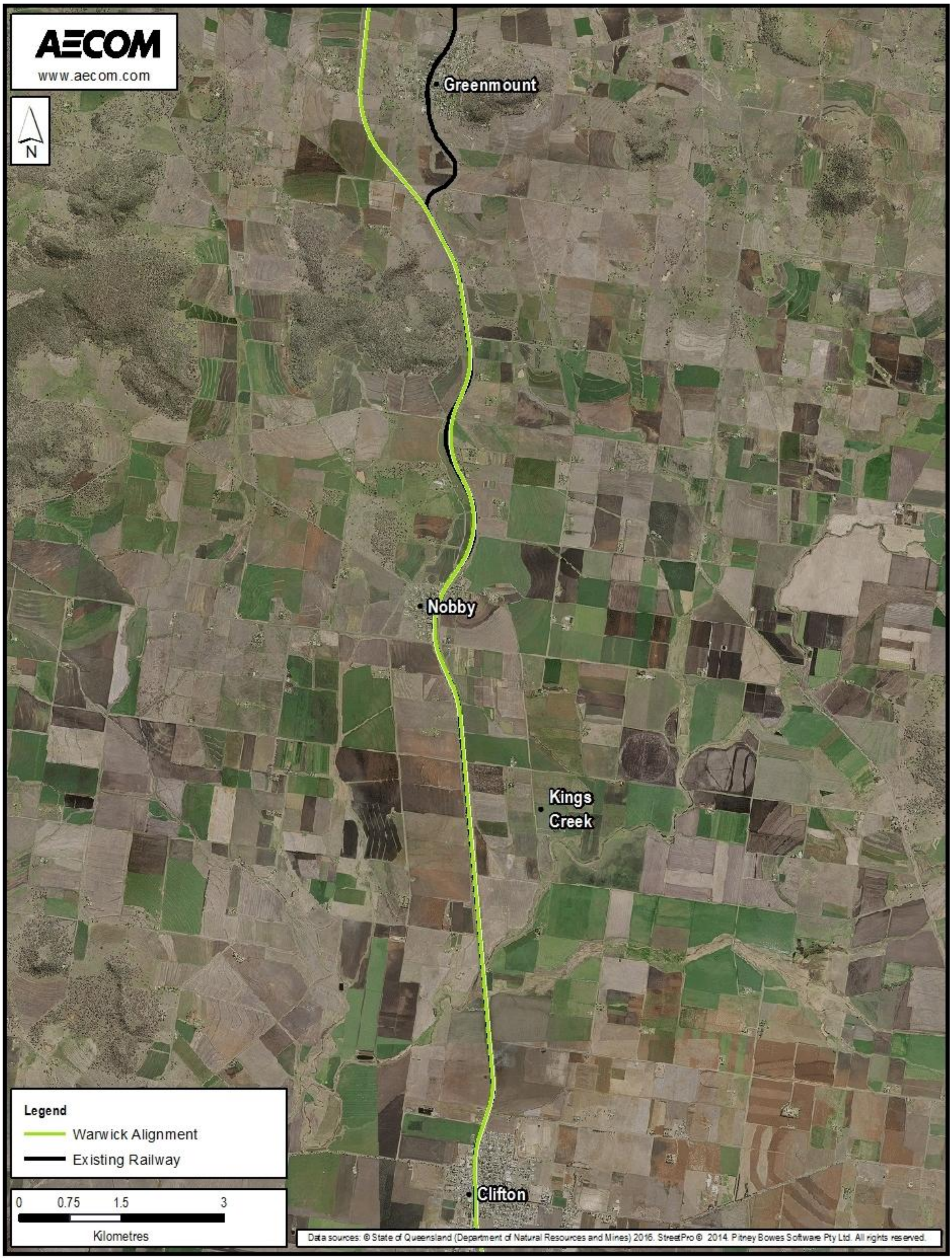

Figure 20 Clifton to Greenmount alignment

5.4.7 Greenmount bypass

From CH 160 km to CH 166 km the alignment bypasses the town of Greenmount. To meet the horizontal curve requirements while following the existing line as close as possible would impact a significant number of residential properties. Therefore, the alignment has been designed to bypass Greenmount away from the residential properties.

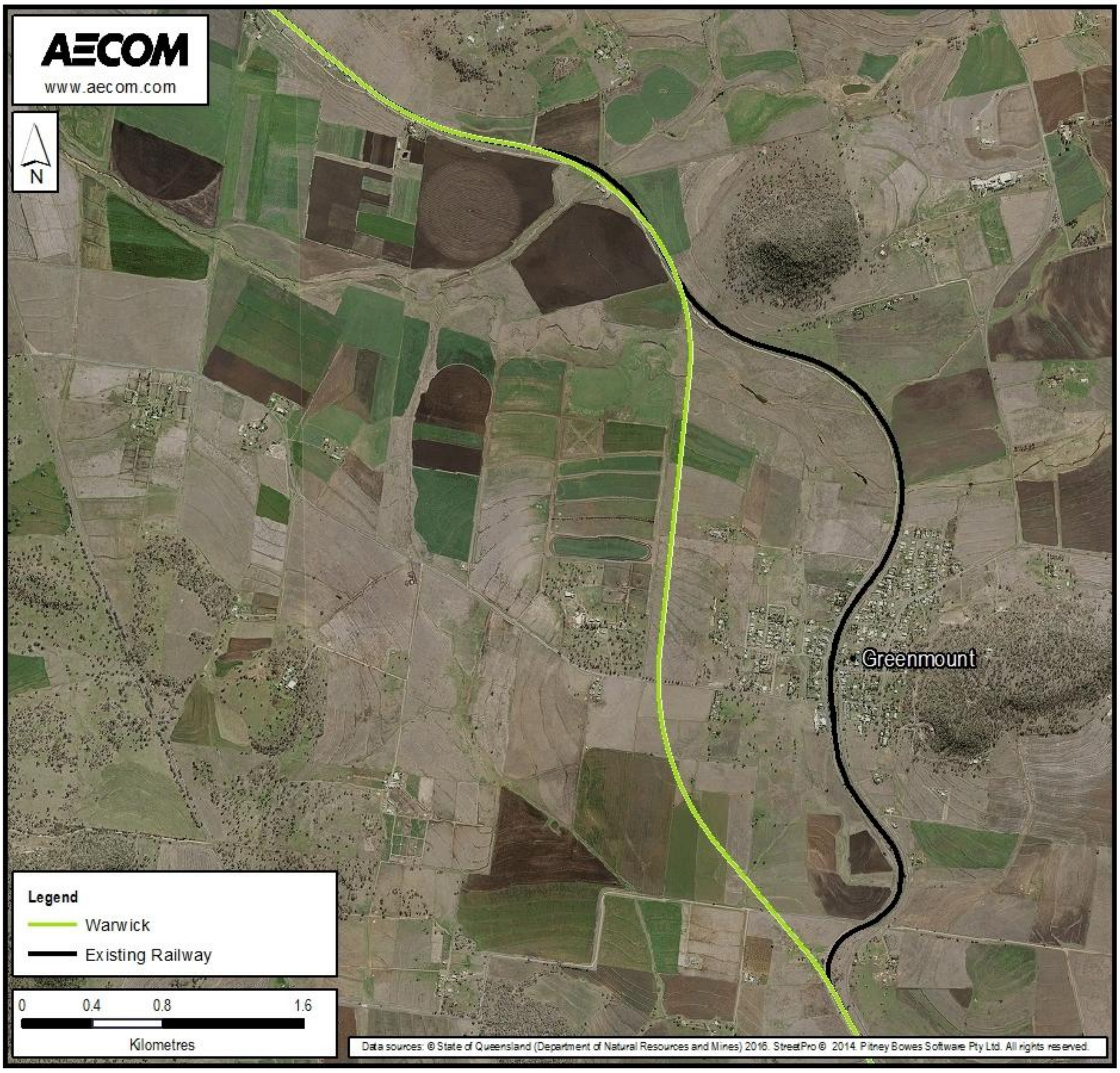

Figure 21 Greenmount bypass

5.4.8 Greenmount to Wyreema

From CH 166km to CH 179km the alignment bypasses the town of Cambooya before connecting back in to the Southern Line at Wyreema. The bypass was added due to restraints in the horizontal and vertical geometry. The main driver to move the alignment was the vertical geometry which would have required a large embankment through the town. This would create a significant visual impact and increase the corridor width so that residential properties would be impacted for the length of the corridor through the town.

Just south of Wyreema the alignment deviates from the existing line due to a number of tight horizontal curves that cannot be matched with the Service Offering criteria.

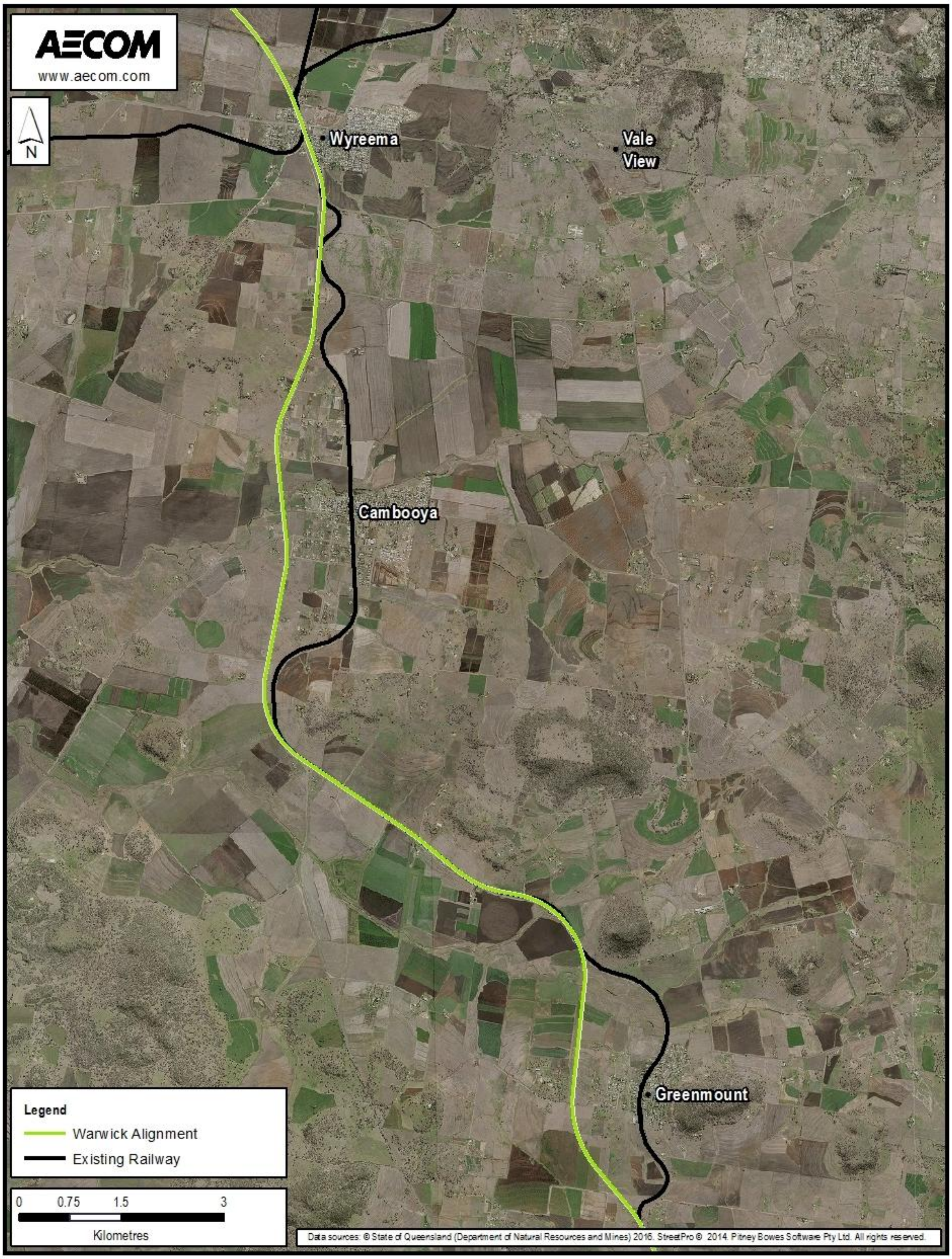

Figure 22 Greenmount to Wyreema alignment

5.4.9 Wyreema to Gowrie

From CH 179 km to CH 208 km the alignment deviates north-west away from the Southern Line towards Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) before cutting back north east to tie in with the Western Line. The design follows the principles of the TMR 2015 alignment with refinements around the Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). In particular, at CH 194 km the alignment ties in with Karara-Leyburn option and bypasses around Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) as described in **Section 5.3.7**. This alignment was adopted to ensure a like-for-like assessment between options as they were both traversing the same section of countryside with common start and finish points.

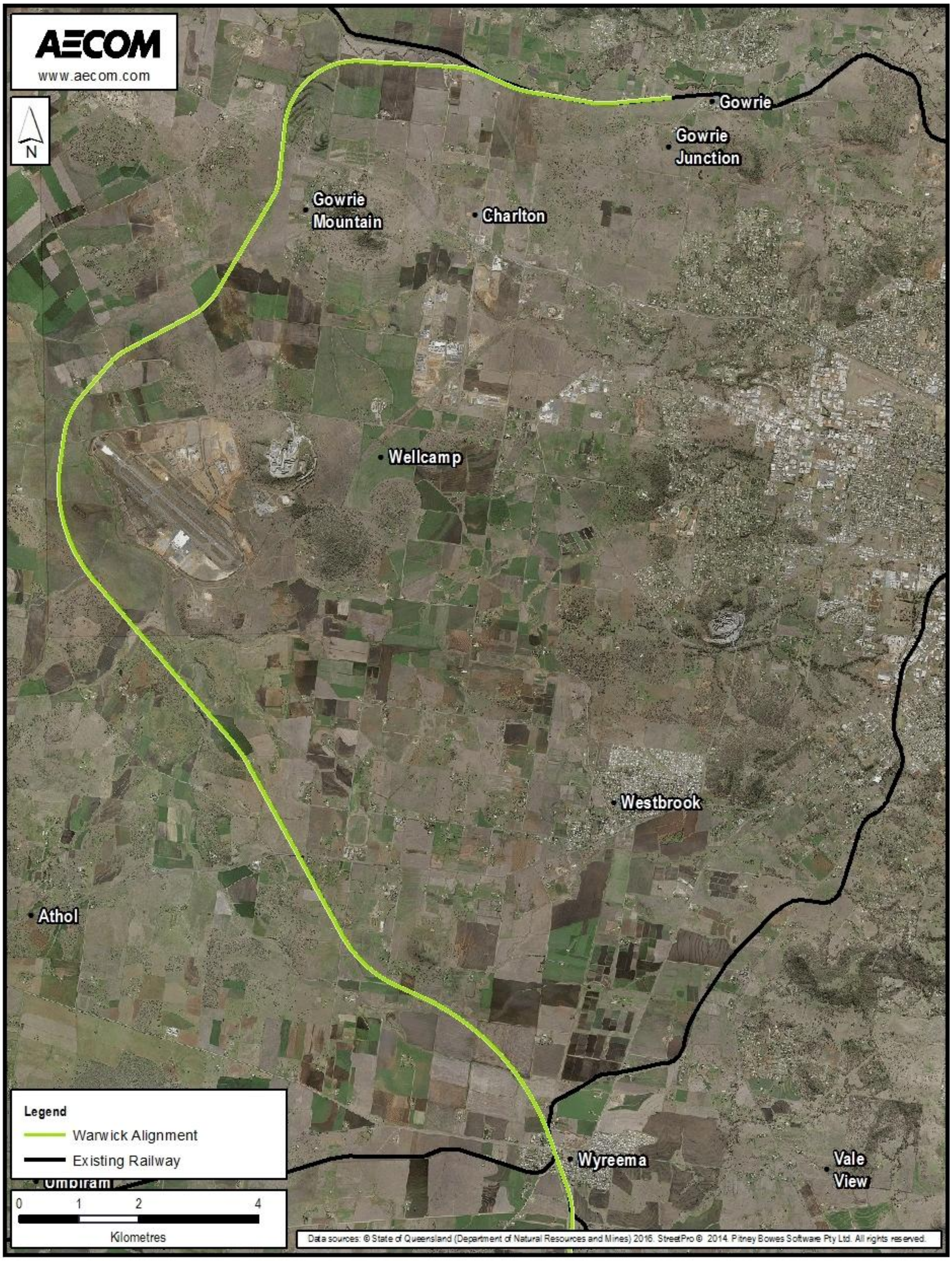

Figure 23 Wyreema to Gowrie alignment

6.0 Project Reference Group engagement

The Project Reference Group (PRG) comprises of community organisations including farming peak bodies and organisations; Chambers of Commerce and business groups; environmental and conservation organisations; and community and progress associations with both local and more regional Darling Downs interests. The PRG was established by the Department of Infrastructure and Regional Development (DIRD).

6.1 PRG process

The chairman for the PRG and Queensland Advisor, Mr Bruce Wilson (AM), was appointed by the federal Minister for Infrastructure and Transport, the Honourable Darren Chester MP. Mr Wilson was supported in a secretariat role by staff from the Department of Infrastructure and Regional Development (DIRD).

The Terms of Reference for the PRG can be seen in **Appendix A.**

A schedule of prospective meetings was discussed by the PRG Chair at the initial PRG meeting on December 14 2016. This schedule was intended to be flexible and changed as the project progressed. Excluding the initial PRG meeting on 14 December 2016, the following meetings were typically to present information on topics or questions that were raised by the PRG at the previous meeting. Therefore, each meeting started with a presentation of the latest project developments and continued with a presentation on topics that had been raised at the previous meeting.

Where there was a request for more detailed work or additional work to be performed, the request was raised by the PRG through the chair for the investigations to be performed. Similarly, any information that was provided by the PRG to the Chair was forwarded to the project team by the Secretariat.

6.2 PRG meetings

The PRG members raised topics and the level of detail that would be required to confirm that there was sufficient rigor in the investigation. Therefore, some key topics received a significant amount of investigation including hydrology and blockage assessment, railway crossings and severance impacts for both new and existing railway corridors and potential salinity impacts. **Table 12** details the dates and topics of the PRG meetings.

Table 12 PRG meetings and drop-in sessions

Date	Location	Topic
14 December, 2016	Toowoomba	Introduction to project and assessment methodology. like-for-like evaluation. Information request.
1 February, 2017	Warwick	Technical Update. MCA Assessment Framework & Case Study.
20 February, 2017	Millmerran	Technical Update Assessment of integration of PRG. Hydrological inputs. Data results and inputs for MCA. Cost estimate approach.
27 February, 2017	Toowoomba	Question and Answer session. Blockage Assessment. Route Changes. Typical Culvert detail.
15 March, 2017	Toowoomba	Question and Answer session. Blockage hydrological modelling. Rail crossings, approach, typical details, frequency. Typical undertrack crossing. Assessment of alternate Warwick Route.
22 March, 2017	Toowoomba	Assessment of alternate Leyburn Route. MCA outcomes presentation. Comparative cost estimate.

During the 14 December 2016 meeting the PRG was asked to provide any information such as:

- Major transit routes for communities and industry.
- Potential land use impacts.
- Crop growing seasons i.e. which times of the year are the fields expected to be covered/under crop or exposed/harvested.
- Evidential data and pictures of previous flood event levels and periods.
- Information on geology, soils.
- Information on areas of ecological value (flora, fauna and habitats).
- Information on places or features of heritage value.
- Planned commercial ventures.
- Potential environmental impacts.
- Any information to inform the corridor route selection.

The advised intent was to use the information to confirm data sets and to consider the information from an impact perspective during the assessment.

The information provided can be seen in **Appendix C**. During following meetings, the PRG were presented with instances of how the information had informed and/or confirmed the assessment. The PRG was provided with a set of maps showing a 500 m wide and 2 km wide investigation corridor for each route to assist with determining any impacts and/or issues that they would like to raise.

One of the outcomes of the PRG meetings was that the topics discussed and the resultant level of investigation assisted in the risk ranging for the comparative cost estimate. For example, due to the additional level of study performed for the hydrological analysis, the risk ranging for the hydrological crossings could be conversely reduced due to the additional certainty provided by the detailed modelling.

6.3 PRG observers

The PRG meetings were also attended observers who were not active PRG members. Rather these attendees were representatives of other interested bodies such as Toowoomba, Goondiwindi and Southern Downs Regional Councils, local regional electorates, State Departments including the Coordinator General, Department of Transport and Main Roads and the Department of Agriculture and Fisheries as well as others.

Contact was made with some of these representatives throughout the investigations to support the analysis and PRG requests.

6.4 Community drop in sessions

To further engage with the broader community outside of the PRG, the PRG Chair, Mr Bruce Wilson (AM) conducted four Drop-In sessions over three days where our consultant team were in attendance. The purpose of these Drop-In sessions was to give the community the opportunity to ask questions and provide further input for the project. The Drop-In session locations were left open for the PRG members to nominate and agree to. The sessions were then facilitated with the assistance of PRG members at the nominated locations. Some PRG members attended various sessions and were identified by the PRG Chair for the benefit of the community members in attendance.

Although the Drop-In sessions were originally expected to be of a more informal nature, due to the amount of interest and attendance size, the sessions turned into a Town Hall style presentation with shared questions and answers. Some community members did approach representatives during breaks and before and after the meeting proper to discuss some items in more of a one-on-one manner.

Table 13 lists the four community Drop-In sessions that were undertaken.

Table 13 Drop-In sessions

Date	Location
8 March, 2017	Millwood
9 March, 2017	Brookstead
9 March, 2017	Felton
10 March, 2017	Southbrook

The community were given the opportunity to register with DIRD for future correspondence and were provided with details to enable them to provide information and make submissions. The timing of these meetings did however limit the information that could be included in the analysis prior to the MCA assessment. The advertisement used to notify the public of the Drop-In sessions is shown in **Appendix D.**

7.0 Options analysis

In order to provide the specific inputs for the MCA and cost estimate, each of the four options required assessment by each of the key disciplines.

Each discipline assessed specific key criteria that would differentiate each option and provide a non-biased like-for-like assessment. The specific criteria were chosen to align with the MCA criteria provided by ARTC, which is detailed in **Section 1.3.1.2**. This phase was specifically related to providing the values and information for the MCA assessment and cost estimate and did not involve any comparison of options.

All data sets used in the MCA assessment were selected for their commonality across all alignment options to ensure a like-for-like analysis. While more detailed data sets may have been available they did not cover all four alignments and as such couldn't be used as they would not provide a like-for-like assessment.

7.1 Risk Assessment

A Risk Assessment was performed and a Risk Register was maintained for the project and updated to include additional risks. This register and the associated risks were also used as an input into the options assessment. Each design discipline incorporated risk Safety in Design considerations in their design and assessment. The project Risk Register can be seen in **Appendix E.**

7.2 Geotechnical

A limited preliminary geotechnical investigation was undertaken by Golder Associates to provide a like-for-like comparative assessment to include the Karara-Leyburn and Warwick routes and to highlight key differentiators to the base case. The scope and limitation of the geotechnical assessment includes the following:

- Preliminary desk top assessment of the additional corridors routes using readily available data pertaining to geotechnical engineering parameters
- Preliminary reconnaissance of publically accessible locations to make general observations of the engineering geology associated with the corridors
- No invasive geotechnical assessment was undertaken
- Observations from public places and roads only (no private property access was available)
- Field observations are intended to complement and support the desktop assumptions and can include but not be limited to:
  - General geomorphology
  - Existing road cuttings and erosional observations and weathering characteristics
  - General observations regarding strength characteristics (e.g. - possible excavation methodologies – drill & blast or ripping)
  - Soil characteristics (e.g. - reactive black soils – Vertosols; dispersive and erodible soils – Sodosols etc.)
  - General observations regarding material suitability for construction and/or borrow pit.

The summary of the key items identified during the desk top study and observations recorded during the site reconnaissance have been included in the report issued by Golder Associates and used in the geotechnical analysis that forms the geotechnical input data for inclusion in the Multi-Criteria Assessment and Bill of Quantities.

7.2.1 Methodology

Geotechnical evaluation of the alignment options was assessed by a preliminary desktop study followed by visual reconnaissance of select areas along the proposed route. Sites were restricted to locations that were visible or accessible from public access to the proposed alignments.

Desktop mapping included a review of geological data along the proposed alignment as contained in digital geological mapping data sets. The approximate chainage of geological and soil unit plotted where they intersect the proposed alignments.

Two primary resources were utilised for preliminary assessment and comparison of ground condition along each route option. They comprised:

- Australian Soil Resource Information System (ASRIS 2014) – Utilising the best publicly available information on soil and land resources in a standard format across Australia
- Queensland Government Department of Natural Resources and Mines (DNRM), Detailed Regional Maps (2008) – Accessing rock name, age, lithology, and characteristics as generated by the Geological Survey of Queensland (GSQ), accurate to a 1: 2,500,000 scale

The desk top assessment was followed up by a visual reconnaissance along the alignments. The reconnaissance was limited to a high level, preliminary assessment at this stage. The reconnaissance was completed in later October 2016. As with the previous assessment along the Base Case Modified alignment, the field observations for this scope were limited to portions of the alignment that were visible or accessible from public access points as no permission was sought to access private property along the routes.

During the reconnaissance, relevant criteria for input into Multi-Criteria Assessment were recorded and photographed, including general site conditions inclusive of bedrock outcrops, general terrain features, as well as several existing rail bridges. The observations were typically recorded at locations where the route intersects or parallels public road corridors.

Surficial sediments and bedrock outcrops at various locations along the alignments that appeared to be consistent with units contained in the referenced digital geological mapping data set were observed. The bedrock outcrops and steep topography were almost exclusively observed within two bedrock units (Tertiary Main Range Volcanics and Texas Beds). In addition, examples of high strength rock were observed in road cuts within these map units. Although most of the outcrops were observed in existing road cuts outside of the proposed alignment the likelihood of encountering higher strength rock units is likely highest along portions of the alignment will extend through these formations.

Field observation confirmed that large sections of the corridor routes are underlain by “black soils” or wet/soft soils. In general, high plasticity black soils will most likely be encountered in the northern portions of both alignments, although localized zones may be present in localised areas further to the south primarily within channel or flood plain areas along prominent creeks.

The risks and opportunities of the alignments’ near-surface, soil foundation conditions can be assessed based on the ASRIS dataset. A descriptive summary of all soil types encountered on any route is provided in **Table 14**.

Table 14 ASRIS dataset soil type summary (ASRIS 2014)

Soil Type	ID	General Description	Opportunities	Risks
Chromosol	CH	Soils with an abrupt increase in clay	General use Generally not dispersive.	Poor infiltration, causing surface erosion. High salt levels causing scalding, erosion, and infrastructure damage. Impeded internal drainage. Mud pumping.
Dermosol	DE	Structured soils.	General use Generally not dispersive. Subsoil generally suitable for most earthwork purposes.	Poor infiltration, causing surface erosion. Topsoil and subsoil prone to structural decline and compaction.
Kandosol	KA	Structureless soils.	Mostly well-drained, permeable soils (although some have impeded subsoil drainage)	Sandier soils encourage rapid infiltration. Reduced cohesion increases susceptibility to rill, sheet and stream bank erosion.
Kurosol	KU	Acidic soils with an abrupt increase in clay		Acidic, pH < 5.5. Low water-holding capacity. Often sodic, leading to high erodibility and dispersivity on interaction with water. Poor infiltration, causing surface erosion.
Sodosol	SO	Soils high in sodium and an abrupt increase in clay	Typically unsuitable for use unless suitably treated through stabilisation. Depending on the particular characteristics of the material potential to use as bulk fill within the embankment core when protected	Very vulnerable to erosion and dryland salinity when vegetation is removed. High salt levels causing scalding, erosion, and infrastructure damage. High sodicity leads to high erodibility and dispersivity on interaction with water. Poor structure. Low permeability, imperfect to poor drainage. Dispersive subsoils make them particularly prone to tunnel and gully erosion. High salt levels causing scalding, erosion, and infrastructure damage
Vertosol	VE	Shrink and swell clay soils	Typically unsuitable for use unless suitably treated through stabilisation. Depending on the particular characteristics of the material potential to use as bulk fill within the embankment core when protected	Potential for material being unsuitable for use in construction Potential for strong cracking and slickenslides. Shrink-swell characteristics. Infiltration rapid if large cracks exist, if saturated infiltration is slow and water runoff is more likely. Variable drainage characteristics (depending on landscape)..

Comparatively, rock types can be considered for their reuse, suitability for application, or lack thereof. **Table 15** describes the rocks that are anticipated to be encountered and their potential reuse application.

Table 15 GSQ dataset rock type summary (DNRM 2008)

Rock Unit Name	ID	Description	Potential Use
Quaternary alluvium and lacustrine deposits	Qa	Clay, silt, sand, gravel; flood plain alluvium	Aggregate
Late Cainozoic floodout and residual sand, soil and gravel	Czs	Sand, soil and gravel	Aggregate
Evergreen Formation, Hutton Sandstone, Marburg Formation (in part), Precipice Sandstone	Jlb	Siltstone, mudstone, sandstone, oolitic ironstone, coal	Bulk & Select fill material
Texas beds	Ctx	Greywacke, mudstone, slate, local phyllite; subordinate jasper, chert, conglomerate, limestone	Bulk and Select fill material
New England Batholith, Unnamed Intrusions	R5	Biotite granite and granodiorite	Capping
Injune Creek Group, Mulgildie Coal Measures, Walloon Subgroup (Moreton Basin)	Ji	Sandstone, siltstone, mudstone, coal, conglomerate	Fill material
Tertiary volcanics, mainly basalt*	Tv	Basalt flows overlying older sedimentary formations. Relatively permeable, and weather to produce vertosols, creating trafficability and foundation issues.	Select Fill and Capping
Bungil Formation, Gubberamunda Sandstone, Hooray Sandstone, Kumbarilla beds, Longsight Sandstone, Mooga Sandstone, Orallo Formation, Southlands Formation	JKb	Glauconitic, labile to quartzose, siltstone, mudstone; sandstone, minor conglomerate, siltstone; coal	Bulk fill and some select fill material

*The Toowoowba region and district to the immediate west and south west is dominated by mid-Tertiary (27–18 Ma Lafferty and Gold- ing (1985) and Webb et al. (1967)) basalts, associated volcanics and palaeosols (Toowoomba Volcanics—a member of the Main Range Volcanics). The MRV is the most extensive surface unit. Latest Tertiary and Quaternary denudation has resulted in more recent soils and colluvial and alluvial deposits.

Soil development is characterised as dominantly vertosol soils (black cracking & reactive clay soils) however the actual depth of soils may be variable and a function of the underlying parent geology. Where topographic relief is maintained through the presence of more resistant, less eroded and less weathered lava flows, it is reasonable to assume reduced soil thickness and a more rapid transition to weathered rock.

The Condamine River alluvial systems are dominantly mapped as vertosol soils as a combined result of alluvial processes and insitu & transported parent geology. Soil thickness is greatly increased through the deposition of alluvial materials and subsequent soil development.

Both mechanisms are supported by geomorphological and agricultural practices. Generally speaking, thicker soils can be correlated with flatter, lower topographic relief and the development of broad acre agricultural cropping practices. Where remnant basalt flows remain, thinner soils can be correlated with a relative increase in topography, reduced cropping and increased livestock grazing.

Soil development and distribution will be subject to further investigation at more mature stages of design development.

By spatially plotting each respective route alignment in Google Earth, overlain by the ASRIS and GSQ data for the correct regions, a preliminary assessment of quantitative soil and rock type presence was undertaken. Once the location of each indicative change in soil or rock type along the alignment was defined, this coordinate was then correlated against chainage markers to determine absolute lengths by which each segment was within a specific soil or rock type. It was deemed more appropriate to compare absolute lengths as opposed to percentages in order to alleviate misrepresentation of quantities as a result of different total alignment lengths.

Complementary to the assessment of soil and rock type presence over the length of each alignment, the vertical alignment at each 5m interval was extracted from GIS systems to derive a high level estimate of cut and fill quantities. By understanding the distribution of soil and rock based on a surface overlay, the estimate cut a 2-dimensional section through the alignment centres, in turn designating the cut and fill quantities required in the presence of each soil and rock type. It is noted that a limitation exists where, in the lack of the required information, the depth of soil and hence the top of rock has not been accounted for.

7.2.2 Material suitability

It is anticipated that some cut materials that are classed as general use soils may be suitable for reuse as fill, in particular as verge material in the railway formation profile. This fill may be supplemented by soils classed as erosive, which would be best designated within the general fill portion of the formation profile. It is proposed that these materials should be used in conjunction with modified fill geometry and zoning to control runoff amounts and rates, including adequate drainage design and sediment control practices.

The presence and quantities of Vertosols are likely unsuitable for application or reuse unless suitably treated through stabilisation. Depending on the particular characteristics of the material it is sometimes possible to use these materials as bulk fill within the embankment core. Otherwise these materials must be replaced as appropriate along the length of the alignment.

Following the same methodology as was completed for soils, the rock types along each respective alignment were assessed for presence, and cut and fill quantities. To varying degrees, the potential reuse of these materials is sustainably and economically efficient through application as aggregate, fill material, or capping. The applicability for reuse is subject to material parameters are to be confirmed in a future project phase. **Section 7.4** provides a summary of the mass haul and material source assumptions have been made for the MCA assessment.

7.2.3 Geotechnical considerations

The following geotechnical considerations have been used in forming the basis of assessment for the MCA.

7.2.3.1 High fill embankments

Potential risks

- Presence of soft alluviums causing short and long term settlement upon placement of the fill materials
- Presence of reactive clays and/or “Black Soils” - Strategy for construction embankments on soft alluvium, black soils and mitigations at structures

Mitigation measures

- Global stability analyses to assess safe batter slopes
- Constructability assessment to identify the need for basal reinforcement where soft alluvials and/or Black Soils are present
- Assessment of requirements for staged construction if required
- Investigating potential need for ground improvement works at isolated areas where presence of soft alluvials may cause adverse impacts on existing structures. This may include limited use of dynamic compaction, stone columns, Controlled Modulus Columns (CMC), soil mixing, installation of mini piles, or other ground improvement measures

Innovations and opportunities

- Considering the use of basal geotextile reinforcement to allow safe access for vehicles during the course of construction as well as providing long term stability for the embankments or to reduce long term settlements
- Considering the use of polymer additives to allow safe access for vehicles during the course of construction as well as long term stability for the embankments

7.2.3.2 Deep cuttings

Potential risks

- Soil and rock slope stability issues
- Groundwater inflow
- Deep cuttings may encounter rocks which may be difficult to excavate using conventional earthmoving equipment
- Ground vibrations from construction activities can adversely affect the people living or working in the area or, when vibrations become sufficiently intense, result in detrimental effects on nearby structures or equipment. Blasting and piling activities are traditionally known as the major sources of vibration. However, the use of larger plants and machinery in construction activities is also emerging as equally important. These machines release large amount of energy in the form of ground vibration and noise in the environment
- Surficial failures can occur as a result of weathering at the surface of the rock cuttings. Weathering will result in breaking the rock and also opening the fissures and cracks. The fissures will act as preferential seepage routes within the rock resulting in progressive weathering of the surface rock, which eventually fails through this significantly reduced strength zone

Mitigation measures

- Inclusion of cut surface treatment as required
- Design of active or passive support measures depending on the requirements and considering the nature of instability (i.e. dowels, anchors, shotcrete, mesh, etc.)
- Design of proper drainage measure to prevent surface or groundwater water entering the proposed cutting or to facilitate drainage of the surface water in the cuttings

Innovations and opportunities

- Allowance will be made for investigation for the rippability of the rocks as part of the design process to enable planning for the use of special equipment and/or blasting as part of the construction works
- Provisions are also proposed for quantifying possible impacts of vibrations and for studying the effects to assure that the induced vibrations conform to the relevant standards and codes;
- Increased cut slope angles through geological mapping and the use of ground support
- Better and more cost effective understanding of the geotechnical issues by developing a longitudinal section presenting the of geology along the alignment based on published maps, site investigation data and site walkover and presenting it visually as zones of anticipated geology and likely geotechnical and geological features/issues, cut slope angles, fill slopes, etc.
- Developed a gap analysis of the geological data to optimise the ground investigation requirements

7.2.3.3 Presence of black soils

Potential risks

- Expansive clays with excessive shrinking and swelling as a consequence of moisture variation
- Workability and access issues during construction after rainfall or contact with water/moisture
- Low strength

Mitigation measures

- Preventing moisture variation by allowing for adequate drainage and/or covering with suitable soils
- Replacement of the entire or part of the black soil layer with a non-expansive material to reduce shrink-swell risk

Innovations and opportunities

- Considering the use of basal geotextile reinforcement to allow safe access for vehicles during the course of construction as well as providing long term protection against shrinking and swelling in expansive soils
- Considering the use of polymer additives to allow safe access for vehicles during the course of construction as well as long term stability for the embankments
- Optimisation of depth of box-out in black soil

7.2.3.4 Earthworks material sourcing

Potential risks

- Not having adequate suitable material for construction of the embankments
- Development lead time for establishment and permitting of new extraction sources

Mitigation measures

- Balancing the cut to fill
- Provide input to decisions regarding cut to fill balance optimisation (based on material suitability assessment)

Innovations and opportunities

- Site reconnaissance to investigate potential borrow areas and recommendation of suitable borrows close to construction areas thereby reducing haulage distance
- Identifying suitable borrows within the corridor and close to construction areas thereby reducing haulage distance
- Reducing the volume fill material imported by developing flexible design, specifications and construction methodologies to allow locally available material which may otherwise be non-conforming to standard specifications
- Considering options such as use of otherwise unsuitable materials e.g. black soils in core of a zoned embankment (fully encapsulated to prevent moisture variations)
- Changes in design to cater for wider and flatter embankments constructed of inferior quality materials or steeper embankments to reduce the volume of fill material where better quality material is available
- Consideration may be also given to design of steep embankments by incorporation of geosynthetic materials where there is a shortage of fill material for construction of embankments

7.2.3.5 Bridge structures

Potential risks

- Variable ground conditions
- Potential issues with construction of some pile types where alluvials (cobbles/boulders) are present on the river beds

Mitigation measures

- Option assessment exercise to determine the most economical piling/ foundation for each bridge structure

Innovations and opportunities

- Potential use of CFA piles as a cost and time effective alternative to conventional bored piles where possible
- Evaluation of options for batter slopes on bridge abutments to reduce bridge lengths or spans

7.2.3.6 Erosion potential and control

Potential risks

- Excessive erosion of some of the naturally available materials when placed in embankments or when exposed after clearing and grubbing

Mitigation measures

- Allowance for proper site drainage including cess drains, sub-surface drains, top drains and interceptor drains for cuttings
- Protection of highly erodible material with a layer of better quality material when placed in embankments

Innovations and opportunities

- An Erosion and Sediment Control Program will be developed to present details of the detail erosion and sediment control measures to be used on site
- The Program will consider the following features:
  - use of available resources
  - maximum utilisation of existing terrain
  - realistic, practical, and easily understood control measures
  - cost-effective solutions
  - flexibility with performance-based objectives and allowance for future program amendments

7.2.3.7 Formation pumping failure

Potential risks

- Under the pressure and deflection in the ground caused by a train passing (cyclic loading) after heavy rainfalls or floods, the slurry formed by the silt and clay in the capping layer can be ‘pumped’ up into the ballast and this may lead to rapid disintegration of the capping material causing subsidence, loss of track alignment and eventually high maintenance costs.

Mitigation measures

- Use of a suitable well graded sand and gravel in the capping layer to prevent rainwater from ‘ponding’ directly on the subgrade and/or allowing for sufficient fine material in the capping layer to form a ‘fine soil filter’ preventing the passage of silts and clays

Innovations and opportunities

- Consideration to be given to use of a layer of geotextile material either directly below the ballast layer or on top of the subgrade material that is prone to pumping failure to stop the fines being pumped out.

7.2.4 MCA inputs

The breakdown for the soil and rock types along the four alignments are summarised in **Table 16** to **Table 23.** It is important to note at the scale and accuracy of this desktop assessment, the data presented is a high level estimate only, with geotechnical investigation in later stages anticipated to inform the design to a greater degree.

Table 16 Base Case Modified - Preliminary assessments of soil type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Base Case Modified				
Soil Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Chromosol	General use	-	-	-
Dermosol	General use	10,800	8,900	5,900
Kandosol	General use	6,900	11,000	5,500
Kurosol	Erosive	-	-	-
Sodosol	Erosive	50,200	101,100	15,500
Vertosol	Potentially unsuitable	113,400	182,000	98,800
Totals		**181,300 m**	**303,000 m^2**	**125,700 m^2**

Table 17 Base Case Modified - Preliminary assessments of rock type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Base Case Modified				
Rock Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Quaternary alluvium and lacustrine deposits	Aggregate	61,900	114,100	25,400
Late Cainozoic floodout and residual sand, soil and gravel	Aggregate	43,400	87,000	60,900
Evergreen Formation, Hutton Sandstone, Marburg Formation (in part), Precipice Sandstone	Bulk & Select material	16,700	19,000	2,600
Injune Creek Group, Mulgildie Coal Measures, Walloon Subgroup (Moreton Basin)	Fill material	18,300	18,200	3,800
Tertiary volcanics, mainly basalt	Capping	38,800	64,600	19,500
Blythesdale Group	Fill and some Select material	2,200	100	13,600
Totals		**181,300 m**	**303,000 m^2**	**125,800m^2**

Table 18 Wellcamp-Charlton - Preliminary assessments of soil type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Wellcamp-Charlton				
Soil Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Chromosol	General use	-	-	-
Dermosol	General use	10,800	8,900	5,900
Kandosol	General use	6,900	11,000	5,500
Kurosol	Erosive	50,200	-	-
Sodosol	Erosive	-	101,100	15,500
Vertosol	Potentially unsuitable	100,200	248,600	234,100
Totals		**168,100 m**	**369,600 m^2**	**261,000 m^2**

Table 19 Wellcamp-Charlton - Preliminary assessments of rock type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Wellcamp-Charlton				
Rock Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Quaternary alluvium and lacustrine deposits	Aggregate	43,800	89,700	22,000
Late Cainozoic floodout and residual sand, soil and gravel	Aggregate	43,400	87,000	60,900
Evergreen Formation, Hutton Sandstone, Marburg Formation (in part), Precipice Sandstone	Bulk & Select material	15,800	19,900	2,800
Injune Creek Group, Mulgildie Coal Measures, Walloon Subgroup (Moreton Basin)	Fill material	11,400	14,300	2,600
Tertiary volcanics, mainly basalt	Capping	51,500	158,400	159,200
Blythesdale Group	Fill and some Select material	2,200	100	13,600
Totals		**168,100 m**	**369,400 m^2**	**261,100 m^2**

Table 20 Karara-Leyburn - Preliminary assessments of soil type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Karara-Leyburn				
Soil Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Chromosol	General use	12,400	39,900	5,100
Dermosol	General use	35,600	74,000	47,300
Kandosol	General use	14,900	20,700	8,900
Kurosol	Erosive	2,600	1,600	10,100
Sodosol	Erosive	45,100	66,000	46,400
Vertosol	Potentially unsuitable	61,400	222,900	192,000
Totals		**172,000 m**	**425,100 m^2**	**309,800 m2**

Table 21 Karara-Leyburn - Preliminary assessments of rock type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Karara-Leyburn				
Rock Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Quaternary alluvium and lacustrine deposits	Aggregate	34,500	86,700	66,000
Late Cainozoic floodout and residual sand, soil and gravel	Aggregate	17,700	21,500	2,900
Evergreen Formation, Hutton Sandstone, Marburg Formation (in part), Precipice Sandstone	Bulk & Select material	20,800	39,700	37,700
Texas beds	Bulk and Select material	56,700	113,200	70,500
Injune Creek Group, Mulgildie Coal Measures, Walloon Subgroup (Moreton Basin)	Fill material	9,600	24,100	10,800
Tertiary volcanics, mainly basalt	Capping	32,500	139,900	121,800
Totals		**171,800 m**	**425,100 m^2**	**309,700 m^2**

Table 22 Warwick - Preliminary assessments of soil type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Warwick				
Soil Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Chromosol	General use	15,400	49,400	7,200
Dermosol	General use	44,000	62,600	115,300
Kandosol	General use	14,900	21,100	8,500
Kurosol	Erosive	600	-	4,400
Sodosol	Erosive	47,700	72,600	75,000
Vertosol	Potentially unsuitable	85,400	229,100	64,700
Totals		**208,000 m**	**434,800 m^2**	**275,100 m^2**

Table 23 Warwick - Preliminary assessments of rock type presence, and cut and fill quantities (m^2) along each alignment (rounded to nearest 100)

Warwick				
Rock Type	**Potential Use**	**Length along Alignment (m)**	**Cut Quantity (m^2)**	**Fill Quantity (m^2)**
Quaternary alluvium and lacustrine deposits	Aggregate	27,700	64,500	13,100
Late Cainozoic floodout and residual sand, soil and gravel	Aggregate	17,700	21,700	2,900
Evergreen Formation, Hutton Sandstone, Marburg Formation (in part), Precipice Sandstone	Bulk & Select material	21,700	23,800	39,900
Texas beds	Bulk and Select material	74,300	139,600	152,100
New England Batholith, Unnamed Intrusions	Capping	4,900	2,300	8,100
Injune Creek Group, Mulgildie Coal Measures, Walloon Subgroup (Moreton Basin)	Fill material	10,700	11,300	12,000
Tertiary volcanic, mainly basalt	Capping	51,200	171,600	47,100
Totals		**208,200 m**	**434,800 m^2**	**275,200 m^2**

7.3 Alignment

7.3.1 Methodology

The design of each alignment was produced in the 12D integrated terrain modelling and civil works software package. All alignments were designed in relation to a 5 m DTM of the ground surface supplied by The State of Queensland Qspatial Catalogue October 2016. While a more detailed Lidar ground surface was available for parts of the alignments it did not cover the entire footprint of the alignment options. Therefore, the 5 m DTM was used as it was the most accurate ground surface data that covered all alignments for a like-for-like assessment.

The alignments were in designed in accordance with the Service Offering criteria in **Section 1.3.2**. Specifically, the grades and curves used in the design did not exceed the design criteria. Plan and sections for each alignment are shown in **Appendix F.**

There is one exception on the Base Case Modified alignment at Mt Tyson where a 600 m radius curve is used where the alignment follows the existing unused Millmerran Line. This curve has remained for the current options assessment as the relatively small section of track will not greatly impact on run times and supports ARTC's design goal of using brownfield corridors where appropriate. A southern bypass has been investigated and has shown to be a feasible alternative to running through the town. This can be investigated further on future stages of the MBIR project and is not seen as a differentiator for the current options assessment.

Once the final alignment corridor was confirmed specific technical details were output from 12d for the MCA inputs.

7.3.2 MCA inputs

Key technical details for railway design were output for each of the four options as shown in **Table 24**.

Table 24 Alignment technical details

Parameters	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Length (km)	**181**	168	172	208
Length of Curve < R1200 (km)	**11**	8	20	18
Length of Curve ≥ R1200 (km)	**40**	44	33	67
Length of Straight Track (km)	**130**	116	119	123
No. of Segments < R1200	**18**	13	36	31
No. of Segments ≥ R1200	**62**	59	41	79
No. of Straight Segments	**80**	72	77	112
Length of Grades ≥ 1% (km)	**36**	44	30	54
Length of Grades < 1% and ≥ 0.5% (km)	**49**	44	35	54
Length of Grades < 0.5% and > 0% (km)	**76**	62	97	99
Length of Grade = 0% (km)	**20**	18	10	2
Length of Uphill Grade (km)	**96**	92	105	105
Elevation Gain > 0.5% grade	**470**	500	376	567
Total Elevation Gain	**563**	575	506	689

The alignment design was used to determine earthworks volumes and the cut and fill values details of which can be found in **Table 25**.

Table 25 Earthworks details

Parameters	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Earthworks				
Cut (Mm^3)	4.4	10.1	11.3	10.2
Fill (Mm^3)	5.3	9.5	9.8	9.3
Balance (Mm^3)	0.9	0.5	1.6	0.9
Total (Mm^3)	10	20	21	20
Length of cut (km)				
0-5 m (km)	39	37	37	55
5-10 m (km)	6	12	13	13
10-15 m (km)	2	5	7	5
15-20 m (km)	0	2	2	2
20-25 m (km)	0	1	1	0
Length of fill (km)				
0-5 m (km)	119	87	81	104
5-10 m (km)	13	16	22	21
10-15 m (km)	3	7	6	8
15-20 m (km)	0	1	2	1

7.4 Earthworks

7.4.1 Methodology

As all corridor options follow different alignment the material quantities and material type obtained from cuts differed for each route. The suitability of material within mass haul sections was considered for use within the embankments as either bulk fill or select fill.

Each route has different mass haul needs as they have differing ground topography. Some sections require the import of material whilst other sections have excess material that requires disposal. The design looked at how material could be won and transported for construction in sections of around 30km to 50km lengths although some shorter sections have also been considered.

Assumptions have been made based on prior construction knowledge of mass haul and material suitability to provide a high level mass haul and material use philosophy for each corridor route being considered.

7.4.1.1 Base Case Modified

The natural grade of the terrain matches the corridor grades relatively well for the Base Case Modified resulting in minimal earthworks. The most significant earthworks occur around Inglewood and again prior to Millmerran. Imported suitable material is required for sections of the corridor.

7.4.1.2 Wellcamp-Charlton

For the Wellcamp-Charlton option to meet the alignment grades significant earthworks are required to cross from the Condamine catchment at Pittsworth through to the Westbrook catchment at Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport), resulting in the earthworks quantities approximately doubling when compared to the Base Case Modified route.

7.4.1.3 Karara-Leyburn

The earthworks for the Karara-Leyburn option are dictated by the alignment criteria between Oman – Ama and Karara which results in relatively large earthwork volumes. Thereafter the corridor generally follows the Toowoomba – Karara road and the alignment can generally follow the topography. At Mount Rolleston the alignment deviates to the north to follow along Hodgson Creek with increased earthworks in order to meet the alignment criteria. As with the Wellcamp-Charlton option significant earthworks are required to enter the Westbrook catchment to Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport). This corridor has the greatest overall earthworks requirements

7.4.1.4 Warwick

The Warwick option is the same as the Karara-Leyburn route between Inglewood and Karara. The quantities for this alignment are as a result of the increased length in conjunction with the grade and curve easing requirements in order to meet the alignment criteria and while trying to follow the existing South Western Line and Southern Line.

7.4.1.5 Earthwork criteria

The following quantity data were adapted to aid in assessment of the material type, location and suitability for use as part of the Earthworks exercise.

Bulk quantities (general bulk cut)

- Excavate bulk cut to fill (no more than 30 km haul, typically 20 km max)
- Excavate bulk borrow to fill (within project site i.e. cut widening)
- Excavate bulk borrow to fill (external to project site e.g. local borrow pit)
- Import bulk fill (from quarry)
- Cut to waste

Select fill quantities (material typically CBR15)

- Excavate select cut to fill (no more than 30 km haul, typically 20 km max)
- Excavate select borrow to fill (within project site, typically 30 km max haul)
- Excavate select borrow to fill (external to project site, e.g. local borrow pit)
- Import select fill (from quarry)

7.4.2 Earthworks formation profiles

Given the varied but predominately poor soil types traversed by the route options, the following batter profiles have been adopted as representative for each corridor route.

A 1 in 3 slope has been chosen throughout for all alignment options as being representative of the final fill profiles. It is noted that in the low embankments across flood plains a flatter batter would be more appropriate for adoption in later design phases, however the variance in earthworks quantities is not significant and is within the bounds of the current alignment refinement. In other locations a 1:2 batter would also be suitable in detail design. An allowance of unsuitable material requiring removal and replacement has been included in areas where the routes cross sols that can be problematic for earthworks construction.

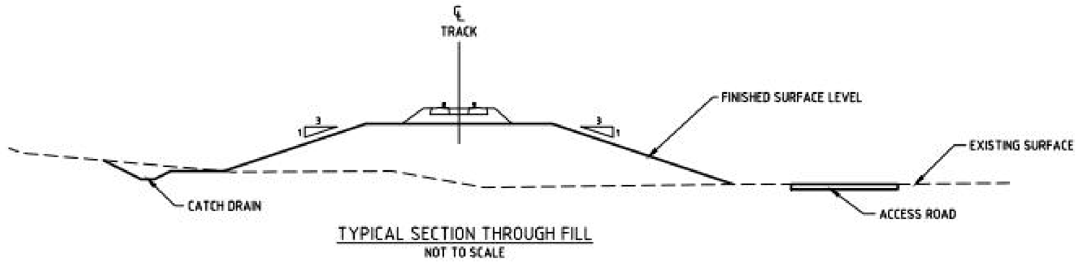

Figure 24 Typical section through fill

In cuts a batter profile of 1 in 2 has been adopted throughout as providing a stable slope for most geotechnical scenarios. As most routes considered require suitable material from within cuts to form the embankments this slope has been adopted for deeper cuts where in practice batters may be locally steepened to minimise expensive rock excavation.

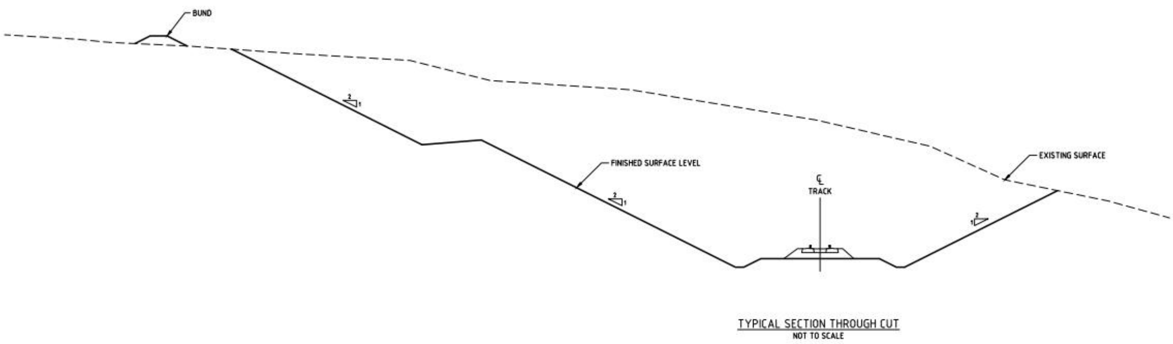

Figure 25 Typical section through cut

7.4.3 MCA inputs

The following provides a summary of the mass haul and earthworks requirements for each corridor route. **Figure 26** provides a summary of the overall earthworks volumes for each route.

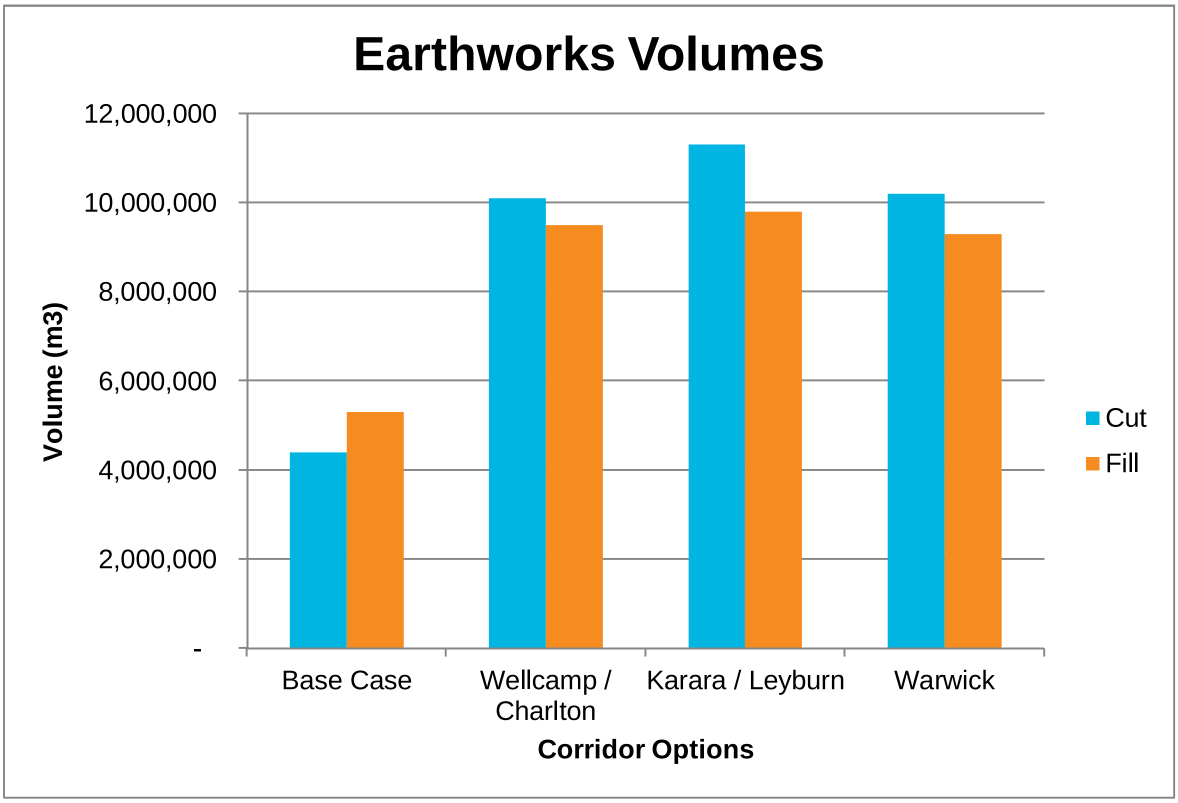

Figure 26 Earthworks volumes summary

The breakdown of mass haul volumes for each alignment has been detailed in **Table 26** to **Table 29**.

Table 26 Base Case Modified earthworks summary

Start CH	End CH	Length (m)	Location	Cut (m^3)	Fill (m^3)	Balance (m^3)	Comments
0	33,000	33,000	Inglewood Proximity	740,063	736,986	3,077	Excavate Bulk Cut to Fill
33,000	71,000	38,000	Inglewood to Commodore Mine	1,280,433	1,232,343	48,090	190,000 Import Select Fill (From Quarry)
71,000	100,000	29,000	Commodore Mine to Pampas	1,331,519	1,187,603	143,916	150,000 Import Select Fill (From Quarry)
100,000	134,000	34,000	Pampas to Iron Gate	47,494	715,756	-668,262	340,000 Import Select Fill (From Quarry) 328,000 Excavate Bulk Borrow to Fill (external to site borrow pit)
134,000	181,000	47,000	Iron Gate to Gowrie	1,012,000	1,420,657	-408,657	270,000 Import Select Fill (From Quarry) 138,000 Excavate Bulk borrow to Fill (external to site borrow pit)
Total				4,411,509	5,293,345	-881,836	
Borrow to Fill					-881,836		

Table 27 Wellcamp-Charlton earthworks summary

Start CH	End CH	Length (m)	Location	Cut (m^3)	Fill (m^3)	Balance (m^3)	Comments
0	33,000	33,000	Inglewood Proximity	740,063	736,986	3,077	Excavate Bulk Cut to Fill
33,000	71,000	38,000	Inglewood to Commodore Mine	1,280,433	1,232,343	48,090	190,000 Import Select Fill (From Quarry), remainder assumed as waste
71,000	100,000	29,000	Commodore Mine to Pampas	1,331,519	1,187,603	143,916	150,000 Import Select Fill (From Quarry), remainder assumed as waste
100,000	134,000	34,000	Pampas to Umbriam	1,742,829	1,715,379	27,450	130,000 Import Select Fill (From Quarry), 157,450 Cut to Waste
134,000	168,000	34,000	Umbriam to Gowrie	4,956,976	4,665,297	291,679	Cut to Waste
Total				10,051,819	9,537,607	514,212	
Cut to Spoil				514,212			

Table 28 Karara-Leyburn earthworks summary

Start CH	End CH	Length (m)	Location	Cut (m^3)	Fill (m^3)	Balance (m^3)	Comments
0	41,000	41,000	Oman Ama Station	550,965	917,584	-366,620	Excavate Select borrow to Fill from adjacent Section (within project site) Typically 30km max haul
41,000	75,000	34,000	Karara	1,691,198	1,329,156	362,042	Export cut to previous section
75,000	100,000	25,000	Leynurn	1,308,896	1,238,511	70,385	Cut to Waste
100,000	130,000	30,000	CH 130	2,435,448	1,479,305	956,143	Cut to Waste
130,000	171,000	41,000	End	5,322,600	4,792,692	529,908	Cut to Waste
Total				11,309,106	9,757,248	1,551,858	
Cut to Spoil				1,551,858			

Table 29 Warwick earthworks summary

Start CH	End CH	Length (m)	Location	Cut (m^3)	Fill (m^3)	Balance (m^3)	Comments
0	41,000	41,000	Oman Ama Station	550,965	917,584	-366,620	Excavate Select borrow to Fill (within project site) Typically 30km max haul
41,000	75,000	34,000	Karara	1,691,198	1,329,156	362,042	See Above
75,000	113,000	38,000	Wheatvale Station	2,484,092	2,408,307	75,786	Cut to Waste
113,000	132,000	19,000	CH 132	1,073,194	482,617	590,577	Cut to Waste
132,000	155,000	23,000	Nobby	328,545	347,864	-19,319	Excavate Select Cut to Fill (No more than 30km Haul) Typically 20km max
155,000	175,000	20,000	Cambooya	1,133,164	1,148,424	-15,260	Excavate Select Cut to Fill (No more than 30km Haul) Typically 20km max
175,000	194,000	19,000	Joins Karara-Leyburn CH157.9	1,664,799	1,490,833	173,966	Cut to Waste
194,000	208,100	14,100	End	1,228,623	1,153,071	75,552	Cut to Waste
Total				10,154,580	9,277,856	876,723	
Cut to Spoil				876,723			

7.5 Operations

7.5.1 Methodology

The four alignment options under review were transmitted to ARTC to undertake an operational modelling assessment. The operations modelling assessment uses the vertical and horizontal geometry of the alignment to determine train speeds and run times for the various trains that are planned to use the MBIR. It is also used to determine the number of passing loops required for each alignment. While the full report was not available for the options assessment, ARTC provided the express train run times for both northbound and southbound directions and the number of passing loops. Overall MBIR run times have not been provided for this assessment.

The operational modelling was also used to determine the length of uphill grade as it directly impacts fuel usage and in turn operational costs. By analysing the speed profiles from the operational modelling it can assessed where the trains are on a continuous uphill grade at full power. The total length of continuous uphill grade impacting train speeds was then added for each alignment for input into the MCA.

A separate assessment was undertaken on the operational connections required for each option. This was split into two separate criteria to better define the operational requirements between connections to the existing QR rail network mainlines and connections to the existing sidings (operational or not) on the QR network.

The connections to the existing rail networks included the start and finish points of the four alignments on the South Western Line and Western Line. It also included where the alignment connected to an existing QR line along the route such as the Millmerran Line and the Southern Line.

7.5.2 MCA inputs

The operational details for each alignment are shown in **Table 30**.

Table 30 Operational details

Parameters	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Transit time (northbound)	2:09:23	2:05:20	2:14:44	2:33:48
Transit time (southbound)	1:56:02	1:48:51	1:53:34	2:18:04
Length of grade impacting speed (km)	26	39	35	45
Passing loops	5	5	5	6
Connections to existing rail networks	4	4	3	4
Connections to existing sidings	9	7	4	13

7.6 Road crossings

7.6.1 Methodology

An assessment was performed to determine an approximate number of level crossings required for each rail alignment option. Each alignment was assessed using the same approach to not display bias for a particular alignment. Individual level crossing assessments were performed for greenfield/new and brownfield/existing alignments, with the final number of level crossings being a combination of the two.

For the assessment the level crossings were split into the following categories:

Active Major: A level crossing that requires flashing lights, signage and gates or barriers, where the lights and gate/barrier are activated prior to and during the passage of a train through the crossing.

Active Minor: A level crossing that requires flashing lights and signage, where the lights are activated prior to and during the passage of a train through the crossing. No gates or barriers are in place at the level crossing.

Grade Separation: A crossing of the rail alignment at a different height or grade either by road over rail or rail over road. In greenfield route sections, all freeways, major highways and major arterial roads shall be grade separated according to ARTC Melbourne-Brisbane Inland Rail Engineering Technical Services Basis of Design September 2015.

Passive Public: A level crossing that requires passive control devices (signage) which provides an unchanging warning to the road user whether or not a train is approaching the crossing. A Public level crossing is a crossing which is situated on a public road, street, track or unconstructed and/or dedicated road.

Passive Private: A level crossing that requires passive control devices (signage) which provides an unchanging warning to the road user whether or not a train is approaching the crossing. Private level crossings are crossings which provide access to a residence, private property or access to rail alignment for maintenance purposes (not open for public access).

7.6.1.1 Greenfield (New track)

For greenfield sections of the alignment options an assessment was undertaken to identify the number of crossings that would be required.

An initial estimate of the number and type of level crossings along each greenfield alignment was determined using GIS road intersection data obtained from DNRM Baseline Roads and Tracks Database Queensland. Each road intersecting the alignment was assigned a crossing type based on its road category as summarised in **Table 31**.

Table 31 Crossing types

Road Category	Crossing Type
Freeways/Motorways	Grade separation
Highways	Grade separation
Secondary Roads	Active major
Local Connector Roads	Active minor
Street/Local - only provides property access	Active minor
Dirt tracks listed as a public road	Passive public
Unconstructed and/or dedicated property access	Passive private

A visual inspection using aerial imagery was undertaken to confirm and refine the initial estimate. Each crossing was inspected and the crossing type was either upgraded or downgraded if necessary. For example, a number of crossings were updated to grade separations where dictated by the geometry, existing terrain and infrastructure. Where a road intersected the alignment multiple times in close proximity it was only counted as a single crossing.

Passive private crossings were counted manually via visual inspection using aerial imagery. A passive private crossing was counted where a road or access track crosses the alignment and leads to a building or property and is not a gazetted road in the GIS data.

7.6.1.2 Brownfield

The brownfield sections of the alignments were assessed independently to the greenfield sections as there are already dedicated crossings for public and private use.

The QR South Western System Information Pack Issue 3.0 – October 2016 and West Moreton System Information Pack Issue 3.1 – October 2016 were reviewed to determine all existing registered level crossings. ARTC's Policy from a safety perspective in brownfield alignment areas is to not create any new level crossings. Therefore, if an existing QR level crossing was identified in or close to a brownfield alignment then a level crossing would be counted in that location for the new alignment.

Four sections of existing QR alignments were identified as coinciding with sections of the proposed alignment options. These are summarised in **Table 32**.

Table 32 QR Regional Network Information

QR Regional Network	QR Alignment Section	Distance (km)
South Western System- Millmerran Branch	Wyreema to Millmerran	69.6
South Western System-South Western Line	Toowoomba to Warwick	94.1
South Western System-South Western Line	Warwick to Goondiwindi	201.5
West Moreton System- Western Line	Toowoomba to Dalby	83.2

Table 33 displays the results of the brownfield/existing level crossing assessment. It should be noted that the proposed MBIR alignments do not directly follow the existing QR rail alignments therefore a level crossing was included in the count if it directly overlayed or was in close proximity to an existing QR level crossing.

Table 33 Number of existing QR crossings overlayed or in close proximity to proposed alignments

QR Regional Network Alignment	Section	Proposed Alignment	Approximate Distance of Track Following Proposed Alignment (km)	Number of QR Level Crossings (in close proximity to proposed alignment)	Approximate Distance Per Level Crossings
Millmerran Branch	Wyreema to Millmerran	Base Case Modified	~26	20	~1.3
		Wellcamp-Charlton	~32	25	~1.3
South Western Line	Toowoomba to Warwick	Warwick	~52	15	~3.5
South Western Line	Warwick to Goondiwindi	Karara-Leyburn	~58	18	~3.2
		Warwick	~100	39	~2.6
West Moreton Line	Toowoomba to Dalby	Base case Modified	~11	3	~3.7
		Wellcamp-Charlton	~3	0	-
		Karara-Leyburn	~3	0	-
		Warwick	~3	0	-

7.6.1.3 Combined greenfield and brownfield assessment

To develop a more accurate estimation of the number of level crossings required for the four proposed alignment options, a combination of the greenfield and brownfield level crossing assessments were used. The brownfield assessment was used in areas where the proposed alignment followed or was within close proximity to existing QR alignments and the greenfield assessment was used in all other areas. The final amount of level crossings required for each alignment is a summation of the greenfield and brownfield level crossing assessments.

Where greenfield alignments ran through high value cropping land it was assumed there will be one crossings every 1.3 km. This assumption was to account for the higher number of crossings required in farming land to allow for additional access points for farmers and their equipment. The 1.3 km per crossing was derived from an assessment of the QR South Western System - Millmerran Branch.

The Millmerran Branch was used to determine an average distance per crossing as it was identified that the Millmerran branch is located in an area which could be considered to have a high density of farming land. 1.3 km is an approximate distance per crossing along the Millmerran Branch alignment through high value cropping land.

The greenfield and brownfield assessment approach and findings were presented to the PRG. Maps detailing the breakdown of crossings for each alignment are shown in **Appendix G**.

7.6.2 MCA inputs

Table 34 displays the estimated total active, passive and overall level crossings for each alignment option as well as the number of grade separations per alignment.

Table 34 Number of Crossings per Alignment

Description	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Grade Separation	2	2	5	4
Active Major	5	5	5	10
Active Minor	44	34	10	12
Total Active	49	39	15	22
Passive Private	58	55	49	50
Passive Public	21	26	32	51
Total Passive	79	81	81	101
Total Crossings	130	122	101	127

7.7 Stock crossings

7.7.1 Methodology

An assessment was performed to determine an approximate number of stock crossings required for each rail alignment option. Each alignment was assessed using the same approach.

Queensland's stock route network (SRN) provides pastoralists with a means of moving stock 'on the hoof' around the state's main pastoral districts, as an alternative to trucking and other contemporary transport methods. Approximately 72 000 km (2.6 million hectares) of Queensland's road network is declared as stock route. These routes, together with reserves for travelling stock, make up the Queensland SRN. The Land Protection (Pest and Stock Route Management) Act 2002 (Land Protection Act) regulates the use of the SRN.

Assessment of stock crossings was performed using QLD Globe datasets (stock routes Queensland). The aim was to identify an approximate number of stock crossings which each alignment option will require to allow continued use of the stock routes in the area.

The criteria for the assessment were:

- Where an alignment intersects a stock route one crossing was counted.
- If an alignment intersected a stock crossing multiple times in one location, only one crossing was counted in the assessment.

In accordance with ARTC's Basis of Design at-grade stock crossing are not permitted on Inland Rail as the speed of cattle crossing the railway is not controllable and cattle can stray along the line. Therefore, for the assessment a stock crossing was considered as two 3.6m x 2.4m RCBC side by side. These will provide plenty of light to allow cattle to pass through easily and significant width to allow multiple cattle to pass through at once

7.7.2 MCA inputs

The number of stock crossing for each alignment option is shown in **Table 35**.

Table 35 Stock crossings

Description	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Stock crossings	9	9	12	11

7.8 Public Utility Plant (PUP)

A PUP assessment was performed to determine the likely impacts and interfaces with existing services within each corridor route. Each corridor was assessed using the same approach to not display bias for a particular option. The assessment sought to define the:

- Likely number of service interfaces as result of each corridor
- Number and type of a service impacted
- The typical complexity and timeframe associated with a service relocation or protection

7.8.1 Methodology

The analyses of PUPs focused on backbone/transmission infrastructure as these services have a longer approval time and are more complex to either protect or relocate than local supplies.

These services include; oil, trunk gas, water, backbone fibre and major power transmission lines. The approach taken during development of the design was:

- Identify possible conflicts using the DBYD and GIS data set and the Route options
- Create potential conflict register for inclusion in the MCA and Cost Estimate assessments
- Assess high level opportunities to avoid or reduce service impact (design out or protect)

A Dial Before You Dig (DBYD) request covering all corridor options was obtained in conjunction with ARTC's GIS team. DBYD data was requested from the following service providers whose infrastructure was determined to potentially interface with the corridor routes being considered:

- Powerlink Qld
- Essential Energy
- Ergon Energy, Toowoomba
- Millmerran Power
- APA Group Networks, Brisbane
- APA Group Transmission (QLD)
- Arrow Energy NL
- APA Group (Allgas) Networks, Qld
- Seqwater (Brisbane)
- Viva Energy Australia Ltd (Qld)

An intersection analysis of the DBYD PUP data was run with the rail control of each corridor alignment to identify the location and type of service potentially impacted. Maps detailing the breakdown of PUPs for each alignment based on the information available are shown in **Appendix H**.

Service outputs were tabulated in a spreadsheet for input into the MCA and cost estimate assessments. The number of properties intersected by the rail alignment was also used in the PUPs assessment as this metric provides an indicator to the likely number of local service connections that would be affected by each corridor.

The final rail corridor rail line will require utilities such as water, wastewater, power and telecommunication services to be provided at select locations. These locations are currently unknown. As services exist along all corridor routes no differentiating criteria were identified that required new services to be considered in the MCA.

7.8.1 MCA Inputs

The PUPs details for each alignment are shown in **Table 36.**

Table 36 PUPs Details

	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Gas or oil pipeline	8	7	5	5
Overhead electrical crossings - 110kV and greater	20	45	43	65
Overhead electrical crossings - less than 110kV	48	62	7	22
Telecommunications & optic fibre U/G	14	19	6	6
Total residential and commercial receptors within 200m of the corridor	225	148	69	576

7.9 Hydrological assessment

7.9.1 Alignment hydrological overview

7.9.1.1 Base Case Modified

The Base Case Modified alignment crosses extensive sections of floodplain at the Condamine River. During high flow events, the Condamine River breaks out into a complex floodplain formed by three main branches, the Northern Branch, Main Branch and Southern Branch (also known as Grasstree Creek). The main Condamine 1% Annual Exceedance Probability (AEP) floodplain crossing length is approximately 12.5 km, although the total floodplain length at this location extends further when tributaries such as Back Creek and Learmonth Gully are included.

Inclusive of two major stream crossings (stream order ≥ 3) and one minor stream crossing (stream order < 3) at the Condamine River and associated floodplain, the Base Case Modified alignment crosses 20 major crossings and 55 minor crossings. The major waterway crossings include the Condamine River, Cattle Creek, Fourteen Mile Creek (Rocky Creek), Linthorpe Creek, West Brook Creek and Gowrie Creek.

The total 1% AEP floodplain length crossed by the Base Case Modified alignment, inclusive of minor waterways, major waterways and the Condamine River floodplain, is estimated at 29 km using the assessment methodology adopted by this study.

7.9.1.2 Wellcamp-Charlton

The Base Case Modified and Wellcamp-Charlton alignment options are identical at the intersection with the Condamine River and floodplain. As with the Base Case Modified alignment, the Wellcamp-Charlton alignment crosses approximately 12.5 km of complex floodplain at the Condamine River in the 1% AEP event.

The Wellcamp-Charlton alignment crosses 15 major waterways and 69 minor waterways. The major waterway crossings included the Condamine River, Cattle Creek, West Brook Creek and Dry Creek.

The total 1% AEP floodplain length crossed by the Wellcamp-Charlton alignment, inclusive of minor waterways, major waterways and the Condamine River floodplain, is estimated at 27 km.

7.9.1.3 Karara-Leyburn

The Karara-Leyburn alignment traverses extensive sections of floodplain on the Macintyre Brook, Condamine River and West Brook Creek.

The Karara-Leyburn alignment option includes 17 crossings of major waterways and 62 crossings of minor waterways. The major waterway crossings include Macintyre Brook (twice), Chain of Ponds Creek (multiple crossing), Thanes Creek, Condamine River, Hodgson Creek, Middle Creek, West Brook Creek and Dry Creek.

The total 1% AEP floodplain length crossed by the Karara-Leyburn alignment, inclusive of minor waterways, major waterways and the Macintyre Brook and Condamine River floodplains, is estimated at 23 km. The most significant crossings are the Condamine River (approximately 5.5 km between Leyburn and Felton East) and Macintyre Brook (approximately 6.8 km at Inglewood for both crossings).

7.9.1.4 Warwick

The Warwick alignment traverses extensive sections of floodplain on the Macintyre Brook and also crosses the Condamine River and several of its tributaries, including West Brook Creek, along the alignment in the upper reaches of the Condamine River catchment.

The Warwick alignment option includes 25 crossings of major waterways and 66 crossings of minor waterways. The major waterway crossings include Macintyre Brook (twice), Chain of Ponds Creek (multiple crossing), Condamine River, West Brook Creek and Dry Creek.

The total 1% AEP floodplain length crossed by the Warwick alignment, inclusive of minor crossings, major crossings and the Macintyre Brook and Condamine River floodplains, is estimated at 26 km. The most significant crossings are the Condamine River and floodplain (approximately 2.2 km) and Macintyre Brook floodplain (approximately 6.8 km at Inglewood for both crossings).

7.9.2 Site visit

A guided tour of the Base Case Modified and Wellcamp-Charlton rail corridor option alignments was undertaken on 18 January 2017. AECOM personnel were accompanied by 23 landholders along the alignments between Millmerran and Pittsworth, within the Condamine River floodplain. The tour was undertaken to provide the opportunity for landholders to present their information and history on flooding. The tour included visiting key locations for flooding and a photo exhibition at the Millmerran Library.

Data provided by the landholders included:

- Anecdotal evidence shared during the tour
- Photos and videos in hard copy
- Historical reports
- Report prepared for Millmerran Farmers Group (Evaluation of Flood & Waterway Impacts, WRM 2016).

In addition, historical water depths from 2010/11 flood and debris markers were photographed, measured with a measuring tape and recorded during the tour by AECOM. These water depths and other data provided by landholders were compared against the results of the TUFLOW flood model simulating the 2010/11 flood.

A comparison of 2010/11 flood model results to the observed flood marks is shown on Map 4 (Appendix A of the Base Case Modified and Wellcamp – Charlton Options Condamine River Hydraulic Assessment Report (**Appendix I** of this report). The comparison shows that the 2010/11 flood model results are within a reasonable level of accuracy to observed flood markers. At locations shown, the greatest difference in model results is ±0.66m near the Southern Branch (Grasstree Creek). Differences in recorded and modelled flood levels can result from a number of causes including:

- Wave and wind effects (debris marks higher than actual flood levels due to waves from wind or traffic
- Timing of the photo capture compared to the peak of the flood
- Timing of hydrograph coincidence and associated backwater effects (at the Grasstree Creek and Back Creek confluence)
- The 2D gridded nature of the flood model's underlying Digital Elevation model (DEM).

Generally, the model is considered to represent the historical data well (four of the six locations within 300mm). As such the model is considered to provide a reasonable representation of the 2010/11 flood in this area.

7.9.3 Methodology

The following sections present the methodology for assessing each corridor alignment option in terms of hydrological characteristics of the catchment, and hydraulic characteristics at waterway crossing locations. The methodology was developed to provide a like-for-like assessment across the four corridor options to provide comparison between each of the alignment options.

7.9.3.1 Waterway identification

Each waterway that crosses the four proposed corridors was classified based on the stream order of that watercourse. The QLD Globe watercourse layer was used to identify and classify the crossings. The QLD Globe watercourse layer classifies stream orders from Order 1 (smallest) up to Order 7 (largest in the study area). The stream order classification (or Strahler number) is an international naming convention, and is used to define stream size based on a hierarchy of tributaries.

For the purposes of this investigation, Stream Orders 1 and 2 were classified as 'minor waterways' and Stream Orders 3 and above were classified as 'major waterways'.

The total number of crossings of each stream order was identified for each alignment option.

7.9.3.2 Condamine river and floodplain hydraulic assessment

Each of the four alignment options cross the Condamine River and floodplain. Due to the complexity and magnitude of flows across the Condamine River and floodplain, detailed two-dimensional (2D) hydraulic modelling was undertaken to assess the floodplain characteristics for each alignment option at this waterway. In order to provide an adequate level of detail for the floodplain assessment LiDAR ground topography was used to for the full extents of the TUFLOW models for all four alignments.

Existing hydrological and hydraulic models were sourced from Toowoomba Regional Council and Southern Downs Regional Council flood studies. The models from the following studies were utilised for the assessment:

- Base Case and Wellcamp-Charlton – Condamine River Flood Study, TRC, 2015
- Karara-Leyburn – Condamine River Flood Study, TRC, 2015
- Warwick – Condamine River and Tributaries Flood Study, Southern Downs Regional Council, March 2012.

Hydrological flows were developed and/or extracted from the various Council adopted URBS models. The hydraulic models established for each Condamine River and floodplain crossing were in TUFLOW. The models were used to investigate the 1% AEP critical design storm to determine flooding characteristics, flood levels and flow velocities within the study areas under existing and developed conditions, based on cross drainage concepts developed as part of this options assessment. Detailed descriptions of the methodologies are provided in the Hydraulic Assessment Reports in **Appendix I, J & K** of this report.

The developed case models for each option were assessed against the design criteria presented in **Section 1.3.3**. For the purposes of like-for-like comparison, the cross drainage infrastructure (viaducts/bridges and balancing culverts) were modified to achieve similar areas of predicted impact for each alignment option.

Blockage

Australian Rainfall and Runoff (ARR 2016) Project 11 – Blockage of Hydraulic Structures was used as a basis for determining blockage factors to apply to the structures. The ARR guideline is a site specific risk based approach which determines:

- debris availability
- debris transportability
- debris mobility
- size of the debris versus the structure type.

Typically, blockage in a local context would be considered in later design phases. At this time, site inspection would be undertaken to review site specific conditions and determine the appropriate blockage factor to apply to different catchments. For the purpose of this options assessment, for like-for-like comparative purposes, an indicative blockage assessment was undertaken for all crossings. This assessment resulted in a blockage factor to be applied to the structures of 20%. This is in agreement with the Queensland Urban Drainage Manual (QUDM) that provides guidance that in the absence of site specific catchment data, a blockage factor of 20% should be applied.

The 20% blockage factor was applied to the balancing culverts in the TUFLOW models for the developed case option for each alignment. In addition, the balancing culvert sizes were increased in the model to account for the impact of blockage.

7.9.3.3 Major and minor waterway assessment

For waterway crossings outside of the Condamine River and floodplain, a high level hydrological and hydraulic assessment approach suitable for comparative assessment of the alignment options was undertaken.

7.9.3.3.1 Hydrological Assessment

The contributing catchments to each of the crossing locations were delineated from a 5m DTM of the ground surface supplied by The State of Queensland Qspatial Catalogue October 2016. This is the same ground surface used for the alignment and earthworks design as it the most accurate surface available for all alignments, as discussed in **Section 1.2**.

Peak 1% AEP flows for each catchment at the crossing locations were derived from the Regional Flood Frequency Estimation (RFFE) tool, developed to provide flood estimates for ungauged catchments. The RFFE tool, developed by Engineers Australia, is based on data from 853 gauged catchments across Australia. The technique is based on the concept of regionalisation, an approach where data from gauged catchments is utilised to make flood flow estimates at ungauged locations.

The RFFE approach is recommended by ARR 2016 to calculate flows where gauge data is not available for calibration of hydrological models. The RFFE tool required requires data inputs including catchment name, area, latitudes and longitudes of the catchment outlet and centroid. The RFFE output is design storm flow estimates for each catchment analysed and upper (95%) and lower (5%) confidence limits on these design storm flow estimates. Using this approach, the 1% AEP peak flows were estimated for each catchment outside of the Condamine River and floodplain.

Uncertainty exists in the accuracy of all hydrological modelling of ungauged catchments, including the RFFE. This uncertainty is demonstrated in the RFFE estimates performed for this study, which showed significant variance between upper and lower confidence limits output by the RFFE tool. The variance is related to the distance of each catchment to the closest gauge data. As this method was applied to provide an estimate of flows for the purposes of a like-for-like comparative assessment between alignment options, the approach is considered acceptable.

7.9.3.3.2 Hydraulic Assessment

The hydraulic assessment of the minor and major waterways outside of the Condamine River and floodplain was undertaken utilising the Federal Highway Administration (FHWA) Hydraulic Toolbox V4.2 software package. The FHWA Hydraulic Toolbox Program is a standalone suite of calculators that performs routine hydraulic computations. The Hydraulic Toolbox requires the following inputs:

- waterway cross-section
- longitudinal slope
- Manning's 'n' roughness
- Flow

Waterway cross section and longitudinal slope were extracted from the 5m DTM ground surface data for each crossing, with the resulting cross-sections at each location entered into Hydraulic Toolbox. Using Manning's equation, Hydraulic Toolbox calculates the flood level and flood width for each crossing location. The 1% AEP peak flood level and flood width was calculated for this assessment.

As described in **Section 7.9.3.2** detailed hydraulic assessments using flood models were carried out to identify main Condamine River floodplain widths for each alignment option.

7.9.3.4 Hydraulic Structure Assessment

7.9.3.4.1 Bridges

A bridge structure was adopted for waterway crossings with a 1% AEP peak flow rate estimate greater than 100m^3/s. The bridges were sized for the 1% AEP peak flow. Estimation of proposed bridge lengths was undertaken using Hydraulic Toolbox, with Manning's equation as the basis for the assessment.

The calculations used for the flood level estimate were used as a basis for bridge assessment. For each crossing, vertical walls were applied at either end of the cross-section to represent the constricted waterway area through a bridge structure. The location of these vertical walls was adjusted to achieve a minimum change to flood levels and velocities from existing conditions in line with the design criteria. The distance between the vertical walls which achieved the design criteria was used as an estimate of the required bridge length.

This is a coarse estimation technique which does not consider the impact of bridge piers, friction losses, etc., however this approach is considered acceptable for comparative purposes between alignment options.

7.9.3.4.2 Culverts

A culvert structure was adopted where practical for waterway crossings with a 1% AEP peak flow rate estimate less than 100m^3/s. The culverts were sized for the 1% AEP peak flow. Manning's equation was used to estimate pipe full flow for pipe and box culvert configurations. The proposed culvert configuration was selected to ensure that:

- the culvert height is equal to or less than flood depth (from Hydraulic Toolbox)
- total culvert width is equal to or less than flooded width (from Hydraulic Toolbox)
- the number of cells and total width of culvert bank is practical (if not, a bridge was considered)
- culverts had sufficient cover to the top of the proposed rail formation

As with the bridge assessment methodology, this high level design approach is a coarse assessment which does not consider headwater levels, tailwater levels, driving heads, etc. However, this approach is considered acceptable for comparative purposes between alignment options in achieving a like-for-like assessment for this level of study.

7.9.4 MCA inputs

7.9.4.1 Waterway identification

For each of the corridor alignment options, the waterway crossings and associated stream orders are presented in **Table 37** and **Table 38.**

Table 37 Number and Stream Order of Crossings

Stream order	No of Crossings			
	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
1	34	47	38	46
2	21	22	24	20
3	8	7	8	12
4	10	6	3	6
5	1	1	2	4
6	1	1	3	2
7	0	0	1	1
8	0	0	0	0
Total	**75**	**84**	**79**	**91**

Table 38 Total Crossings

Crossing Type	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
No. Major Crossings	20	15	17	25
No. Minor Crossings	55	69	62	66
Total Crossings	75	84	79	91
Total	**75**	**84**	**79**	**91**

The major and minor stream crossing locations identified for each alignment option, as part of this options assessment are shown in **Appendix L**.

7.9.4.2 Length of floodplain crossed

The lengths of 1% AEP floodplain crossed for major waterways, minor waterways and the Condamine River and floodplain for each alignment option as derived using the assessment methodology outlined in **Section 7.9.3.3.2** is presented in **Table 39**.

Table 39 Length of floodplain crossed

Waterway Type	Length of 1% AEP floodplain crossed			
	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
Major waterways	8.8	7.0	10.4	15.7
Minor waterways	7.4	7.8	6.9	7.6
Condamine River and floodplain	12.5	12.5	5.5	2.2
Total	**28.7**	**27.3**	**22.8**	**25.5**

7.9.4.3 Condamine River cross drainage structures

The results of the Condamine River and floodplain modelling for the Base Case Modified, Wellcamp-Charlton, Karara-Leyburn, and Warwick alignment options determined the proposed bridge and balancing culvert infrastructure shown in **Table 40**. The culverts include an allowance for 20% blockage and also adopt a minimum culvert size to avoid blockage from hay bales, etc.

The number of balancing culverts is relative to the floodplain width. Bridge structures are located where the major flows pass with culverts added for the remainder of the floodplain to allow the wide, low velocity flows to pass. Downstream on the Condamine the Base Case Modified and Karara-Leyburn alignments cross 12.5 km of floodplain and have 900 balancing culverts while further upstream at Warwick the floodplain is 2.2 km wide and therefore has 93 balancing culverts.

Table 40 Proposed Condamine River and Floodplain Viaducts/Bridges and Balancing Culverts

Alignment Option	Condamine River and Floodplain structures		
	No. Water Crossings on Condamine River Floodplain	Proposed Viaduct/Bridge Configuration	Proposed balancing culvert configuration
Base Case Modified & Wellcamp-Charlton	Major - 2 Minor - 2	750 m – Main Branch 750 m – South Branch 300 m – North Branch	590/1.8 m RCP 310/2.1 m RCP (**900 RCPs)** 30/3.6 m x 1.5 m RCBC (at Pampas)
Karara-Leyburn	Major - 2 Minor - 1	350 m – Condamine River 750 m – Floodplain 400 m – Thane Creek	420/1.8 m RCP 170/2.1 m RCP (**590 RCPs)**
Warwick	Major - 1	260 m 400 m 60 m	93/1.5 m RCP

It is noted that optimised viaducts/bridge solutions were developed for the main Condamine River floodplains for each corridor alignment option, based on hydraulic modelling. For the Modified Base Case and Charlton-Wellcamp alignment options the Condamine River flows are concentrated in three distinct flow paths, with shallow out of bank (~0.5 m deep) flow across the floodplain. As such three viaducts have been assessed as sufficient to conform with the high level design criteria, supported by a large number of 'balancing culverts' to spread the flow. For the upper Condamine River crossing a series of individual bridges are required to span the individual river crossings, resulting in a larger number of bridges. Detailed hydraulic modelling of these crossings will be required in further design stages to refine and optimise bridging solutions.

7.9.4.4 Major and minor catchments

The catchment sizes contributing to major and minor crossings for the four alignment options outside of the Condamine River are presented in **Appendix M** along with the hydrological assessment, including the estimated 1% AEP peak flows.

7.9.4.5 Major and minor structures

The cross drainage structures proposed for minor and major crossings, excluding the Condamine River and floodplain (reported separately in **Table 40**), are presented in **Table 41**. Structure locations and flow details for individual bridge and culvert crossing for each of the four alignments are shown in **Appendix M**.

The total number of viaducts/bridges required for each option including, the Condamine River and floodplain, is presented in **Table 42**. The total bridge length for each alignment option is presented in **Table 43.**

Table 41 Proposed Drainage Structures for Minor and Major crossings (excluding Condamine River floodplain)

Alignment Option	Estimated Number of Minor and Major Crossing Structures (excluding Condamine River and Floodplain)		
	Number of Pipe Culverts (locations)	Number of Box Culverts (locations)	Number of Bridges (locations)
Base Case Modified	9	44	18
Wellcamp-Charlton	18	50	12
Karara-Leyburn	7	51	19
Warwick Alignment	10	48	32

Table 42 Number of viaducts/bridges

Alignment Option	Estimated Number of Viaducts/Bridges			
	Major	Minor	Condamine	Total
Base Case Modified	16	2	3	21
Wellcamp-Charlton	11	1	3	15
Karara-Leyburn	14	4	3	21
Warwick Alignment	23	9	3	35

Table 43 Total viaduct/bridge length

Alignment Option	Estimated Viaduct/Bridge Length (km)			
	Major	Minor	Condamine	Total
Base Case Modified	2.27	0.13	1.8	**4.20**
Wellcamp-Charlton	1.48	0.06	1.8	**3.34**
Karara-Leyburn	4.50	0.35	1.5	**6.35**
Warwick Alignment	7.50	0.98	0.7	**9.18**

Hydrological investigations completed to inform this options assessment have incorporated detailed modelling for nominated 10% and 1% AEP events for the Condamine River floodplains. The design of the infrastructure will likely vary according to a controlling event that is neither of these events and as such further investigation will be required during the more detailed design stages, where design criteria will be nominated in the EIS phase.

Detailed hydrological and hydraulic assessments supported by modelling and site survey (or LiDAR) are also required for other waterway crossings during further design development stages, to confirm cross drainage arrangements.

7.10 Ecological impacts

7.10.1 Methodology

Potential impacts to fauna, flora and vegetation communities were assessed using a combination of desktop assessment of environmental values, field survey and an assessment of ecological constraints along each Route Corridor option, based on the ground-truthed information in conjunction with existing state-wide mapping. Desktop assessment of ecological constraints involved review of the following databases and mapping:

- EPBC Act Protected Matters Search Tool (PMST), undertaken with a 10 km buffer around the rail alignments (approximately digitised into the online tool) on 17 October 2016.

- Wildlife Online Database Search, a rectangular area that encompassed the entire rail alignment bounded by the coordinate -27.4752 to -28.4333 and 151.1933 to 152.0986 on 17 October 2016 for all fauna and flora species list and individual records of listed species
- Atlas of Living Australia database using a 10 km buffer around the Route Corridor options on 17 October 2016 for all flora and fauna species listed
- RE mapping (Queensland Herbarium 2015a) and the DEHP's "former" HVR mapping (DNRM, 2016).
- Queensland MSES mapping (DSIP, 2015) which includes wetlands, Essential Habitat, Endangered and Of Concern remnant vegetation etc.
- DEHP's Protected Plants Flora Survey Trigger Area mapping (DEHP, 2014b)
- DEHP's Wetland mapping (Queensland Herbarium, 2015b)
- VMA Stream order mapping (DNRM, 2015)
- Aerial imagery.

For the purpose of ecological impact assessment, focus was placed on matters of national and state environmental significance as specified under the following legislation:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Vegetation Management Act 1999* (VM Act)
- *Nature Conservation Act 1992* (NC Act).

Matters protected under the *Fisheries Act 1994* were considered under the flooding and waterway impacts MCA sub-criteria (refer **Section 7.13**).

For the purpose of informing the MCA, the metrics specified in **Table 44** were adopted.

Table 44 Ecological MCA metrics

Ecological Aspect	Legislative Trigger	Assessment
Threatened Ecological Communities (TEC)	EPBC Act	Area of TEC within the notional construction corridor of each route option
Remnant vegetation under the Regional Ecosystem (RE) classifications of Endangered, Of Concern and Least Concern.	VM Act	Area of RE, by classification, within the notional construction corridor of each route option
Essential Habitat	VM Act	Area of Essential Habitat within the notional construction corridor of each route option
Non-remnant vegetation	Nil, but mapped under the VM Act	Area of non-remnant vegetation within the notional construction corridor of each route option
Protected Area: National Park, Reserve, State Forest, Conservation Areas	Various	Area of Protected Area within the notional construction corridor of each route option

The likelihood of occurrence of Endangered, Vulnerable and Near Threatened (EVNT) flora and fauna species under the EPBC Act and NC Act involved combination of publically available database queries and ground-truthing of habitat suitability through field survey. This assessment identified:

- 38 flora species are considered as known, likely to occur or potentially occurring along the Route Corridor options.
- 46 fauna species are considered as known, likely to occur or potentially occurring along the Route Corridor options.

The assessment concluded that whilst individual EVNT species may have localised confirmed occurrences, the potential for EVNT species to occur is reasonably ubiquitous across all four route options. Consequently, confirmed records of EVNT species was not considered to be an appropriate metric for consideration in the MCA.

The Ecological Constraints Assessment for the alternative route options is presented as an appendix to the Preliminary Environmental Assessment Reports for the Karara-Leyburn and Warwick route options (AECOM, 201 7). Ecological features are shown on Map Series 2 in **Appendix N, O & P**.

7.10.2 MCA Inputs

The metric values presented in **Table 45** were utilised in the MCA to inform a quantitative assessment of the ecological impact potential for each route option.

Table 45 Ecological MCA inputs

Item	Units	Modified Base Case	Wellcamp - Charlton	Karara - Leyburn	Warwick
Threatened Ecological Community (EPBC Act) within the notional construction corridor					
• Total	ha	**19.7**	18.8	52.5	64.4
• Greenfield	ha	**19.2**	18.3	47.7	60.9
• Brownfield	ha	**0.5**	0.5	4.8	3.5
Remnant vegetation within the notional construction corridor:					
Endangered (total)	ha	**4.3**	4.3	10.1	12.9
• Greenfield	ha	**4.3**	4.3	9.9	12.7
• Brownfield	ha	**0**	0.0	0.2	0.2
Of Concern (total) within the notional construction corridor:	ha	**22.8**	20.3	42.1	79.5
• Greenfield	ha	**20.1**	19.2	37.6	71.2
• Brownfield	ha	**2.7**	1.1	4.5	8.3
Least Concern (total) within the notional construction corridor:	ha	**65.1**	85.6	25.2	11.9
• Greenfield	ha	**62.7**	84.8	25.0	11.8
• Brownfield	ha	**2.4**	0.8	0.2	0.1

Item	Units	Modified Base Case	Wellcamp - Charlton	Karara - Leyburn	Warwick
Essential habitat within the notional construction corridor	ha	**3.8**	16.8	2.4	15.0
Non-remnant vegetation within the notional construction corridor	ha	**843**	885	983	1093
State Forest within the notional construction corridor	ha	**39.8**	39.8	0.1	19.5

7.11 Visual impacts

7.11.1 Methodology

Visual impacts arise from changes in available views of the landscape that occur as a result of development. Visual impact is determined through the subjective assessment of sensitivity of the visual receptors (i.e. residents, outdoor recreational users) and the magnitude (scale) of the change in view. Sensitivity is dependent upon the receptor’s location; the importance of their view; their activity (i.e. working, recreational, or travelling through); expectations; available view; and the extent of screening of this view.

For the purposes of assessing potential impacts to visual amenity, the Basis of Design for Inland Rail (Parsons Brinkerhoff, 2015) specifies a reference train that is double stacked (7.1m above rail formation) with maximum length of 1,800m (initially, with a maximum future length of 3,600m), travelling a maximum operating speed of 115km/h.

Additional to those visual impacts associated with the movement of trains through the environment, the principal visual amenity issues associated with the project include, but are not limited to, the following:

- The railway corridor will typically comprise an elevated ballast and track some ~730mm above natural ground level
- Changes in landform with embankments of varying height
- Creation of passing loops, and associated signals
- Passive crossings, and associated signs
- Active crossings, and associated signs, flashing lights and boom gates etc.
- Multiple new bridges and upgrades to existing bridges
- Culverts
- Additional road network infrastructure across the project properties, as a result of road closures
- Loss of vegetation
- Severance of agricultural land and loss of rural amenity.

Temporary visual impacts are also anticipated, associated with construction works. These include:

- Localised concentration of machinery and laydown areas
- Equipment and personnel at active construction sites
- Temporary construction camps.

For the purpose of informing the MCA, the metrics specified in **Table 46** were adopted to inform assessment of an otherwise subjective aspect.

Table 46 Visual MCA metrics

Visual Aspect	Assessment
Greenfield alignment length	Total length of each route option considered to be greenfield, i.e. not previously used for railway purposes
Total length of high embankments (10 m+)	Total length of embankments higher than 10 m along each route option
Total length of viaducts/bridges	Total length of viaducts/bridges along each route option
Residential receptors	Residential receptors within 200 m* of the notional construction corridor, broken down for each route option to provide a total number and the number along greenfield sections.

* Visual impacts will be experience by residential receptors greater than 200 m from each route option. However, 200 m buffer was applied to gain an appreciation for the density of residences in proximity to each route option.

The Preliminary Environment Assessments Reports for the route options (AECOM, 2017) provide greater detail on the landscape character along each of the route options.

7.11.2 MCA inputs

The metric values presented in **Table 47** were utilised in the MCA to inform an otherwise qualitative assessment of the visual impact potential for each route option.

Table 47 Visual impact MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Greenfield alignment length	km	**126**	137	122	115
Brownfield alignment length	km	**55**	30	49	93
Total length of high embankments (10m+)	km	**3**	8	8	9
Total length of bridge	m	**4,275**	3,375	6,465	9,395
Residential receptors within 200m of the notional construction corridor:					
• Total	no.	**203**	126	67	508
• Greenfield	no.	**24**	61	38	46
• Brownfield	no.	**179**	65	29	462

7.12 Noise and vibration impacts

7.12.1 Methodology

The applicable noise impact assessment criteria for MBIR are currently proposed by ARTC to be in accordance with the New South Wales Rail Infrastructure Noise Guideline (NSW RING) (State of NSW, 2013).

Noise level criteria in the NSW RING are given in terms of “trigger levels” for noise receptors for:

- Residential land uses, for the
  - day (7am-10pm)
  - night (10pm-7am) periods
- Non-residential sensitive land uses, for the periods when the land use is in use.

For both types of land uses the NSW RING distinguishes between the cases of a new rail development and a redevelopment of an existing rail line.

It should be noted that the ordinary use of a rail line in Queensland is excluded from assessment of environmental harm under the EP Act. The typical noise criteria for railways in Queensland are less stringent than the trigger levels in the NSW RING.

For the purpose of informing the MCA, the metrics specified in **Table 48** were adopted.

Table 48 Noise and vibration MCA metrics

Noise and Vibration Aspect	Assessment
Residential receptors	Residential receptors within 200 m of the notional construction corridor, broken down for each route option to provide a total number and the number along greenfield sections.
Other sensitive receptors	Other sensitive receptors (such as schools, health care facilities etc.) within 200 m of the notional construction corridor
Commercial or industrial receptors	Commercial or industrial receptors within 200 m of the notional construction corridor

7.12.2 MCA inputs

The metric values presented in **Table 49** were utilised in the MCA to inform an assessment of the noise and vibration impact potential for each route option.

Table 49 Noise and vibration MCA inputs

Item	Units	Modified Base Case	Wellcamp - Charlton	Karara-Leyburn	Warwick
Residential receptors within 200m of the notional construction corridor:					
• Total	no.	203	126	67	508
• Greenfield	no.	24	61	38	46
• Brownfield	no.	179	65	29	462
Other sensitive receptors within 200m of the notional construction corridor	no.	2	2	0	6
Commercial/ industrial receptors within 200m of the notional construction corridor	no.	22	22	2	68

7.13 Environmental flooding and waterway impacts

7.13.1 Methodology

This MCA sub-criteria is focussed on the potential impacts of any one route option on the existing flooding and waterway conditions.

Potential impacts to waterway condition were assessed based on two aspects, being:

- Quantity: the number of waterways crossed by each route option
- Quality: the ecological value of waterways crossed by each route option.

The number of waterways crossed by each route option was determined through intersect analysis using the Department of Natural Resources and Mines' Ordered Drainage 100K for Queensland. This dataset is based on the GeoScience Australia 1:100,000 drainage network of Queensland (where 1:100,000 coverage exists) and has streams connected and directionalised, and ordered using the Strahler method of stream ordering.

The ecological quality of waterways crossed by each route option was determined through intersect analysis using the Department of Agriculture and Fisheries' *Queensland waterways for waterway barrier works* data set. This data set provides an indication of the risk of impact to any one waterway due to works within the waterway on fish movement and fish communities.

Potential impacts to flooding were assessed based on the length of each route option that crosses 1% AEP floodplain. The basis for this assessment was that the greater the length of floodplain, the greater the possibility of modification of flood regimes in significant events.

For the purpose of informing the MCA, the metrics specified in **Table 120** were adopted.

Table 50 Flooding and waterway MCA metrics

Flooding and Waterway Aspect	Assessment
Stream crossings	Number of major and minor waterways crossed by each route option
Waterway barrier works classification	Number of waterways crossed by each route option, by waterway barrier work classification
Length of floodplain	Length of each route option that is aligned through 1% AEP floodplain

7.13.2 MCA inputs

The metric values presented in **Table 51** were utilised in the MCA to inform an otherwise qualitative assessment of the flooding and waterway impact potential for each route option.

Table 51 Flooding and waterway impact MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Stream crossings:					
• Major	no.	**20**	15	17	25
• Minor	no.	**55**	69	62	66
• Total	no.	**75**	84	79	91
Waterway Barrier Works mapped watercourses crossed by the notional alignment:					
• Purple (Major)	no.	**15**	10	9	17
• Red (High)	no.	**8**	8	12	16

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
• Amber (Moderate)	no.	**26**	27	25	23
• Green (Low)	no.	**33**	46	46	53
Total Major and High	no.	**23**	18	21	**33**
Length of 1% AEP floodplain crossed:	km	**29**	27	23	26

7.14 Air quality impacts

7.14.1 Methodology

Construction

The primary construction phase pollutant of concern will be particulate matter due to disturbance of earth and rock associated with construction activities such as excavation and land clearing. Emissions of combustion products from construction plant exhaust will also occur.

Localised air quality impacts may vary between route options due to proximity of sensitive receivers to major earthworks locations or unsealed haul roads. Receivers have been identified along the route within a 400m wide corridor (200m either side of the route option) as required for input into the project MCA for the current alignment options (refer to **Table 52**).

Localised air quality impacts from construction operations are typically able to be managed through a construction air quality management plan.

Operation

The primary operational pollutants of concern are products of combustion (Particulate Matter, CO, NO_2, SO_2, VOCs) from train locomotives. Some fugitive particulate emissions from loaded grain or cotton wagons or from wheel-generated dust from rail line ballast may also occur; however, these are expected to be relatively minor.

Combustion emissions from train locomotives are dependent on the rate of fuel consumption. Preliminary estimates for combustion emissions of the magnitudes estimated are unlikely to have any significant impact beyond 50m from the railway line (refer to the Preliminary Environmental Assessment Reports for the route options (AECOM, 2017). A single train per hour moving past a sensitive receptor at 115km/h is unlikely to emit enough NO_2 to contribute to 1-hour average concentrations above the air quality objective beyond 50m from the rail alignment.

For the purpose of informing the MCA, the metrics specified in **Table 52** were adopted.

Table 52 Air quality MCA metrics

Air Quality Aspect	Assessment
Residential receptors	Residential receptors within 200 m of the notional construction corridor, broken down for each route option to provide a total number and the number along greenfield sections.
Other sensitive receptors	Other sensitive receptors (such as schools, health care facilities etc.) within 200 m of the notional construction corridor
Commercial or industrial receptors	Commercial or industrial receptors within 200 m of the notional construction corridor

7.14.2 MCA inputs

The metric values presented in **Table 53** were utilised in the MCA to inform an assessment of the air quality impact potential for each route option.

Table 53 Air quality MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Residential receptors within 200 m of notional construction corridor:					
• Total	no.	**203**	126	67	508
• Greenfield	no.	**24**	61	38	46
• Brownfield	no.	**179**	65	29	462
Other sensitive receptors within 200 m of the notional construction corridor	no.	**2**	2	0	6
Commercial/ industrial receptors within 200 m of the notional construction corridor	no.	**22**	22	2	68

7.15 Greenhouse gas emissions

7.15.1 Methodology

ARTC has recently become a member of the Infrastructure Sustainability Council of Australia (ISCA) and will be evaluating the Inland Rail Programme under the ISCA rating scheme. ISCA is Australia's only comprehensive rating system for evaluating sustainability across design, construction and operation of infrastructure. ISCA evaluates the sustainability (including environmental, social, economic and governance aspects) of infrastructure projects and assets.

Greenhouse gas emissions for the project should be considered in terms of construction phase and operational phase emissions.

For the purpose of gauging the potential greenhouse gas emissions during construction, the total volume of earthworks (cut and fill) has been identified as a suitable surrogate metric to provide an indication of the number of vehicular operational hours and consequential emissions.

For the purpose of assessing the potential for operational phase greenhouse gas emissions over the life-of-asset, the northbound (loaded) journey time has been identified as the most appropriate metric to provide an indication of the likely fuel consumption for each of the route options. Loaded journey time was selected as the most appropriate metric as total track length on its own does not give consideration to gradients and the consequential additional energy consumption.

For the purpose of informing the MCA, the metrics specified in **Table 54** were adopted.

Table 54 Greenhouse gas emissions MCA metrics

Greenhouse Gas Aspect	Assessment
Earthworks	Total earthworks (cut plus fill) required along each route option
Transit time	Total transit time for a train between Yelarbon and Gowrie in a 1) northbound; and 2) southbound direction
Operational length	Total length of track for each route option

7.15.2 MCA inputs

The metric values presented in **Table 55** were utilised in the MCA to inform an assessment of the greenhouse gas impact potential for each route option.

Table 55 Greenhouse gas emissions MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Earthworks:					
• Cut	Mm^3	**4.4**	10.1	11.3	10.2
• Fill	Mm^3	**5.3**	9.5	9.8	9.3
• Balance	Mm^3	**0.9**	0.5	1.6	0.9
• Total	Mm^3	**10**	20	21	20
Transit time (northbound)	hh:mm:ss	**2:09:23**	2:05:20	2:14:44	2:33:48
Transit time (southbound)	hh:mm:ss	**1:56:02**	1:48:51	1:53:34	2:18:04
Total operational length	km	**181**	168	172	208

7.16 Property impacts

7.16.1 Methodology

This MCA sub-criteria is focussed on the potential impacts of any one route option on property in a legal, cadastral sense and in terms of structures and operational infrastructure.

Cadastral property impacts have been assessed by determining the number of properties (lot on plan) that would be traversed or severed by each route option. The purpose of this has been to gauge the magnitude of community disruption and the potential complexity of the land acquisition process.

To achieve greater clarity of the potential complexity of cadastral property impacts, land parcels that would be traversed by each route option were classified first by land tenure and secondly by land use. For the purpose of these sub-criteria both land tenure and land use were obtained from the Queensland Valuer-General's property valuation data set for 2016.

Land tenure provides a preliminary indication of the potential complexity of the land acquisition process.

Land use provides a preliminary indication of the potential for operational infrastructure to occur on a property and land-dependency of each activity. Collectively this provides an indication for the type of impact that may be experienced by any one property owner

The potential for structural impacts were assessed through a count of the number of receptors (residential and other structures) located within the greatest modelled extent of afflux as a consequence of the project. For this purpose, conservative buffers of 500 m upstream and 200 m downstream of the notional construction corridor were applied to each route option through areas of 1% AEP floodplain.

For the purpose of informing the MCA, the metrics specified in **Table 56** were adopted.

Table 56 Property impact MCA metrics

Property Aspect	Assessment
Number of land parcels traversed/severed	Number of properties (lot on plan) that would be directly impacted by the notional construction corridor within greenfield sections for each route option, classified by land tenure
Number of receptors susceptible to afflux due to the project	Number of receptors (residential and other structures) that are located within the footprint of foreseeable afflux during a significant event, based on published QLD Globe floodplain overlays
Number of properties traversed/severed by land use classification	Number of properties (lot on plan) that would be directly impacted by the notional construction corridor within greenfield sections for each route option, classified by primary land use

7.16.2 MCA inputs

The metric values presented in **Table 57** were utilised in the MCA to inform an assessment of the property impact potential for each route option.

Table 57 Property impacts MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
No. of land parcels traversed, by tenure:					
• Freehold	no.	**297**	260	191	330
• Leasehold	no.	**22**	12	8	24
• Reserve	no.	**2**	0	4	8
• State land	no.	**1**	0	2	3
• State forest	no.	**4**	4	1	7
• Easement	no.	**13**	15	9	10
• Total	no.	**339**	291	215	382
Residential receptors within 500 m upstream and 200 m downstream of the notional alignment within floodplain:	no.	**49**	49	24	67
Other receptors within 500 m upstream and 200 m downstream of the notional alignment within floodplain:	no.	**67**	66	103	161
Property types (Valuer General) crossed by the notional construction corridor:					
Cropping (total)	no.	**153**	113	58	88
• Cotton	no.	**17**	6	0	0
• Grain	no.	**129**	101	50	79
• Small Crops & Fodder - Irrigated	no.	**6**	5	7	8

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
• Other Cropping	no.	**1**	1	1	1
Pastoral/Animal Husbandry (total)	no.	**89**	90	98	131
• Cattle Breeding & Fattening	no.	**50**	52	41	68
• Cattle Fattening	no.	**2**	3	3	2
• Cattle Grazing & Breeding	no.	**10**	11	11	13
• Goats	no.	**0**	0	1	3
• Horses	no.	**0**	2	5	2
• Milk - No Quota	no.	**6**	3	3	5
• Pigs	no.	**2**	2	2	3
• Poultry	no.	**1**	1	0	0
• Sheep Breeding	no.	**0**	0	11	1
• Sheep Grazing - Dry	no.	**1**	1	21	34
• Other	no.	**17**	15	0	0
Industrial (total)	no.	**4**	2	0	10
Residential (total)	no.	**35**	42	69	170
Urban (total)	no.	**16**	8	1	11
Resources (total)	no.	**8**	6	2	7
Vacant Land (total)	no.	**115**	78	17	33
Other (total)	no.	**28**	5	6	27

7.17 Heritage

7.17.1 Methodology

In keeping with legislative and project requirements, the key elements of the cultural heritage due diligence assessment of the route options were:

- a search of the Commonwealth Australian Heritage Database
- a search of the National Native Title Tribunal registers to identify any Native Title Claims and Claimants
- a search of the Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP) Aboriginal and Torres Strait Islander Cultural Heritage Database and Register to identify:
  - Aboriginal Party(s) and/or Cultural Heritage Bodies for the study area, across all route options
  - any registered Aboriginal cultural heritage within the study area, across all route options
- a search of the Queensland State Heritage Register
- searches of Local Heritage Registers for the Toowoomba Regional Council, Southern Downs Regional Council and Goondiwindi Regional Council
- a review of historical and archaeological research in the area to identify:
  - any additional places of cultural heritage significance
  - previous land use and levels of ground disturbance
  - assessment of potential project impacts on identified heritage items.

For the purpose of informing the MCA, the metrics specified in **Table 58** were adopted.

Table 58 Heritage MCA metrics

Heritage Aspect	Assessment
Registered Aboriginal cultural heritage	Number of locations listed on the DATSIP cultural heritage register within 200 m of the notional construction corridor
Registered non-Indigenous cultural heritage	Number of locations listed on the Commonwealth Australian Heritage Database, Queensland State Heritage Register and Local Heritage Registers within the notional construction corridor
Native title	Number of accepted native title claims and determinations made along each of the route options
Stream crossings	The total number of major and minor waterways crossed by each route option. Archaeological studies elsewhere in Australia have shown a correlation between the size of a waterway (or stream order), and the potential for Aboriginal heritage sites such as artefact scatters (White & McDonald, 2010).

Detailed heritage descriptions are presented in the Preliminary Environmental Assessment Reports for the respective route options (AECOM, 2017).

7.17.2 MCA inputs

The metric values presented in **Table 59** were utilised in the MCA to inform an assessment of the heritage impact potential for each route option.

Table 59 Heritage MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
DATSIP Register places within 200 m of the notional construction corridor	no.	**0**	0	0	4
QLD Heritage Register places within the notional construction corridor	no.	**0**	0	0	0
Local heritage places within the notional construction corridor	no.	**0**	0	2	7
Register of National Estate (within 200 m of the notional construction corridor)	no.	**0**	0	1	0
Accepted Native Title Claims	no.	**1**	1	1	1
Native Title Determinations	no.	**1**	1	1	1
Total stream crossings	no.	**75**	84	79	91

7.18 Impact on community

7.18.1 Methodology

The purpose of this sub-criteria is to assess the potential impacts of each route option due to modifications to community infrastructure and accessibility.

Whilst the assessment has qualitative components, quantifiable aspects have been identified to provide an indication of the likelihood of community disruption occurring. For the purpose of informing the MCA, the metrics specified in **Table 60** were adopted.

Table 60 Community impact MCA metrics

Community Impact Aspect	Assessment
Number of grade separations	Count of the number of grade separation crossings required for each route option
Number of road crossings	Count of the number of level crossings required for each route option, inclusive of both passive and active crossings
Interfaces with towns and public spaces	Count of the number of towns and/or public spaces that are situated within 2 km of each route option
Stock route crossings	Count of the number of stock route crossings traversed by each route option
Greenfield alignment length	Total length of each route option considered to be greenfield, i.e. not previously used for railway purposes

7.18.2 MCA inputs

The metric values presented in **Table 61** were utilised in the MCA to inform an otherwise qualitative assessment of the community impact potential for each route option.

Table 61 Community impact MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Grade Separations:					
• 2 lanes or less	no.	**2**	2	5	4
Active Crossings:					
• Total	no.	**49**	39	15	22
• Major (Boom gates)	no.	**5**	5	5	10
• Minor (Lights only)	no.	**44**	34	10	12
Passive Crossings:					
• Total	no.	**79**	81	81	101
• Public	no.	**21**	26	32	51
• Private	no.	**58**	55	49	50
Total Road Crossings (active and passive)	no.	**128**	120	96	123
Interfaces with towns/public spaces within 2km	no.	**6**	5	5	11
Stock Route Crossings	no.	**9**	9	12	11
Greenfield alignment length	km	**126**	137	122	115

7.19 Community response

7.19.1 Methodology

The purpose of this sub-criteria is to assess the potential community response to each route option, including the likelihood of community resistance being encountered.

Whilst the assessment is largely qualitative, quantifiable aspects have been identified to provide an indication of the likely community response to each option. The following aspects were identified through community and stakeholder consultation (including PRG meetings) as being key indicators of the potential community response to any one option:

1. Loss or severance of agricultural land, particularly resulting is disruption to broadacre cropping practices along a route option
2. The potential for afflux caused by the project and consequential impacts to land and property along a route option
3. Impacts (direct and indirect) to residential and other sensitive receptors (i.e. schools, hospitals etc.) along a route option
4. Total length of each route option considered to be greenfield, i.e. not previously used for railway purposes
5. The number of landholders impacted by a route option

At the second PRG meeting, held in Warwick on 1st February 2017, the PRG were advised that key indicators 1 to 3 had been identified as suitable indicator metrics for the possible community response to each option. This approach was not challenged by the PRG attendees. Over the course of the remaining PRG meetings, key indicators 4 and 5 were identified as additional suitable indicator metrics for the possible community response to each option.

For the purpose of informing the MCA, the metrics specified in **Table 62** were adopted.

Table 62 Community response MCA metrics

Community Response Aspect	Assessment
Impacts to potential broadacre cropping land	Number of hectares of potential broadacre cropping land[1] within the notional construction corridor of each route option
Greenfield alignment length	Total length of each route option considered to be greenfield, i.e. not previously used for railway purposes
Number of receptors susceptible to afflux due to the project	Number of receptors (residential and other structures) that are located within the footprint of foreseeable afflux during a significant event (refer to **Section 7.16** for further details), based on published QLD Globe floodplain overlays
Residential receptors	Residential receptors within 200 m of the notional construction corridor, broken down for each route option to provide a total number and the number along greenfield sections
Other sensitive receptors	Other sensitive receptors (such as schools, health care facilities etc.) within 200 m of the notional construction corridor
Number of freehold properties traversed/severed	Number of freehold properties (lot on plan) that would be directly impacted by the notional construction corridor within greenfield sections for each route option

1. Land identified by the Department of Agriculture and Fisheries' Qld Agricultural Land Audit (2013) as having biophysical potential for broadacre cropping, irrespective of current day use.

7.19.2 MCA inputs

The metric values presented in **Table 63** were utilised in the MCA to inform an otherwise qualitative assessment of the potential community response for each route option.

Table 63 Community response MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Potential broadacre cropping land	ha	**698**	732	601	663
Greenfield alignment length	km	**126**	137	122	115
Brownfield alignment length	km	**55**	30	49	93
Residential receptors within 500 m upstream and 200 m downstream of the notional alignment within floodplain:	no.	**49**	49	24	67
Other receptors within 500 m upstream and 200 m downstream of the notional alignment within floodplain:	no.	**67**	66	103	161
Residential receptors within 200 m of the notional construction corridor:					
• Total	no.	**203**	126	67	508
• Greenfield	no.	**24**	61	38	46
• Brownfield	no.	**179**	65	29	462
Other sensitive receptors within 200 m of the notional construction corridor	no.	**2**	2	0	6
Freehold	no.	**297**	260	191	330

7.20 Current and future land use impacts

7.20.1 Methodology

The purpose of this sub-criteria is to assess the potential impacts from each route option on current and future land uses.

The Queensland Department of Agriculture and Fisheries (DAF) was consulted in order to determine the best means of identifying and assessing impacts to current land uses and to assess potential impacts to each. DAF advised that the Queensland Land Use Mapping Program (QLUMP) is currently the best available means of mapping and assessing land use patterns and changes across Queensland, in accordance with the Australian Land use and Management Classification system.

QLUMP is part of the Australian Collaborative Land Use and Management Program (ACLUMP), coordinated by the Australian Bureau of Agricultural and Resource Economics and Sciences. Government, the private sector, research agencies and community groups use the QLUMP datasets for natural resource assessment, monitoring and planning.

Future land use impacts were assessed with reference to DAF's Qld Agricultural Land Audit (2013) data set, to identify potential agricultural land, and resource tenures as published by the Department of Natural Resources and Mines' (DNRM).

For the purpose of informing the MCA, the metrics specified in **Table 64** were adopted.

Table 64 Current and future land use MCA metrics

Land Use Aspect	Assessment
Impacts to current land use	Number of hectares of current land use within the notional construction corridor of each route option, categorised to QLUMP secondary level.
Impacts to potential agricultural land	Number of hectares of potential agricultural land within the notional construction corridor of each route option
Impacts to resource tenures	Area or frequency of resource tenures within the notional construction corridor of each route option.

In addition to the broad-scale mapping of current, future and potential land uses, the assessment team received anecdotal and documented evidence of localised instances of planned and/or approved future developments. In each instance, the potential for planned and/or approved future developments to co-exist in proximity to freight rail infrastructure was assessed at a high level.

The assessment concluded that whilst isolated development proposals occur in proximity to all route options, the variance in development type meant that planned and/or approved future developments were not considered to be an appropriate metric for consideration in the MCA.

7.20.2 MCA inputs

The metric values presented in **Table 65** were utilised in the MCA to inform an otherwise qualitative assessment of the current and future land use impacts potential for each route option.

Table 65 Current and future land use inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Current land use (QLUMP, secondary level) crossed by alignment					
Cropping (total)	ha	**407**	409	301	271
• Cropping	ha	**376**	373	263	222
• Irrigated cropping	ha	**22**	27	38	50
• Irrigated cropping - Cotton	ha	**8**	8	0	0
Animal production (total)	ha	**463**	509	745	851
• Intensive animal production	ha	2	8	0	0
• Grazing native vegetation	ha	460	488	734	842
• Grazing modified pastures	ha	0	13	11	9
Production forestry	ha	40.0	40.0	0.1	33.4
Residential	ha	1.1	12.6	6.0	11.0
Manufacturing and industrial	ha	0.1	0.0	0.0	0.3
Services	ha	2.8	1.2	0.0	3.2
Transport and communication	ha	5.8	11.0	1.3	17.4
Water	ha	4.9	4.2	2.1	1.8
Conservation and natural environments	ha	10.1	7.7	0.5	7.6

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Potential agricultural land (Agricultural Land Audit):					
• Broadacre cropping	ha	684	726	583	644
• Annual horticulture	ha	691	750	630	657
• Perennial horticulture	ha	144	133	201	213
• Intensive livestock	ha	714	766	676	680
Strategic Cropping Land	ha	**698**	732	601	663
Agricultural Land Class A	ha	**721**	783	651	698
Agricultural Land Class B	ha	**49**	49	35	35
Resource Tenures:					
Exploration Permit (Coal)	ha	**202**	210	311	159
Exploration Permit (Minerals)	ha	**0**	0	267	246
Mineral Development Licence	ha	**107**	107	99	0
Mining Lease	ha	**45**	45	36	0
Petroleum Pipeline Licence	no.	**2**	2	2	2

7.21 Planning and approval timescale

Irrespective of the preferred route option, it is ARTC's intention to apply to the Queensland Coordinator-General to have this project declared a 'Coordinated Project' for which an Environmental Impact Statement (EIS) is required under Section 26 of the *State Development and Public Works Organisation Act 1971* (SDPWO Act).

Under the SDPWO Act, a proponent has 18 months from the finalisation of the Terms of Reference for the EIS to the time that the Coordinator-General accepts the Draft EIS as the Final EIS.

Also irrespective of the preferred route option, ARTC propose to refer the project to the Australian Minister for the Environment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Subject to the receipt of a referral, the Minister will determine whether assessment and approval under the EPBC Act is required.

If the action is considered a 'Controlled Action', an environmental assessment must be submitted to the Minister for approval. ARTC would propose to have the project assessed under the Assessment Bilateral Agreement between the Commonwealth of Australia and the State of Queensland.

No material difference is anticipated in the planning and approval timescale for the route options assessed.

7.22 State & Federal agency buy in

The intention of this options assessment process was for it to be conducted as an independent, non-biased technical comparison of the four route options, removed from political preferences. Consequently, state and federal buy-in or preference was not assessed or included in the MCA.

7.23 Local government buy in

Local governments are considered a key stakeholder for the project and support at this level will be pivotal to the successful delivery of this section of the MBIR project. Consequently, the relative local government support for each route option is considered and assessed for this sub-criteria.

Three local governments have two or more route options extending through their jurisdiction. These are:

- Goondiwindi Regional Council (all route options)
- Southern Downs Regional Council (Karara-Leyburn and Warwick route options)
- Toowoomba Regional Council (all route options)

Each of these local governments has been formally consulted since January 2016 to gauge their individual key concerns and needs for the project.

Table 66 Summary of local government key needs and concerns

Local Government	Key Needs or Concerns
Goondiwindi Regional Council	· A bypass of Inglewood needs to be incorporated into the route. · Impacts to agricultural land should be minimised.
Southern Downs Regional Council	· A route via Warwick would provide the greatest commercial benefit for businesses with interests in SDRC.
Toowoomba Regional Council	· Impacts to agricultural land should be minimised.

An otherwise qualitative assessment of the local government buy-in for each route option was based on metrics that relate to the needs and concerned summarised in **Table 66** that had been determined for the purpose of informing assessment under other sub-criteria.

7.24 Other statutory and regulatory approvals

7.24.1 Methodology

The purpose of this sub-criteria is to assess the relative complexity of applying for and obtaining secondary statutory and regulatory approvals for each of the route options. For this purpose, secondary approvals are considered to be those that are required for the project after regulatory approval of an EIS under the SDPWO Act and EPBC Act, but prior to the commencement of construction.

Secondary approval triggers for a project typically become clear as the EIS and detailed design process progress. However, at this early stage of the project, the need for the following secondary approvals has been identified:

1. Revocation of state forest under Section 26 of the *Forestry Act 1959*. Revocation under the Act requires amendment regulation to amend the Schedule of the *Forestry (State Forests) Regulation 1987*. All four route options extend, in part, into at least one state forest consisting of multiple lots.
2. Development approvals under the *Sustainable Planning Act 2009* (SP Act) are expected to be required regardless of which route option is selected. Works are expected to trigger the need to obtain development permits for operational works to construct or raise a waterway barrier.

For the purpose of informing the MCA, the metrics specified in **Table 67** were adopted.

Table 67 Other statutory and regulatory approval MCA metrics

Land Use Aspect	Assessment
Impacts to state forest	Number of properties (lot on plan) designated as state forest under the *Forestry Act 1959* within the notional construction corridor of each route option
Waterway barrier works classification	Number of waterways crossed by each route option, by waterway barrier work classification

7.24.2 MCA inputs

The metric values presented in **Table 68** were utilised in the MCA to inform an otherwise qualitative assessment of the secondary approvals complexity for each route option.

Table 68 Other statutory and regulatory approval MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
State forest properties	No.	4	4	1	7
Waterway barrier works (Major and High risk only)	No.	23	18	21	33

7.25 Service authorities

7.25.1 Methodology

The purpose of this sub-criteria is to assess the relative complexity of negotiating agreements with public utility owners and operators due to PUP interfaces.

For the purpose of informing the MCA, the metrics specified in **Table 69** were adopted.

Table 69 Service authority MCA metrics

Service Authority Aspect	Assessment
Gas or oil pipeline	The number of interactions with gas or oil pipelines along each of the route options
Overhead transmission or distribution network	The number of interactions with electricity transmission (≥ 110 kV) or distribution (< 110 kV) infrastructure along each of the route options
Telecommunications and optic fibre	The number of interactions with telecommunications and optic fibre cables along each of the route options

7.25.2 MCA inputs

The metric values presented in **Table 70** were utilised in the MCA to inform an otherwise qualitative assessment of the service authority complexity for each route option.

Table 70 Service authority MCA inputs

Item	Units	Modified Base Case	Wellcamp-Charlton	Karara-Leyburn	Warwick
Gas or oil pipeline	No.	8	7	5	5
Overhead electrical lines:					
· ≥ 110 kV	No.	20	45	43	65
· < 110 kV	No.	48	62	7	22
Telecommunications and optic fibre	No.	14	19	6	6

8.0 Route options MCA assessment

The route options are assessed by the ARTC MCA approach. This is a process where weightings are given to key qualitative and quantitative criteria to enable transparency and rigour. The MCA is an industry standard and is widely used in Australia and internationally.

ARTC's intent for the MCA is to adopt a robust methodology for the MBIR project that:

- Can be consistently applied by multiple teams across differing sections
- Provides transparency of the process and rigour adopted
- Directly aligns with ARTC's and the governments objectives and polices
- Compliments works and decisions made during previous studies

The MCA criteria used in the assessment has been provided by ARTC and is detailed in **Section 1.3.1**.

Criteria for assessment have been chosen that would provide and identify differentiating characteristics to enable a robust route selection and objective analysis within the MCA. Prior to the workshop the criteria for assessment was prepopulated in the MCA scoring sheet. This included commentary and information for the range of sub-criteria, based on the engineering and environmental work undertaken. Details on how the specific criteria were calculated and the values obtained from this assessment are detailed in **Section 7.0**.

In relation to scoring all corridor options are assessed and scored relative to the Base Case Modified i.e. the Base Case Modified is scored as zero with each alternative option scoring positively or negatively against the Base Case. All scoring is based on a 5 point scale that is integral to the MCA assessment used across the MBIR project. A definition of the scores is detailed in **Table 71**.

Table 71 MCA scoring definitions

Score	Definition	Description
10	Significant improvement	Major positive impacts resulting in substantial and long term improvement or enhancements
5	Improvement	Positive impacts resulting in long term improvements or enhancements
0	Neutral	Neutral - no discernible or predicted positive or negative impact
-5	Decline	Negative impacts with long term and possible irreversible effects leading to serious damage, degradation or deterioration of the physical, economic or social environment. Requires a commitment to extensive management strategies to mitigate effect.
-10	Significant decline	Major negative impacts with serious, long term and possible irreversible effects leading to serious damage, degradation or deterioration of the physical, economic or social environment. Requires a major commitment to extensive management strategies to mitigate effect.

The following sections breakdown each MCA sub-criteria and explain the key drivers for each criteria from the options assessment along with the scoring that was adopted on the MCA scoring day.

The information used to assess the criteria detailed in the following sections is not exhaustive. However, the assessment has used all information that was available to the team during the corridor options assessment process. In particular, it has focused on items that are seen as key differentiators across the alignment to confidently provide a qualitative and quantitative comparison of the options.

8.1 MCA workshop

The MCA workshop was held on the 17 March 2017 within AECOM's Brisbane office. The following representatives took part in the workshop:

Technical Representatives

Mark Barnett – Environmental Lead, AECOM

Martin Boshoff – Hydrology and Hydraulics Lead, AECOM

Tony Frazer – General Manager, Operations Interstate Network, ARTC

Robert Green – Project Manager, AECOM

Chris Huddy – Geotechnical Lead, AECOM

Lindsay Klein – Senior Civil and Rail Engineer, Aurecon

James O'Kane – Construction Manager, AECOM

Emily Reid – Senior Civil Engineer (Hydrology and Hydraulics), Aurecon

Luke Smith – Design Manager, Aurecon

Robert Storrs – Group Director Environment QNT, AECOM

David Taylor – Civil and Rail Lead, AECOM

Garry Ware – Civil Engineer, AECOM

Observers

Bruce Wilson (AM) – PRG Chair

DIRD, two representatives

PRG, Warwick Chamber of Commerce representative

PRG, Leyburn representative

PRG representative on behalf of Millwood Farmers Group

PRG representative on behalf of Queensland Farmers Federation

PRG observer for TMR

The full day workshop was conducted in a sequential manner, undertaking one sub criteria at a time. The alternative alignments were introduced, with a discussion of the benefits and constraints, before evaluating each option against the sub-criteria. All alternative options scoring were assessed relative to the Base Case Modified route with the Base Case Modified scoring a benchmark zero (0) across all assessment criteria.

The completed MCA spreadsheet can be found **Appendix Q**.

8.2 Technical viability scoring

The technical viability assesses the technical engineering aspects of each alignment.

8.2.1 Alignment

The alignment sub-criterion is a comparison of the changes to alignment geometry such as grades, curves and the ability to provide consistency of operation speed. The key metrics that impact this sub-criterion are:

- Length of horizontal curves less than 1200 m radius
- Number of segments with curves less than 1200 m radius

- Length of alignment with grades greater than or equal to 1%
- Total vertical climb of the alignment

These were all chosen as they are factors that are best minimised in an alignment as a straighter and flatter alignment is preferred for train operations.

Wellcamp-Charlton was given a score of +5 as is scored better than Base Case Modified on length number of tight radius curves and scored similarly on total climb.

Karara-Leyburn was given a score of -5 as it scored significantly worse on the number and length of tight radius curves and only slightly better for length of steep grades and total climb.

Warwick was given a score of -10 as it scored significantly worse for tight length and number of tight curves, significantly worse on length of steep grades and slightly worse on total climb.

A summary of the key metrics and scoring is listed in **Table 72**.

Table 72 Alignment key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of horizontal curves < R1200 m (km)	11	8	+5	20	-5	18	-10
Number of segments < R1200 m (km)	18	13		36		31	
Length of grades ≥ 1% (km)	36	44		30		54	
Total climb (m)	563	575		506		689	

8.2.2 Impact on PUP and other assets

The impacts on PUP and other assets sub-criterion is a comparison of the impacts on public utility providers for the alignments. The key metrics that impact this sub-criterion are:

- Gas or oil pipelines
- Total residential and commercial receptors within 200 m of the corridor
- Overhead electrical <110kV
- Telecommunications and optic fibre

These were all chosen as they are the utilities that would require significant additional works to relocate or protect. The gas or oil pipelines are significant infrastructure that as a minimum would require significant protection works and may require relocation. The overhead electrical crossings <110kV would require higher poles as a minimum to clear a MBIR train. The telecommunications and optic fibre lines are major trunk infrastructure that as a minimum would require significant protection works and may require relocation. The total residential and commercial receptors within 200 m were added as it gives an indication of the number of residential services that will require protection and/or relocation as part of the works.

Wellcamp-Charlton was given a score of -5 as is scored slightly worse than the than Base Case Modified on the number of crossings for <110kV overhead and telecommunications and optic fibre while scoring similarly on the number of gas or oil pipelines.

Karara-Leyburn was given a score of +10 as it scored significantly better on residential and commercial receptors, <110kV overhead and telecommunications and optic fibre.

Warwick was given a score of +5 as it scored significantly better on <110kV overhead and telecommunications and optic fibre, slightly better on gas or oil pipeline and significantly worse on residential and commercial receptors.

A summary of the key metrics and scoring is listed in **Table 73**.

Table 73 Impact on PUP and other assets key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Gas or Oil Pipeline (no.)	8	7	-5	5	+10	5	+5
Total residential and commercial receptors within 200 m of the corridor (no.)	225	148		69		576	
Overhead Electrical Crossings: Less than 110kV (no.)	48	62		7		22	
Telecommunications & Optic Fibre U/G (no.)	14	19		6		6	

8.2.3 Geotechnical conditions

The geotechnical conditions sub-criterion is a comparison of the geotechnical conditions impacting bulk earthworks, material sources and structural foundations. The key metrics that impact this sub-criterion are:

- Material suitability – poor soils for use – vertosols (black soils) and sodosols
- Material suitability – cut material suitable for embankments – dermosols, sedimentary and volcanic
- Length and depth of cuts

Vertosols and sodosols are poor materials that are not desired for use in earthworks. While dermosols, sedimentary and volcanic materials are all suitable structural fill materials for use in embankments. The length and depth of cuts gives an indication where suitable material can be won along the alignment.

A sensitivity analysis and detailed review of the data used in the MCA was undertaken after the MCA session to ensure that the information and scores assessed during the workshop were correct.

Upon review it was found that the geotechnical quantities utilised on the day had cut and fill quantities transposed. The MCA spreadsheet has been updated to reflect the correct values and this section reassessed. The reassessed values do not require a change in the scoring adopted during the MCA workshop.

Wellcamp-Charlton was given a score of -5 as is it slightly worse than the Base Case Modified when comparing the key criteria above.

Karara-Leyburn was given a score of +5 as it is slightly better when comparing the key criteria above.

Warwick was given a score of +5 as it is slightly better when comparing the key criteria above.

A summary of the key metrics and scoring is listed in **Table 74**.

Table 74 Geotechnical conditions key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Soil cut (area impacted m^2) Dermosols	8,900	8,900	-5	74,000	+5	62,600	+5
Soil cut (area impacted m^2) Sodosols	101,100	101,100		66,000		72,600	
Soil cut quantities (area impacted m^2) Vertosols	182,000	248,600		222,900		229,100	
Length of alignment in Sodosols (km)	50	50		45		48	
Length of alignment in Vertosols (km)	113	100		61		85	
Rock cut (area impacted m^2) Ctx - Sedimentary	0	0		113,200		139,600	
Rock cut (area impacted m^2) Tv – Volcanic Basalt	64,600	158,400		139,900		171,600	
Rock cut (area impacted m^2) Jkb – Sedimentary	100	100		0		0	
Length of cut 5-25 m (km)	8	19		22		20	

8.2.4 Impacts on existing road and rail networks

This sub-criterion compares the impacts of the rail alignments on existing road and rail networks. It is a technical assessment and does not consider safety as it is covered by the safety section in the MCA criteria. The key metrics that impact this sub-criterion are:

- Total active and passive public crossings
- Connections to existing rail networks
- Connections to existing sidings on the QR network

These were chosen as they are the significant constraints in relation to existing road and rail. The number of public level crossings directly impacts road users with wait times at crossings and possible road relocations that could impact travel distances. Preference is to minimise the number of connections to existing rail networks and sidings as this increases operational difficulties by having to accommodate MBIR trains with existing services and having to manage the different signalling interfaces.

Wellcamp-Charlton was given a score of 0 as is scored similar to the Base Case Modified alignment.

Karara-Leyburn was given a score of +10 as it scored significantly better on crossings, connections to existing sidings and slightly better on connection to existing sidings.

Warwick was given a score of 0 as it scored similar to the Base Case Modified alignment.

A summary of the key metrics and scoring is listed in **Table 75**.

Table 75 Impacts on existing road and rail networks key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Total active and passive public crossings (no.)	70	65	0	47	+10	73	0
Connections to existing rail networks (no.)	4	4		3		4	
Connections to existing sidings on QR network (no.)	9	7		4		13	

8.2.5 Flood immunity / hydrology

The flood immunity sub-criterion is a comparison of the alignments ability to deliver flood immunity and the associated hydraulic impacts. The key metrics that impact this sub-criterion are:

- Total length of 1% AEP floodplain crossed
- Number of major stream crossings
- Total alignment viaduct/bridge length
- Number of viaducts/bridges
- Number of waterway culverts
- Number of flood balancing culverts
- Length of alignment in sodosols and vertosols

These were all chosen as they provide details on the total width and number of major waterways and the associated number and length of structures required to pass the flood flows. The length of alignment in sodosols and vertosols gives an indication of the length of erosive material along each alignment.

Wellcamp-Charlton was given a score of +5 as is scored slightly better than the Base Case Modified for length of floodplain, viaduct/bridge length, number of viaducts/bridges, length of sodosols and vertosols and scores significantly better on the number of major streams.

Karara-Leyburn was given a score of +5 as it scored slightly better on number of major stream crossings, number of flood balancing culverts and scores significantly better on length of floodplain and length of sodosols and vertosols.

Warwick was given a score of -5 as it scored significantly worse on number of major stream crossings, viaduct/bridge length and waterway culverts. It scored significantly better on flood culverts and length of sodosols and vertosols however the large number of streams, waterway crossings and bridge length drove the -5 scoring.

A summary of the key metrics and scoring is listed in **Table 76**.

Table 76 Flood immunity/ hydrology key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of 1% AEP floodplain crossed: Total (km)	29	27	+5	23	+5	26	-5
Stream crossings: Major (stream order 3 & greater) (no.)	20	15		17		25	
Total viaduct/bridge length (m)	4275	3375		6465		9395	
Total number of viaducts/bridges (no.)	21	15		21		35	
Waterway crossing culverts: Total number of cells (box and pipe) (no.)	195	250		198		426	
Flood balancing culverts: Total number of cells (box and pipe) (no.)	950	950		590		93	
Length of alignment in sodosols and vertosols: Total (km)	164	150		106		133	

8.2.6 Future proofing

The future proofing sub-criterion is a comparison of the potential for upgrades to the rail infrastructure in the future. The key metrics that impact this sub-criterion are:

- Length of grades 0% to <0.5%
- Total earthworks

The length of grades was chosen as it shows the total length of flat grades along the alignment that would allow passing loops to be installed. The total earthworks show the total cut or fill along each alignment and thus an indication of the scale of earthworks required to install passing loops.

Wellcamp-Charlton was given a score of -5 as there is double the amount of earthworks required than the Base Case Modified alignment. As the length of flat grades is similar it hasn’t impacted the scoring.

Karara-Leyburn was given a score of -5 as there is double the amount of earthworks required than the Base Case Modified alignment. As the length of flat grades is similar it hasn’t impacted the scoring.

Warwick was given a score of -5 as there is double the amount of earthworks required than the Base Case Modified alignment. As the length of flat grades is similar it hasn’t impacted the scoring.

A summary of the key metrics and scoring is listed in **Table 77**.

Table 77 Future proofing key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of grades 0% to < 0.5% (km)	96	80	-5	107	-5	100	-5
Total earthworks (Mm^3)	10	20		21		20	

8.3 Safety assessment scoring

The safety assessment reviews all safety aspects of the proposed alignment.

8.3.1 Operational safety

The operational safety scoring sub-criterion is a comparison of the safety aspects related to track geometry, height of rail above natural surface and conflict points along the alignment. The key metrics that impact this sub-criterion are:

- Number of passing loops
- Number of curves with radius <1200 m
- Length of fill 10-20 m high
- Number of bridges
- Number of minor active crossings
- Number of passive crossings

These were all chosen as the impact on the operational safety of MBIR. The number of passing loops increase the number of conflict points between trains. The number of curves <1200 m show where trains have to slow down and increases the rail maintenance required. The length of deep fill is increases the danger for maintenance crew. The number of bridges is used to define where the formation changes in stiffness which can cause sudden vertical alignment changes which increases the risk of derailment. Finally, the road crossings show the number of conflict points between road users and trains.

Wellcamp-Charlton was given a score of 0 as it scores similar to the Base Case Modified after reviewing all the criteria above. It scores better on the number of bridges and crossings but worse on the length of deep fill.

Karara-Leyburn was given a score of -5 as it is worse on deep fill and tight curves while only scoring better on minor active crossings.

Warwick was given a score of -10 as it is significantly worse on tight curves, deep fill, number of bridges and passive crossings. It is only better on the number of minor active crossings.

A summary of the key metrics and scoring is listed in **Table 78**.

Table 78 Operational safety key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Passing loops (no.)	5	5	0	5	-5	6	-10
Number of segments < R1200 m (no.)	18	13		36		31	
Length of fill: 10-15 m (km)	3	7		6		8	
Length of fill: 15-20 m (km)	0	1		2		1	
Total number of bridges (no.)	24	15		21		35	
Active Crossings: Minor (Lights only) (no.)	44	34		10		12	
Passive Crossings: Total (no.)	79	81		81		101	

8.3.2 Public safety

The public safety scoring sub-criterion is a comparison of the relative risk of trespass for each alignment. The key metrics that impact this sub-criterion are:

- Interfaces with towns and public spaces within 2 km of the alignment

The risk of trespass is directly related to the ease at which the public can access the rail corridor therefore it was considered that if the alignment is within 2 km of a town or public space there is a high safety risk.

Wellcamp-Charlton was given a score of 0 as it scores similar to the Base Case Modified.

Karara-Leyburn was given a score of 0 as it scores similar to the Base Case Modified.

Warwick was given a score of -10 as it has nearly double the number of towns/public spaces within 2 km of the rail corridor.

A summary of the key metrics and scoring is listed in **Table 79**.

Table 79 Public safety key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Interfaces with towns/public spaces within 2 km (no.)	6	5	0	5	0	11	-10

8.3.3 Road and safety interfaces

The road safety interfaces sub-criterion is a comparison of the safety aspect of high/motorway crossings, public road crossings and local property access crossings. The key metrics that impact this sub-criterion are:

- Minor active crossings
- Total passive crossings

These crossing types were chosen as they pose the greatest safety risk due to the fact that they have no physical barrier or separation between the railway and vehicles.

Wellcamp-Charlton was given a score of +5 as it has less minor active crossings and a similar number of passive crossings.

Karara-Leyburn was given a score of +10 as it has significantly less minor active crossings and a similar number of passive crossings.

Warwick was given a score of -5 as it has significantly more passive crossings which was considered to have a significant impact on safety as property owners can become complacent with the continual use of a crossing.

A summary of the key metrics and scoring is listed in **Table 80**.

Table 80 Road safety interfaces key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Active Crossings: Minor (Lights only) (no.)	44	34	+5	10	+10	12	-5
Passive Crossings: Total (no.)	79	81		81		101	

8.3.4 Emergency response

The emergency response sub-criterion is a comparison of the ability to access the railway corridor for emergency services. The key metrics that impact this sub-criterion are:

- Hospitals and major towns in vicinity of alignment
- Length of major arterial road within 500 m of corridor
- Length of minor road within 500 m of the corridor
- Total active and passive road crossings

These were all chosen as they are the main access routes for emergency services being able to enter the railway corridor. Unlike the technical criteria the additional road crossings will provide a positive score here as they provide more access points to the corridor.

Wellcamp-Charlton was given a score of 0 as is scored similar to the Base Case Modified.

Karara-Leyburn was given a score of -5 as it scored worse on minor roads within 500 m of the corridor and on the number of total road crossings.

Warwick was given a score of +10 as it has an additional hospital in the vicinity of the alignment and has significantly more minor road crossings.

A summary of the key metrics and scoring is listed in **Table 81**.

Table 81 Emergency response key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Hospitals/major towns in vicinity of alignment (no.)	2	2	0	2	-5	3	+10
Length of road within 500 m of the rail corridor: Major Arterial Road (type 1,2,3) (km)	61	66		69		68	
Length of road within 500 m of the rail corridor: Minor Road (type 4 and 5) (km)	20	12		10		45	
Total Road Crossings (active and passive) (no.)	128	120		96		123	

8.3.5 Construction safety

The construction safety sub-criterion is a comparison of the high risk construction activities. High embankments, deep cuts, road crossings and PUPs all provide a safety risk to the construction team however it was felt the two key drivers separating the construction safety between the alignments were:

- Total earthworks
- Total bridge length

These were chosen due to the sheer quantity of works required. This is simply because the huge man-hours required to construct both the earthworks and bridges will have the greatest impact on construction safety.

These were all chosen as they are factors that are best minimised in an alignment as a straighter and flatter alignment is preferred for train operations.

Wellcamp-Charlton was given a score of -5 as it has double the volume of earthworks to the Base Case Modified however has slightly less bridge length.

Karara-Leyburn was given a score of -10 as is has double the volume of earthworks and a longer overall bridge length.

Warwick was given a score of -10 as is has double the volume of earthworks and double the length of bridges. A summary of the key metrics and scoring is listed in **Table 82**.

Table 82 Construction safety key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Total earthworks (Mm^3)	10	20	-5	21	-10	20	-10
Total bridge length (m)	4275	3375		6465		9395	

8.4 Operational approach including OPEX scoring

The operational approach assesses factors that impact on the railway operations.

8.4.1 Above rail OPEX

The above rail OPEX sub-criterion is a comparison of the above rail operational costs such as fuel and wear on rollingstock. The key metrics that impact this sub-criterion are:

- Length of grade impacting speed
- Total climb
- Number of horizontal curves <1200 m radius

These were all chosen as they are factors that increase operating costs. While the items above gave an indication of the above rail OPEX further discussions during the MCA workshop determined that the key drivers could be refined to:

- Length of grade impacting speed

When looking at the operating life of the railway fuel usage is the most significant cost and the length of grade impacting speed is the main driver of fuel usage.

Wellcamp-Charlton was given a score of -5 as it is scored slightly worse than Base Case Modified on the grade impacting speed.

Karara-Leyburn was given a score of -5 as it is slightly worse on the grade impacting speed.

Warwick was given a score of -10 as it is significantly worse on the grade impacting speed.

A summary of the key metrics and scoring is listed in **Table 83**.

Table 83 Above rail OPEX key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of grade impacting speed (km)	26	39	-5	35	-5	45	-10

8.4.2 Below rail OPEX

The below rail OPEX criteria is a comparison of below rail operational costs such as complexity, structural elements and ability to continue train movements whist maintaining sections. The key metrics that impact this sub-criterion are:

- Alignment length in sodosols and vertosols
- Length of corridor
- Total bridge length
- Total number of bridges
- Total number of culverts
- Alignment length with grades ≥1%
- Number of horizontal curves <1200 m radius
- Number of turnouts
- Total active and passive road crossings

These were all chosen as they are factors that increase maintenance costs. While the items above gave an indication of the below rail OPEX further discussions during the MCA workshop determined that the key drivers could be refined to:

- Length of corridor
- Number of horizontal curves <1200 m radius

The rail is the main below rail operational cost and thus every additional kilometre and additional tight curve has a significant impact over the life of the railway.

Wellcamp-Charlton was given a score of +5 as it is a shorter alignment and has less tight radius curves.

Karara-Leyburn was given a score of -5 as it has a slightly shorter alignment but significantly more tight radius curves.

Warwick was given a score of -10 as it is a significantly longer alignment and has significantly more tight radius curves.

A summary of the key metrics and scoring is listed in **Table 84**.

Table 84 Below rail OPEX key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of corridor (km)	181	168	+5	172	-5	208	-10
Horizontal Curves < R1200 (no.)	18	13		36		31	

8.4.3 Effect / impact on travel time

The effect / impact on travel time are a comparison of travel time between options. The key metric that impacts this sub-criterion is:

- Transit time (northbound)

Wellcamp-Charlton was given a score of +5 as it had a transit time approximately 4 minutes quicker than the Base Case Modified alignment.

Karara-Leyburn was given a score of -5 as it had a transit time approximately 5 minutes slower.

Warwick was given a score of -10 as it had a transit time approximately 24 minutes slower.

A summary of the key metrics and scoring is listed in **Table 85**.

Table 85 Effect/Impact on travel time key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Transit time (northbound) (hh:mm:ss)	2:09:23	2:05:20	+5	2:14:44	-5	2:33:48	-10

8.4.4 Effect on reliability and availability

The effect on reliability and availability is a comparison of reliability between options. The key metrics that impact this sub-criterion are:

- Alignment length in vertosols
- Bridge length
- Length of grades ≥1%
- Number of turnouts
- Total active and passive road crossings

These were chosen as they are all aspects of a rail alignment that can impact the reliability and availability of trains on the MBIR network.

Wellcamp-Charlton was given a score of 0 as it is similar to the Base Case Modified when comparing the key criteria listed above.

Karara-Leyburn was given a score of 0 as while it was significantly better on turnouts and road crossings the significant length of bridges means overall it is similar to the Base Case Modified alignment.

Warwick was given a score of -10 as it scored significantly worse on most of the key criteria listed above.

A summary of the key metrics and scoring is listed in **Table 86**.

Table 86 Effect on reliability and availability key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of alignment in soil type: Vertosols (km)	113	100	0	61	0	85	-10
Total bridge length (m)	4275	3375		6465		9395	
Length of alignment with: grades ≥ 1% (1 in 100) (km)	36	44		30		54	
Number of turnouts: total (no.)	19	17		14		25	
Total Road Crossings (active and passive) (no.)	128	120		96		123	

8.4.5 Network interoperability and connectivity

The network interoperability and connectivity sub-criterion is a comparison of reliability between options. The key metrics that impact this sub-criterion are:

- Connections to existing sidings on the QR network

The connections to existing QR sidings increase the interoperability of the alignment as it provides access to additional customers.

Wellcamp-Charlton was given a score of -5 as is had slightly less connections to QR sidings than Base Case Modified alignment.

Karara-Leyburn was given a score of -10 as it had significantly fewer connections to QR sidings.

Warwick was given a score of +10 as it had significantly more connections to QR sidings.

A summary of the key metrics and scoring is listed in **Table 87**.

Table 87 Network interoperability and connectivity key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Connections to existing sidings on QR network (no.)	9	7	-5	4	-10	13	+10

8.5 Constructability and schedule scoring

The constructability and schedule scoring assess how the alignments differ in construction difficulty and duration.

8.5.1 Construction duration

The construction duration criteria are a comparison of construction time between options. The key metrics that impact this sub-criterion are:

- Length of high bridges (6 m to 18 m high)
- Length of viaducts
- Total earthworks

These were all chosen as they are the main factors that increase the construction duration. With respect to the scoring the total earthworks were given the most weighting as it is the most significant aspect of the works.

Wellcamp-Charlton was given a score of -10 as it has double the volume of earthworks to the Base Case Modified alignment.

Karara-Leyburn was given a score of -10 as it has double the volume of earthworks.

Warwick was given a score of -10 as it has double the volume of earthworks.

A summary of the key metrics and scoring is listed in **Table 88**.

Table 88 Construction duration key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of bridges: Type 2 (6 to 11 m high) (m)	800	650	-10	1075	-10	1150	-10
Length of bridges: Type 3 (11 to 18 m high) (m)	300	575		1800		1275	
Viaduct (0 to 3 m high and longer than 250 m) (m)	1800	1800		3315		4395	
Total earthworks (Mm^3)	10	20		21		20	

8.5.2 Construction access

The construction access sub-criterion is a comparison of the locations for site access during construction including adjacent road access, access from existing railway corridors and access from properties. The key metrics that impact this sub-criterion are:

- Total percentage of public roads with respect to alignment length within 500 m of the corridor
- Total public road crossings

These were chosen as they are the main access routes into the construction corridor. During the MCA workshop discussions, it was agreed that the percentage of public roads close to the corridor would be the main driver for the scoring as this gives the best indication of how accessible the corridor is for construction.

Wellcamp-Charlton was given a score of 0 as it scored similar to the Base Case Modified for the percentage of roads within 500 m of the corridor.

Karara-Leyburn was given a score of 0 as it scored similar for the percentage of roads within 500m of the corridor.

Warwick was given a score of +5 as it scored slightly better with a greater percentage of roads within 500 m of the corridor.

A summary of the key metrics and scoring is listed in **Table 89**.

Table 89 Construction access key metrics and scoring

<table>
<tr><th rowspan="2">Key Criteria</th><th>Base Case Modified</th><th colspan="2">Wellcamp-Charlton</th><th colspan="2">Karara-Leyburn</th><th colspan="2">Warwick</th></tr>
<tr><th>Value</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th></tr>
<tr><td>Total % of minor & major roads within 500 m of corridor</td><td>45%</td><td>46%</td><td rowspan="2">0</td><td>45%</td><td rowspan="2">0</td><td>54%</td><td rowspan="2">+5</td></tr>
<tr><td>Total public road crossings</td><td>70</td><td>65</td><td>47</td><td>73</td></tr>
</table>

8.5.3 Construction complexity

The construction complexity criteria are a comparison of the construction complexity and specialisation of the workforce and equipment. The key metrics that impact this sub-criterion are:

- Length of cut deeper than 10 m
- Length of fill higher than 5 m
- Length of 1% AEP floodplain crossed
- Length of bridges higher than 6 m
- Number of waterway crossing culverts

These were all chosen as they are factors that add a level of difficulty to the construction. However, during the MCA workshop further discussions were held and it was decided that the key drivers for the scoring are:

- Length of cut deeper than 10 m
- Length of bridges higher than 6 m

Both of these items significantly impact the construction complexity due to the specialised equipment and the additional safety procedures required.

Wellcamp-Charlton was given a score of -5 as it has a significant amount of deep cut compared to the Base Case Modified and has a similar length of high bridges.

Karara-Leyburn was given a score of -10 as it has a significant amount of deep cut and a significant length of high bridges.

Warwick was given a score of -10 as it has a significant amount of deep cut and a significant length of high bridges.

A summary of the key metrics and scoring is listed in **Table 90**.

Table 90 Construction complexity key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Length of cut: 10-25 m (km)	2	7	-5	10	-10	7	-10
Length of bridges: Type 2 (6 to 11 m high) (m)	800	650		1075		1150	
Length of bridges: Type 3 (11 to 18 m high) (m)	300	575		1800		1275	

8.5.4 Resources / material sources

The resources and material sources sub-criterion is a comparison of the material sources available in order to construct the alignment options. The key metrics that impact this sub-criterion are:

- Earthworks balance volume
- Alignment length in dermosols
- Alignment length in sodosols and vertosols
- Alignment length in volcanic basalt
- Alignment length in sedimentary material

The earthworks balance gives an indication of the amount of material that needs to be obtained from either within the corridor through cut widening or from outside of the alignment from a suitable source works as there is shortage of fill material within an area. The following soil types are the predominant soils that each route corridor passes through.

Dermosols are materials that can be used as both as general bulk fill and select fill in embankments.

Sodosols and Vertosols can be highly dispersive and have significant shrink/swell characteristics therefore cannot be used for general fill material unless suitably treated through stabilisation. Depending on the particular characteristics of the material it is sometimes possible to use these materials as bulk fill within the embankment core or for other reasons where the fill material is not required to meet certain characteristics. Otherwise the material must be disposed of.

Volcanic basalt is a high strength material that can be used both in the select fill and in capping. Sedimentary materials can be used in general fill in the embankments.

Wellcamp-Charlton was given a score of 0 as it scores similar overall to the Base Case Modified when comparing the key criteria above.

Karara-Leyburn was given a score of +10 as it has a significant greater length of dermosols and sedimentary material and significantly less vertosols.

Warwick was given a score of +10 as it has a significant greater length of dermosols and sedimentary material and significantly less vertosols.

A summary of the key metrics and scoring is listed in **Table 91**.

Table 91 Resources/ material sources key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Earthworks: balance (Mm^3)	0.9	0.5	0	1.6	+10	0.9	+10
Length of alignment in soil type: Dermosols (km)	11	11		36		44	
Length of alignment in soil type: Sodosols (km)	50	50		45		48	
Length of alignment in soil type: Vertosols (km)	113	100		61		85	
Length of alignment in rock type: Tv - Volcanic (Basalt)	39	52		33		51	
Total sediments (km)	37	29		87		107	

8.5.5 Interface with operational railways

The interface with operational railways sub-criterion is a comparison of the number of interfaces with existing operational railways. The key metrics that impact this sub-criterion are:

- Connections to existing rail networks
- Connections to existing sidings on the QR network

With respect to construction activities it is preferable to minimise the connections as this minimises the staging works required. In addition, connection works can only be undertaken during a shutdown of the existing line which is often a short duration window at specific times during the year.

Wellcamp-Charlton was given a score of +5 as it has slightly less connections to existing sidings than the Base Case Modified and scores similar on connections to the existing networks.

Karara-Leyburn was given a score of +10 as it has significantly fewer connections to existing sidings and scores similar on connections to the existing networks.

Warwick was given a score of -5 as it has slightly more connections to existing sidings and scores similar on connections to the existing networks.

A summary of the key metrics and scoring is listed in **Table 92**.

Table 92 Interface with operational railway key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Connections to existing rail networks (no.)	4	4	+5	3	+10	4	-5
Connections to existing sidings on QR network (no.)	9	7		4		13	

8.5.6 Staging opportunities

The staging opportunities sub-criterion is a comparison of staging opportunities for the alignment options. An assessment of possible sidings and staging opportunities has not been undertaken by ARTC at this stage. Therefore, from a high level assessment the only staging opportunity identified in the study area was for the Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport).

Wellcamp-Charlton, Karara-Leyburn and Warwick all scored +5 as they all provide a staging opportunity at the Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) while the Base Case Modified does not. A summary of the key metrics and scoring is listed in **Table 93**.

Table 93 Staging opportunities key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Potential new stage siding to Wellcamp (no.)	0	1	+5	1	+5	1	+5

8.6 Environmental impacts scoring

This section summarises the MCA process, as undertaken for the scoring of sub-criteria within the 'Environmental Impacts' criterion.

8.6.1 Ecological impacts

The ecological impacts sub-criterion compares the potential impacts of each route option on flora, fauna and vegetation communities. The key aspects that impact this sub-criterion are:

- Area of TEC, designated under the EPBC Act within the greenfield sections of the notional construction corridor
- Area of remnant vegetation within the greenfield sections of the notional construction corridor which are Endangered or Of Concern, as designated under the *VM Act*

The reason for the selection of these metrics has previously been discussed in **Section 7.10.1.**

The Wellcamp-Charlton route was given a score of 0 as it was similar to the Base Case Modified alignment across all key criteria. The Karara-Leyburn route was given a score of -5 due to greater impacts to TEC and remnant vegetation (Endangered and Of Concern) than the Base Case Modified.

The Warwick route was given a score of -10 due to greater impacts to TEC and remnant vegetation (Endangered and Of Concern) than the Base Case Modified and the Karara-Leyburn route options. A summary of the key metrics and scoring is listed in **Table 94**.

Table 94 Ecological impacts key metrics and scoring

<table>
<tr><th rowspan="2">Key Criteria</th><th>Base Case Modified</th><th colspan="2">Wellcamp-Charlton</th><th colspan="2">Karara-Leyburn</th><th colspan="2">Warwick</th></tr>
<tr><th>Value</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th></tr>
<tr><td>Threatened Ecological Community (EPBC Act): Greenfield (ha)</td><td>19.2</td><td>18.3</td><td rowspan="3">0</td><td>47.7</td><td rowspan="3">-5</td><td>60.9</td><td rowspan="3">-10</td></tr>
<tr><td>Remnant vegetation within the construction corridor: Greenfield (ha)</td><td>4.3</td><td>4.3</td><td>9.9</td><td>12.7</td></tr>
<tr><td>Of Concern: Greenfield (ha)</td><td>20.1</td><td>19.2</td><td>37.6</td><td>71.2</td></tr>
</table>

8.6.2 Visual impacts

The visual impacts sub-criterion compares the qualitative extent to which each option would result in a landscape or visual change to sensitive receptors. Visual impact is determined through the subjective assessment of sensitivity of the visual receptors (i.e. residents, outdoor recreational users) and the magnitude (scale) of the change in view. The key aspects that impact this sub-criterion are:

- Length of greenfield alignment
- Number of residential receptors within 200 m of the notional construction corridor along greenfield sections of the notional alignment
- The reason for the selection of these metrics has previously been discussed in **Section 7.11.1**

The Wellcamp-Charlton route was given a score of -10 as it has a greater length of greenfield alignment and more residential receptors along greenfield sections of the notional alignment when compared to the Base Case Modified route.

The Karara-Leyburn route was given a score of 0 as it has slightly less greenfield alignment but marginally more residential receptors along greenfield sections of the notional alignment when compared to the Base Case Modified route.

The Warwick route was given a score of +5 as it has a significantly shorter greenfield alignment length which was weighted more highly than the greater number of residential receptors along greenfield sections of the notional alignment.

A summary of the key metrics and scoring is listed in **Table 95**.

Table 95 Visual impacts key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Greenfield alignment length (km)	126	137	-10	122	0	115	+5
Residential receptors within 200m of the corridor: Greenfield (no.)	24	61		38		46	

8.6.3 Noise and vibration impacts

The noise and vibration impacts sub-criterion compares the number of potentially impacted receptors along each route option. The key aspects that impact this sub-criterion are:

- Number of residential receptors within 200 m of the notional construction corridor
- Number of other sensitive receptors (such as schools, health care facilities etc.) within 200 m of the notional construction corridor

The reason for the selection of these metrics has previously been discussed in **Section 7.12.1**.

The Wellcamp-Charlton route was given a score of +5 as it had fewer sensitive receptors within 200 m of the notional construction corridor than the Base Case Modified alignment.

The Karara-Leyburn route was given a score of +10 as it had significantly fewer sensitive receptors within 200 m of the notional construction corridor than the Base Case Modified alignment.

The Warwick route was given a score of -10 as it had significantly more sensitive receptors within 200 m of the notional construction corridor than the Base Case Modified alignment.

A summary of the key metrics and scoring is listed in **Table 96**.

Table 96 Noise and vibration impacts key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Residential receptors within 200 m of the notional construction corridor: Total (no.)	203	126	+5	67	+10	508	-10
Other sensitive receptors within 200 m of the notional construction corridor (no.)	2	2		0		6	

8.6.4 Flooding and waterway impacts

The flooding and waterway impact sub-criterion compares potential impacts to the existing flooding and waterway conditions. The key aspects that impact this sub-criterion are:

- Total number of stream crossings
- Number of waterways crossed that have a ‘major’ or ‘high’ risk of impacting fish movement and fish communities due to works within the waterway, as identified by DAF Waterway Barrier Works mapping
- Length of 1% AEP floodplain crossed

The reason for the selection of these metrics has previously been discussed in **Section 7.13.1**.

The Wellcamp-Charlton route was given a score of 0 as it has marginally more stream crossings, but marginally fewer ‘major’ or ‘high’ ecological risk watercourses and marginally less 1% AEP floodplain. Overall the key metrics were similar to the Base Case Modified alignment.

The Karara-Leyburn route was given a score of +5 as it has marginally more stream crossings, but marginally fewer ‘major’ or ‘high’ ecological risk watercourses and 6 km less 1% AEP floodplain.

The Warwick route was given a score of -5 as it has 16 more stream crossings and 33 more ‘major’ or ‘high’ ecological risk watercourses, which is slightly offset by 3 km less 1% AEP floodplain.

A summary of the key metrics and scoring is listed in **Table 97**.

Table 97 Flooding and waterway impacts key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Total stream crossings (no.)	75	84		79		91	
Waterway barrier Works mapped watercourses crossed by the alignment centre line: Total purple (major) and red (high) (no.)	23	18	0	21	+5	33	-5
Length of 1% AEP floodplain crossed (km)	29	27		23		26	

8.6.5 Effect on air quality

The effect on air quality sub-criterion compares the number of potentially impacted receptors along each route option. The key aspects that impact this sub-criteria are:

- Number of residential receptors within 200 m of the notional construction corridor
- Number of other sensitive receptors (such as schools, health care facilities etc.) within 200 m of the notional construction corridor

The reason for the selection of these metrics has previously been discussed in **Section 7.14.1**.

The Wellcamp-Charlton route was given a score of +5 as it had fewer sensitive receptors within 200 m of the notional construction corridor than the Base Case Modified alignment.

The Karara-Leyburn route was given a score of +10 as it had significantly fewer sensitive receptors within 200 m of the notional construction corridor than the Base Case Modified alignment.

The Warwick route was given a score of -10 as it had significantly more sensitive receptors within 200 m of the notional construction corridor than the Base Case Modified alignment.

A summary of the key metrics and scoring is listed in **Table 98**.

Table 98 Effect on air quality key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Residential receptors within 200 m of the notional construction corridor: Total (no.)	203	126	+5	67	+10	508	-10
Other sensitive receptors within 200 m of the notional construction corridor (no.)	2	2		0		6	

8.6.6 Effect on greenhouse gas emissions

The effect on greenhouse gas emissions sub-criterion compares the potential greenhouse gas emissions during the construction phase and operational phase of the project. The key aspects that impact this sub-criterion are:

- Total volume of earthworks
- Transit time (northbound)

The reason for the selection of these metrics has previously been discussed in **Section 7.15.1**.

The Wellcamp-Charlton route was given a score of +5 as it has a transit time (northbound) four minutes faster than the Base Case Modified alignment which, over the operational life-of-asset was deemed sufficient to offset the additional earthworks required for this option.

The Karara-Leyburn route was given a score of -5 as it has a transit time (northbound) five minutes slower and twice the volume of earthworks when compared to the Base Case Modified.

The Warwick route was given a score of -10 as it has a transit time (northbound) 24 minutes slower and twice the volume of earthworks when compared to the Base Case Modified.

A summary of the key metrics and scoring is listed in **Table 99**.

Table 99 Effect on greenhouse gas emissions key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Earthworks: Total (Mm^3)	10	20	+5	21	-5	20	-10
Transit time (northbound) (hh:mm:ss)	2:09:23	2:05:20		2:14:44		2:33:48	

8.7 Community and property impacts scoring

This section summarises the MCA process, as undertaken for the scoring of sub-criteria within the 'Community and Property Impacts' criterion.

8.7.1 Property impacts

The property impacts sub-criterion compares the potential impacts on property in a legal, cadastral sense and in terms of structures and operational infrastructure. The key aspects that impact this sub-criterion are:

- Number of freehold land parcels traversed
- Residential receptors within 500 m upstream and 200 m downstream of the notional alignment, within the 1% AEP floodplain, based on published QLD Globe floodplain overlays
- Other receptors within 500 m upstream and 200 m downstream of the notional alignment, within the 1% AEP floodplain, based on published QLD Globe floodplain overlays
- Properties traversed by the notional alignment with a registered primary land use (Queensland Valuer-General's 2016 data set) of:
  - Cropping
  - Animal husbandry
  - Residential

The reason for the selection of these metrics has previously been discussed in **Section 7.16.1**.

The Wellcamp-Charlton route was given a score of +5 as it traverses 37 fewer freehold properties and 40 fewer properties used for cropping purposes than the Base Case Modified alignment.

The Karara-Leyburn route was given a score of +5 as it traverses 106 fewer freehold properties and 95 fewer properties used for cropping purposes than the Base Case Modified alignment. The positivity of the score was moderated down due to the increased number of animal husbandry and residential properties impacted and the number of receptors within the potential footprint of afflux.

The Warwick route was given a score of -5 as it traverses 33 more freehold properties, 42 more animal husbandry properties and 135 more residential properties than the Base Case Modified route. It also has 60 more receptors within the potential footprint of afflux. The negativity of the score was moderated up due to 65 fewer cropping properties being traversed by the Warwick notional alignment.

A summary of the key metrics and scoring is listed in **Table 100**.

Table 100 Property impacts key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
No. of land parcels traversed, by tenure: Freehold (no.)	297	260	5	191	5	330	-5
Residential Receptors within 500 m upstream and 200 m downstream of the notional alignment within 1% AEP floodplain (no.)	49	49		24		67	
Other receptors within 500 m upstream and 200 m downstream of the notional alignment within 1% AEP floodplain (no.)	67	66		103		161	
Property types (Valuer-General) crossed by alignment: Total cropping (no.)	153	113		58		88	
Property types (Valuer-General) crossed by alignment: Total animal husbandry (no.)	89	90		98		131	
Property types (Valuer-General) crossed by alignment: Total residential (no.)	35	42		69		170	

8.7.2 Heritage

The heritage sub-criterion compares the potential impact on indigenous and non-indigenous heritage sites. The key aspects that impact this sub-criterion are:

- Number of DATSIP Register places within 200 m of the notional construction corridor
- Number of QLD Heritage Register places within the notional construction corridor
- Number of local heritage places within the notional construction corridor
- Total number of stream crossings

The reason for the selection of these metrics has previously been discussed in **Section 7.17.1**.

The Wellcamp-Charlton route was given a score of -5 as it has nine more stream crossings than the Base Case Modified route.

The Karara-Leyburn route was given a score of 0 as it scored similar on all key metrics.

The Warwick route was given a score of -10 as it has four more registered DATSIP places, seven more local heritage places and 16 more stream crossings than the Base Case Modified route.

A summary of the key metrics and scoring is listed in **Table 101**.

Table 101 Heritage key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
DATSIP Register places within the construction corridor (no.)	0	0	-5	0	0	4	-10
QLD Heritage Register places within the construction corridor (no.)	0	0		0		0	
Local heritage places within the construction corridor (no.)	0	0		2		7	
Total stream crossings (no.)	75	84		79		91	

8.7.3 Impact on community

The impact on community sub-criterion compares the changes to community including accessibility through changes to the road networks and impact on community, civic facilities and businesses. The key aspects that impact this sub-criterion are:

- Number of active and passive road crossings
- Number of interfaces with towns and public spaces within 2 km
- Length of greenfield alignment

The reason for the selection of these metrics has previously been discussed in **Section 7.18.1**.

The Wellcamp-Charlton route has eight fewer road crossings and one fewer interface with towns, but a 11 km longer greenfield alignment length than the Base Case Modified route. These metrics were deemed to cancel one another out and consequently a score of 0 was given.

The Karara-Leyburn route was given a score of +5 as it has 32 fewer road crossings, one fewer interface with towns and 4 km less greenfield alignment. The Warwick route was given a score of -5 as it has five more interfaces with towns, despite five fewer road crossings and 11 km less greenfield alignment when compared to the Base Case Modified.

A summary of the key metrics and scoring is listed in **Table 102**.

Table 102 Impact on community key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Total Road Crossings (active and passive) (no.)	128	120	0	96	+5	123	-5
Interfaces with towns/public spaces within 2 km of the notional alignment (no.)	6	5		5		11	
Greenfield alignment length (km)	126	137		122		115	

8.7.4 Community response

The community response sub-criterion compares the community and stakeholder risk and the community resistance and its perception of risk. The key aspects that impact this sub-criteria are:

- Area of potential broadacre cropping land
- Length of greenfield alignment
- Residential receptors within 500 m upstream and 200 m downstream of the notional alignment within the 1% AEP floodplain, based on published QLD Globe floodplain overlays
- Other receptors within 500 m upstream and 200 m downstream of the notional alignment within the 1% AEP floodplain, based on published QLD Globe floodplain overlays
- Greenfield residential receptors within 200 m of the notional construction corridor
- Number of freehold properties

The reason for the selection of these metrics has previously been discussed in **Section 7.19.1**.

The Wellcamp-Charlton route was given a score of -5 as it is less favourable than the Base Case Modified when considering all relevant metrics, apart from the number of receptors (total) within the 1% AEP floodplain.

The Karara-Leyburn route was given a score of +5 as it impacts 100 ha less potential broadacre cropping land and has 4 km less greenfield alignment. This is despite having 14 more greenfield residential receptors and 32 more receptors (total) within the 1% AEP floodplain.

The Warwick route was given a score of -5 as it has 305 more residences within 200 m when compared to the Base Case Modified route, in addition to 60 more receptors (total) within the 1% AEP floodplain. This is despite 40 fewer hectares of potential broadacre cropping land and 11 km less greenfield alignment.

A summary of the key metrics and scoring is listed in **Table 103**.

Table 103 Community response key metrics and scoring

<table>
<tr><th rowspan="2">Key Criteria</th><th>Base Case Modified</th><th colspan="2">Wellcamp-Charlton</th><th colspan="2">Karara-Leyburn</th><th colspan="2">Warwick</th></tr>
<tr><th>Value</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th></tr>
<tr><td>Potential broadacre cropping land (ha)</td><td>698</td><td>732</td><td rowspan="6">-5</td><td>601</td><td rowspan="6">+5</td><td>663</td><td rowspan="6">-5</td></tr>
<tr><td>Greenfield alignment length (km)</td><td>126</td><td>137</td><td>122</td><td>115</td></tr>
<tr><td>Residential Receptors within 500 m upstream and 200 m downstream of the notional alignment within 1% AEP floodplain (no.)</td><td>49</td><td>49</td><td>24</td><td>67</td></tr>
<tr><td>Other receptors within 500 m upstream and 200 m downstream of the notional alignment within 1% AEP floodplain (no.)</td><td>67</td><td>66</td><td>103</td><td>161</td></tr>
<tr><td>Residential receptors within 200 m of the notional construction corridor: Greenfield (no.)</td><td>24</td><td>61</td><td>38</td><td>46</td></tr>
<tr><td>Freehold properties (no.)</td><td>297</td><td>260</td><td>191</td><td>330</td></tr>
</table>

8.7.5 Current and future land use impacts

The current and future land use impacts sub-criterion is an assessment of impacts on existing development and impacts on future development. The key aspects of this sub-criterion are:

- Impacts on the total area cropping land
- Impacts on total area animal production land
- Impacts to residential properties
- Impacts to potential broadarce cropping land
- Impacts to resource tenures

The reason for the selection of these metrics has previously been discussed in **Section 7.20.1**.

The Wellcamp-Charlton route was given a score of -5 as it impacts more animal production, cropping and residential land (current use), in addition to impacting 43 ha more potential broadacre cropping land than the Base Case Modified route.

The Karara-Leyburn route was given a score of +10 as it impacts 106 ha less cropping land (current), 100 ha less potential agricultural land (future) and 9 ha less ML than the Modified Base Case route, all of which are reflective of land uses that are dependent on a localised, underlying finite resource. This is despite greater impacts to animal husbandry and residential land uses.

The Warwick route was given a score of +10 as it impacts 136 ha less cropping land (current), 40 ha less potential agricultural land (future) and 45 ha less ML than the Modified Base Case route, all of which are reflective of land uses that are dependent on a localised, underlying finite resource. This is despite greater impacts to animal husbandry and residential land uses.

A summary of the scoring key metrics and scoring is listed in **Table 104**.

Table 104 Current and future land use impacts key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Total cropping (ha)	407	409	-5	301	+10	271	+10
Total animal production (ha)	463	509		745		851	
Residential (ha)	1.1	12.6		6.0		11.0	
Potential agricultural land (Agricultural Land Audit): Broadacre cropping (ha)	684	726		583		644	
Resource Tenures: ML (ha)	45	45		36		0	

8.8 Approvals and stakeholder risk scoring

This section summarises the MCA process, as undertaken for the scoring of sub-criteria within the 'Approvals and Stakeholder Risk' criterion.

8.8.1 Planning and approval timescale scoring

The planning and approval timescale sub-criterion is an assessment of likely planning approvals required and the anticipated duration to obtain them for each route option. The key aspect of this assessment is an understanding for the EIS process that will be applicable to each route option.

Regardless of which route option is selected as the preferred, ARTC intend to apply for the project to be declared a 'Coordinated Project' under the SDPWO Act and subsequently prepare an EIS to meet the requirements under this Act and the EPBC Act. The estimated timeframe to obtain approval of an EIS under both of these Acts is approximately 24 months.

As the approval pathway is consistent for all route options, the three alternative options all received a score of 0 relative to the Base Case Modified.

A summary of the scoring key metric and scoring is presented in **Table 105**.

Table 105 Planning and approval timescale key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Primary Approval process	SDWPO Act & EPBC Act EIS Approx. 24 months	Same as Base Case	0	Same as Base Case	0	Same as Base Case	0

8.8.2 State and Federal agency buy in

The State/Federal agency buy in sub-criterion is an assessment of State and Federal agency support for a given route option. The intention of this options assessment process was for it to be conducted as an independent, non-biased technical comparison of the four route options, removed from political preferences. Consequently, State and Federal buy-in or preference was not assessed or included in the MCA. The three alternative options all received a score of 0 relative to the Base Case Modified.

A summary of the scoring key metric and scoring is presented in **Table 106**.

Table 106 State/ Federal agency buy in key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Assessment of agency support for the option	N/A - no State or Federal preference to influence this MCA	N/A - no State or Federal preference to influence this MCA	0	N/A - no State or Federal preference to influence this MCA	0	N/A - no State or Federal preference to influence this MCA	0

8.8.3 Local government buy in scoring

The local government buy in sub-criterion is an assessment of local government support for a given route option. Consultation was undertaken with Goondiwindi Regional Council, Southern Downs Regional Council and Toowoomba Regional Council to assess both local government and community concerns and support for the respective route options. The key aspects of this sub-criteria are:

- Impact on total cropping land
- Impact on potential broadacre cropping land
- Proximity to townships

The reason for the selection of these metrics has previously been discussed in **Section 7.23**.

The Warwick route was given a +5 due to the preference by Southern Downs Regional Council to have the project aligned close to the township of Warwick. The Wellcamp-Charlton and Karara-Leyburn routes were given scores of 0 as there was no preference had been shown by any of the councils for either alignment over the Base Case Modified.

A summary of the scoring key metrics and scoring is listed in **Table 107**.

Table 107 Local government buy in key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
Total cropping (ha)	407	409	0	301	0	271	+5
Potential broadacre cropping land (ha)	684	726		583		644	
Goondiwindi Regional Council	Bypass of Inglewood. 17.8 ha cropping land in GRC	Same as Base Case		Bypass of Inglewood. More cropping land (22.4 ha)		Bypass of Inglewood. More cropping land (22.4 ha)	
Southern Downs Regional Council	Not via Warwick	Same as Base Case		Closer to Warwick		Via Warwick	
Toowoomba Regional Council	327.3 ha cropping land in TRC	Less cropping land (306.1 ha)		Less cropping land (232.3 ha)		Less cropping land (115.8 ha)	

8.8.4 Other statutory and regulatory approvals scoring

The other statutory and regulatory approvals sub-criterion is an assessment of secondary statutory and regulatory approvals. Secondary approvals are considered to be those that are required for the project after regulatory approval of an EIS under the SDPWO Act and EPBC Act, but prior to the commencement of construction. At this early stage of the project, the metrics know to require secondary approvals are:

- Number of interactions with state forest properties
- Number of Development Permits for Operational Works (waterway barrier works) required

These metrics were chosen as they are the only aspects that can be identified at this stage that will trigger the need for secondary approvals, falling outside of the EIS process.

The Wellcamp-Charlton route was given a score of 0 as it crosses a similar number of state forest properties with only five fewer crossings of watercourses mapped as major or high for waterway barrier works purposes when compared to the Base Case Modified route.

The Karara-Leyburn route was given a score of 0 as it crosses only three fewer state forest properties with only two fewer crossings of watercourses mapped as major or high for waterway barrier works purposes when compared to the Base Case Modified route.

The Warwick route was given a score of -5 as it crosses three more state forest properties and ten more crossings of watercourses mapped as major or high for waterway barrier works purposes when compared to the Base Case Modified route.

A summary of the scoring key criteria and scoring is listed in **Table 108**.

Table 108 Other statutory and regulatory approvals key metrics and scoring

Key Criteria	Base Case Modified	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Value	Value	Score	Value	Score	Value	Score
State Forest properties (no.)	4	4	0	1	0	7	-5
Waterway Barrier Works (Major + High) (no.)	23	18		21		33	

8.8.5 Service authorities

The service authorities sub-criterion is an assessment of the number of impacts to significant (HV/trunk/distribution) utilities and local utilities networks. The key aspects of the design that impact this sub-criterion are:

- Number of gas or oil pipeline changes
- Number of telecommunications and optic fibre changes

These were chosen as they are the major utilities that will require significant negotiations with the asset owners.

The Wellcamp-Charlton, Karara-Leyburn and Warwick routes were all given a score of 0 as all notional alignments have major utilities which will require approvals. The number of similar utilities along a given alignment is largely immaterial if there is consistency in the asset owner as the approval for multiple gas mains or optic fibre relocations can be negotiated in parallel.

A summary of the scoring key criteria and scoring is listed in **Table 109.**

Table 109 Service authorities key metrics and scoring

<table>
<tr><th rowspan="2">Key Criteria</th><th>Base Case Modified</th><th colspan="2">Wellcamp-Charlton</th><th colspan="2">Karara-Leyburn</th><th colspan="2">Warwick</th></tr>
<tr><th>Value</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th><th>Value</th><th>Score</th></tr>
<tr><td>Gas or Oil Pipeline (no.)</td><td>8</td><td>7</td><td rowspan="2">0</td><td>5</td><td rowspan="2">0</td><td>5</td><td rowspan="2">0</td></tr>
<tr><td>Telecommunications & Optic Fibre U/G (no.)</td><td>14</td><td>19</td><td>6</td><td>6</td></tr>
</table>

8.9 MCA summary

The results of the MCA have indicated that two of the alternative options scored closely to the Base Case Modified option, these being the Wellcamp-Charlton route (-0.283) and the Karara-Leyburn route (0.490). The third alternative option, the Warwick route (-3.03), did not score as closely and scored negatively when compared to the Base Case Modified route. This is function of the extra length of the alignment, the interfaces with local communities and sensitive receptors and the requirement to modify the existing alignment to meet the ARTC design standards and the ARTC Service Offering.

The MCA scoring according to the seven key criteria can be seen in **Table 128**.

Table 110 MCA scoring

Assessment Criteria	Weighting	Wellcamp-Charlton	Karara-Leyburn	Warwick
Technical viability	17%	-0.043	0.595	-0.298
Safety assessment of the proposed alignment	16.5%	0.041	-0.289	-0.784
Operational approach, including opex	16.5%	0	-0.817	-0.545
Constructability and schedule	12.5%	-0.125	0.094	-0.188
Technical Sub-Total		***-0.126***	***-0.417***	***-1.815***
Environmental and heritage Impacts	12.5%	0.094	0.281	-0.844
Community and property impacts	12.5%	-0.250	0.625	-0.375
Approvals and stakeholder risk	12.5%	0	0	0
Non-Technical Sub-Total		***-0.156***	***0.906***	***-1.22***
TOTAL	**100%**	**-0.283**	**0.490**	**-3.03**

The criteria have been separated into what has been considered as Technical and Non-Technical Criteria. For the Technical criteria all of the options scored less favourably than the Base Case Modified route. For the Non-Technical criteria, the Karara-Leyburn route scored more favourably (+0.906) while the others scored less favourably.

The key non-technical criteria were the community and property impacts. The MCA assessment was scored against quantifiable elements such as the number of sensitive receptors along the route, the number of road interfaces, and the number of properties impacted plus additional items as detailed in the MCA scoring. These attributes do not capture the softer personal and community impacts that may be felt by a community.

It must be noted that this study has attempted to be as quantitative as possible so as to remove subjectivity in the assessment. It must also be noted that the more subjective criteria around community impacts has been assessed through sensitivity testing.

8.10 MCA sensitivity check

Sensitivity analysis was performed on some MCA Sub-Criteria to assess the impact upon the scoring. Analysis was applied to a few key criteria where there is either perceived sensitivity, or where the scoring was considered to be more subjective in nature.

The three key areas of sensitivity that were carried out during the MCA workshop were:

1. Sub Criteria 7.3 - Local government buy in.
2. Sub Criteria 6.3 - Impact on Community and 6.4 - Community Response were assessed against the Base Case Modified to assess community stakeholder sensitivity.
3. Sub Criteria for Hydrology, 1.5 - Flood immunity/ hydrology, 5.4 - Flooding and waterway impacts, 6.1 - Property impacts, 6.4 - Community response (community stakeholder risk) assessed as sensitivity combinations for hydrology.

The sensitivity result for sub-criteria 7.3 - Local government buy in was that there was no net comparative change.

Table 111 Sensitivity analysis 7.3 local government buy in

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
7.3 Original Score	0	*0*	*0*	*5*
7.3 Revised Score	0	**-10**	**-10**	**10**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		**-0.53**	**0.24**	**-2.91**

The sensitivity for sub-criteria 6.3 - Impact on Community & 6.4 - Community Response was performed with two scenarios. The first with only the 6.4 - Community Response changed and the second with both sub-criteria changed. The results can be seen in the following two tables.

Table 112 Community Scenario 1 – sensitivity analysis 6.4 community response

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
6.4 Original Score	0	-5	*5*	*-5*
6.4 Revised Score	0	-5	**-10**	**0**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		-0.28	**0.11**	**-2.91**

As can be seen in the table above, the changes bought the Karara-Leyburn and Warwick routes closer to the Base Case, however there was no net comparative change between the options.

The second sensitivity scenario included sensitivity testing of sub-criteria 6.3 - Impact on the Community along with 6.4 - Community Response. The results are presented in the following table.

Once again, the changes bought the Karara-Leyburn and Warwick routes closer to the Base Case, however there was no net comparative change between the options.

Table 113 Community Scenario 2 – sensitivity analysis 6.3 & 6.4 impact on community and community response

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
6.3 Original Score	0	0	*5*	-5
6.3 Revised Score	0	0	**0**	-5
6.4 Original Score	0	-5	*5*	*-5*
6.4 Revised Score	0	-5	**-10**	**0**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		-0.28	**0.01**	**-2.41**

A sensitivity check was also undertaken on flood immunity/hydrology. Four scenarios were investigated as a combination of hydrological related items across the upper level key criteria.

The scenarios were:

1. 1.5 - Flood immunity/ hydrology.
2. 1.5 - Flood immunity/ hydrology + 5.4 - Flooding and waterway impacts.
3. 1.5 - Flood immunity/ hydrology + 5.4 - Flooding and waterway impacts + 6.1 - Property impacts.
4. 1.5 - Flood immunity/ hydrology + 5.4 - Flooding and waterway impacts + 6.1 - Property impacts + 6.4 - Community response (community stakeholder risk).

The scenarios change the scores in relation to the Base Case Modified route however no net comparative change was evident across the options. The results are shown in the following tables.

Table 114 Flooding/hydrology Scenario 1 – sensitivity analysis 1.5 flood immunity/hydrology

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
1.5 Original Score	0	*5*	*5*	*-5*
Changed scores to	0	**0**	**10**	**10**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		**-0.45**	**0.66**	**-2.52**

Table 115 Flooding/hydrology Scenario 2 – sensitivity analysis 1.5 & 5.4 flood immunity/hydrology and flooding and waterway impacts

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
1.5 Original Score	0	*5*	*5*	*-5*
5.4 Original Score	0	0	*5*	*-5*
Changed scores to	0	**0**	**10**	**10**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		**-0.45**	**0.78**	**-2.52**

Table 116 Flooding/hydrology Scenario 3 – sensitivity analysis 1.5, 5.4 & 6.1 flood immunity/hydrology, flooding and waterway impacts and property impacts

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
1.5 Original Score	0	*5*	*5*	*-5*
5.4 Original Score	0	0	*5*	*-5*
6.1 Original Score	0	*5*	*5*	*-5*
Changed scores to	0	**0**	**10**	**10**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		**-0.58**	**0.91**	**-1.77**

Table 117 Flooding/hydrology Scenario 3 – sensitivity analysis 1.5, 5.4, 6.1 & 6.4 flood immunity/hydrology, flooding and waterway impacts, property impacts and community response

Sub Criteria	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
1.5 Original Score	0	*5*	*5*	*-5*
5.4 Original Score	0	0	*5*	*-5*
6.1 Original Score	0	*5*	*5*	*-5*
6.4 Original Score	0	*-5*	*5*	*-5*
Changed scores to	0	**0**	**10**	**10**
Total Original Score		-0.28	0.49	-3.03
Sensitivity Score		**-0.45**	**1.03**	**-1.4**

Although some PRG representatives did not want sensitivity testing to occur, the testing was performed to validate the MCA results and the results of the sensitivity tested were reported back to the PRG.

8.11 MCA technical validation

8.11.1 MCA technical scoring validation

A detailed review of all MCA technical scores was undertaken after the MCA workshop to ensure all sub-criteria scores accurately reflect the data. As part of the review process all technical sub-criteria were reassessed using the following more rigorous assessment methodology.

Items listed under each MCA cub-criteria were discussed within the engineering team and ranked in terms of importance from a scale of 1-5 as follows:

- 1 - Not relevant
- 2 - Not important
- 3 - Moderate
- 4 - Important
- 5 - Very important

All items were given a percentage weighting based on their level of importance, with ‘not relevant’ items receiving a weighting of 0%. The items were scored relative to the Base Case Modified using the same 5 point scale adopted for MCA sub-criteria scoring as detailed in **Table 71**. The individual item weightings and scores were then used to calculate an overall sub-criteria score which was rounded to the nearest score on the 5 point scale detailed in **Table 71.**

The calculated sub-criteria scores were then compared to the sub-criteria scores agreed upon during the MCA workshop. The cases where the refined scores differ to the MCA workshop scores are detailed in **Table 118**.

Table 118 Comparison of MCA workshop scores and refined scores

Sub-criteria	MCA Workshop Sub-Criteria Scores			Refined Sub-Criteria Scores			Reason Refined Score Differs to MCA Workshop Score
	Wellcamp-Charlton	Karara-Leyburn	Warwick	Wellcamp-Charlton	Karara-Leyburn	Warwick	
2.3 Road safety interfaces	5	10	-5	**0**	**5**	-5	All items scored separately with individual weightings applied to level crossings.
2.5 Construction safety	-5	-10	-10	-5	**-5**	**-5**	All items scored separately with individual weightings applied.
3.2 Below rail opex	5	-5	-10	5	**0**	-10	All items scored separately with individual weightings applied.
3.4 Effect on reliability and availability	0	0	-10	0	**5**	-10	All items scored separately with individual weightings applied.
4.1 Construction duration	-10	-10	-10	**-5**	-10	-10	All items scored separately with individual weightings applied.
4.2 Construction access	0	0	5	0	**-5**	5	All items scored separately with individual weightings applied.
4.6 Staging opportunities	5	5	5	**0**	**0**	**0**	Wellcamp-Charlton Industrial Precinct (including Wellcamp Airport) does not provide benefit for current freight traffic on inland rail route. Potential for future benefit for passenger services.

A validation check of the total MCA scores for each alignment option was undertaken to determine the impact of the refined sub-criteria scores. The total MCA scores based on the refined sub-criteria scores and the total MCA scores determined in the workshop are detailed in **Table 119** for comparison. It can be seen the refined Wellcamp-Charlton score shows a small decline from the Base Case Modified while there is no significant difference between the Karara-Leyburn and Warwick scores. The scoring difference is within the sensitivity threshold of the MCA.

Table 119 MCA scoring technical validation check

	Base Case Modified	Wellcamp-Charlton	Karara-Leyburn	Warwick
MCA workshop score	0	-0.28	0.49	-3.03
Sensitivity score based on analytical assessment method	0	-0.46	0.53	-2.96

8.11.2 MCA data verification

A detailed check of the data used in the MCA was undertaken after the MCA workshop to ensure the information assessed during the workshop was correct. Upon review of the MCA data it was found that the geotechnical quantities utilised on the day had cut and fill quantities transposed. The MCA spreadsheet has been updated to reflect the correct values and this section reassessed. The reassessed values do not require a change in the scoring adopted during the MCA workshop.

The number of residential and other receptors within the floodplain for each alignment option was updated after the MCA workshop. The relevant sections of the MCA spreadsheet have been updated to reflect the correct values and reassessed. The reassessed values do not require a change in the scoring adopted during the MCA workshop.

9.0 Cost estimate

The department of Infrastructure and Regional Development (DIRD) through ARTC has engaged AECOM/Aurecon to provide a comparative cost analysis of four route options considered between NSW to Toowoomba as part of the Melbourne to Brisbane Inland Rail (MBIR). An independent estimator (Project Support) was engaged to develop the cost comparison estimate for each option considered from the BOQ.

The cost estimate was undertaken in parallel to the MCA assessment with the final costs delivered after the scoring day to ensure there was no bias to a particular alignment within the MCA process.

9.1 Development of the Comparative Cost Estimate

The development of the comparative cost estimates has been completed using as a guide the TMR Guidelines for the Preparation of Cost Estimates and have been prepared to a level between Strategic and Concept Phase of a project suitable to determine an Options analysis estimate.

The routes costed were as follows:

- Base Case Modified
- Wellcamp-Charlton
- Karara-Leyburn
- Warwick

Main Assumptions were:

- The estimate has been prepared in accordance with the ARTC guidelines
- The project options would be delivered as a D&C project with track and sleeps supplied by ARTC.
- The ARTC work breakdown structure (WBS) numbering is to be adopted.
- Level 3 elemental coding to be developed by cost estimator.
- ARTC Estimating guidelines and MBIR Rates book
- Options are greenfield
- Drainage structures to be categorised by size and structure
- Track is all dual gauge
- Overheads/indirect costs, design, owner’s cost, contingency all to be derived using TMR Construction Estimation rule book
- Detailed Design is included and has a value of 5% of Construction value.

It should be noted that the cost estimate has been provided solely to provide a comparison between the routes considered. This estimate should not be interpreted as providing project costs.

9.2 Strategic comparative estimates

Estimates can be considered to fall into a number of classes or categories depending upon the level of information available, or the accuracy of estimate required relative to the value of the project. However, intrinsically every estimate is unique and the type of estimating techniques employed varies to suit the requirements of the particular estimate being undertaken.

The estimate prepared for this study is based upon conceptual but practical design and uses accepted industry practice including TMR guidelines. This estimate is a design estimate with a project definition level of approximately 15% and should be used for comparative costing only. The level of technical design undertaken in this study is still conceptual, however due to the several route options not proving sufficient differentiation in earthworks and or structural quantities, additional technical design has been undertaken in this study to move these design elements beyond the traditional conceptual phase, enabling some uncertainty to be removed and allowing more precise quantities to be determined.

The estimate has been developed by assessing major civil earthworks, structural and drainage features. Soil conditions have been assessed to determine material suitability and to define an initial mass haul philosophy that could be adopted during construction.

The intent of this estimate is to establish and provide a cost estimate that is more than an order of magnitude estimate. It is suitable for this options analysis study/phase to determine meaningful economic evaluation and differentiation to compare the routes being considered.

9.3 Bill of Quantities / Work Breakdown Structure

AECOM developed a bill of quantities (BOQ) for each option selected for progression into the MCA and Cost Estimate. The BOQ structure and breakdown of BOQ items was based upon prior phases of the MBIR project for consistency. This summarised estimated quantities at a concept level, focussing on key items such as earthworks, bridges, and drainage structures. The structure and basis for the BOQ was coordinated with the Cost Estimator, to ensure quantities were presented to an appropriate level of detail.

A BOQ has been prepared to provide comparative cost estimates using the following top level elements. Elements were then expanded at the next level to provide sufficient information for the estimate to the prepared based on the details in **Table 120**.

Table 120 Description of key elements included in Bill of Quantities Direct Costs

Element	Description
Environmental	
Earthworks - No more than 30km haul distance	Clearing and Grubbing - by vegetation type Cut to Fill. · Bulk fill earthwork quantities · Select fill earthwork quantities Borrow to Fill · Bulk earthwork quantities · Select fill earthwork quantities Cut to Spoil · Bulk earthwork quantities
Capping	Capping either in embankment or cut
Fencing	Type, length of fence including allowance for gates and cattle grids
Trackwork	Installation of trackwork, ballast, sleepers, fasteners and rail Installation of turnouts
Culverts	Described by type (RCBC or Pipe) Described by groupings (No. of culverts in a group) Length assumed for each culvert Stock route crossings (If provided by culvert structure)
Drainage	Additional Drainage protection or treatment as assessed
Bridges	Described by Types 1 -3 (relating to height above ground) Described by Length Viaduct crossing over flood plain
Grade Separation	Described by major road realignment and grade separation over rail
Level Crossings	Describes number and type of level crossings · Active Level Crossings Major (Boom gates and Lights) · Active Level Crossings Minor (Lights) · Passive Level Crossings (Signage)
PUPS	Describes no and type of PUP interface
Noise Mitigation	Describes Noise amelioration requirements

Operational costs were considered at a broad level, which was deemed to be appropriate for the current scope for input into the MCA.

9.4 Basis of cost plans

- The ARTC work breakdown structure (WBS) numbering is to be adopted.
- Level 4 elemental developed by cost estimator.
- ARTC estimating guidelines have been adopted
- MBIR rates book adopted as a basis

9.5 Cost Estimate Assumptions

The assumptions and exclusions are shown below in **Table 121**.

Table 121 Assumptions

Item	Assumption / Clarification
Earthworks	Earthwork quantities derived from concept level alignment and 5m Digital Terrain model derived from QLD QSpatial Catalogue
Trackwork	Dual gauge.
Bridges	Based on number and type supplied in the BoQ. Derived from Rational Method Assessment and Hydrology analysis calculations
Drainage	Minor drainage structures categorised by flow stream classification and by Rational Method Assessment Major Drainage Structures determined Rational Method Assessment and detailed hydrology analysis
Property	Property areas derived from QLD Globe data sets. Estimate includes area of land acquired (ha) times a land rate ($) plus a one off crop loss depending on land use. Land acquired equals corridor cut and fill footprint plus 15m either side, plus sections of land cut-off by the corridor (accessibility issues). Inconvenience factor based on land use and cropping type, applied to properties divided by corridor. No cost included in estimate to rebuild, relocate infrastructure or structures. No cost included in estimate to retro fit homes with measures to reduce noise or air quality impacts. If greater than 30% of property covered by corridor entire lot acquired. Land rates and crop loss rates supplied by Maloney Field Services- National Valuation and Land Access Solutions.
Escalation	Excluded

9.6 Risk assessment

Project estimates need to be regarded as having a range of accuracies depending on many factors. These include the degree of resolution of design and specification, resolved scope and market conditions and predictability. This report highlights a number of project risks, and it is to be noted these are not exhaustive.

A risk assessment was developed based on the four (4) options listed above. Rather than adopt an overall blanket contingency applied to the Base Estimate (Construction Value and Owners Costs) The guidelines of the Federal Government publication “Cost Estimation for Federally Publicly funded road and rail Construction” issued in May 2011 have been adopted to provide a contingency amount

The basis or risk estimation was undertaking in accordance with the QLD Transport and Main Roads (TMR) Project Cost Estimating Manual, appropriate to a level for an options analysis.

A deterministic approach was adopted based on the Australian Government Publication “Best Practice Cost Estimation Standard for Publicly Funded Road and Rail Construction” May 2011.

A draft publication has been issued for comment by the Department of infrastructure and Regional Development (DIRD) called “Cost Estimation Guidance – Guidance Note 3B Deterministic Contingency Estimation, however as this has not been endorsed it is only used as information.

9.7 Construction cost estimate

A summary of the construction cost estimates can be seen in **Table 123.** The underlying Direct Job Costs and Construction Costs have been shown in **Table 124** and the full breakdown can be seen in **Appendix R**. The Construction Cost Summary Items are listed in **Table 122**.

Table 122 Cost estimate WBS

Construction Cost Summary Items
011 Environmental
031 Earthworks
033 Capping
043 Fencing
050 Trackworks
061 Culverts
062 Bridges
064 Grade Separations
065 Crossing
022 PUP's

Owners Costs and risk ranging have been excluded from these costs to enable a direct base line construction comparison. The Owners Costs and upper bound risk contingency will be best determined by the proponent for the selected route based upon the project delivery method chosen. While the Owners Costs have been excluded it can be noted that they would be typical across the four options and not be seen as a differentiator.

Table 123 Construction cost estimates

Alignment option	Construction estimate	Difference compared to Base Case Modified	% Difference
Base Case Modified	$ 1,232,743,893	$ -	0%
Wellcamp-Charlton	$ 1,334,949,841	$ 102,205,948	8%
Karara-Leyburn	$ 1,518,129,385	$ 285,385,493	23%
Warwick	$ 1,647,485,972	$ 414,742,079	34%

Notes:

- Base Case Modified is the control alignment
- Included in construction estimate: direct job costs, construction overheads, clients supply and property costs

Construction estimate does not include design and clients cost, other owner’s costs, contingency and risk

The comparative cost estimate shows that there are a few key material differentiators that drive the cost. These being the length of the track and hence track structure, the length of bridge structures required to cross the creeks and rivers and most significantly the earthworks.

The key differentiators can be seen in the **Table 124** as both a dollar and comparative cost percentage.

Table 124 Cost estimate differentiators

Cost Description	Base Case Modified (BCM)	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Amount	Amount	% Diff.	Amount	% Diff.	Amount	% Diff.
Environmental	$ 22,245,138	$ 24,611,175		$ 28,502,198		$ 30,010,678	
Difference from BCM		$ 2,366,037	11%	$ 6,257,060	28%	$ 7,765,540	35%
Earthworks	$ 261,055,168	$ 373,052,643		$ 385,132,697		$ 377,621,309	
Difference from BCM		$ 111,997,475	43%	$ 124,077,529	48%	$ 116,566,141	45%
Capping	$ 51,619,495	$ 46,929,505		$ 47,123,720		$ 56,596,080	
Difference from BCM		-$ 4,689,990	-9%	-$ 4,495,775	-9%	$ 4,976,585	10%
Fencing	$ 14,124,411	$ 13,883,596		$ 13,622,180		$ 17,099,892	
Difference from BCM		-$ 240,815	-2%	-$ 502,231	-4%	$ 2,975,481	21%
Trackworks	$ 132,186,002	$ 123,016,068		$ 124,898,323		$ 152,599,531	
Difference from BCM		-$ 9,169,934	-7%	-$ 7,287,679	-6%	$ 20,413,529	15%
Culverts	$ 82,431,140	$ 83,115,058		$ 58,373,510		$ 23,621,102	
Difference from BCM		$ 683,918	1%	-$ 24,057,630	-29%	-$ 58,810,038	-71%
Viaducts/Bridges	$ 137,975,797	$ 119,338,854		$ 255,948,910		$ 312,916,719	
Difference from BCM		-$ 18,636,943	-14%	$ 117,973,113	86%	$ 174,940,922	127%
Grade Separations	$ 5,732,638	$ 5,732,638		$ 14,331,595		$ 11,465,276	
Difference from BCM		$ -	0%	$ 8,598,957	150%	$ 5,732,638	100%
Road Crossings	$ 32,351,148	$ 28,555,728		$ 20,712,937		$ 29,240,970	
Difference from BCM		-$ 3,795,420	-12%	-$ 11,638,211	-36%	-$ 3,110,178	-10%
PUP's	$ 1,783,630	$ 2,137,205		$ 1,427,188		$ 2,547,222	
Difference from BCM		$ 353,575	20%	-$ 356,442	-20%	$ 763,592	43%
Direct Job Costs	$ 741,504,567	$ 820,372,470		$ 950,073,258		$ 1,013,718,779	
Difference from BCM		$ 78,867,903	11%	$ 208,568,691	28%	$ 272,214,212	37%

Notes:
- Base Case Modified is the control alignment
- Red fill indicates a cost value higher than the Base Case Modified
- Green fill indicates a cost value lower than the Base Case Modified

Looking at an additional level of detail for the earthworks as a key differentiator, the underlying breakdown demonstrates how the embankment footprint as a function of earthworks and/or length of the corridor determines the cost as shown in **Table 125.**

Table 125 Earthworks breakdown

Cost Description	Base Case Modified (BCM)	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Amount	Amount	% Diff.	Amount	% Diff.	Amount	% Diff.
Clear & Grub	$ 5,743,290	$ 6,196,790		$ 5,852,415		$ 7,181,861	
Difference from the BCM		$ 453,500	8%	$ 109,125	2%	$ 1,438,571	25%
Strip Topsoil	$ 23,636,740	$ 29,451,940		$ 32,220,900		$ 33,672,400	
Difference from the BCM		$ 5,815,200	25%	$ 8,584,160	36%	$ 10,035,660	42%
Bulk Earthworks	$ 166,057,422	$ 251,156,416		$ 254,402,370		$ 239,168,946	
Difference from the BCM		$ 85,098,994	51%	$ 88,344,948	53%	$ 73,111,524	44%
Earthworks Preparation	$ 25,791,766	$ 49,497,599		$ 55,099,630		$ 51,981,282	
Difference from the BCM		$ 22,843,134	128%	$ 27,935,280	156%	$ 23,259,312	130%
Access Road	$ 39,825,950	$ 36,749,898		$ 37,557,382		$ 45,616,820	
Difference from the BCM		-$ 3,076,052	-8%	-$ 2,268,568	-6%	$ 5,790,870	15%
Sub Total Earthworks	**$ 261,055,168**	**$ 373,052,643**		**$ 385,132,697**		**$ 377,621,309**	
Difference		**$ 111,997,475**	**43%**	**$ 124,077,529**	**48%**	**$ 116,566,141**	**45%**

The viaducts/bridges required to cross the creeks and rivers have been assessed within the hydrological investigations and are detailed below. They have been broken down into lengths based on bridge height/type. In Table 126 it can be seen that the majority of the bridges that cross the Base Case Modified and Wellcamp-Charlton routes are at a lower height and therefore lower unit rate cost.

In comparison the Warwick and Karara-Leyburn routes have longer viaducts and a longer length of high bridges. The higher bridges have greater cost per meter than a lower bridge and therefore an increased capital cost.

Table 126 Waterway viaduct/bridges breakdown

Bridge type and height (m)	Base Case Modified (BCM)		Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Qty	Amount	Qty	Amount	Qty	Amount	Qty	Amount
Viaduct (0-3m)	1800	$ 34,765,734	1800	$ 34,765,734	3315	$ 63,172,363	4395	$ 85,264,332
Difference from BCM				$ -		$ 28,406,629		$ 50,498,598
Type 1 (0-6m)	1375	$ 46,609,654	350	$ 13,023,019	275	$ 10,095,584	2575	$ 82,843,351
Difference from BCM				-$ 33,586,635		-$ 36,514,070		$ 36,233,697
Type 2 (6-11m)	800	$ 33,292,685	650	$ 27,258,590	1075	$ 45,130,109	1150	$ 47,815,049
Difference from BCM				-$ 6,034,095		$ 11,837,424		$ 14,522,364
Type 3 (11-18m)	300	$ 23,307,724	575	$ 44,291,511	1800	$ 137,550,854	1275	$ 96,993,987
Difference from BCM				$ 20,983,787		$ 114,243,130		$ 73,686,263
Totals	4275	$ 137,975,797	3375	$ 119,338,854	6465	$ 255,948,910	9395	$ 312,916,719
Difference from BCM				-$ 18,636,943		$ 117,973,113		$ 174,940,922

Notes:
- Base Case Modified (BCM) is the control alignment
- Red fill indicates a cost value higher than the Base Case Modified
- Green fill indicates a cost value lower than the Base Case Modified

It should be noted that the Base Case Modified and Wellcamp-Charlton routes have an increased number of culverts when compared against the Karara-Leyburn and Warwick Routes. Table 127 shows the difference in culvert and bridges costs, individually as well as jointly, against the Base Case Modified route.

Table 127 Culvert and Waterway viaducts/bridges breakdown

Cost Description	Base Case Modified (BCM)	Wellcamp-Charlton		Karara-Leyburn		Warwick	
	Amount	Amount	% Diff.	Amount	% Diff.	Amount	% Diff.
Culverts	$ 82,431,140	$ 83,115,058		$ 58,373,510		$ 23,621,102	
Difference from BCM		$ 683,918	1%	-$ 24,057,630	-29%	-$ 58,810,038	-71%
Viaducts/Bridges	$ 137,975,797	$ 119,338,854		$ 255,948,910		$ 312,916,719	
Difference from BCM		-$ 18,636,943	-14%	$ 117,973,113	86%	$ 174,940,922	127%
Culverts and Bridge Difference from BCM		-$ 17,953,025	-8%	$ 93,915,483	43%	$ 116,130,884	53%

Notes:
- Base Case Modified (BCM) is the control alignment
- Red fill indicates a cost value higher than the Base Case Modified
- Green fill indicates a cost value lower than the Base Case Modified

10.0 Areas for future assessment

The purpose of this study was to perform a comparative assessment of the three additional route options against the Base Case Modified corridor. Consequently, the level of investigation undertaken to complete the MCA and inform this report has been commensurate with that required to undertake a like-for-like analysis of four route options, supported with concept designs. The quantified results that have populated the MCA have been determined from a central alignment for each investigation corridor.

Hydrological investigations completed to inform this options assessment have incorporated detailed modelling for nominated 10% and 1% AEP events for the Condamine River floodplains. During the detailed design phase additional AEP events will need to be assessed to confirm the controlling events for bridges and structures. The EIS phase will be able to confirm the design criteria for flood immunity and in particular the maximum afflux allowable. Detailed hydrological and hydraulic assessments supported by modelling and site survey (or LiDAR) are also required for other waterway crossings during further design development stages, to confirm cross drainage arrangements.

Comparative costs estimated have indicated that the earthworks required for each alignment largely dictates the outcome of the comparative assessment. The earthworks design to date has been based on desktop geotechnical analysis that has been supplemented with field observations from publically accessible areas. More detailed geotechnical investigations will be required to better refine the earthworks and mass-haul movements for the selected investigation corridor.

The PRG meetings and community engagements have highlighted the potential impacts that the proposed railway would have on individuals, local communities and businesses from personal, operational and economic perspectives. Early community engagement to discuss prospective impacts and requirements should be undertaken.

This includes an assessment of community, livestock and machinery movements in close proximity to the corridor and the local preference in planning for an alignment route that could minimise any prospective impacts. One example of a prospective alternative that has been raised through the PRG, should the Base Case Modified Investigation Corridor be selected, is the consideration of an alignment on the western side of Inglewood Millmerran Road within the State Forest, which may reduce the prospective impact on landowners.

An express transit time of 24 hours is one of the ARTC Service Offerings. The Warwick route has shown to be approximately 24 minutes longer for the northbound express service. If the Warwick route was to be considered the overall Melbourne to Brisbane transit time would need to be assessed against this Service Offering requirement.

11.0 Conclusions

The assessment resulting from this comparative study has been carried out using two primary methods:

- Multi Criteria Analysis to compare options
- A comparative cost estimate

The results of the MCA have indicated that two of the alternative options scored closely to the Base Case Modified option, these being the Wellcamp-Charlton route (-0.283) and the Karara-Leyburn route (0.490). The third alternative option, the Warwick route (-3.03), did not score as closely and scored negatively when compared to the Base Case Modified route. This is function of the extra length of the alignment, the interfaces with local communities and sensitive receptors and the requirement to modify the existing alignment to meet the ARTC design standards and the ARTC Service Offering.

The MCA scoring according to the seven key criteria can be seen in **Table 128**.

Table 128 MCA scoring

Assessment Criteria	Weighting	Wellcamp-Charlton	Karara-Leyburn	Warwick
Technical viability	17%	-0.043	0.595	-0.298
Safety assessment of the proposed alignment	16.5%	0.041	-0.289	-0.784
Operational approach	16.5%	0	-0.817	-0.545
Constructability and schedule	12.5%	-0.125	0.094	-0.188
Technical Sub-Total		***-0.126***	***-0.417***	***-1.815***
Environmental and heritage Impacts	12.5%	0.094	0.281	-0.844
Community and property impacts	12.5%	-0.250	0.625	-0.375
Approvals and stakeholder risk	12.5%	0	0	0
Non-Technical Sub-Total		***-0.156***	***0.906***	***-1.22***
TOTAL	**100%**	**-0.283**	**0.490**	**-3.03**

The criteria have been separated into what has been considered as Technical and Non-Technical Criteria. For the Technical criteria all of the options scored less favourably than the Base Case Modified route. For the Non-Technical criteria, the Karara-Leyburn route scored more favourably (+0.906) while the others scored less favourably.

The key Non-Technical criteria were community and property impacts. The MCA assessment was scored against quantifiable elements such as the number of sensitive receptors along the route, the number of road interfaces, and the number of properties impacted plus additional items as detailed in the MCA scoring. These attributes do not capture the softer personal and community impacts that may be felt by a community. It must be noted that this study has attempted to be as quantitative as possible so as to remove subjectivity in the assessment. It must also be noted that the more subjective criteria around community impacts have been assessed through sensitivity testing.

Sensitivity testing for local government buy-in, the community impact and hydrologic impacts has demonstrated that there is no net comparative change in the MCA scoring outcome. It should also be noted that the MCA and comparative cost estimate will be provided for consideration along with the PRG Chairman's report. This report will provide additional social and community context to assist with the assessment of a preferred investigation corridor.

Although all four options were investigated and assessed, the standard ARTC process is to ensure that any option must meet the ARTC Service Offering. There is no particular feature in this study that may result in an option not meeting the Service Offering. However, the Warwick route takes approximately 24 minutes longer to traverse the Northbound express service.

This is due to the length of the alignment and the terrain it traverses. This study has not addressed whether this increase in transit time would impact upon the 24 hour Service Offering requirement, however it has the potential to impact and is also an indicator for future operational cost.

The comparative cost estimate has indicated that the key cost differentiators are based on the length of the corridors, and in particular the earthworks required, and the structures required for waterway crossings. The three alternative alignments all require a significant increase in earthworks quantities above the Base Case Modified corridor and this has been demonstrated to be the key differentiator.

Table 129 Construction cost estimates

Alignment option	Construction estimate	Difference compared to Base Case Modified	% Difference
Base Case Modified	$ 1,232,743,893	$ -	0%
Wellcamp-Charlton	$ 1,334,949,841	$ 102,205,948	8%
Karara-Leyburn	$ 1,518,129,385	$ 285,385,493	23%
Warwick	$ 1,647,485,972	$ 414,742,079	34%

Notes:

- Base Case Modified is the control alignment
- Included in construction estimate: direct job costs, construction overheads, clients supply and property costs
- Construction estimate does not include design and clients cost, other owners costs, contingency and risk

Table 130 Earthworks and viaducts/bridges breakdown

Element	Base Case Modified (BCM)	Wellcamp-Charlton	Karara-Leyburn	Warwick
Length (km)	181	168	172	208
Earthworks	$ 261,055,168	$ 373,052,643	$ 385,132,697	$ 377,621,309
Difference from BCM		$ 111,997,475	$ 124,077,529	$ 116,566,141
Waterway viaducts/bridges	$ 137,975,797	$ 119,338,854	$255,948,910	$312,916,719
Difference from BCM		-$ 18,636,943	$ 117,973,113	$ 174,940,922

In summary, the MCA and comparative cost estimate for the investigation corridors can be seen in **Table 131.**

Table 131 MCA scoring and cost estimate summary

Element	Base Case Modified (BCM)	Wellcamp-Charlton	Karara-Leyburn	Warwick
Corridor Length (km)	181.3	168.1	171.9	208.3
MCA Overall	0	-0.283	0.490	-3.03
MCA (Technical)	*0*	*-0.126*	*-0.417*	*-1.815*
MCA (Non-Technical)	*0*	*-0.156*	*0.906*	*-1.22*
Construction Cost	$1,232,743,893	$ 1,334,949,841	$ 1,518,129,385	$ 1,647,485,972
Construction Cost Difference to BCM	-	+ $ 102,205,948	+ $ 285,385,493	+ $ 414,742,079

Notes:

- Base Case Modified (BCM) is the control alignment
- Included in construction estimate: direct job costs, construction overheads, clients supply and property costs

Appendix A

PRG Terms of Reference

Appendix B

Corridor Maps

Appendix C

PRG Inputs

Appendix D

Drop-In Sessions Advertisement

Appendix E

Project Risk Register

Appendix F

Alignment Plan and Profiles

Appendix G

Road Crossings

Appendix H

PUP Crossings

Appendix I

Condamine River Hydraulic Assessment Report - Modified Base Case and Wellcamp

Appendix J

Condamine River
Hydraulic Assessment
Report - Karara-Leyburn

Appendix K

Condamine River Hydraulic Assessment Report - Warwick

Appendix L

Stream Crossings

Appendix M

Major and Minor Hydrological Assessment

Appendix N

Base Case Modified and Wellcamp-Charlton Environmental Map Series

Appendix O

Karara-Leyburn Environmental Map Series

Appendix P

Warwick Environmental Map Series

Appendix Q

MCA Worksheet

Appendix R

Cost Estimate