ARTC

Melbourne–Brisbane Inland Rail Alignment Study

Working Paper No. 3
Stage 1 Capital Works Costings

PB

Connell Wagner

Halcrow

Contents

List of tables

List of figures

List of appendices

1 Introduction

In March 2008 the Australian Government announced that the Australian Rail Track Corporation (ARTC) had been asked to conduct the Melbourne-Brisbane Inland Rail Alignment Study.

The announcement stated that in developing a detailed route alignment, the ARTC would generally follow the far western sub-corridor identified by the previous North-South Rail Corridor Study and shown on the map below. This study, completed in June 2006, established the broad parameters for a potential future inland rail corridor between Melbourne and Brisbane.

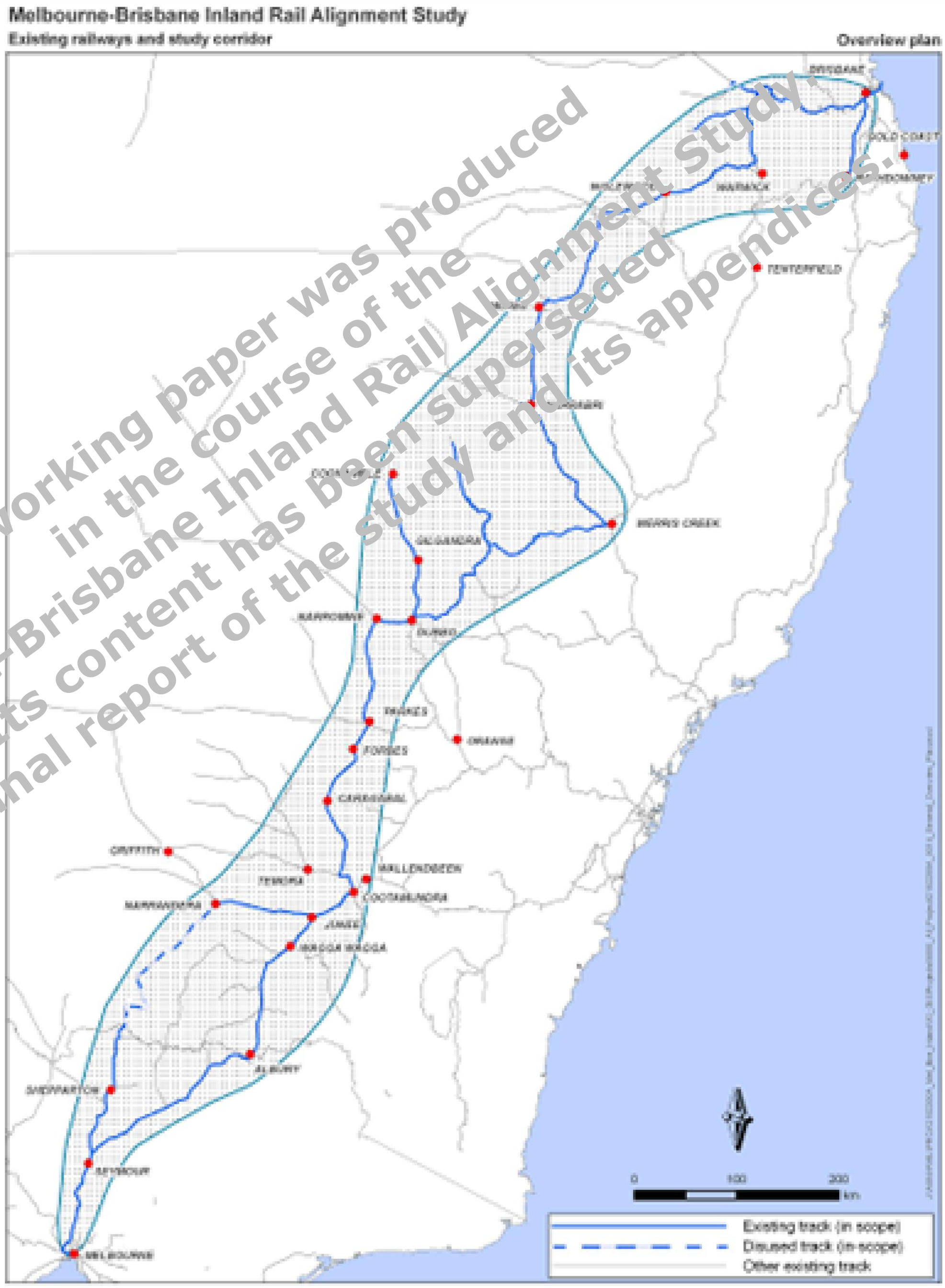


Figure 1-1 Melbourne Brisbane inland rail corridor

1.1 Background to Melbourne-Brisbane Inland Rail

The railways of NSW, Victoria and Queensland date from the 19th century. They were constructed using different gauges and developed for differing purposes. At present, the only north-south rail corridor in eastern Australia runs through Sydney. North of Sydney the railway runs fairly close to the coast. For that reason, the existing Melbourne-Brisbane line is referred to as the coastal route throughout this working paper.

In September 2005 the Australian Government commissioned the North-South Rail Corridor Study which undertook a high level analysis of the various corridors and routes which had been proposed for an inland rail alignment to provide an additional rail line to move freight from Melbourne to Brisbane by rail.

In its March 2008 announcement the Government stated that the Melbourne-Brisbane Inland Rail Alignment Study would build on previous work by undertaking a more detailed engineering, land corridor and environmental assessment, to allow scoping of the project's capital cost. In the announcement, the Minister for Infrastructure, Transport, Regional Development and Local Government requested a customer focused and consultative study involving consultations with state governments, industry, local governments and major rail customers.

1.2 Study objectives, stages and working papers:

The objectives of the Melbourne-Brisbane Inland Rail Alignment Study (the study) are to determine:

- the optimum alignment of the inland railway, taking into account user requirements and the economic, engineering, statutory planning and environmental constraints. The alignment will be sufficiently proven up so it can be quickly taken through the statutory planning and approval process and into the detailed engineering design and construction, should a decision be taken to proceed;
- the likely order of construction costs +/-20%;
- the likely order of below-rail (infrastructure) operating and maintenance costs;
- above-rail operational benefits;
- the level and degree of certainty of market take up of the alignment;
- a project development and delivery timetable; and
- a basis for evaluating the level of private sector support for the project.

The study is being carried out in three stages, as follows:

- Stage 1 — Determination of the Route for Further Analysis
- Stage 2 – Engineering, Environmental and Land Base Analysis
- Stage 3 – Development of the Preferred Alignment

A series of working papers is being produced within each stage. A list of the planned working papers follows.

Table 1-1 Working papers

Stage	Working paper		Lead Responsibility
Stage 1	WP1	Demand and Volume Analysis	FEC
	WP2	Review of Route Options	LTC
	WP3	Stage 1 Capital Works Costings	LTC
	WP4	Preliminary Operating and Maintenance Cost Analysis	LTC
	WP5	Stage 1 Financial and Economic Assessment and Identification of the Route for Further Analysis	FEC
Stage 2	WP6	Design Standards	LTC
	WP7	Preliminary Environmental Assessment	LTC
	WP8	Preliminary Land Assessment	LTC
	WP9	Engineering Data Collection	LTC
	WP10	Development of Alignment Options	LTC
	WP11	Stage 2 Capital Works Costings	LTC
	WP12	Stage 2 Economic and Financial Analysis and Confirmation of the Preferred Route	FEC
Stage 3	WP13	Preferred Alignments Environmental Assessment	LTC
	WP14	Preferred Alignments Land Assessment	LTC
	WP15	Refinement of Preferred Alignments	LTC
	WP16	Stage 3 Capital Works Costing	LTC
	WP17	Delivery Program	LTC
	WP18	Stage 3 Economic and Financial Assessment	FEC
	WP19	Policy Issues, Options and Delivery Strategies	FEC

1.3 Roles of the Lead Technical Consultant (LTC) and the Financial and Economic Consultant (FEC)

The study's activities are headed by two lead consultants whose activities are coordinated by ARTC.

The Lead Technical Consultant is responsible for engineering and environmental work and associated activities, including railway operational analysis. The Financial and Economic Consultant is responsible for financial and economic analysis. The two consultants work jointly and collaboratively with each other.

The Lead Technical Consultant (LTC) is Parsons Brinckerhoff (PB) and the Financial and Economic Consultant (FEC) is PricewaterhouseCoopers (PwC). Each consultant acts independently and each has a lead responsibility for specific working papers. Whilst this occurs the other consultant plays a support role for that particular working paper.

Parsons Brinckerhoff has engaged Halcrow to support it in alignment development, operations and maintenance costing and Connell Wagner to support it in engineering and alignment development. Connell Wagner has in turn engaged Currie and Brown to assist in capital costing.

PricewaterhouseCoopers has engaged ACILTasman to undertake volume and demand analysis and support it in economic review, and SAHA for peer review.

1.4 Working Paper No. 3 objective

The objective of Working Paper No. 3 is to develop the capital costings to enable evaluation of the different routes on a comparable basis to enable selection of the preferred route.

Working Paper No. 3 details the development of capital cost to the extent that this has been completed in Stage 1. These costs will be further refined in the subsequent stages of the study and will be documented in Working Papers Nos. 11 and 16.

2 Stage 1 capital costs approach

Two approaches will be used during the course of the study to calculate the capital costs for the Melbourne to Brisbane inland rail alignment. These are:

- benchmarking – a top down approach using data from similar projects throughout Australia and several from international sources
- first principles estimating - bottom up estimating for the key elements of the construction works including permanent way, earthworks and structures

This working paper details the basis for the calculation of these capital costs (capex) for the Melbourne-Brisbane Inland Rail Alignment Study, specifically addressing the work completed in Stage 1. The capex cost comprises the construction costs and land acquisition costs associated with the study.

The purpose of the Stage 1 capex cost primarily is to allow for meaningful comparisons between the various options for comparative purposes only, and only to a lesser extent to reflect the actual anticipated outturn cost of the project. Stage 1 does not involve the detailed investigations or design such as its intent was to be used for options analysis. An overall estimate for the route has been derived from the high level benchmarking data; however it is not possible at this stage to derive an end-to-end cost estimate using first principles estimating as there is insufficient accuracy in the definition of the scope of works this stage of the study.

The strategy to develop the Stage 1 estimates for each option involved initially gathering and analysing industry wide benchmarking data for projects of a similar nature. Added to this was detailed benchmarking information which was available to us from previous projects of a similar nature. A range of costs was established within which we believe the projects options would most likely fall. Extremes of the range were also identified which might relate to particular issues on these sections. These were noted so as to be available if similar issues were identified in any of the sections and be subject for further investigations and rationalisation during the next two stages of the study.

Simultaneously, the LTC is developing a cost model based on first principle estimating which will be used to develop the outturn cost of the project by the end of Stage 3. The initial model is being created based on the assumptions detailed later in this working paper.

3 Benchmarking

The project has been benchmarked against a variety of major freight rail and other rail projects from Australia and several international examples. These benchmarked rates are all inclusive including construction costs, overheads, client costs and land acquisition.

3.1 Greenfield track installation

Detailed below are some of the major freight rail projects in Australia that have been used in compiling the benchmarking. These rates includes for all permanent way, earthworks and level crossings.

Table 3-1 Track installation benchmarking data

Name of project	Year	Length	Cost	Rate per km
Alice Springs - Darwin	2001	1,410 km	$1.1 billion	$0.78 million
Cloudbreak Mine to Port Headland	2006	285 km	$680 million	$2.39 million
Bauthinia Regional Rail Line	2005	110 km	$240 million	$2.18 million
Coal Connect (various)	Ongoing	69 km	$217 million	$3.14 million
Surat Basin Railway	Design	200 km	$1 billion	$5.00 million
Minimbah Bank Third Track	Design	10.8 km	$100 million	$9.26 million

The wide range of rates indicates the difficulty of using benchmarking data especially on rail projects. The Cloudbreak Mine line had significant costs incurred due to the impact of a cyclone on the project. The Coal Connect rates were based on short lengths of track and indicate the impact of cost inefficiencies. The Alice Springs to Darwin project was able to capture the economies of scale for such a large scale project and a high proportion of its length is across very easy terrain. Whilst the inland rail project has short sections of line, the overall quantum of the project should deliver economies of scale and so it was decided to use a rate of $2m per kilometre for constructing in flat terrain, with incremental increases in the rate through the terrain types up to a rate of $6.5m per kilometre for mountainous areas.

3.2 Bridges and structures

The table below details bridges and structures benchmarked data.

Table 3-2 Bridges and structures benchmarking data

Name of project	Year	Length	Cost	Rate per unit
Wagga Wagga bridge replacement	2007	200m	$17 million	$85 million/km
Tank Street pedestrian bridge, Brisbane		200m span	$63 million	$315 million/km
Goodwill pedestrian bridge, Brisbane		250m, span 130m	$33 million	$132 million/km

Name of project	Year	Length	Cost	Rate per unit
Green Bridge, Brisbane	2005	185m span	$55.5 million	$300 million/km
Doyle Road Overbridge, Sydney	2009	28m span	$2.5 million	$89 million/km
Cabramatta Creek Crossing	Design	32m span	$2.3 million	$72 million/km

The water crossings and dry creek crossings were based on the Cabramatta Creek crossing $72m per kilometre based on a span of 32 m. The cost efficiency of a bridge per kilometre increases substantially the longer the bridge which is demonstrated in the benchmarked rates used for this exercise.

For the tunnel benchmarked rate, we have chosen the final rate based on recent tunnel experience in NSW and Queensland for both single and dual track. The majority of the tunnel sections are located in Queensland, in poor geotechnical conditions, which may result in fully lined tunnels. Considering these parameters, the tunnel rate of $55m per kilometre has been used based on a similar sized single track tunnel project in Queensland with similar geotechnical conditions.

3.3 Upgrading existing infrastructure

The cost of upgrading the existing abandoned track or Class 3/4/5 track has been based on previous projects and benchmarking data as detailed in the table below.

Table 3.3 Upgrading existing track installation benchmarking data

Name of project	Year	Length	Cost	Rate per km
Seymour to Albury (Upgrade from broad to standard)	Complete 2010	200 km	$501 million	$2.51 million
Mildura Rail Line (replacement 2 out of 5 sleepers)	Ongoing	525 km	$73 million	$0.14 million
Cootamundra to Parkes upgrade (replace all sleepers)	Ongoing	201 km	$91.50 million	$0.46 million

The works involved in the upgrading of the Seymour to Albury line including full concrete resleepering involved possession regimes and the installation of a new signalling system, as this is the main line connecting Melbourne and Sydney. Due to the nature of the lines under consideration in this study, upgrade works being carried out as part of this study would generally not include any possession regime, nor would an extensive signalling system be required. Accordingly, a rate of $1.6m per kilometre was used where track is to be upgraded from Class 3, 4, 5 or abandoned.

Any structures that require upgrading have been based on the new cost with a 30% uplift to cover demolition of existing structures and works associated with tying-in the new structure with the existing infrastructure.

Where partial upgrade of Class 2 track is required to achieve the benchmarked speed, the works involved would comparable to the Cootamundra to Parkes upgrade with sleeper replacement, deeper ballast and upgrading some bridges. A rate of $0.8m per kilometre has been used.

3.4 Benchmarked rates

3.4.1 Benchmark rates used

The table below details the rates from the benchmarking data exercise that have been used for the top down estimate on this project.

Table 3-4 Benchmarked rates used in top down estimate

Item	Rate
Upgrading of abandoned, existing Class 3, existing Class 4 and existing Class 5 track	$1.6 million per kilometre
Upgrading of existing broad gauge to standard Class 1	$1.6m per kilometre
Upgrading of existing narrow gauge to dual gauge	$2.5m per kilometre
Upgrading existing Class 2 to Class 1	$0.8m per kilometre
Floodplain works	$2.5m per kilometre
New track in flat terrain	$2m per kilometre
New track in undulating terrain	$3m per kilometre
New track in rolling terrain	$4m per kilometre
New track in hilly terrain	$5m per kilometre
New track in mountainous terrain	$6.5m per kilometre
New water crossing, 275 m long	$12m each
New water crossing, 400 m long	$20m each
New dry creek crossing, 175 m long	$10m each
Upgrading existing water crossing, 275 m long	$15m each
Upgrading existing water crossing, 400 m long	$26m each
Upgrading existing dry creek crossing, 175 m long	$13m each
New tunnel	$55m per kilometre
New viaduct	$30m per kilometre

3.4.2 Uplifting for shorter sections

In analysing the benchmarking data above, it was decided to use standard rates for the estimate with uplifts for the shorter sections. These uplifts would multiply the total cost of a section by different factors depending on the length of greenfield installation/upgrade:

- A factor of 2 if the length is below 2 km long
- A factor of 1.6, if the length is between 2 km and 4 km long
- A factor of 1.35, if the length is between 4 km and 6 km long
- A factor of 1.15, if the length is between 6 km and 8 km long
- A factor of 1.08, if the length is between 8 km and 10 km long

These factors are based on recent experience in Queensland on multiple projects for a single client.

3.5 Benchmarked section costs

The route for Stage 1 was divided into sections which were mapped on GIS to quantify its characteristics. The total length of the sections is 7,179 km as this covers every route option between Melbourne and Brisbane. The characteristics of each section are detailed in Appendix 2 of this working paper. As an example, a section would detail the following characteristics for a section of new construction:

- Length 148.1 km
- 38.0 km of floodplains
- 68.1 km of track in flat terrain
- 32.1 km of track in undulating terrain
- 24.5 km of track in rolling terrain
- 12.8 km of track in hilly terrain
- 6.6 km of track in mountainous terrain
- 5 off dry creek crossings, 35 m long
- 4.0 km of tunnels

These rates were then applied to the quantities for each section produced by GIS producing a total cost per section, as detailed in Appendix 1 – Summary of Benchmarked Route Sections. This document details the total length of each section and the actual cost per kilometre based on the characteristics quantified by GIS.

This produced a range of cost per kilometre for the each section as detailed in the table below.

Table 3-5 Benchmarked section costs

Cost per Kilometre	No of Sections from GIS	Total Kilometres
Nil (Class 1/Class 2 existing track)	38	1,420km
Less than $2m	15	845 km
$2m to $3m	42	2,228 km
$3m to $4m	20	506 km
$4m to $5m	6	202 km
$5m to $6m	5	73 km
$6m to $7m	2	22 km
$7m to $10m	1	1 km
$10m - $15m	9	892 km
$15m - $20m	7	982 km
$20m +	1	8 km

The large range of sections in the $10m plus range are located in Queensland, where significant lengths of tunnels and viaducts were located. The study identified multiple deviations of different node to node connections in this area which has resulted in the long lengths of sections in this cost range.

3.6 Benchmarking exercise results

The benchmarking exercise indicated that the majority of the sections could be constructed at a rate of between $2m and $5.5m per kilometre, deemed the 'most likely' range. The extremes of the range between $10m and $20m mainly occurred in the sections in Queensland that required major tunnel and viaduct construction.

For each of the area routes considered in WP2, an 'order of magnitude' outturn cost has been derived using the benchmarking approach. The results are provided in the table below. These results have been carried forward into WP5 to assist in route selection.

Table 3-6 Benchmarked area route cost

Area route	Description	Length (km)	Cost ($m)	Cost/km ($)
AA01	Melbourne – Junee via Albury	475	0	0
AA02	Melbourne – Junee via Shepparton – Tocumwal (new Finley deviation), Narrandera	519	803	1,547,000
AA03	Melbourne – Junee via Shepparton – Tocumwal (no Finley deviation), Narrandera	537	820	1,527,000
BB01	Junee – Narromine via Cootamundra, Stockinbingal and Parkes	363	0	0
BB02	Junee – Narromine via Cootamundra, Stockinbingal (deviation between Yeo Yeo and Stockinbingal) and Parkes	364	26	714,000
BB03	Junee – Narromine via Stockinbingal (deviation at Cootamundra) and Parkes	363	128	2,836,000
BB04	Junee – Narromine via Stockinbingal (deviation at Cootamundra and between Yeo Yeo and Stockinbingal) and Parkes	364	155	426,000
BB05	Junee – Narromine via Cootamundra (new route between Yeo Yeo and Maleeja) and Parkes	355	36	101,000
BB06	Junee – Narromine via Cootamundra (new route between Yeo Yeo and Maleeja) and Parkes	355	164	462,000
BB07	Junee – Narromine via Cootamundra (deviations between Junee and Frampton), Stockinbingal and Parkes	357	463	1,297,000
BB08	Junee – Narromine via Cootamundra (deviations between Junee and Frampton, Yeo Yeo and Stockinbingal), Stockinbingal and Parkes	358	490	1,369,000
BB09	Junee – Narromine via Stockinbingal (deviations between Junee and Frampton and at Cootamundra) and Parkes	357	592	1,658,000
BB10	Junee – Narromine via Stockinbingal (deviations between Junee and Frampton, at Cootamundra and Yeo Yeo and Stockinbingal) and Parkes	358	618	1,726,000

Area route	Description	Length (km)	Cost ($m)	Cost/km ($)
BB11	Junee – Narromine via Stockinbingal (deviations between Junee and Frampton) and new route between Yeo Yeo and Maleeja) and Parkes	349	499	1,430,000
BB12	Junee – Narromine via Stockinbingal (deviations between Junee and Frampton and at Cootamundra, new route between Yeo Yeo and Maleeja) and Parkes	349	627	1,797,000
BB13	Junee – Narromine via Stockinbingal (new route between Junee and Stockinbingal) and Parkes	327	139	425,000
Area C base case	Narromine – Moree via Dubbo, Binnaway, Premer, Turilawa, Werris Creek, Emerald Hill, Baan Baa and Narrabri	581	52	90,000
CC01	Narromine – Moree via Curban, Coonamble and Burren Junction	397	960	2,418,000
CC02	Narromine – Moree via Dubbo, Curban, Coonamble and Burren Junction	435	954	2,193,000
CC03	Narromine – Moree via Curban, Coonamble, Merebene (Gwabegar), Kiandool and Narrabri	429	768	1,790,000
CC04	Narromine – Moree via Curban, Coonamble, Merebene (Gwabegar), Kiandool and Narrabri	467	762	1,632,000
CC05	Narromine – Moree via Dubbo, Binnaway, Premer, Werris Creek, Emerald Hill, Baan Baa and Narrabri (with Moree and Binnaway deviations)	579	71	123,000
CC06	Narromine – Moree via Dubbo, Binnaway, Premer, Werris Creek, Emerald Hill, Baan Baa and Narrabri (with Moree, Dubbo and Binnaway deviations)	577	120	208,000
CC07	Narromine – Moree via Dubbo, Binnaway, Premer, Werris Creek, Emerald Hill, Baan Baa and Narrabri (with Moree, Dubbo and Binnaway deviations)	574	108	188,000
CC08	Narromine – Moree via Dubbo, Binnaway, Premer, Werris Creek, Emerald Hill, Baan Baa and Narrabri (with Moree, Dubbo, Narrabri and Binnaway deviations)	572	156	273,000
CC09	Narromine – Moree via Dubbo, Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri (with Moree and Binnaway deviations)	445	88	198,000
CC10	Narromine – Moree via Dubbo, Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri (with Moree, Dubbo and Binnaway deviations)	573	137	239,000
CC11	Narromine – Moree via Dubbo,	570	125	219,000

Area route	Description	Length (km)	Cost ($m)	Cost/km ($)
	Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri			
CC12	Narromine – Moree via Dubbo, Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri (with Moree, Dubbo, Narrabri and Binnaway deviations)	568	173	305,000
CC12 + dev	Narromine – Moree via Dubbo, Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri (with Moree and Narrabri by-passes)	561	455	811,000
CC13	Narromine – Moree via Dubbo, Binnaway, Baan Baa and Narrabri (with Moree deviation)	472	741	1,570,000
CC14	Narromine – Moree via Dubbo, Binnaway, Baan Baa and Narrabri (with Moree and Dubbo deviations)	470	789	1,679,000
CC15	Narromine – Moree via Dubbo, Binnaway, Baan Baa and Narrabri	467	777	1,664,000
CC16	Narromine – Moree via Dubbo, Binnaway, Baan Baa and Narrabri (with Moree, Dubbo and Narrabri deviations)	466	825	1,770,000
CC16 + dev	Narromine – Moree via Dubbo, Binnaway, Baan Baa and Narrabri (with Moree and Narrabri by-passes)	457	989	2,164,000
CC17	Narromine – Moree via Dubbo, Binnaway, Premer, Emerald Hill, Baan Baa and Narrabri (with Moree deviation)	491	260	530,000
CC18	Narromine – Moree via Dubbo, Binnaway, Premer, Emerald Hill, Baan Baa and Narrabri (with Moree and Dubbo deviations)	490	309	631,000
CC19	Narromine – Moree via Dubbo, Binnaway, Premer, Emerald Hill, Baan Baa and Narrabri	487	297	610,000
CC20	Narromine – Moree via Dubbo, Binnaway, Premer, Emerald Hill, Baan Baa and Narrabri (with Moree, Dubbo and Narrabri deviations)	485	345	711,000
CC20 + dev	Area C base case with reversals at Binnaway removed plus deviations, plus new construction Premer – Emerald Hill	477	627	1,314,000
CC21	Narromine – Moree via Dubbo, Binnaway, Merebene (Gwabegar), Kiandool and Narrabri	511	472	924,000
CC22	Narromine – Moree via Dubbo, Binnaway, Merebene (Gwabegar), Kiandool and Narrabri (with Dubbo deviation)	509	520	1,022,000
CC23	Narromine – Moree via Dubbo, Binnaway, Premer, Werris Creek, Emerald Hill, Baan Baa and Narrabri	581	52	90,000

Area route	Description	Length (km)	Cost ($m)	Cost/km ($)
CC24	Narromine – Moree via Dubbo, Binnaway, Premer, Turilawa, Emerald Hill, Baan Baa and Narrabri (Area C base case with reversals at Werris Creek and Binnaway removed)	578	52	90,000
DD01	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Cecilvale, Yargullen, Oakely, Gowrie, Gatton, Grandchester and Kagaru	499	1,847	3,978,000
DD02	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Cecilvale, Yargullen, Oakely, Gowrie, Gatton, Grandchester and Kagaru	487	1,826	4,035,000
DD03	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Cecilvale, Wyreema West, Oakely, Gowrie, Gatton, Grandchester and Kagaru	494	1,850	4,021,000
DD04	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Cecilvale, Wyreema West, Oakely, Gowrie Gatton, Grandchester and Kagaru	483	1,829	4,080,000
DD05	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Cecilvale, Wyreema, Oakely, Gowrie, Gatton, Grandchester and Kagaru	508	1,834	3,874,000
DD06	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Cecilvale, Wyreema West, Oakely, Gowrie, Gatton, Grandchester and Kagaru	496	1,814	3,927,000
DD07	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema West, Gowrie, Gatton, Grandchester and Kagaru	525	1,976	4,026,000
DD08	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema West, Gowrie, Gatton, Grandchester and Kagaru	513	1,955	4,081,000
DD09	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema, Gowrie, Gatton, Grandchester and Kagaru	532	1,968	3,952,000
DD10	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Watts, Wyreema, Gowrie, Gatton, Grandchester and Kagaru	520	1,947	4,005,000
DD11	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Clifton, Gatton, Grandchester and Kagaru	495	2,443	5,302,000
DD12	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Clifton, Gatton, Grandchester	483	2,422	5,395,000

Area route	Description	Length (km)	Cost ($m)	Cost/km ($)
	and Kagaru			
DD13	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton and Kagaru	488	2,809	6,832,000
DD14	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton and Kagaru	477	2,788	6,981,000
DD15	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton and Kagaru	530	3,559	7,852,000
DD16	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Rathdowney, Tamrookum, Bromelton and Kagaru	519	3,538	8,013,000
DD17	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	468	2,557	6,346,000
DD18	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	457	2,537	6,484,000
DD19	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	487	2,980	7,063,000
DD20	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	476	2,959	7,214,000
DD21	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	487	2,971	7,051,000
DD22	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	475	2,950	7,202,000
DD23	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	476	2,698	6,564,000
DD24	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	465	2,677	6,705,000
DD25	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Tamrookum, Bromelton and Kagaru	465	2,299	5,750,000
DD26	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood,	454	2,279	5,870,000

Area route	Description	Length (km)	Cost ($m)	Cost/km ($)
	Warwick, Tamrookum, Bromelton, and Kagaru			
DD27	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	459	2,528	6,114,000
DD28	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	448	2,507	6,241,000
DD29	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	478	3,123	7,232,000
DD30	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	466	3,102	7,385,000
DD31	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	467	2,830	6,712,000
DD32	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	456	2,809	6,854,000
DD33	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	467	2,830	6,712,000
DD34	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	456	2,809	6,854,000
DD35	Moree North (Camurra) – Acacia Ridge via North Star, Kildonan, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	456	2,480	6,043,000
DD36	Moree North (Camurra) – Acacia Ridge via North Star, Yelarbon, Inglewood, Warwick, Bromelton and Kagaru	444	2,460	6,169,000

3.7 Comparative costs for representative routes

Three potential routes were selected in WP2 to show representative summary sections characteristics, to which we have prepared capital costs using the benchmarked data. These routes were taken from individual route sections identified in WP2, and grouped into three sectors Melbourne–Parkes, Parkes–Moree and Moree-Brisbane. This provides a representative summary of the engineering features of individual route sections.

The cost of these routes have been separated into upgrading existing track, new track (including earthworks, formation, level crossings and land acquisition); bridges (including culverts) and structures (including viaducts and tunnels), all expressed as a percentage of the total cost. This is shown in tables 3.7.1, 3.7.2 and 3.7.3 below.

The comparative capital cost exercise collated the values from all of the sections, separated into:

- Melbourne to Parkes
- Parkes to Moree
- Moree to Brisbane

A full list of all route sections is given in Working Paper No. 2.

The route for Stage 1 was divided into sections which were mapped on GIS to quantify its characteristics i.e. terrain type, dry and wet creek crossings, tunnels, viaducts etc. The total length of the sections in 7,179 km as this covers every route option between Melbourne and Brisbane. The characteristics of each section are detailed in Appendix B of this working paper.

3.7.1 Melbourne to Parkes

A map detailing the Melbourne to Parkes selected routes is shown below.

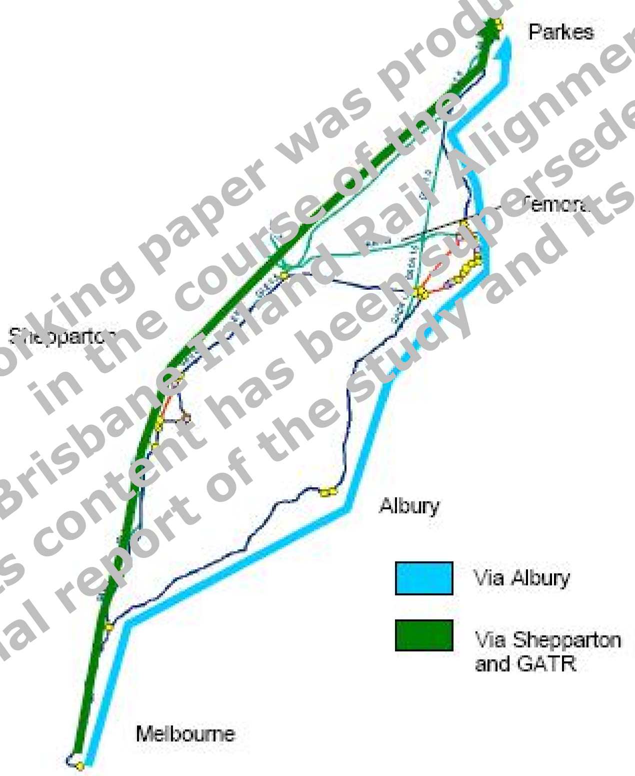


Figure 3-1 Melbourne to Parkes plan

Table 3-7 Melbourne to Parkes comparative cost comparison

Route	Distance km	Cost	% of cost in Upgrade	New	Bridges	Structures
Melbourne to Parkes via Albury	726	$0	0%	0%	0%	0%
Melbourne to Parkes via Shepparton and GATR	655	$1.05bn	39%	47%	14%	0%

3.7.1.1 Melbourne to Parkes via Albury (Blue Route)

This route comprises the following sections:

- A01 Melbourne to Mangalore
- A02 Mangalore to Wodonga Deviation South
- A03 Wodonga Deviation South to Wodonga Deviation North
- A04 Wodonga Deviation North to Junee
- B01 Junee to Junee By-pass East
- B02 Junee By-pass East to Bethungra Deviation South
- B03 Bethungra Deviation South to Bethungra Deviation North
- B04 Bethungra Deviation North to Frampton Deviation South
- B05 Frampton Deviation South to Frampton Deviation North
- B07 Frampton Deviation North to Cootamundra Deviation South
- B08 Cootamundra Deviation South to Bauloora
- B10 Bauloora to Yeo Yeo Deviation South
- B11 Yeo Yeo Deviation South to Yeo Yeo Deviation North
- B12 Yeo Yeo Deviation North to Stockinbingal
- B15 Stockinbingal to Stockinbingal Deviation North
- B16 Stockinbingal Deviation North to Maleeja
- B18 Maleeja to Parkes Deviation South

This route is based on using the existing track that ARTC is currently upgrading due for completion by the time this project commences. Therefore no costs have been allocated for upgrade works for this study.

3.7.1.2 Melbourne to Parkes via Shepparton and GATR (Green Route)

This route comprises the following sections:

- A01 Melbourne to Mangalore (existing Class 1 or Class 2)
- A05 Mangalore to Murchison Deviation South (upgrade from Broad to Class 1)
- A06 Murchison Deviation South to Murchison Deviation North (upgrade from Broad to Class 1)
- A07 Murchison Deviation North to Tocumwal (upgrade from Broad to Class 1)
- A08 Tocumwal to Finley Deviation North (upgrade from Abandoned to Class 1)
- A14 Finley Greenfield to Jerilderie Deviation North (greenfield)

- A16 Jerilderie Deviation North to Narrandera (upgrade from Abandoned to Class 1)
- G02 Narrandera to Existing line north of Caragabal (direct) (greenfield)
- B18 Maleeja to Parkes Deviation North (existing Class 1 or Class 2)

3.7.2 Parkes to Moree

A map detailing selected routes from Parkes to Moree is shown below.

Figure 3-2 Parkes to Moree

Table 3-6 Parkes to Moree comparative cost comparison

Route	Distance km	Cost	% of cost in Upgrade	New	Bridges	Structures
Parkes to Moree via Werris Creek and Narrabri[1]	690	$0.07bn	0%	72%	28%	0%
Parkes to Moree via Narromine, Coonamble, Merebene, and Narrabri[2]	593	$0.76bn	31%	57%	11%	0%

[1] Reversals at Binnaway and Werris Creek removed

[2] C01+C02+C15+C55+C13+C56+C11+C17B

3.7.2.1 Parkes to Moree via Werris Creek and Narrabri (Blue Route)

This route comprises the following sections:

- B19 Parkes Deviation South to Parkes Deviation North (existing Class 1 or Class 2)
- B20 Parkes Deviation North to Narromine (existing Class 1 or Class 2)
- C01 Narromine to Dubbo (West) (existing Class 1 or Class 2)
- C02 Dubbo (West) to Dubbo (North East) (existing Class 1 or Class 2)
- C03a Dubbo (North East) to Binnaway (existing Class 1 or Class 2)
- C04a Binnaway to Premer (South) (existing Class 1 or Class 2 and greenfield)
- C16a Premer (South) to Premer (existing Class 1 or Class 2)
- C05 Premer (South) to Turilawa (west) (existing Class 1 or Class 2)
- C06 Turilawa (West) to Werris Creek (existing Class 1 or Class 2)
- C18 Werris Creek to Turilawa (North) (existing Class 1 or Class 2)
- C07 Turilawa (North) to Emerald Hill (existing Class 1 or Class 2)
- C08 Emerald Hill to Baan Baa (existing Class 1 or Class 2)
- C09 Baan Baa to Narrabri (South) (existing Class 1 or Class 2)
- C10 Narrabri (South) to Narrabri (North) (existing Class 1 or Class 2)
- C11 Narrabri (North) to Moree (South) (existing Class 1 or Class 2)
- C17b Moree (South) to Moree (North) (greenfield)

3.7.2.2 Parkes to Moree via Narromine, Coonamble, Merebene, and Narrabri (Green Route)

This route comprises the following sections:

- B19 Parkes Deviation South to Parkes Deviation North (existing Class 1 or Class 2)
- B20 Parkes Deviation North to Narromine (existing Class 1 or Class 2)
- C01 Narromine to Dubbo (West) (existing Class 1 or Class 2)
- C53 Dubbo (West) to Dubbo (North – Talbragar) (greenfield)
- C14 Dubbo (North – Talbragar) to Curban (upgrade from Class 3 to Class 1)
- C15 Curban to Coonamble (upgrade from Class 5 to Class 1)
- C54 Coonamble to Merebene (Gwabegar) (greenfield)
- C55 Mereben (Gwabegar) to Kiandool (greenfield)
- C13 Kiandool to Narrabri (West) (existing Class 1 or Class 2)
- C56 Narrabri (West) to Narrabri (North) (greenfield)
- C11 Narrabri (North) to Moree (South) (existing Class 1 or Class 2)
- C17b Moree (South) to Moree (North) (greenfield)

3.7.3 Moree to Brisbane

Detailed below is the map detailing the Moree to Brisbane selected routes.

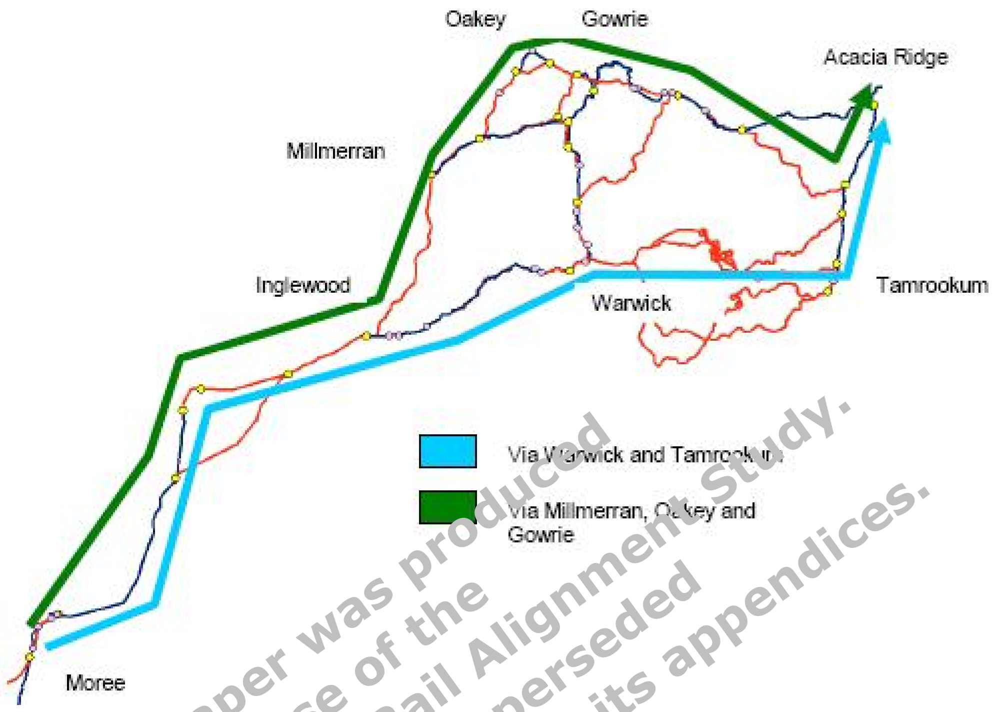


Figure 3-3 Moree to Brisbane

Table 3-9 Moree to Brisbane comparative cost comparison

Route	Distance km	Cost	% of cost in			
			Upgrade	New	Bridges	Structures
Moree to Acacia Ridge via Millmerran, Oakey and Gowrie	499	$1.86bn	23%	43%	6%	28%
Moree to Acacia Ridge via Warwick and Tamrookum	465	$2.31bn	17%	32%	3%	48%

3.7.3.1 Moree to Acacia Ridge via Millmerran, Oakey and Gowrie (Green Route)

This route comprises the following sections:

- DO1A Moree North (Camurra) to North Star (upgrade existing Class 3 to Class 1)
- D02A North Star to Boggabilla (upgrade Abandoned to Class 1)
- D03C Boggabilla to Kildonan (greenfield)
- D04A Kildonan to Yelarbon (upgrade Narrow to Dual Gauge)
- D06A Yelarbon to Inglewood (upgrade Narrow to Dual Gauge)
- D07C Inglewood to Millmerran (greenfield)
- D08A Millmerran to Cecilvale (upgrade Narrow to Dual Gauge)

- D14C Cecilvale to Yargullen (greenfield)
- D15C Yargullen to Oakley (greenfield)
- D16A Oakley to Gowrie (upgrade existing Narrow to Dual Gauge)
- D24C Gowrie to Gatton (greenfield)
- D25C Gatton to Grandchester (greenfield)
- D26C Grandchester to Kagaru (greenfield)
- D28A Kagaru to Acacia Ridge (existing Class 1 or Class 2)
- D28A Kagaru to Acacia Ridge (existing Class 1 or Class 2)

3.7.3.2 Moree to Acacia Ridge via Warwick and Tamrookum (Blue Route)

This route comprises the following sections:

- DO1A Moree North (Camurra) to North Star (upgrade existing Class 3 to Class 1)
- D02A North Star to Boggabilla (upgrade Abandoned to Class 1)
- D03C Boggabilla to Kildonan (greenfield)
- D04A Kildonan to Yelarbon (upgrade Narrow to Dual Gauge)
- D06A Yelarbon to Inglewood (upgrade Narrow to Dual Gauge)
- D10B Inglewood to Warwick (upgrade Narrow to Dual Gauge and greenfield)
- D33C5 Warwick to Tamrookum (greenfield)
- D30A Tamrookum to Bromelton (existing Class 1or Class 2)
- D29A Bromelton to Kagaru (existing Class 1 or Class 2)
- D28A Kagaru to Acacia Ridge (existing Class 1 or Class 2)

4 Cost model development

4.1 Approach

The LTC is in the process of developing an IT based cost model using first principles estimating which will be applied to the key elements of the construction works, permanent way, earthworks, bridges and structures and fencing. As the project progresses to stages 2 and 3, this model will be progressively refined to provide the accuracy of cost estimation required.

In general terms, the cost model at each stage will consist of:

- At Stage 2, unit rates for generic work types and activities, applied to quantities developed through a combination of the GIS model from Stage 1 as well as a vertical and horizontal alignments developed for specific sections, particularly those areas of the route where a new route or significant upgrade works are necessary.
- At Stage 3, a combination of unit rates applied to quantities derived from the vertical and horizontal alignments, and estimates developed against specific designs, will be used.

Following the completion of the Stage 2, the LTC will use the cost estimate as the basis for a probabilistic risk estimate. This allows the risk associated with the project, both in terms of the estimate itself and all other identified risks, to be incorporated into the capex for the project. The approach to be taken for the probabilistic risk estimating is detailed in Appendix 5 of this working paper.

The sections below outline the basis on which the cost model for Stage 2 is being developed.

4.2 Indirect construction costs

The indirect construction costs will be applied against the total direct construction cost for each section on a percentage basis. The indirect construction costs comprise the on-site overheads and preliminaries and the off-site overheads and margin.

4.2.1 On-site overheads and preliminaries

A percentage will be applied against each section to cover the contractor's on-site overheads and preliminaries. The percentage will be applied on the basis that works will be performed concurrently to a whole route rather than each section being constructed on an individual basis. A range of costs have been considered and the 'most likely' percentages were selected based on the nature of the project and location of the sites.

A breakdown of the percentage is detailed below:

- contractor's supervision including indirect labour – 9%
- contractor's site establishment, maintenance and demobilisation – 5%
- insurances and securities – 1.5%
- contractor's design – 5%
- wet weather and delay allowances – 1%
- contractor's contingency – 5%

These percentages have been derived from rail and large infrastructure projects. The percentage for the site establishment is based upon allowing a maximum of 10 work camps being used along the length of the route, including mobilising and demobilising the camps as required. This quantity was based on experience from other projects such as a 200 km length of track in Queensland.

During stages 2 and 3 of this study, these percentages will be refined, moving towards a first-principles assessment once the preferred route alignment has been selected.

4.2.2 Off-site overheads and margin

Thirteen per cent will be included against each section for contractors' off-site overheads and margins.

This allowance includes for:

- off-site management costs;
- head office contributions;
- legal costs; and
- off-site overheads

The percentage is based on the current market experienced for large scale rail projects. In spite of the downturn in the current market, the rail market is still buoyant and no drops have been seen in the levels being applied by the companies with the capacity and capability to carry out these works, which we have assumed to be major national infrastructure companies. However, the market is very fluid and this will be addressed in stages 2 and 3 of this study

4.2.3 Total indirect construction costs

The overall percentage addition for the indirect construction costs is 42.9%. This is based on:

- direct construction cost x 26.5% (on-site overheads and preliminaries) = on-site costs
- on-site costs x 13% = construction cost

4.3 Direct construction costs

The cost model will be based upon the quantities developed from the GIS, which has used the data from geotechnical, infrastructure, hydrological, planning and other sources to produce quantities for each of the sections under review. The direct construction costs will be split into the various main elements, permanent way, earthworks, bridges, structures and fencing.

Initial costing of these categories and the remainder of the works will be based upon the LTC's knowledge of rail infrastructure cost information obtained from current projects being worked on in NSW, Queensland and Victoria. In many instances these costs are calculated on a first principles basis and are bespoke to this project.

4.3.1 Track

4.3.1.1 Materials – rail

Discussions were held with EMRails in Victoria where a rate of $2,920 per tonne for 60.6 kg per metre rail in standard lengths of 13.72 m was provided. EMRails were aware of the magnitude of the project scope and this rate allowed for delivery in any state in Australia and has taken account for the large quantity involved on this project.

4.3.1.2 Materials – sleepers

In researching details of suppliers of concrete sleepers, ROCLA Australia's website detailed that they were awarded the contract to supply sleepers to the ARTC at a contract value of $115m for 1.35 million sleepers. This equates to $85 per sleeper.

However, in a separate enquiry to ROCLA on costs for sleepers, they advised of a cost of between $115 and $120 per sleeper ex-works would be the standard rate. An additional cost of $25 per sleeper was suggested to be appropriate for delivery to the site(s).

A rate of $145 per sleeper will be used in the cost model, although given the information on the website of ROCLA regarding their awarded contract, there is potential opportunity to reduce the cost which will be investigated further in the next stage.

4.3.1.3 Materials – ballast

Quotations for ballast were sought and received from Boral quarries in Queensland, NSW and Victoria. All responded with quotes based on the estimated quantity requirement and provided different rates depending on the travel distances from the respective quarries to the points of delivery.

Different rates were developed for the various potential distances that could be involved in the ballast delivery and applied them accordingly. Ultimately, it was decided that a distance of 100 km, based on the location of existing suitable quarries, for delivery of ballast be used in establishing the unit rate for the ballast. This cartage will be reviewed in stages 2 and 3 of the project, together with the use of mobile and temporary quarries.

4.3.1.4 Labour rates

Rates for various levels of skilled labour associated with rail work were sought and received from Queensland, NSW and Victoria and for application to the scope of works appropriate for each state. These rates were obtained from a range of current rail projects being performed in the various states.

4.3.1.5 Plant rates

Rates for various items of plant appropriate for rail work were sought and received from Queensland, NSW and Victoria and for application to the scope of works appropriate for each state.

4.3.1.6 Rate build-ups

Detailed below are the assumptions currently being used in developing the cost of the installation of the track, sleepers and ballast.

Table 4-1 Track installation assumptions per 10,000 tm

Activity	Assumptions	Productivity
Unload sleepers and stockpile	2 x front end loaders 2 x plant operators 1 x leading hand 3 x RW2 rail workers	
Discharge sleepers	1 x front end loader; 1 x plant operator 1 x HIAB truck including driver 1 x leading hand 2 x RW2 rail workers	40 days

Activity	Assumptions	Productivity
Place bottom ballast	1 x front end loader; 1 x excavator 2 x 10 wheel tipper; 1 x 11t roller; ballast box; 4 x plant operators 1 x leading hand 2 x RW2 rail workers	40 days
Lay sleepers	1 x excavator; 1 x plant operator 1 x leading hand; 4 x RW2 rail workers 1 x fitter	40 days
Lay rail	1 x FBW; 1 x Atlas; 1 x front end loader 1 x FBW supervisor; 1 x leading hand 2 x plant operators 1 x leading hand 8 x RW2 rail workers	30 days
Fasten Rail	1 x leading hand 4 x RW2 rail workers	30 days
Top Ballast – Load Wagon	2 x front end loaders; 1 x excavator 1 x 10 wheel tipper; 4 x plant operators	
Place top ballast – Wagon	Loco and wagon train hire including 2 x engineers 4 x RW2 rail workers	17 days
Tamp & Profile	1 x tamper; 1 x regulator 2 x tamper operators, 2 x regulator operators 1 x leading hand	30 days
Weld & De-stress Rail	1 x leading hand 8 x RW2 rail workers 4 x welders	40 days

Key:

- RW2 Rail Worker Class 2
- FBW Flashbutt welder

4.3.1.7 Upgrading of existing track

Part of the route selection involved the upgrade of existing sections of track which includes:

- Class 3
- Class 4
- Class 5
- Abandoned
- Broad gauge
- Narrow gauge

For all the above categories, the scope of works is:

- Remove existing rail and remove from site (cost neutral on the basis of scrap value offsetting the cost of removal)
- Remove existing sleepers and dispose off-site (treated as waste)
- Tamp and profile existing surface including making up levels where appropriate (allowed 1 tonne of crushed rock per linear metre of track)

- Place bottom ballast
- Lay sleepers
- Lay and fasten rail
- Place top ballast
- Tamp and profile
- Weld and de-stress rail

No allowance has been made for upgrading the existing embankments to suit the loadings of the Reference Train.

The LTC is assuming that narrow gauge track in Queensland will be upgraded to dual gauge for cost comparison purposes only. No discussions have been held with Queensland Rail as to whether such an approach would be adopted.

4.3.2 Earthworks costs

As an initial step, a terrain model has been developed based on five different terrain types whose quantities per kilometre remain constant. This means that the amount of fill, cut, area of embankments and cuttings remain a constant. The terrain categories have been fed into the GIS database which then produces the lengths of each terrain type within each section.

The classifications are:

- Terrain Class A: Flat
- Terrain Class B: Undulating
- Terrain Class C: Rolling
- Terrain Class D: Hilly
- Terrain Class E: Mountainous

The minimum height of fill, or depth of cut, is assumed to be 500 mm, excluding 150 mm of capping layer. Generally, the maximum travel distance to move material for the construction of the embankments was 10 km each way.

Having the above categories provides a measure of uniformity across the length of the corridor where no detailed investigations have taken place.

In stages 2 and 3 of this study, vertical and horizontal alignments will be developed to refine the earthworks quantities and to optimise the cut/fill balance in each section.

4.3.3 Geotechnical consideration

The geotechnical consideration matrix has been developed for the project based on the types of conditions identified on the GIS. The types of conditions identified are:

- Soil/alluvium
- Aeolian
- Black soils/Gilgai
- Soft rock
- Hard rock

The geotechnical engineers developed treatments for each of the identified geotechnical conditions.

In summary the treatments were as detailed below.

4.3.3.1 Soil/alluvium

- 200 mm topsoil strip
- 5% soft spots (replaced with well graded gravel fill)
- Embankments constructed from suitable excavated material
- 20% of cuttings to have soil nailing
- Grassing to batters at 6 m^2 per track metre
- Grassing to total area of embankments
- Rate of excavation – 26 m^3/hours in Terrain Type 1 decreasing through the terrain types to 18 m^3/hour in Terrain Type 5

4.3.3.2 Aeolian

- Over-excavation of 1.5m below design sub-grade level and replacement with well
- graded gravel fill
- Embankments constructed from suitable excavated material
- 50% of cuttings to have rock bolts
- Grassing to batters at 6 m^2 per track metre
- Grassing to total area of embankments
- Rate of excavation – 26 m^3/hours in flat (only occurs in Terrain Type 1)

4.3.3.3 Black soils/Gilgai

- Strip 200 mm topsoil
- Lime stabilise upper 300 mm of soil below sub-grade level
- Embankments constructed from suitable excavated material
- 20% of cuttings to have soil nailing
- Grassing to batters at 6 m^2 per track metre
- Grassing to total area of embankments
- Rate of excavation – 26 m^3/hours in Terrain Type 1, decreasing through the terrain types to 18m^3/hour in Terrain Type 5

4.3.3.4 Soft rock

- Tyne/scarify/loosen rock surface and re-compact
- Embankments constructed from suitable excavated material
- 50% of cuttings to have rock bolts with at a rate of 1 bolt per 18 m^2
- Grassing to batters at 6 m^2 per track metre
- Grassing to total area of embankments
- Rate of excavation – 10 m^3/hours in Terrain Type 1, decreasing through the terrain types to 5m^3/hour in Terrain Type 5

4.3.3.5 Hard rock

- Tyne/scarify/loosen rock surface and re-compact
- Embankments constructed from suitable excavated material
- 25% of cuttings to have rock bolts with at a rate of 1 bolt per 36 m^2
- Grassing to batters at 6 m^2 per track metre
- Grassing to total area of embankments

- Rate of excavation – 5 m^3/hours in Terrain Type 1, decreasing through the terrain types to 3 m^3/hour in Terrain Type 5

4.3.4 Bridges and structures

4.3.4.1 Summary of bridges and structures

Detailed in the table below are the bridges and structures developed for this stage.

Table 4-2 Bridge and structure costs

Type	Length	Width
Grade Separation Major	38 m	10 m
Grade Separation Minor	19 m	8 m
Perennial 1_1 (T1)	35 m	9 m
Perennial 1_2(T2)	75 m	8 m
Perennial 1_3 (T3)	150 m	6 m
Perennial 1_4 (T3)	275 m	6 m
Perennial 1_5 (T3)	400 m	6 m
Dry Creek 2_1 (T1)	35 m	9 m
Dry Creek 2_2 (T2)	75 m	8 m
Dry Creek 2_4 (T3)	175 m	6 m
Viaduct	206 m	6 m
Culvert 3_1	26 m	1 cell (1800 x 900)
Culvert 3_2	26 m	2 cells (1800 x 900)
Culvert 3_3	26 m	3 cells (1800 x 900)
Culvert 3_4	26 m	4 cells (1800 x 900)
Floodplain culverts	16 m	167 off (Class 4, 600 mm diameter)

4.3.4.2 Methodology

The estimates for bridges and structures will be prepared using Pronamics Expert Estimation. The direct costs are generally estimated using first principle detailed build-up for rates.

Where details are not available to allow a first principle rate to be calculated, typical rates applicable for the relevant type of construction will be adopted. This applies generally for items that require further detail design.

4.3.4.3 Assumptions/data used: bridges and structures

The bridges and structures have been considered as being constructed as individual, stand-alone projects, accordingly they include an allowance for subcontractor overheads. The assumptions in this regard are addressed in Appendix 4 'Summary of Assumptions for Structures' of this working paper.

The maturity of the design is at a pre-concept stage meant assumptions have been made for the dimensions of the bridge components. The assumptions are dependent on the configuration of the particular structure, which have been derived from a combination of various types of precast beam, numbers of spans involved, method of beam erection and the condition of area being crossed, i.e. over dry ground or water.

Structures having the same beam type have had common assumptions assigned for piles, abutments, pilecaps, columns and headstocks (where appropriate).

Data sheets are referenced to identify the structure characteristics using a convention that indicated structure type, whether rail or road bridge, number of spans, span length, type of beam and whether over wet or dry ground conditions. An example is as follows:

Table 4-3 Bridge data sheet

Bridge reference	Water crossing, bridge classification 1_5
Type	T3
Rail/Road	Rail
No of Spans	16
Span Length	25.000 m
Wet/Dry	Wet

The assumptions relating to three basic configurations for structures are detailed in Appendix 5 – Summary of Assumptions for Structures.

4.3.4.4 Direct cost estimate

Quantities for the items are determined on the basis of the assumptions detailed in Appendix 4, and where appropriate the number of spans and the ground conditions will be altered to suit the structure configuration.

The following major issues that impact on the total cost estimate are highlighted below:

Subcontractor overhead allowance

A subcontractor overhead allowance is assessed as a generic cost based on a minimum site set-up and staffing by a subcontractor. A further item makes adjustment of this amount to provide an addition to allow for each structure to be constructed in isolation from the overall project. The total overhead allowance is assessed as 35% of the direct job costs.

Ground conditions

The difference between a structure being constructed over dry ground and one constructed over water is that an allowance is made for the installation of a cofferdam and for pumping costs over a period shown in the data sheets. The estimate is expected to be refined as the designs mature.

Type 3 structure: box girder

The Box Girder section and span suggest precast units weighing about 470 tonnes. These girders are described as being incrementally launched.

The cost estimate allows for a concrete casting area and access to the initial launching area, together with the subsequent removal.

The costs of the subcontractor designing the equipment required for launching the box girders will be spread over the whole of the project, is understood to comprise four No. 8 span structures and seven No. 11 span structures that is the design costs are spread over 109 box girder spans.

However, it is considered that to allow for the geographic and program considerations, five sets of launching equipment will be required for the project as a whole, and that the manufacture and fabrication costs for five sets of equipment would be spread over the 109 box girders.

Type 4 structure: segmental viaduct

The design details for this structure are insufficient to allow proper consideration of an estimate based on first principles. However, the basic criteria appeared to relate to a structure of similar proportions to the Gateway Bridge currently under construction across the Brisbane River.

In consequence, after adjusting the costs, understood to be associated with the Gateway Bridge, for costs expected to cover the subcontractor's margins and costs of constructing approach roads, a benchmark rate per square metre of deck was calculated.

Further work will be required to confirm the applicability of this unit rate as the design matures and further details become available.

Tunnels

There is no design developed for the proposed tunnels as this is dependent on the geotechnical factors. Therefore it has been decided to use benchmarked data from other similar tunnel projects.

The benchmarked data used were the estimate developed for the new Liverpool Range rail alignment costings by G M Peck & Associates in June 2006 and a rail tunnel project in Queensland of a similar size and length in June 2007. The tunnel for the Liverpool Range project was a $68m^2$ face area, approximate length 4.2 km. The rate developed was $42m per kilometre. However, there were a number of items missing from the costs including power for the tunnel boring machine (TBM)/roadheader, the purchase of a TBM/roadheader etc. The Queensland tunnel was a twin tunnel, approximately 7.5 km long. The overall rate per kilometre was $52m.

During discussions with the designers, it became evident that the location of most of the tunnels, namely the area around Toowoomba and Warwick, had significant geotechnical issues. It was decided, therefore, that a rate of $55m per kilometre be used for the study to allow for the geotechnical treatments.

4.3.4.5 Assumptions/data used: drainage

Reinforced concrete box culverts

The reinforced concrete box culverts (RCBC) have an internal span of 1,800 mm and leg height of 900 mm. The unit rates cover configurations of 1, 2, 3, 5 and 8 cells across and a length of RCBC units of 26.0 m.

The RCBC units considered are of the size and type designed for use on Queensland Rail work, and the typical details for construction are likewise based on Queensland Rail specifications.

The estimates will include for excavation to commence 1 m above RCBC obvert, construction of the base slab, supply and installation of RCBC units including any required in-situ work, construction of apron slabs and wingwalls, and backfill including geotextiles.

Reinforced concrete pipe culverts

The reinforced concrete pipes of diameters 600 mm, 675 mm and 750 mm, are based on pipe lengths of 26.0m, single pipe. The unit rates will include for the installation of a precast headwall unit at each end of the pipe run.

4.3.4.6 Other direct costs associated with bridges and structures

Traffic management

Traffic management has been ignored for the purposes of this cost estimate.

Environmental protection management

A generic allowance will be made for environmental protection management, and applied to each structure configuration. This allowance is expected to be refined as the designs mature.

This allowance will not apply to the unit rates for RCBC and RCP construction.

4.3.4.7 Upgrading

The cost model will allow for upgrading all existing grade separations, bridges and culverts along the existing track where the track itself is subject to upgrade i.e. where the existing track if Class 3 or higher, the associated structures would be upgrade to be suitable for a Class 1 track.

The cost of the upgrade is based on the cost of a new structure with an uplift of 30%. This uplift is to cover items as:

- Demolition and removal of existing structures
- Unproductive working
- Modifications of any works impacted by the structure upgrade

4.3.5 Level crossings

Five different level crossing types have been identified for use in this study. Information has been extracted from the GIS data to calculate the number of different crossings. No details have been provided for the upgrading of existing level crossings. We have therefore made the assumption that an upgrade equates to the cost of a new installation plus 30% for demolition of existing crossing, non-productive working and tying-in to existing infrastructure.

The cost build up for the different type of level crossing will be based on the description provided benchmarked against the individual crossing type with costs obtained from projects in both Victoria and Queensland.

All level crossings are deemed to form part of an overall level crossing works package and have not been priced on an individual basis.

4.3.6 Fencing

The GIS model identified the various land uses that the alignment was passing through. Detailed below are the land uses encountered.

- Rural
- Residential
- Commercial
- Industrial
- Special use
- Open space
- Environmental protection
- National park/nature reserve
- Rail corridor
- Upgrading existing corridors

4.3.7 General assumptions

The LTC will make the following assumptions in developing the cost models:

- The construction contract is let on a design and construct basis
- That free and unobstructed access will be available to the sites at all times
- That normal working hours only are included
- That sufficient compound area will be available for storage containers, sheds, delivery vehicles/cranes
- That there will be not impact on normal construction activities as a result of maintenance of pedestrian or vehicular access

4.3.8 Pricing exclusions

The following factors have been excluded in the calculation of the cost model at this stage. During stages 2 and 3, detailed studies will be undertaken to identify any potential issues affecting the preferred alignment and these will be factored into the capex costs during these stages.

- Owner's costs
- Signalling
- Power supplies
- Overhead wiring
- Land acquisition
- Specific location factors
- Modifications to existing rail infrastructure
- Native title
- Aboriginal and heritage artefacts
- Authority fees and charges
- Active security to the construction zones (chain wire fence only)
- Compliance with any planning conditions
- Relocating existing services
- Possession costs
- Financing
- Legal costs

- Escalation
- Compensation
- GST

5 High level estimated land acquisition cost model

5.1 Overview of land valuation assessment

A Land Valuation Assessment was undertaken by Trevor Hudson & Associates on behalf of the LTC as part of the Melbourne-Brisbane Inland Rail Alignment Study.

The purpose of the assessment was to assess the variability in land acquisition costs for two similar indicative alignment options by applying the ‘before and after’ valuation approach that is considered necessary to determining acquisition cost and considering the value of structures, improvements and water entitlements held by the landowner.

The findings of the land valuation assessment will be used to focus land valuation efforts during stages 2 and 3 of the study.

5.2 Compensation for compulsorily taking part of a property

The courts have for many years dictated that compensation for the taking of only part of a property is the difference in value of the property before and after the subject land acquisition.

The courts have also, more often than not, decided it is fair and reasonable to consider the affect upon a ‘rural property’ to embrace non contiguous lands in the same ownership, and or, affect upon other lands in a different ownership if it can be demonstrated that the subject affected land forms an integral part of an aggregated operational holding.

For example, recent acquisition of land in Queensland for the Tarong to Surat railway disclosed that the market value of the property before and after acquisition of land for the rail corridor often equated to an acquisition cost of 200% to 400% of the value per hectare of the ‘before’ market value of the property.

This relative difference in ‘before’ value per hectare to actual acquisition cost per hectare was predominately due to size of affected land holding, land use and corridor alignment through the property resulting in affect upon residential amenity, severance of the subject land holding and/or the operational land holding that may be an aggregation of non contiguous lands.

The acquisition cost was also affected by limiting the number of private occupational at grade railway crossing so as to preserve the operational integrity of railway.

Determination of an estimated purchase price for the rail corridor lands to equate to fair and reasonable compensation payable for compulsory acquisition of the lands under the ‘Just Terms’ type of legislation, dictates consideration of affect upon the market value of the land and having regard to ‘value to owner’.

5.3 Case study: comparison of two indicative routes

Two indicative routes between Coonamble and Moree were selected for comparative land valuation analysis to assist in developing the land valuation cost model. Note that these two routes, shown in Figure 5, are not representative of any of the actual route sections being assessed in the inland rail study and were purely indicative, discounting topography, roads and infrastructure.

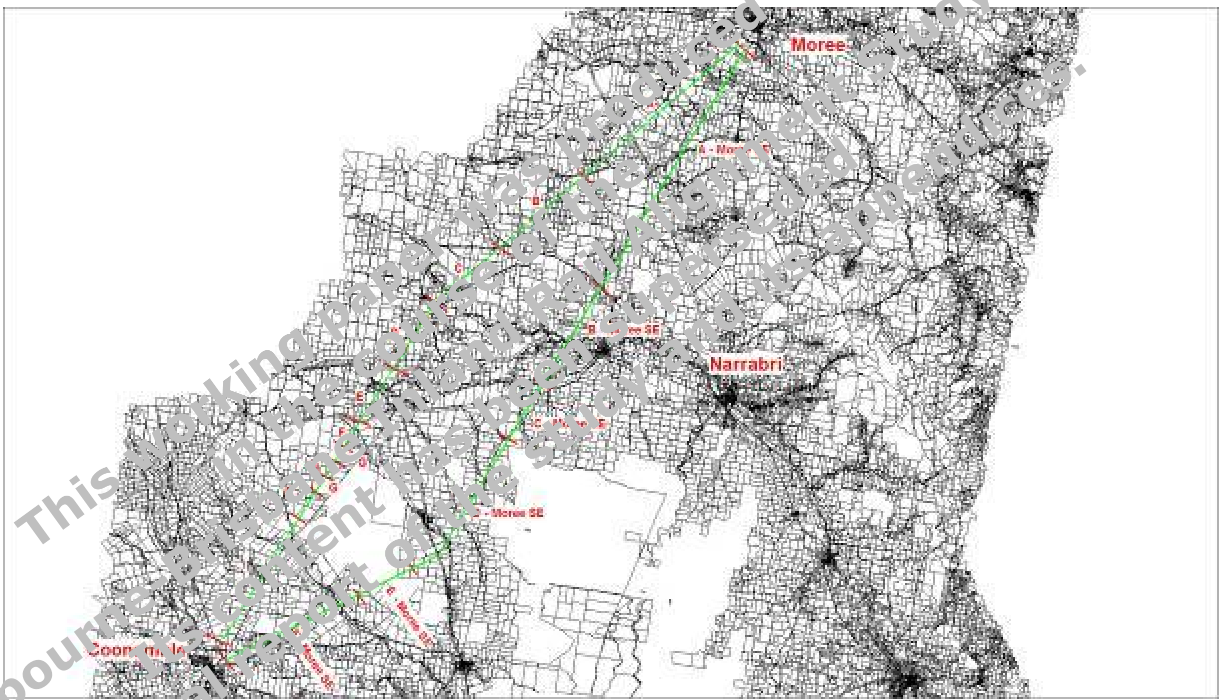
5.3.1 Methodology

The method used for applying assessing land values along the indicative routes was to derive per hectare purchase price for distinct land uses based on compensation for taking of part of a property by comparing the before and after value of the property.

This method considers the loss of total value of the property, taking into account:

- Size of affected land holding;
- Land use and impact to productive land;
- Effect upon residential amenity;
- Severance of the subject land holding; and
- Compensation for impacts to improvements, e.g. irrigation infrastructure.

Figure 5-1 Case study route between Moree and Coonamble



5.3.2 Sales analysis

Sales data of recent land sales was collected for relevant local government areas. The collected and collated sales and valuation/rating data were imported into a Mapinfo database containing the rail corridor alignments and the Digital Cadastral Database within some 30 km of each alignment.

Interrogation of sales evidence allowed identification of any 'splitting' of property sales across local government boundaries and/or being subject to different land uses and/or occupations. The sales data was then further interrogated using Mapinfo through creating thematic maps based upon various ranges of land size, sale price (and date), ownership and land use.

5.3.3 Land use analysis

An aerial imagery overlay was also incorporated into the Mapinfo system to allow desktop assessment of land use and likely type of structures and land improvements into very broadly classified types of land use and level of improvements, as follows:

- Lands within town environs with possible higher use capability
- Small farms or larger rural residential sites
- Irrigation properties separated into:
  - medium sized properties with river and or bore water supply;
  - larger broad acre properties with river or bore water supply; and/or
  - overland water harvesting with onsite irrigation water storage and channel reticulation
- Non-irrigated cultivation lands separated according to size and land quality
- Properties with mixed grazing and cultivation pursuits separated by size and land quality
- Grazing properties separated by size and land quality and degree of timber treatment.
- Predominantly timbered lands.

Figure 6 and Figure 7 show the approximate extent of irrigated lands and landholding configuration respectively of a section of the two case study alignments.

Figure 5-2 Land use south-west of Moree

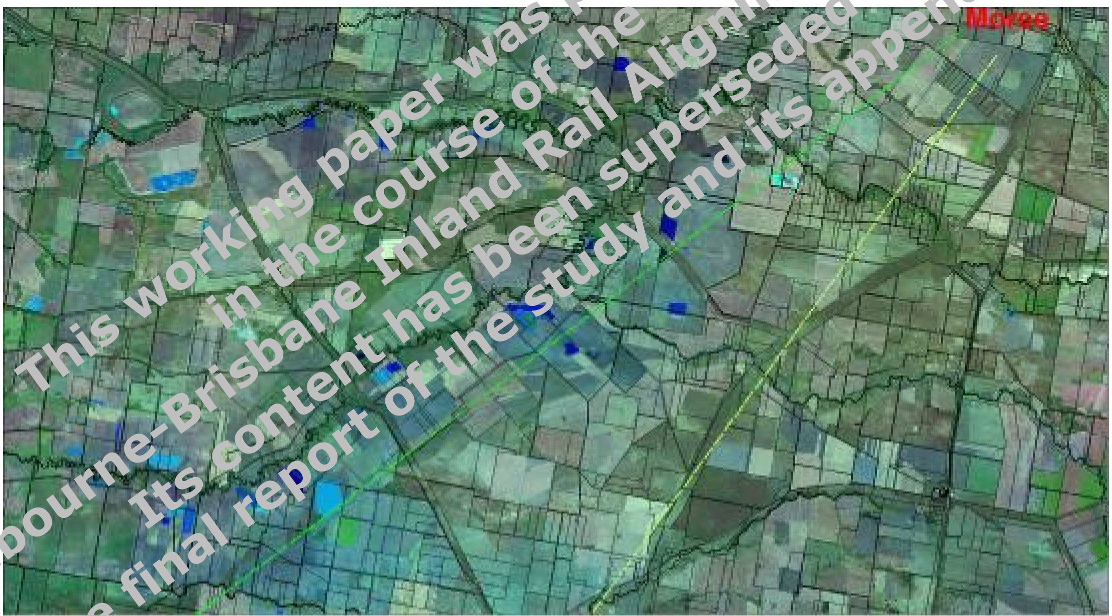


Figure 5-3 Landholding configuration South of Moree

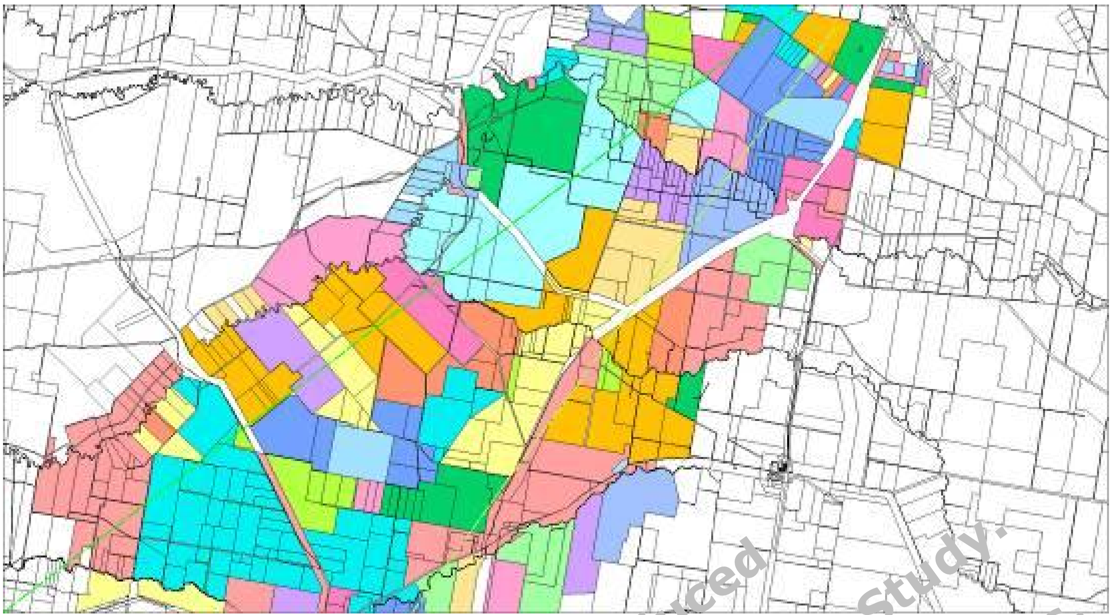


Figure 6 shows the proliferation of major irrigation water storage tanks that form only part of the irrigation improvements upon these properties. Figure 7 shows the landholdings, as units. However it does not take into account the possibility of 'family' operational units, and or, the non contiguous holdings.

The case study routes were apportioned approximately by land use, and the total land value for each alignment was calculated based on indicative per hectare purchase prices for the different land uses along the alignment (using a 50 m corridor),

5.4 Route optimisation using land constraints

The key finding of the land valuation assessment case study was that land acquisition costs varied significantly between the two case study alignments, largely due to land use. As an example of how land use can affect the cost model, for example, the case study indicated that, cultivated lands with irrigation improvements would be more expensive to acquire than non-irrigated cultivated lands, which would in turn be more expensive to acquire than grazing lands.

Additionally, factors such as property severance, restriction of access to properties and between severed land parcels and depreciation of infrastructure would also influence land acquisition costs.

The findings of the land valuation assessment will be used to assist in the development of the preferred route through Stage 2 of the study by optimising alignments based on the following potential land use constraints and opportunities:

- Avoidance of high cost land uses such as cultivated land with irrigation improvements;
- Minimising severance of properties; and
- Minimising restrictions to access to, or across, properties.

By considering these constraints and opportunities during route optimisation, it is hoped that potential property impacts will be minimised and the overall land acquisition costs will be reduced.

Additional considerations that would greatly enhance any further land valuation for the purpose of determining overall property acquisition costs would include:

- Possible minor variations in corridor alignment to reduce the impacts of severance and, where possible, the number of impacted properties;
- The 'risk areas' generated by environmental and other constraints as defined by various states and Federal legislation, such as NSW State Environmental Planning Policy (Infrastructure) 2007, Environmental Protection Biodiversity Conservation Act and the generally more restrictive aspects of National Parks, Forests, Native Title and in particular, where there is possibly loss of amenity to villages/towns, etc which could delay or prevent securing statutory approvals and or licences for a proposed alignment;
- Identification of properties for possible total acquisition if it is considered that the project will be forced to provide offset vegetated lands to allow destruction of vegetation etc within the rail corridor.

5.5 Further consideration of land valuation

Further refinement of the land valuation assessment to assist in development of a land acquisition cost model would require:

- In depth investigation of land ownership, a detailed sales analysis of properties sold and discreet 'without property' inspections to determine the actual land use and other factors that affect the land acquisition cost;
- Possible adjustment of land acquisition costs depending on provision of access to severed lands, curtailment in number of at grade public road crossings and additional impacts on land use;
- Estimation of reinstatement of fencing, water supply, and in particular, the impacts on any irrigation system;
- Consideration of land acquisition experiences (both compulsory acquisition and non-compulsory negotiated purchase) in similar infrastructure projects, for example, Hume Highway deviations in southern NSW;
- Possible minor variations in corridor alignment to reduce the impacts of severance and where possible the number of impacted properties;
- The 'risk areas' generated by environmental and other constraints as defined by various States and Federal legislation, such as NSW State Environmental Planning Policy (Infrastructure) 2007, Environmental Protection Biodiversity Conservation Act and the generally more restrictive aspects of National Parks, Forests, Native Title and in particular, where there is possibly loss of amenity to villages/towns, etc which could delay or prevent securing statutory approvals and or licences for a proposed alignment;
- Defining if reinstatement of private and public infrastructure and relocation of water supply/reticulation and fencing upon affected properties is to be considered as a compensation or construction cost. There are many instances where it is beneficial to have the land purchase price include a component to allow the affected land owner to provide reinstatement of fencing and water supply, etc; and
- Identification of properties for possible total acquisition if it is considered that the project will be forced to provide offset vegetated lands to allow destruction of vegetation etc within the rail corridor.

6 Conclusion

6.1 Basis and range of cost for Stage 1

The LTC used the benchmarked data as the basis for costs during Stage 1. The purpose of Stage 1 was to produce a comparative cost between the different options to enable the selection of a preferred rail corridor for Stage 2. The benchmarked data costs were more than adequate to allow this cost comparison to be carried out on an even basis. The costs for each of the routes and route segments under consideration have been incorporated in Working Paper No. 5 of this study to assist in the selection of the preferred route.

The LTC has also commenced the development of a bottom-up cost model for the route; the key assumptions have been described herein. At this stage this model is not sufficiently developed (as the design for the route is also insufficiently developed) to provide a bottom-up estimate of the likely capex for the route.

Based on work done to date, the LTC has identified a 'most likely' range, demonstrating the potential range that could be incurred in constructing the preferred route. The range of the costs would 'most likely' be between $2.5m and $5.5m per kilometre of new track.

There will, of course, be exceptions to this range, in areas that will have tunnelling and viaducts as the rates for these are significantly higher than the 'most likely' range. Further work by the LTC will be looking to identify alternative strategies and construction methods to eliminate or minimise the cost associated with these features.

The actual capital cost of the overall route will be estimated in the subsequent stages of the study and will depend on the amount and cost of new construction as well the extent of re-use of existing track and whether upgrade of this track is necessary.

6.2 Focus areas for stages 2 and 3

Work in stages 2 and 3 will focus on the development of the bottom-up cost model to give a level of accuracy that will permit an outturn cost to be developed. It is expected at this stage that the following outcomes will be achieved:

- Completion of Stage 2 – cost model providing indicative outturn costs, using first-principles unit rates against quantities derived for the preferred route.
- Completion of Stage 3 – cost model providing refined outturn costs, using first-principles costs derived for specific designs or unit rates against quantities derived for the preferred route.

Stage 1 has highlighted some key areas to focus on in terms of cost during stages 2 and 3. These include:

6.2.1 Earthworks

The earthworks model, as discussed previously in this working paper, was developed from the terrain model used specifically for this comparative analysis, based on a 22 km section of track. This, therefore, does not reflect the actual route conditions being incurred across the complete length of the sections. The benchmarking data is based on actual contract costs from similar projects, with a significant level of design and rationalisation of the preferred route alignment. We believe that the further stages of the project will take into consideration significant value engineering and rationalisation to reflect expectations set in the benchmarking data.

Stage 2 will develop the horizontal and vertical alignments which are essential to move away from a terrain model to actual site specific locations. This also has the benefit of detailing the actual lengths of structures required along the route which will also rationalise the cost model.

6.2.2 Viaducts

The benchmarking data used for the viaducts was similar to the water crossings. However, the proposed viaduct solution is a more substantial structure due to the height of the piers needed in the Queensland sections. This highlighted an area which requires value engineering and rationalisation in Stage 2 including minimising or eliminating the length of viaducts required.

6.2.3 Productivity rates

The productivity rates for earthworks and track installation are areas that provide opportunities for further refinement during the next stages. The LTC will liaise with rail owners and contractors to identify actual rates achieved in locations similar to those identified in the study, to enable site specific rates to be developed.

6.2.4 Material supply

There is a significant difference between the supply rates given for key materials such as rail, sleepers and ballast. During stages 2 and 3, the LTC will discuss with ARTC the opportunity for using existing supply contracts as the basis of the cost estimates.

6.2.5 Review of exclusions

The list of exclusions from the cost model needs to be reviewed and included in the cost model. As the preferred route has been identified, this will allow more detailed analysis of these items to ensure that the total outturn cost of the project can be developed by the end of Stage 3.

6.2.6 Land valuation

Further refinement of the land valuation model is required during stages 2 and 3.

Appendix A

Summary of benchmarked route sections

Appendix B

Summary of route sections characteristics

A01 Melbourne to Mangalore

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Length 116.7 km

A02 Mangalore to Wodonga Deviation South

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 188.3 km

A03 Wodonga Deviation South to Wodonga Deviation North

This section of track is a Class 1 track currently under construction.

- Track length 6.9 km

A03a Wodonga Deviation

This section of track is currently being constructed by ARTC and therefore no upgrading has been allowed for within this study.

- Track length 5.4 km

A04 Wodonga Deviation North to Junee

- Tack length 163.2 km

This section of track is an existing Class 1 track and therefore no upgrading is required.

A05 Mangalore to Murchison Deviation South

This section of track is Class 3 and therefore requires upgrading to Class 1. The works include the upgrading of the following structures:

- Track length 36.3 km
- 1 off 150 m long water crossing
- 3 off 75 m long dry creek crossings
- 4 off culverts
- 3 off grade separations
- 21 off level crossings
- 0.3 km of security fencing

A06 Murchison Deviation South to Murchison Deviation North

This section of track is an upgrade from broad gauge to Class 1 standard gauge. The works include the upgrading of the following:

- Track length 4.1 km
- 1 off grade separation
- 2 off level crossings
- 0.5 km of stock fencing
- 0.1 km of security fencing

A06a Murchison Deviation

This section of track is new and involves the following works:

- Track length 3.6 km
- 3.6 km of track in flat terrain
- 0.1 km of track in undulating terrain
- 1 off grade separation
- 2 off level crossings
- 2.4km of stock fencing
- 0.1 km of security fencing

A07 Murchison Deviation North to Tocumwal

This section of track is an upgrade from broad gauge to Class 1 standard gauge. The works include the upgrading of the following:

- Track length 101.8 km
- 1 off water crossing, 150 m long
- 1 off water crossing, 275 m long
- 2 off water crossing, 400 m long
- 1 off dry creek crossing, 35 m long
- 3 off dry creek crossing, 75 m long
- 2 off dry creek crossing, 175 m long
- 4 off culverts
- 8 off grade separations
- 72 off level crossings
- 3.4 km of stock fencing
- 0.6 km of Residential acoustic barriers and security fencing
- 1.4 km of security fencing

A08 Tocumwal to Finley Deviation North

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 13.0 km
- 1 off grade separation
- 7 off level crossings
- 12.7 km of stock fencing
- 0.3 km of residential acoustic barriers and security fencing

A09 Finley Greenfield to Finley Deviation South

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 2.9 km
- 1 off level crossings
- 2.9 km of stock fencing

A10 Finley Deviation South to Finley Deviation North

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 4.6 km
- 5 off level crossings
- 2.7 km of stock fencing
- 1.9 km of residential acoustic barriers and security fencing

A10a Finley Deviation

This section of track is new and involves the following works:

- Track length 3.9 km
- 3.9 km of track in flat terrain
- 1 off level crossings
- 2.8 km of stock fencing
- 1.1 km of residential acoustic barriers and security fencing

A11 Finley Deviation North to Berrigan Deviation South

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 14.1 km
- 7 off level crossings
- 14.1 km of stock fencing

A12 Berrigan Deviation South to Berrigan Deviation North

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 8.4 km
- 2 off grade separation
- 8 off level crossings
- 6.8 km of stock fencing
- 1.6 km of residential acoustic barriers and security fencing

A12a Berrigan Deviation

This section of track is new and involves the following works:

- Track length 7.5 km
- 7.5 km of track in flat terrain
- 4 off grade separations
- 4 off level crossings
- 7.1 km of stock fencing
- 0.4 km of residential acoustic barriers and security fencing

A13 Berrigan Deviation North to Jerilderie Deviation South

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 28.6 km
- 16 off level crossings
- 28.6 km of stock fencing

A14 Finley Greenfield to Jerilderie Deviation North

This section of track is new and involves the following works:

- Track length 41.1 km
- 40.4 km of track in flat terrain
- 0.7 km of track in undulating terrain
- 1 off dry creek crossing, 35 m long
- 3 off grade separation
- 20 off level crossings
- 40.3 km of stock fencing

A15 Jerilderie Deviation South to Jerilderie Deviation North

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 5.8 km
- 1 off culvert
- 1 off grade separation
- 3 off level crossings
- 4.3 km of stock fencing

A15a Jerilderie Deviation

This section of track is new and involves the following works:

- Track length 4.7 km
- 4.7 km of track in flat terrain
- 1 off dry creek crossing, 75 m long
- 1 off minor grade separation
- 3 off level crossings
- 4.3 km of stock fencing

A16 Jerilderie Deviation North to Narrandera

This section of track is an upgrade from Abandoned to Class 1. The works include the upgrading of the following:

- Track length 102.1 km
- 1 off water crossing, 400 m long
- 1 off dry creek crossing, 75 m long
- 3 off dry creek crossing, 175 m long
- 4 off culverts
- 5 off grade separations
- 16 off level crossings
- 98.7 km of stock fencing
- 3.4 km of residential acoustic barriers and security fencing

A17 Narrandera to Junee By-pass West

This section of track is an upgrade from Class 3 to Class 1. The works include the upgrading of the following:

- Track length 93.0 km
- 1 off dry creek crossing, 35 m long
- 3 off dry creek crossing, 75 m long
- 11 off culverts
- 5 off grade separations
- 21 off level crossings
- 84.0 km of stock fencing
- 9.0 km of residential acoustic barriers and security fencing

A18 Junee By-pass West to Junee

This section of track is an upgrade from Class 3 to Class 1. The works include the upgrading of the following:

- Track length 5.4 km
- 3 off culverts
- 1 off grade separation
- 4.3 km of stock fencing
- 1.1 km of residential acoustic barriers and security fencing

B01 Junee to Junee By-pass East

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 3.6 km

B01a Junee By-pass (Cootamundra)

This section of track is new and involves the following works:

- Track length 5.2 km
- 0.5 km of track in flat terrain
- 1.8 km of track in undulating terrain
- 1.7 km of track in rolling terrain
- 1.2 km of track in hilly terrain
- 2 off culverts
- 2 off grade separations
- 3 off level crossings
- 5.2 km of stock fencing

B01b Junee By-pass (Stockinbingal)

This section of track is new and involves the following works:

- Track length 4.9 km
- 1.6 km of track in flat terrain
- 2.5 km of track in undulating terrain
- 0.8 km of track in rolling terrain
- 1 off culvert
- 1 off level crossing
- 4.9 km of stock fencing

B01c Junee to Junee By-pass North

This section of track is new and involves the following works:

- Track length 4.2 km
- 0.5 km of track in undulating terrain
- 3.5 km of track in rolling terrain
- 0.2 km of track in hilly terrain
- 3 off culverts
- 2 off grade separations
- 1 off level crossings
- 3.0 km of stock fencing
- 1.2 km of residential acoustic barriers and security fencing

B02 Junee By-pass East to Bethungra Deviation South

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 25.5 km

B03 Bethungra Deviation South to Bethungra Deviation North

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 7.9 km

B03a Bethungra Deviation

This section of track is new and involves the following works:

- Track length 7.5 km
- 1.0 km of track in undulating terrain
- 1.3 km of track in rolling terrain
- 1.5 km of track in hilly terrain
- 0.7 km of track in mountainous terrain
- 3 off culverts
- 1 off grade separation
- 4 off level crossings
- 3.0 km of tunnels
- 4.5 km of stock fencing

B04 Bethungra Deviation North to Frampton Deviation South

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 3.8 km

B05 Frampton Deviation South to Frampton Deviation North

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 5.2 km

B05a Frampton Deviation

This section of track is new and involves the following works:

- Track length 4.7 km
- 1.0 km of track in undulating terrain
- 2.7 km of track in rolling terrain
- 1.0 km of track in hilly terrain
- 1 off culvert
- 4.7 km of stock fencing

B06 Junee to Frampton Deviation North

This section of track is a mixture of 22.9 km of existing Class 1 and 17km of new track involving the following works:

- Track length 39.9 km
- 4.7 km of track in flat terrain
- 5.8 km of track in undulating terrain
- 5 off culverts
- 1 off grade separation
- 3 off level crossings
- 6.5 km of tunnels
- 10.5 km of stock fencing

B07 Frampton Deviation North to Cootamundra Deviation South

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 5.6 km

B07a Cootamundra Deviation South

This section of track is new and involves the following works:

- Track length 5.1 km
- 0.3 km of track in flat terrain
- 1.7 km of track in undulating terrain
- 1.7 km of track in rolling terrain
- 0.5 km of track in hilly terrain
- 0.9 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off grade separation
- 2 off level crossings
- 5.1 km of stock fencing

B08 Cootamundra Deviation South to Bauloora

This section of track is a mixture of existing Class 1 and Class 2 track and therefore no upgrading is required.

- Track length 9.0 km

B09 Cootamundra Deviation

This section of track is new and involves the following works:

- Track length 9.3 km
- 0.9 km of track in flat terrain
- 2.7 km of track in undulating terrain
- 3.1 km of track in rolling terrain
- 0.8 km of track in hilly terrain
- 0.1 km of track in mountainous terrain
- 3 off culverts
- 1 off grade separation
- 2 off level crossings
- 1.7 km of tunnels
- 9.3 km of stock fencing

B10 Bauloora to Yeo Yeo Deviation South

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 10.1km

B11 Bauloora to Yeo Yeo Deviation

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 3.5 km

B11a Yeo Yeo Deviation

This section of track is new and involves the following works:

- Track length 3.0 km
- 0.1 km of track in flat terrain
- 0.8 km of track in undulating terrain
- 2.1 km of track in rolling terrain
- 1 off level crossings
- 3.0 km of stock fencing

B12 Yeo Yeo Deviation North to Stockinbingal

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 8.5 km

B13 Yeo Yeo Deviation North to Stockinbingal Deviation

This section of track is a mixture of 8.0 km of existing Class 1 track and 1.5 km of new track involving the following works:

- Track length 9.5 km
- 1.5 km of track in rolling terrain
- 1 off culvert
- 1.5 km of stock fencing

B14 Junee By-pass North to Stockinbingal (greenfield)

This section of track is new and involves the following works:

- Track length 46.9 km
- 14.6 km of track in flat terrain
- 21.2 km of track in undulating terrain
- 11.1 km of track in rolling terrain
- 0.5 km of track in hilly terrain
- 16 off culverts
- 1 off grade separation
- 18 off level crossings
- 46.9 km of stock fencing

B15 Stockinbingal to Stockinbingal Deviation North

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 1.1 km

B16 Stockinbingal Deviation North to Maleeja

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 8.0 km

B17 Yeo Yeo to Maleeja (greenfield)

This section of track is new and involves the following works:

- Track length 13.2 km
- 6.7 km of track in flat terrain
- 4.1 km of track in undulating terrain
- 2.3 km of track in rolling terrain
- 0.1 km of track in hilly terrain
- 2 off culverts
- 1 off grade separation
- 2 off level crossings
- 13.2 km of stock fencing

B18 Maleeja to Parkes Deviation South

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 159.3 km

B19 Parkes Deviation South to Parkes Deviation North

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 5.7 km

B19a Parkes Deviation

This section of track is new and involves the following works:

- Track length 4.6 km
- 1.4 km of track in flat terrain
- 1.9 km of track in undulating terrain
- 1.3 km of track in rolling terrain
- 1 off grade separation
- 4 off level crossings
- 4.4 km of stock fencing
- 0.2 km of security fencing

B20 Parkes - Narromine

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 106.0 km

C01 Narromine - Dubbo (West)

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 32.2 km

C02 Dubbo (West) - Dubbo (North East)

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 12.3 km

C03a Dubbo (North East) - Binnaway

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 129.5 km

C03b Dubbo (North East) - Binnaway

This section of track is a mixture of 64.6 km of existing Class 2 track and 56.4 km of new track involving the following works:

- Track length 121.0 km
- 8.8 km of floodplains
- 18.2 km of track in flat terrain
- 23.4 km of track in undulating terrain
- 11.4 km of track in rolling terrain
- 3.1 km of track in hilly terrain
- 0.3 km of track in mountainous terrain
- 5 off dry creek crossings, 35 m long
- 19 off culverts
- 2 off grade separations
- 24 off level crossings
- 48.3 km of stock fencing
- 6.6 km of security fencing

C04a Binnaway - Premer (South)

This section of track is a mixture of 62.7 km of existing Class 2 track and 0.9 km of new track involving the following works:

- Track length 63.6 km
- 0.9 km of floodplains
- 0.4 km of track in undulating terrain
- 0.5 km of track in rolling terrain
- 1 off dry creek crossings, 35 m long
- 2 off dry creek crossings, 75 m long
- 19 off culverts
- 1 off grade separation
- 21 off level crossings
- 0.9 km of stock fencing

C04b Binnaway - Premer (South)

This section of track is a mixture of 31.7 km of existing Class 2 track and 32.9 km of new track involving the following works:

- Track length 64.6 km
- 3.1 km of floodplains
- 3.9 km of track in flat terrain
- 9.5 km of track in undulating terrain
- 14.4 km of track in rolling terrain
- 4.8 km of track in hilly terrain
- 0.3 km of track in mountainous terrain
- 2 off dry creek crossings, 35 m long
- 1 off dry creek crossings, 75 m long
- 7off culverts
- 2 off grade separation
- 13 off level crossings
- 32.9 km of stock fencing

C05 Premer (South) - Turilawa (West)

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 67.6 km

C06 Turilawa (West) - Werris Creek

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 4.5 km

C07 Turilawa (North) - Emerald Hill

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 80.8 km

C08 Emerald Hill - Baan Baa

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 28.8 km

C09 Baan Baa - Narrabri (South)

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 28.7 km

C10 Narrabri (South) - Narrabri (North)

This section of track is a mixture of existing Class 1 and Class 2 track and therefore no upgrading is required.

- Track length 15.4 km

C11 Narrabri (North) - Moree (South)

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 84.8 km

C12 Binnaway - Merebene

This section of track is a mixture of 3.5 km of existing Class 2 track and 138.3 km of upgrade from Class 5 to Class 1. The works include the upgrading of the following:

- Track length 141.8 km
- 33.7 km of floodplains
- 5 off dry creek crossings, 35 m long
- 4 off dry creek crossings, 75 m long
- 25 off culverts
- 11 off grade separations
- 52 off level crossings
- 126.5 km of stock fencing
- 9.9 km of residential acoustic barriers and security fencing
- 1.8 km of security fencing

C13 Kiandool - Narrabri (West)

This section of track is an upgrade of existing Class 3. The works include the upgrading of the following:

- Track length 3.5 km
- 1 off dry creek crossing, 175 m long
- 1 off level crossings
- 3.3 km of stock fencing

C14 Dubbo (North - Talbragar) – Curban

This section of track is a mixture of upgrade of existing Class 3 and Class 5. The works include the upgrading of the following:

- Track length 84.5 km
- 15.1 km of floodplains
- 1 off dry creek crossings, 35 m long
- 1 off dry creek crossings, 75 m long
- 1 off dry creek crossings, 175 m long
- 27 off culverts
- 2 off grade separation
- 33 off level crossings
- 60.2 km of stock fencing
- 3.1 km of residential acoustic barriers and security fencing
- 21.2 km of security fencing

C15 Curban - Coonamble

This section of track is an upgrade of existing Class 5. The works include the upgrading of the following:

- Track length 56.8 km
- 53.6 km of floodplains
- 20 off level crossings
- 56.2 km of stock fencing
- 0.6 km of residential acoustic barriers and security fencing

C16a Premer (South) - Premer

This section of track is an existing Class 2 track and therefore no upgrading is required.

- Track length 5.3 km

C16b Premer (South) to Premer deviation

This section of track is new and involves the following works:

- Track length 4.4 km
- 1.3 km of floodplains
- 1.8 km of track in flat terrain
- 0.9 km of track in undulating terrain
- 1.7 km of track in rolling terrain
- 1 off dry creek crossing, 35 m long
- 1 off culvert
- 1 off level crossings
- 4.4 km of stock fencing

C17a Moree (South) - Moree (North)

This section of track is a mixture of 9.2 km of existing Class 1 and upgrade 14.9 km of existing Class 3. The works include the upgrading of the following:

- Track length 24.1 km
- 9.4 km of floodplains
- 3 off dry creek crossings, 75 m long
- 2 off dry creek crossings, 175 m long
- 1 off culvert
- 2 off grade separations
- 8 off level crossings
- 11.4 km of stock fencing
- 3.5 km of security fencing

C17b Moree (South) - Moree (North)

This section of track is new and involves the following works:

- Track length 21.2 km
- 12.2 km of floodplains
- 21.2 km of track in flat terrain
- 2 off dry creek crossing, 75 m long
- 2 off dry creek crossing, 175 m long
- 1 off culvert
- 1 off grade separation
- 17 off level crossings
- 18.8 km of Rural fencing
- 2.3 km of security fencing

C18 Werris Creek - Turilawa (North)

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 3.9 km

C19 Binnaway (centre) - Binnaway (East)

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 2.8 km

C50 Narromine - Curban

This section of track is new and involves the following works:

- Track length 92.4 km
- 12.2 km of floodplains
- 84.4 km of track in flat terrain
- 7.2 km of track in undulating terrain
- 0.8 km of track in rolling terrain
- 1 off water crossing, 400 m long
- 1 of dry creek crossing, 35 m long
- 2 off dry creek crossing, 75 m long
- 4 off culverts
- 2 off major grade separation
- 30 off level crossings
- 91.8 km of stock fencing
- 0.6 km of security fencing

C51 Coonamble - Burren Junction

This section of track is new and involves the following works:

- Track length 115.4 km
- 54.9 km of floodplains
- 109.6 km of track in flat terrain
- 5.8 km of track in undulating terrain
- 1 off dry creek crossing, 35 m long
- 6 off dry creek crossing, 75 m long
- 4 off dry creek crossing, 175 m long
- 4 off grade separations
- 49 off level crossings
- 114.3 km of stock fencing
- 1.1 km of security fencing

C52 Burren Junction - Moree (South)

This section of track is new and involves the following works:

- Track length 111.2 km
- 82.7 km of floodplains
- 110.1 km of track in flat terrain
- 1.1 km of track in undulating terrain
- 4 off dry creek crossings, 75 m long
- 1 off dry creek crossing, 175 m long
- 5 off culverts
- 5 off grade separation
- 37 off level crossings
- 111.2 km of stock fencing

C53 Dubbo (West) - Dubbo (North - Talbragar)

This section of track is new and involves the following works:

- Track length 9.7 km
- 5.3 km of track in flat terrain
- 3.7 km of track in undulating terrain
- 0.7 km of track in rolling terrain
- 1 off water crossing, 400 m long
- 1 off dry creek crossing, 175 m long
- 2 off grade separations
- 16 off level crossings
- 7.3 km of stock fencing
- 2.0 km of security fencing

C54 Coonamble - Merebene (Gwabegar)

This section of track is new and involves the following works:

- Track length 76.1 km
- 8.1 km of floodplains
- 72.2 km of track in flat terrain
- 3.9 km of track in undulating terrain
- 1 off dry creek crossing, 35 m long
- 2 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 6 off culverts
- 4 of grade separation
- 40 off level crossings
- 76.1 km of stock fencing

C55 Merebene (Gwabegar) - Kiandool

This section of track is new and involves the following works:

- Track length 85.4 km
- 76.6k m of track in flat terrain
- 8.6 km of track in undulating terrain
- 0.2 km of track in rolling terrain
- 2 off dry creek crossings, 35 m long
- 3 off dry creek crossing, 75 m long
- 22 off culverts
- 43 off level crossings
- 85.4 km of stock fencing

C56 Narrabri (West) - Narrabri (North)

This section of track is new and involves the following works:

- Track length 8.7 km
- 5.0 km of floodplains
- 7.9 km of track in flat terrain
- 0.8 km of track in undulating terrain
- 1 off water crossing, 275 m long
- 1 off dry creek crossing, 75 m long
- 1 off culvert
- 1 off grade separation
- 7 off level crossings
- 8.7 km of stock fencing

C57 Dubbo (West) - Dubbo (North East)

This section of track is new and involves the following works:

- Track length 10.5 km
- 4.1 km of track in flat terrain
- 5.6 km of track in undulating terrain
- 0.8 km of track in rolling terrain
- 1 off water crossing, 400 m long
- 2 off grade separation
- 16 off level crossings
- 7.7 km of rural fencing
- 2.5 km of security fencing

C58 Narrabri (South) - Narrabri (North)

This section of track is new and involves the following works:

- Track length 10.5 km
- 3.2 km of floodplains
- 9.2 km of track in flat terrain
- 1.1 km of track in undulating terrain
- 0.2 km of track in rolling terrain
- 1 off water crossing, 275 m long
- 1 off dry creek crossing, 35 m long
- 1 off culvert
- 2 off grade separation
- 7 off level crossings
- 10.3 km of stock fencing
- 0.2 km of security use fencing

C59 Turilawa (South) - Turilawa (North) (high speed)

This section of track is new and involves the following works:

- Track length 4.5 km
- 2.7 km of floodplains
- 2.8 km of track in flat terrain
- 0.9km of track in undulating terrain
- 0.8 km of track in rolling terrain
- 1 off dry creek crossing, 35 m long
- 2 off level crossings
- 4.5 km of stock fencing

C60 Turilawa (South) - Turilawa (North) (low speed)

This section of track is new and involves the following works:

- Track length 0.9 km
- 0.2 km of floodplains
- 0.3 km of track in rolling terrain
- 0.3 km of track in hilly terrain
- 0.3 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off level crossings
- 0.9 km of stock fencing

C61 Binnaway - Baan Baa

This section of track is new and involves the following works:

- Track length 148.1 km
- 38.0 km of floodplains
- 68.1 km of track in flat terrain
- 32.1 km of track in undulating terrain
- 24.5 km of track in rolling terrain
- 12.8 km of track in hilly terrain
- 6.6 km of track in mountainous terrain
- 5 off dry creek crossings, 35 m long
- 57 off culverts
- 4 off grade separations
- 61 off level crossings
- 4.0 km of tunnels
- 142.9 km of stock fencing
- 1.2 km of residential acoustic barriers and security fencing

C62 Premer (South) - Emerald Hill

This section of track is new and involves the following works:

- Track length 75.0 km
- 69.1 km of floodplains
- 64.1 km of track in flat terrain
- 9.6 km of track in undulating terrain
- 1.3 km of track in rolling terrain
- 2 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 11 off culverts
- 3 off grade separation
- 31 off level crossings

- 75.0 km stock fencing

D01A Moree North (Camurra) - North Star

This section of track is an upgrade of existing Class 3 to Class 1. The works include the upgrading of the following:

- Track length 78.3 km
- 1 off dry creek crossing, 35 m long
- 2 off dry creek crossing, 75 m long
- 22 off culverts
- 21 off level crossings
- 78.3 km of stock fencing

D02A North Star - Boggabilla

This section of track is an upgrade of an abandoned track to Class 1. The works include the upgrading of the following:

- Track length 25.7 km
- 5.0 km of floodplains
- 2 off dry creek crossing, 35 m long
- 2 off dry creek crossing, 75 m long
- 4 off culverts
- 3 off minor grade separation
- 6 off level crossings
- 25.7 km of stock fencing

D03C Boggabilla - Kildonan

This section of track is new and involves the following works:

- Track length 12.6 km
- 4.7 km of floodplains
- 12.4 km of track in flat terrain
- 0.2 km of track in undulating terrain
- 1 off water crossing, 275 m long
- 2 off culverts
- 1 off grade separation
- 5 off level crossings
- 12.6 km of stock fencing

D04A Kildonan - Yelarbon

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 33.9 km
- 1 off grade separation
- 4 off level crossings

- 8.0 km of stock fencing
- 20.8 km of security fencing

D04B Kildonan - Yelarbon

This section of track is new and involves the following works:

- Track length 33.9 km
- 32.7 km of track in flat terrain
- 1.2 km of track in undulating terrain
- 1 off major grade separation
- 4 off level crossings
- 13.2 km of stock fencing
- 20.7 km of security fencing

D05C North Star - Yelarbon

This section of track is new and involves the following works:

- Track length 60.4 km
- 13.3 km of floodplains
- 50.4 km of track in flat terrain
- 9.1 km of track in undulating terrain
- 0.9 km of track in rolling terrain
- 1 off water crossing, 275 m long
- 1 off dry creek crossing, 35 m long
- 2 off dry creek crossing, 75 m long
- 2 off dry creek crossing, 175 m long
- 16 off culverts
- 3 off grade separations
- 16 off level crossings
- 60.4 km of stock fencing

D06A Yelarbon - Inglewood

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 33.8 km
- 2 off dry creek crossings, 175 m long
- 1 off culvert
- 2 off grade separation
- 5 off level crossings
- 28.4 km of stock fencing
- 5.4 km of security fencing

D06B Yelarbon - Inglewood

This section of track is new and involves the following works:

- Track length 33.8 km
- 27.6 km of track in flat terrain
- 5.0 km of track in undulating terrain
- 1.2 km of track in rolling terrain
- 2 off dry creek crossings, 175 m long
- 1 off culvert
- 2 off grade separations
- 5 off level crossings
- 28.4 km of stock fencing
- 5.4 km of security fencing

D07C Inglewood - Millmerran

This section of track is new and involves the following works:

- Track length 73.8 km
- 35.7 km of track in flat terrain
- 27.5 km of track in undulating terrain
- 10.1 km of track in rolling terrain
- 0.5 km of track in hilly terrain
- 5 off dry creek crossings, 85 m long
- 18 off culverts
- 1 off grade separation
- 26 off level crossings
- 73.2 km of stock fencing
- 0.6 km of security fencing

D08A Millmerran - Cecilvale

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 23.4 km
- 2 off dry creek crossing, 175 m long
- 3 off culverts
- 2 off grade separations
- 8 off level crossings
- 23.0 km of stock fencing
- 0.4 km of security fencing

D08B Millmerran - Cecilvale

This section of track is new and involves the following works:

- Track length 23.3 km
- 23.1 km of track in flat terrain
- 0.2 km of track in undulating terrain
- 2 off dry creek crossings, 35 m long
- 2 off culverts
- 2 of grade separations
- 8 off level crossings
- 1.5 km of stock fencing
- 21.8 km of security fencing

D09B Cecilvale - Wyreema West

This section of track is new and involves the following works:

- Track length 33.0 km
- 2.8 km of track in flat terrain
- 13.7 km of track in undulating terrain
- 13.0 km of track in rolling terrain
- 3.2 km of track in hilly terrain
- 0.3 km of track in mountainous terrain
- 4 off culverts
- 5 off grade separations
- 13 off level crossings
- 21.3km of stock fencing
- 11.7 km of security fencing

D10A Inglewood - Warwick

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 95.5 km
- 3 off dry creek crossings, 35 m long
- 17 off culverts
- 4 off grade separations
- 20 off level crossings
- 83.2 km of stock fencing
- 0.6 km of residential acoustic barriers and security fencing
- 11.7 km of security fencing

D10B Inglewood - Warwick

This section of track is a mixture of 22.4 km of upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard and 69.5 km of new Class 1 track. The works include the following:

- Track length 91.9 km
- 7.6 km of track in flat terrain
- 21.8 km of track in undulating terrain
- 31.0 km of track in rolling terrain
- 9.0 km of track in hilly terrain
- 0.1 km of track in mountainous terrain
- 3 off dry creek crossings, 35 m long
- 21 off culverts
- 13 off grade separations
- 33 off level crossings
- 61.8 km of stock fencing
- 0.2 km of residential acoustic barriers and security fencing
- 14.5 km of security fencing

D11A Warwick - Clifton

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 33.7 km
- 2 off dry creek crossings, 75 m long
- 1 off dry creek crossing, 175 m long
- 8 off culverts
- 3 off grade separations
- 7 off level crossings
- 27.4 km of stock fencing
- 6.3 km of security fencing

D11B Warwick - Clifton

This section of track is new and involves the following works:

- Track length 32.0 km
- 14.8 km of track in flat terrain
- 9.4 km of track in undulating terrain
- 7.5 km of track in rolling terrain
- 0.3 km of track in hilly terrain
- 1 off dry creek crossing, 175 m long
- 6 off culverts
- 6 off grade separations
- 17 off level crossings
- 28 km of stock fencing
- 4.0 km of security fencing

D12A Clifton – Watts

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 24.1 km
- 1 off dry creek crossings, 75 m long
- 6 off culverts
- 1 off grade separation
- 6 off level crossings
- 0.5 km of stock fencing
- 23.6 km of security fencing

D12B Clifton - Watts

This section of track is new and involves the following works:

- Track length 22.9 km
- 7.8 km of track in flat terrain
- 7.3 km of track in undulating terrain
- 5.7 km of track in rolling terrain
- 1.6 km of track in hilly terrain
- 0.5 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 5 off culverts
- 2 off grade separations
- 7 off level crossings
- 7.2 km of stock fencing
- 15.7 km of security fencing

D13A Watts - Wyreema

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 11.3 km
- 1 off culvert
- 1 off grade separation
- 1 off level crossing
- 0.4 km of stock fencing
- 10.9 km of security fencing

D14C Cecilvale - Yargullen

This section of track is new and involves the following works:

- Track length 31.3 km
- 7.6 km of track in flat terrain
- 10.8 km of track in undulating terrain
- 9.8 km of track in rolling terrain
- 2.5 km of track in hilly terrain
- 0.6 km of track in mountainous terrain
- 2 off dry creek crossings, 35 m long
- 11 off culverts
- 6 off grade separations
- 9 off level crossings
- 30.4 km of stock fencing
- 0.9 km of security fencing

D15A Yargullen - Oakey

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 18.5 km
- 2 off dry creek crossing, 75 m long
- 1 off culvert
- 4 off grade separations
- 7 off level crossings
- 16.7 km of stock fencing
- 1.8 km of residential acoustic barriers and security fencing

D15C Yargullen - Oakey

This section of track is new and involves the following works:

- Track length 14.4 km
- 4.0 km of track in flat terrain
- 4.5 km of track in undulating terrain
- 5.6 km of track in rolling terrain
- 0.3 km of track in hilly terrain
- 2 off dry creek crossings, 35 m long
- 3 off grade separations
- 5 off level crossings
- 14.4 km of stock fencing

D16A Oakey - Gowrie

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 11.6 km
- 1 off dry creek crossing, 35 m long
- 2 off culverts
- 1 off grade separation
- 1 off level crossing
- 11.0 km of stock fencing
- 0.5 km of residential acoustic barriers and security fencing

D16B Oakey - Gowrie

This section of track is new and involves the following works:

- Track length 11.6 km
- 4.0 km of track in flat terrain
- 5.0 km of track in undulating terrain
- 2.6 km of track in rolling terrain
- 1 off dry creek crossing, 35 m long
- 2 off culverts
- 1 off grade separation
- 1 off level crossing
- 11.3 km of stock fencing
- 0.3 km of residential acoustic barriers and security fencing

D17C Wyreema West - Gowrie

This section of track is new and involves the following works:

- Track length 20.1 km
- 3.6 km of track in flat terrain
- 9.5 km of track in undulating terrain
- 6.6 km of track in rolling terrain
- 0.4 km of track in hilly terrain
- 6 off culverts
- 3 off grade separations
- 11 off level crossings
- 17.5 km of stock fencing
- 2.6 km of security fencing

D18A Cecilvale - Wyreema

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 36.7 km
- 6 off culverts
- 7 off grade separations
- 21 off level crossings
- 32.7 km of stock fencing
- 0.7 km of residential acoustic barriers and security fencing
- 3.3 km of security fencing

D19C Watts - Wyreema West

This section of track is new and involves the following works:

- Track length 14.1 km
- 2.1 km of track in flat terrain
- 6.7 km of track in undulating terrain
- 4.9 km of track in rolling terrain
- 0.4 km of track in hilly terrain
- 1 off dry creek crossing, 35 m long
- 1 off culvert
- 3 off grade separations
- 6 off level crossings
- 12.7 km of stock fencing
- 1.4 km of security fencing

D20A Wyreema - Toowoomba

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 18.5 km
- 6 off culverts
- 4 off grade separations
- 17 off level crossings
- 0.5 km of stock fencing
- 18.0 km of security fencing

D21A Gowrie - Toowoomba

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 11.5 km
- 2 off culverts
- 10 off level crossings
- 2.6 km of stock fencing
- 8.9 km of security fencing

D22A Toowoomba - Gatton

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 64.1 km
- 2 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 175 m long
- 17 off culverts
- 3 off grade separations
- 24 off level crossings
- 40.1k m of stock fencing
- 24.0 km of security fencing

D23C Clifton - Gatton

This section of track is new and involves the following works:

- Track length 67.5 km
- 17.3 km of track in flat terrain
- 7.8 km of track in undulating terrain
- 7.6 km of track in rolling terrain
- 5.2 km of track in hilly terrain
- 6.1 km of track in mountainous terrain
- 2 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 7 off culverts
- 3 off grade separations
- 27 off level crossings
- 12 km of tunnels
- 11.5 km of viaducts
- 41.8 km of stock fencing
- 1.4 km of residential acoustic barriers and security fencing
- 0.8 km of security fencing

D24C Gowrie - Gatton

This section of track is new and involves the following works:

- Track length 40.5 km
- 4.1 km of track in flat terrain
- 6.3 km of track in undulating terrain
- 9.7 km of track in rolling terrain
- 6.9 km of track in hilly terrain
- 6.7 km of track in mountainous terrain
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 13 off culverts
- 2 off grade separations
- 24 off level crossings
- 6.5 km of tunnels
- 0.3 km of viaducts
- 25.2 km of stock fencing
- 4.3 km of residential acoustic barriers and security fencing
- 4.2 km of security fencing

D25A Gatton - Grandchester

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 33.3 km
- 3 off dry creek crossings, 35 m long
- 4 off culverts
- 4 off grade separations
- 8 off level crossings
- 4.9 km of stock fencing
- 28.4 km of security fencing

D25C Gatton - Grandchester

This section of track is new and involves the following works:

- Track length 28.8 km
- 17.0 km of track in flat terrain
- 4.3 km of track in undulating terrain
- 2.4 km of track in rolling terrain
- 2.4 km of track in hilly terrain
- 1.6 km of track in mountainous terrain
- 2 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 5 off culverts
- 5 off grade separations
- 18 off level crossings
- 1.1km of tunnels
- 18.9 km of stock fencing
- 0.2 km of residential acoustic barriers and security fencing
- 8.6 km of security fencing

D26C Grandchester - Kagaru

This section of track is new and involves the following works:

- Track length 56.2 km
- 18.2 km of track in flat terrain
- 12.2 km of track in undulating terrain
- 13.4 km of track in rolling terrain
- 8.6 km of track in hilly terrain
- 2.0 km of track in mountainous terrain
- 1 off water crossing, 275 m long
- 4 off dry creek crossings, 35 m long
- 2 off dry creek crossings, 75 m long
- 20 off culverts
- 3 off grade separations
- 39 off level crossings
- 1.8 km of tunnels
- 47.6 km of stock fencing
- 6.8 km of security fencing

D27A Grandchester – Port Brisbane

This section of track is an upgrade from narrow gauge to dual gauge comprising narrow and Class 1 standard. The upgrade works include the following:

- Track length 83.7 km
- 1 off water crossing, 275 m long
- 4 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 17 off culverts
- 21 off grade separations
- 53 off level crossings
- 1.7k m of stock fencing
- 81.6 km of security fencing

D28A Kagaru – Acacia Ridge

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 34.3 km

D29A Bromleton - Kagaru

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 11.5 km

D30A Tamrookum - Bromelton

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 19.6 km

D31A Rathdowney - Tamrookum

This section of track is an existing Class 1 track and therefore no upgrading is required.

- Track length 11.8 km

D31b Rathdowney - Tamrookum

This section of track is a mixture of 7.1 km of existing Class 1 track and 4.4 km of new track involving the following works:

- Track length 11.5 km
- 0.2 km of track in undulating terrain
- 1.5 km of track in rolling terrain
- 1.1 km of track in hilly terrain
- 1.6 km of track in mountainous terrain
- 1 off grade separation
- 2 off level crossings
- 2.9 km of stock fencing
- 1.5 km of security fencing

D32C1 Warwick - Rathdowney

This section of track is new and involves the following works:

- Track length 133.6 km
- 20.3 km of track in flat terrain
- 10.7 km of track in undulating terrain
- 21.3 km of track in rolling terrain
- 20.1 km of track in hilly terrain
- 17.2 km of track in mountainous terrain
- 2 off water crossings, 35 m long
- 1 off water crossing, 75 m long
- 2 off water crossings, 150 m long
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 32 off culverts
- 17 off grade separations
- 44 off level crossings
- 14.6 km of tunnels
- 29.4 km of viaducts
- 88.6 km of stock fencing
- 1.0 km of security fencing

D32C2 Warwick - Rathdowney

This section of track is new and involves the following works:

- Track length 177.0 km
- 20.2 km of track in flat terrain
- 15.2 km of track in undulating terrain
- 27.6 km of track in rolling terrain
- 31.6 km of track in hilly terrain
- 32.5 km of track in mountainous terrain
- 2 off water crossings, 75 m long
- 2 off water crossings, 150 m long
- 4 off dry creek crossings, 35 m long
- 2 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 43 off culverts
- 14 off grade separations
- 52 off level crossings
- 24.4 km of tunnels
- 25.5 km of viaducts
- 125.7 km of stock fencing
- 1.4 km of security fencing

D33C1 Warwick - Tamrookum

This section of track is new and involves the following works:

- Track length 126.7 km
- 11.7 km of track in flat terrain
- 5.4 km of track in undulating terrain
- 21.7 km of track in rolling terrain
- 28.3 km of track in hilly terrain
- 22.4 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 36 off culverts
- 8 off grade separations
- 22 off level crossings
- 11.2 km of tunnels
- 26.0 km of viaducts
- 83.5 km of stock fencing
- 6.0 km of security fencing

D33C2 Warwick - Tamrookum

This section of track is new and involves the following works:

- Track length 145.6 km
- 12.1 km of track in flat terrain
- 5.9 km of track in undulating terrain
- 25.3 km of track in rolling terrain
- 32.7 km of track in hilly terrain
- 27.8 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 38 off culverts
- 8 off grade separations
- 22 off level crossings
- 19.5 km of tunnels
- 22.3 km of viaducts
- 95.5 km of stock fencing
- 8.3 km of security fencing

D33C3 Warwick - Tamrookum

This section of track is new and involves the following works:

- Track length 145.1 km
- 12.4 km of track in flat terrain
- 6.6 km of track in undulating terrain
- 24.1 km of track in rolling terrain
- 32.6 km of track in hilly terrain
- 26.3 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 35 off culverts
- 7 off grade separations
- 21 off level crossings
- 18.1 km of tunnels
- 25.0 km of viaducts
- 94.6 km of stock fencing
- 7.4 km of security fencing

D33C4 Warwick - Tamrookum

This section of track is new and involves the following works:

- Track length 134.8 km
- 11.7 km of track in flat terrain
- 5.7 km of track in undulating terrain
- 23.1 km of track in rolling terrain
- 33.2 km of track in hilly terrain
- 23.8 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 37 off culverts
- 7 off grade separations
- 21 off level crossings
- 15.1 km of tunnels
- 22.2 km of viaducts
- 91.5 km of stock fencing
- 6.0 km of security fencing

D33C5 Warwick - Tamrookum

This section of track is new and involves the following works:

- Track length 123.7 km
- 12.4 km of track in flat terrain
- 5.2 km of track in undulating terrain
- 24.0 km of track in rolling terrain
- 34.0 km of track in hilly terrain
- 20.6 km of track in mountainous terrain
- 2 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 175 m long
- 26 off culverts
- 9 off grade separations
- 22 off level crossings
- 12.5 km of tunnels
- 14.0 km of viaducts
- 122.9 km of stock fencing
- 0.8 km of security fencing

D34C1 Warwick - Bromelton

This section of track is new and involves the following works:

- Track length 137.3 km
- 11.6 km of track in flat terrain
- 5.9 km of track in undulating terrain
- 25.7 km of track in rolling terrain
- 33.3 km of track in hilly terrain
- 28.4 km of track in mountainous terrain
- 3 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 39 off culverts
- 9 off grade separations
- 34 off level crossings
- 12.6 km of tunnels
- 19.8 km of viaducts
- 131.0 km of stock fencing
- 6.3 km of security fencing

D34C2 Warwick - Bromelton

This section of track is new and involves the following works:

- Track length 156.1 km
- 11.9 km of track in flat terrain
- 6.4 km of track in undulating terrain
- 28.6 km of track in rolling terrain
- 36.0 km of track in hilly terrain
- 32.0 km of track in mountainous terrain
- 1 off water crossing, 35 m long
- 3 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 42 off culverts
- 9 off grade separations
- 34 off level crossings
- 23.5 km of tunnels
- 17.7 km of viaducts
- 106.3 km of stock fencing
- 8.6 km of security fencing

D34C3 Warwick - Bromelton

This section of track is new and involves the following works:

- Track length 155.6 km
- 12.3 km of track in flat terrain
- 7.1 km of track in undulating terrain
- 26.6 km of track in rolling terrain
- 35.4 km of track in hilly terrain
- 32.0 km of track in mountainous terrain
- 3 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 39 off culverts
- 8 off grade separations
- 34 off level crossings
- 22.9 km of tunnels
- 19.3 km of viaducts
- 105.6 km of stock fencing
- 7.8 km of security fencing

D34C4 Warwick - Bromelton

This section of track is new and involves the following works:

- Track length 145.3 km
- 11.5 km of track in flat terrain
- 6.3 km of track in undulating terrain
- 26.7 km of track in rolling terrain
- 35.3 km of track in hilly terrain
- 29.4 km of track in mountainous terrain
- 3 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 75 m long
- 1 off dry creek crossing, 175 m long
- 41 off culverts
- 8 off grade separations
- 34 off level crossings
- 19.3 km of tunnels
- 16.8 km of viaducts
- 102.9 km of stock fencing
- 6.3 km of security fencing

D34C5 Warwick - Bromelton

This section of track is new and involves the following works:

- Track length 134.2 km
- 12.1 km of track in flat terrain
- 5.6 km of track in undulating terrain
- 27.6 km of track in rolling terrain
- 35.0 km of track in hilly terrain
- 25.9 km of track in mountainous terrain
- 3 off dry creek crossings, 35 m long
- 1 off dry creek crossing, 175 m long
- 29 off culverts
- 10 off grade separations
- 33 off level crossings
- 15.9 km of tunnels
- 12.1 km of viaducts
- 105.0 km of stock fencing
- 1.2 km of security fencing

G01 Narrandera - Temora Junction

This section of track is new and involves the following works:

- Track length 104.2 km
- 53.0 km of track in flat terrain
- 33.0 km of track in undulating terrain
- 17.4 km of track in rolling terrain
- 0.8 km of track in hilly terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 11 off culverts
- 4 off grade separations
- 63 off level crossings
- 101.0 km of stock fencing
- 3.2 km residential acoustic barriers and security fencing

G02 Narrandera - existing line north of Caragabal (direct)

This section of track is new and involves the following works:

- Track length 172.4 km
- 126.5 km of track in flat terrain
- 28.0 km of track in undulating terrain
- 14.6 km of track in rolling terrain
- 3.3 km of track in hilly terrain
- 3 off dry creek crossings, 35 m long
- 3 off dry creek crossings, 75 m long
- 1 off dry creek crossing, 175 m long
- 22 off culverts
- 5 off grade separations
- 81 off level crossings
- 169.2 km of stock fencing
- 3.2 km residential acoustic barriers and security fencing

G03 Near Gilgandra - Narrabri

This section of track is new and involves the following works:

- Track length 257.0 km
- 7.2 km of floodplains
- 230.6 km of track in flat terrain
- 24.5 km of track in undulating terrain
- 1.6 km of track in rolling terrain
- 1 off water crossing, 27 5m long
- 12 off dry creek crossings, 35 m long
- 6 off dry creek crossings, 75 m long
- 2 off dry creek crossing, 175 m long
- 64 off culverts
- 4 off grade separations
- 105 off level crossings
- 256.7 km of stock fencing
- 0.3 km of security fencing

G04 Temora Junction North - existing near Caragabal

This section of track is new and involves the following works:

- Track length 65.9 km
- 50.1 km of track in flat terrain
- 8.0 km of track in undulating terrain
- 7.0 km of track in rolling terrain
- 0.5 km of track in hilly terrain
- 0.3 km of track in mountainous terrain
- 4 off dry creek crossings, 35 m long
- 4 off dry creek crossing, 175 m long
- 30 off culverts
- 4 off grade separations
- 33 off level crossings
- 65.9 km of stock fencing

G05 Temora Junction East - existing near Wallendbeen

This section of track is new and involves the following works:

- Track length 54.1 km
- 19.7 km of track in flat terrain
- 16.7 km of track in undulating terrain
- 12.9 km of track in rolling terrain
- 3.0 km of track in hilly terrain
- 1.8 km of track in mountainous terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 31 off culverts
- 4 off grade separations
- 34 off level crossings
- 54.1 km of stock fencing

G06 Temora Junction South - existing near Wagga Wagga

This section of track is new and involves the following works:

- Track length 64.2 km
- 38.5 km of track in flat terrain
- 19.1 km of track in undulating terrain
- 6.6 km of track in rolling terrain
- 1 off dry creek crossing, 35 m long
- 1 off dry creek crossing, 75 m long
- 19 off culverts
- 4 off grade separations
- 33 off level crossings
- 64.2 km of stock fencing

Appendix C

Preliminary volume analysis SD Contours V02

Appendix D

Summary of assumptions for structures

Grade separation minor assumptions

Bridge reference		Grade separation - minor
Type		Grade separation - minor
Rail/Road		Rail
No of Spans		2
Span Length		25.000 metres
Beams		Railcorp standard beams
Wet/Dry		Wet
Span Details		
	2	Number of spans
	25.000	m Span centreline to centreline
	2.000	m Total deck thickness TOR to soffit
	6.200	m Bridge width internal barrier to barrier
	8.100	m Skew length
General Site Details		
	1.75	km Laydown area to bridge site distance
	20.00	m Right of way each side
Levels		
	47.000	OGL Abutment A
	48.000	OGL Abutment B
	47.500	OGL Pier pile cap (average)
	53.162	Top of rail level
	35.000	Pile toe level Abutment
	35.000	Pile toe level Pier
Earthwork Details		
	1.30	Earthworks bulking factor
	1.60	tonnes per cum earthworks density
	600	m earthworks distance to spoil on site
	2	km earthworks distance to tip off site
	15	km/h truck speed to spoil onsite
	30	km/h truck speed to tip offsite
	2.0	Batter ratio h:1vertical abutment face
Pile Details		
	0.900	m pile diameter
	7.000	No piles each abutment
	3.000	No piles each pier pilecap
	1.500	m Excavation below pile liners
Abutment Details		

Bridge reference		Grade separation - minor
	1.250	m Abutment face wall thickness
	0.300	m Abutment stub wall thickness
	0.500	m Abutment wingwall thickness
	1.500	m Abutment groundbeam height
	1.250	m Abutment groundbeam width
Pier Details		
	1.250	m Pier pilecap height
	1.250	m Pier pilecap width
Headstock Details		
	1.250	m Headstock depth
	1.250	m Headstock width
Deck Details		
	0.200	m Concrete deck slab thickness
Relieving Slab Details		
	4.000	m Relieving slab length
	0.400	m Relieving slab thickness
Precast Beam Details		
	1.300	m PCC beam depth
	2.483	tonnes per cu m
	0.596	m PCC beam width
	6	number of ties per span
Reinforcement Details		
	0.225	tonnes reinforcement per cu m of concrete piles
	0.225	tonnes reinforcement per cu m of concrete abutment wall
	0.225	tonnes reinforcement per cu m of concrete abutment wingwall
	0.225	tonnes reinforcement per cu m of concrete pilecap/groundbeam
	0.225	tonnes reinforcement per cu m of concrete pier above pilecap/groundbeam
	0.225	tonnes reinforcement per cu m of concrete headstock
	0.175	tonnes reinforcement per cu m of concrete deck
	0.200	tonnes reinforcement per cu m of concrete relieving slab
Cable Containment Details		
	8	number of ducts in cable containment (combined)
	0.700	m Cable containment (combined) depth
	1.000	m Cable containment (combined) width
	2	number of ducts in cable containment (power)
	0.700	m Cable containment (power) depth
	0.700	m Cable containment (power) width
Traffic Barrier Details		
	2	No of traffic barriers

Bridge reference		Grade separation - minor
	0.600	m Traffic barrier width
Cofferdam Details		
	15.000	m Sheet pile length (temporary)
	3.000	m distance sheetpile to pilecap face
	12	Weeks per pilecap pump time

Bridge type 1_5 assumptions

Bridge reference		Water crossing, bridge classification 1_5
Type		T3
Rail/Road		Rail
No of Spans		16
Span Length		25.000 metres
Beams		T Roff (precast concrete T beams)
Wet/Dry		Wet
Span Details		
	16	Number of spans
	25.000	m Span centreline to centreline
	2.500	m Total Deck thickness TOR to underside of bearing
	6.200	m Bridge width internal barrier to barrier
	8.100	m Skew length
General Site Details		
	1.75	km laydown area to bridge site distance
	20.00	m Right of way each side
Levels		
	47.000	OGL Abutment A
	48.000	OGL Abutment B
	44.500	OGL pier pile cap (average)
	53.162	Top of rail level
	35.000	Pile toe level abutment
	35.000	Pile toe level pier
Earthwork Details		
	1.30	Earthworks bulking factor
	1.60	tonnes per cum earthworks density
	600	m earthworks distance to spoil on site
	2	km earthworks distance to tip off site
	15	km/h truck speed to spoil onsite
	30	km/h truck speed to tip offsite
	2.0	Batter ratio h:1vertical abutment face
Pile Details		

Bridge reference		Water crossing, bridge classification 1_5
	0.900	m pile diameter
	7.000	No piles each abutment
	3.000	No piles each pier pilecap
	1.500	m Excavation below pile liners
Abutment Details		
	1.250	m Abutment face wall thickness
	0.300	m Abutment stub wall thickness
	0.500	m Abutment wingwall thickness
	1.500	m Abutment groundbeam height
	1.250	m Abutment groundbeam width
Pier Details		
	1.250	m Pier pilecap height
	1.250	m Pier pilecap width
Headstock Details		
	1.250	m Headstock depth
	1.250	m Headstock width
Deck Details		
	0.200	m Concrete deck slab thickness
Relieving Slab Details		
	4.000	m Relieving slab length
	0.400	m Relieving slab thickness
Precast TRoff Details		
	1.500	m PCC T Roff depth
	1.423	tonnes per m (type T4)
	2	m PCC beam width
	0	number of ties per span
Reinforcement Details		
	0.225	tonnes reinforcement per cu m of concrete piles
	0.225	tonnes reinforcement per cu m of concrete abutment wall
	0.225	tonnes reinforcement per cu m of concrete abutment wingwall
	0.225	tonnes reinforcement per cu m of concrete pilecap/groundbeam
	0.225	tonnes reinforcement per cu m of concrete pier above Pilecap/Groundbeam
	0.225	tonnes reinforcement per cu m of concrete headstock
	0.175	tonnes reinforcement per cu m of concrete deck
	0.200	tonnes reinforcement per cu m of concrete relieving slab
Cable Containment Details		
	8	number of ducts in cable containment (combined)
	0.700	m Cable containment (combined) depth
	1.000	m Cable containment (combined) width

Bridge reference		Water crossing, bridge classification 1_5
	2	number of ducts in cable containment (power)
	0.700	m Cable containment (power) depth
	0.700	m Cable containment (power) width
Traffic Barrier Details		
	2	No of traffic barriers
	0.600	m Traffic barrier width
Cofferdam Details		
	15.000	m Sheet pile length (temporary)
	3	m distance sheetpile to pilecap face
	12.000	Weeks per pilecap pump time

Bridge classification 1_4 assumptions

Bridge reference		Water crossing, classification 1_4
Type		T[illegible]
Rail/Road		Rail
No of Spans		8
Span Length		38.350 metres
Beams		Box girder
Wet/Dry		Wet
Span Details		
	8	Number of spans
	38.350	m Span centreline to centreline **(Check PCB Rates updated)**
	4.000	m Total deck thickness TOR to underside of bearing
	6.200	m Bridge width (deck)
	8.100	m Skew length
General Site Details		
	1.75	km laydown area to bridge site distance
	20.00	m Right of way each side
Levels		
	47.000	OGL Abutment A
	47.000	OGL Abutment B
	42.500	OGL Pier pile cap (average)
	54.000	Top of rail level
	27.000	Pile toe level abutment
	20.000	Pile toe level pier
Earthwork Details		
	1.30	Earthworks bulking factor
	1.60	tonnes per cum earthworks density

Bridge reference		Water crossing, classification 1_4
	600	m earthworks distance to spoil on site
	2	km earthworks distance to tip off site
	15	km/h truck speed to spoil onsite
	30	km/h truck speed to tip offsite
	2.0	Batter ratio h:1vertical abutment face
Pile Details		
	1.200	m pile diameter
	11.000	No piles each abutment
	6.000	No piles each pier pilecap
	1.500	m Excavation below pile liners
Abutment Details		
	1.500	m Abutment facewall thickness
	6.200	m Abutment facewall and groundbeam length
	0.500	m Abutment stub wall thickness
	0.500	m Abutment wingwall thickness
	2.500	m Abutment groundbeam height
	4.000	m Abutment groundbeam width
Pier Details		
	2.500	m Pier pilecap height
	3.000	m Pier pilecap width
	6.200	m Pier pilecap length
	2.000	m Pier width
	4.000	m Pier length
Box Girder		
	12.273	tonnes per m of box girder
Relieving Slab Details		
	6.000	m Relieving slab length
	0.400	m Relieving slab thickness
Reinforcement Details		
	0.225	tonnes reinforcement per cu m of concrete piles
	0.225	tonnes reinforcement per cu m of concrete abutment wall
	0.225	tonnes reinforcement per cu m of concrete abutment wingwall
	0.225	tonnes reinforcement per cu m of concrete pilecap/groundbeam
	0.225	tonnes reinforcement per cu m of concrete pier above pilecap/groundbeam
	0.200	tonnes reinforcement per cu m of concrete relieving slab
Cable Containment Details		
	8	number of ducts in cable containment (combined)
	0.700	m Cable containment (combined) depth
	1.000	m Cable containment (combined) width

Bridge reference		Water crossing, classification 1_4
	2	number of ducts in cable containment (power)
	0.700	m Cable containment (power) depth
	0.700	m Cable containment (power) width
Traffic Barrier Details		
	2	No of traffic barriers
	0.600	m Traffic barrier width
Cofferdam Details		
	15.000	m Sheet pile length (temporary)
	3	m distance sheetpile to pilecap face
	12.000	Weeks per pilecap pump time

Appendix E

Probabilistic risk estimating

Appendix E: Probabilistic risk estimating

Introduction

With the development of sophisticated risk management and analysis techniques, the process for estimating capital works projects has moved from the traditional approach of allowing an arbitrary sum of money for unforeseen circumstances in the budget to:

- risk identification and statistical analysis of the risks pertaining to each individual project; and
- the incorporation of that risk analysis into the budget .

The statistical analysis produces the budget both numerically and graphically with resultant confidence intervals produced where indicative confidence levels can be ascertained which will inform the potential for cost overruns. It is generally referred to as probabilistic estimating.

Concept

A 'single figure' estimate is generally flawed in two aspects. The level of risk incorporated within the estimate is usually impossible to determine with any degree of accuracy and many risks will have been dealt with by exclusion. Also the extremes of 'worst case' risk exposure are unknown and cannot readily be determined. While this is not necessarily a problem for small or for straightforward projects, if the project is of a reasonable size, and/or exposes a significant level of risk then a 'risk estimate' is a better approach.

The outcome of a risk estimate is a series of figures linked to a confidence index, usually expressed in 10 percentile intervals of confidence, e.g. a P50 value for the estimate indicates that the project will have a fifty percent chance of costing this value or less. A P90 value might be considered to be the standard level for funding the project at this stage of a project and if there were a large difference between the P50 and the P90, this would indicate an unusual level of volatility in the model demonstrating an increased risk component and greater possibility that the costs may significantly exceed the estimate in a 'worst case' situation. We generally refer to the differences between the figures as the confidence intervals.

Typically the initial process of creating a risk estimate is similar to that of a normal estimate. It is important, however, that the estimator resist the temptation to 'load' their figures where they are uncertain of the cost. Where this occurs, this uncertainty should be flagged so that it can be dealt with later. The completed estimate should not include any contingency sums as these are best provided by the 'risk estimating' process. This estimate would then be coded to create a number of cost centres which can be assessed in terms of certainty. For example, any work involving modifications or upgrading the existing network will be kept separate from the main work.

The estimate in this format would be presented to a working group, in the case of large capital projects comprising designers, construction supervisors, estimators, environmental and legal experts as necessary and other specialists who could provide cost input. The values in the estimate would provide a 'most likely' value and the working group would discuss and reach a consensus agreement on the minimum and maximum possible values. These further values would represent the extremes of a bell curve of risk distribution.

A further exercise would be to consider Discrete of Event risk, i.e. those risks to the project that may or may not eventuate; from the team's point of view a generic list could be produced which would be ticked to show that the risks have been assessed accordingly. They are typically grouped under suitable headings such as:

- construction,
- contract,
- environment,
- community, etc.

These risks require an estimate of their likelihood of occurrence in percentage terms and their minimum, most likely and maximum values. The workshop should also consider the question of mitigation of these risks, the model being based on the remaining risk after all avenues of mitigation have been allowed for and added to the estimate if they incur a cost.

At this stage, a risk model has been constructed which closely resembles the actual project. To determine the likely outcomes it is necessary to run the model using Monte Carlo simulation over several thousand iterations or until convergence is achieved. A summary of these results will generate a bell curve of possible outcomes. In its cumulative format, this bell curve yields an ‘S’ curve with its maximum inclination about the centre of the curve. The probabilities are indicated on the X axis and the values on the Y axis. The contingency allowance is thus dependent upon the confidence level considered appropriate and typically a P80 contingency would be expressed as the difference between the base estimate cost and the P80 value.

It is important to remember that this process considers not only risk, but also opportunity and all participants should consider this aspect during the workshop.

A useful spin-off of this process is that of bringing together all stakeholders in the project and ‘brainstorming’ to identify the issues surrounding its construction. It is possible that issues which do not directly affect the cost of the project, but which will adversely affect the project may be identified during the workshop and these issues should be captured.

The timing of the risk estimating process is important. It is often most useful at a preliminary stage when there are still a great many uncertainties. At this stage, it will highlight the need for various aspects of the design to be modified to assist the construction process and avoid needless re-working later.

Application

The LTC’s probabilistic estimating is based on Monte Carlo simulation and @Risk software provides a suitable framework for a systematic and disciplined assessment of project risks that creates a more robust and reliable cost estimate.

The key to probability analysis is the development of a risk analysis model. The model used by the LTC includes variables affecting the outcome, taking into account the interrelationships and interdependence between the variables. Each risk variable in the model is expressed as a probability distribution. The model also permits assessment of risks at the desired level of detail and accuracy. This sometimes involves the breakdown of risk variables into their subcomponents to enable accurate assessment of the impact of risk on such subcomponents.

The LTC would either convert the cost models as a model for probabilistic cost estimating. The method to be used will depend on the information available and how easily it can be converted to useful data.

The probability analysis process prepared by the LTC using @Risk and Monte Carlo simulation would involve the following steps:

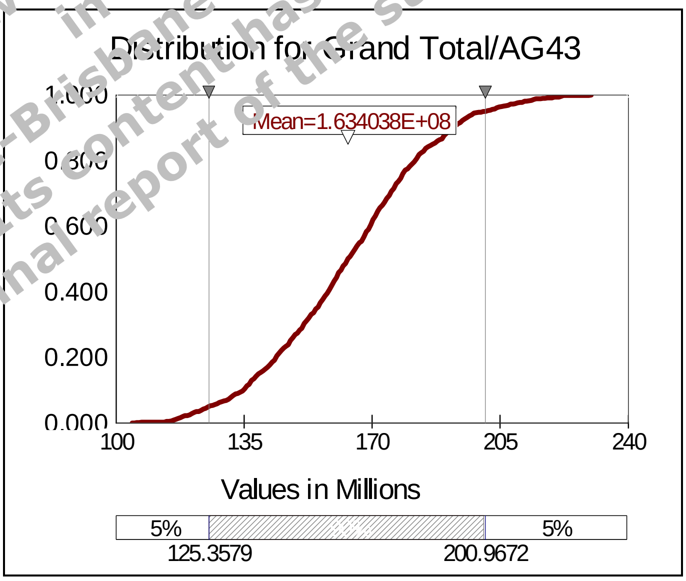
- Developing a risk analysis model;
- Eliciting data and assigning appropriate probability distributions to the identified risk variables;
- Selecting a random value from each of the probability distributions;
- Calculating the outcome by combining the random values generated;
- Repeating the last two steps a large number of times to obtain a large number of outcomes, which according to the Central Limit Theorem fall on a normal distribution curve;
- Calculating the measures of central tendency and dispersion of the normal output probability distribution; and
- Output is shown both statistically and graphically.

Presentation of results

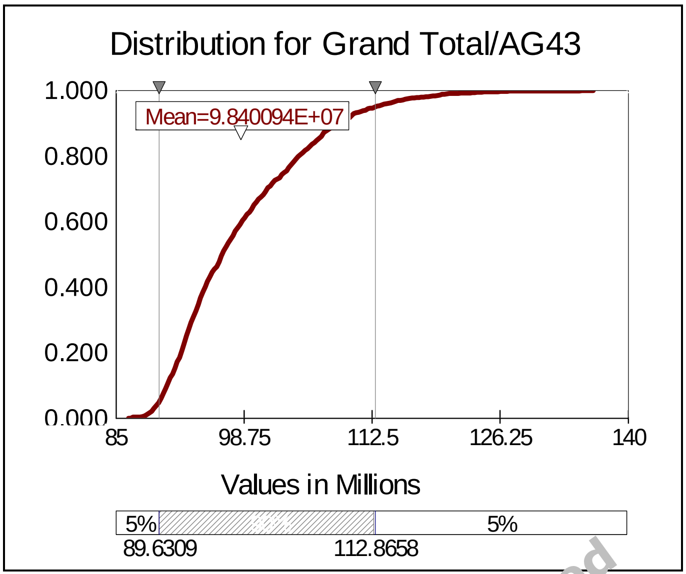
The presentation of results can range from quite detailed statistical analysis and associated graphs through to a simplified reporting structure showing key information with a histogram and 'S' curve graph.

We have included below two graphs from a generic project, representing 'S' curves at different stages of the project lifecycle. When the confidence levels reduce, the 'S' curves become steeper showing that the potential for cost overruns or underruns is reduced.

In the graph below, we have a relatively shallow 'S' curve at Feasibility stage, representing a larger variability in cost outcomes, e.g. 90% of the outcomes range between $125m to $201m.



In the second graph below, we have a relatively steep 'S' curve at Contract Award, representing a reduced variability in cost outcomes e.g. 90% of the outcomes now range between $90m to $113m.


Distribution for Grand Total/AG43
1.000
0.800
0.600
0.400
0.200
0.000
Mean=9.840094E+07
85
98.75
112.5
126.25
140
Values in Millions
5%
5%
89.6309
112.8658