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Australian Government

Department of Infrastructure, Transport, Regional Development & Local Government

Adelaide Rail Freight Movements Study

Final Report

June 2010

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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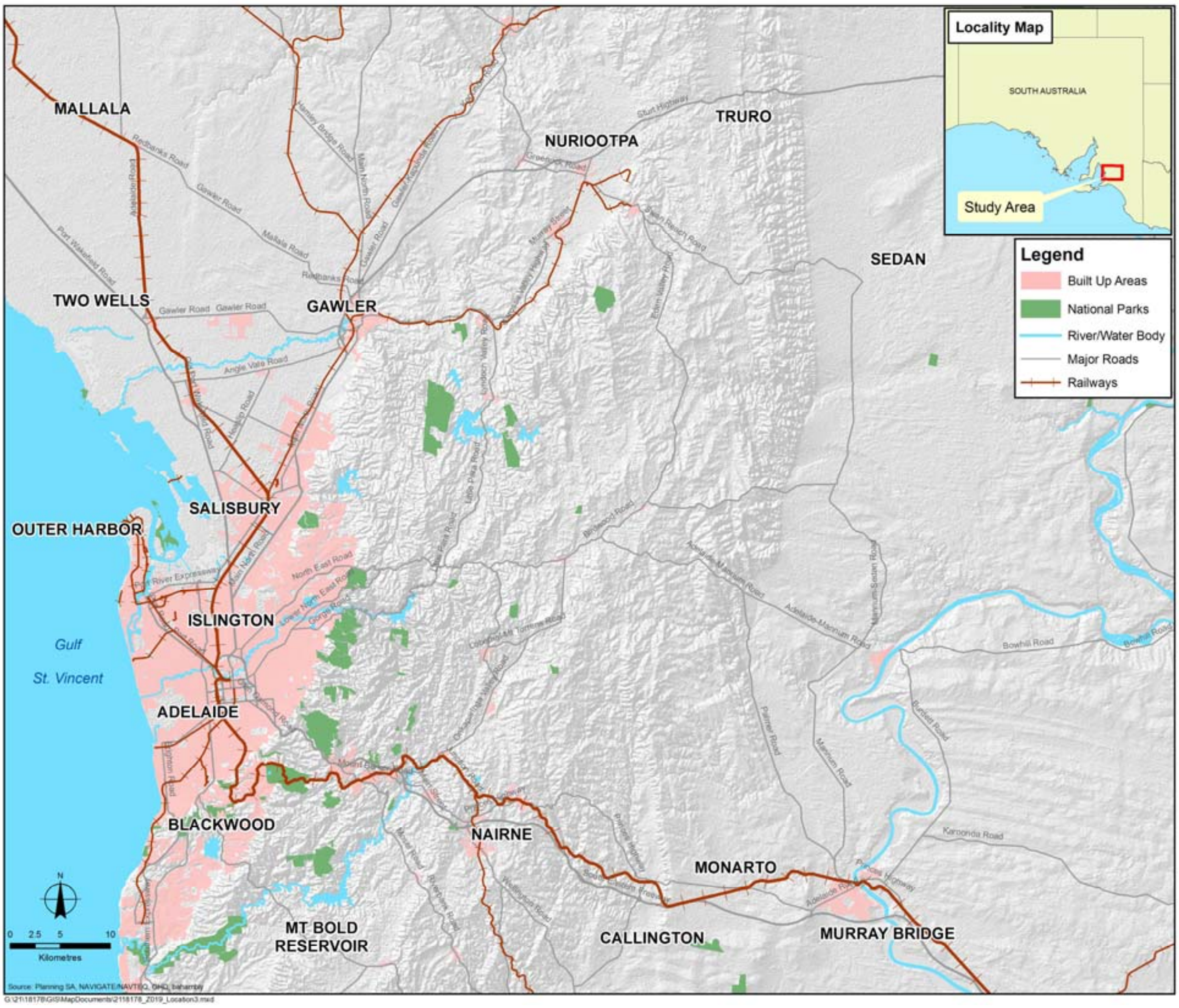
Executive Summary

Study Purpose and Background

The key purpose of the Study was to provide the Australian Government with a better understanding of the freight rail movements across the Adelaide region. Specifically, the Study was to determine how Adelaide's freight rail network can be made to work better, including assessing options of relocating the city's main freight line to the north of the Adelaide Hills. Refer to Appendix A for the Study Terms of Reference.

The Study was to analyse the current and future rail movements to, from and through Adelaide and determine the capacity of the existing line to meet these demands. Options which would ensure the future freight rail demand can be met were to be examined and the impact of the current rail line on the community was to be assessed. Figure 1 identifies the Study Area and existing rail line between Murray Bridge and Adelaide.

Figure 1: Melbourne – Adelaide rail route through the Adelaide Hills



Source: GHD, 2010

The Study

In addressing the specific Terms of Reference GHD has provided a series of investigations, designs, cost engineering and assessments that were managed in three phases as follows:

Phase One

In phase one, the existing Adelaide Hills line from Murray Bridge through the Adelaide Hills into Adelaide, including connections to the Port of Adelaide and intermodal terminals at Dry Creek and Islington was assessed from a rail operational and engineering design perspective. The environmental and social impacts were also considered. The assessment considered:

- Performance capability of the corridor and train operations requirements – existing and future constraints in terms of 1800 metre trains double-stacked, with appropriate speed and axle loading capability, speed, end-to-end journey times and rolling stock and gauge requirements.
- Connectivity with the Port of Adelaide and existing and proposed intermodal terminals.
- Interaction with the passenger rail network and road network.
- Safety issues.
- Environmental issues, including specifically noise levels through the Adelaide Hills (including wheel squeal).

Concurrently, the freight task was analysed to identify the volumes currently carried by the line and to forecast East-West freight task growth over the next 5, 10, 20 and 30 years. The analysis considered the frequency of freight trains, the origin and destination of the freight, the volume of freight moving along the corridors and the value of the freight moving along the corridors; and any significant developments that would have an impact on the freight task.

Phase Two

In phase two, the capacity of the existing Adelaide Hills line was assessed against the freight task forecasts and options were generated to satisfy the operational capacity requirements.

By using current ARTC track and civil design standards and operator accepted assumptions, five different alignment options were developed to meet the future freight demand. The aim of the options was to ensure the forecast growth in demand in the rail freight task could be met, taking into account the performance capability of the corridor. The options included strategies consisting of capital investment such as new alignments, maintenance options such as reducing cant deficiencies, and flow management options such as improved signalling technologies.

These options were then further examined against environmental and social community impacts and the alignments refined to meet planning requirements. The options were subjected to rigorous examination as well as risk evaluation in workshops with the Project Steering Committee (PSC) and Project Reference Group (PRG).

To support the rigour of the design and analysis, regular input was sought and gained from the PSC, consisting of the Department of Infrastructure, Transport, Regional Development and Local Government (DITRDLG) and the South Australia Department for Transport, Energy and Infrastructure (DTEI), and the PRG. The PRG representatives consisted of South Australian Local Government representatives, the Australian Rail Track Corporation (ARTC) and the Freight Rail Operators Group (FROG). Members of the PSC and PRG are listed in Appendix B.

Phase Three

In phase three, each option was subjected to a qualitative assessment as to how well the option achieved transport systems objectives, policies and strategies (strategic fit analysis[1]) and whether or not the option should proceed to the next stage of appraisal. This strategic fit analysis is the preliminary assessment of the relative economic, environmental and social performances of the alignment options against the transport system objectives, policies and strategies, along with any barriers to implementation. The results of the work performed were then incorporated into a Discussion Paper, which was issued for public comment and response.

The Discussion Paper was made available via the Department's website[2] on 12th October 2009. Submissions were invited from the public by 20th November 2009. These were to respond to a series of questions in a framework of issues on which the Study was seeking feedback. In total, 76 submissions were received from Local Government Councils, Regional Council Groups, Regional Development Boards, Community Associations, Rail Operators, Industry Associations, residents, individuals and community members.

Submissions received were considered against the strategic fit analysis framework and incorporated into the Study as appropriate.

Options which met the strategic fit conditions were subject to another element of the appraisal process which involved a review of the main benefits and costs - a rapid benefit cost analysis[3]. In this analysis the main benefits and costs as well as a high level risk assessment of the financial, engineering and environmental issues for the option was undertaken.

One option was rejected at the strategic fit analysis stage but the remaining four options were taken forward and the costs and benefits of these were compared against the Base Case (existing line/'do nothing' option).[4]

The Study Team regularly tested the validity of assumptions underlying the analysis. For example, whilst it is not possible to double-stack containers from Melbourne to Adelaide at present, the Study Team together with the PSC and PRG made the assumption that this would be possible in the future. The Study Team also verified assessment and design elements with the PSC and PRG throughout the process by conducting risk management workshops to consider and resolve risks associated with the freight demand, capacity analysis, design, and options identification.

Key Findings

The following key findings were identified:

- **Capacity and demand**

Based on the freight demand forecasts (discussed in Section 3) including ARTC's estimates and in light of the committed works on the corridor,[5] capacity is not likely to be a constraining factor until between

[1] The Strategic Merit Test which provides strategic fit analysis is described in detail in Part 5, Appraisal and Business Case, of the Australian Transport Council, National Guidelines for Transport System Management in Australia, 2006.

[2] Http://www.nationbuildingprogram.gov.au/projects/ProjectDetails.aspx?Project_id=RAIL002.

[3] The benefit cost analysis used in this Study was a rapid benefit cost analysis which is applied to options which pass the strategic merit test and warrant further consideration. The rapid benefit cost analysis is a project appraisal technique and is described in detail in National Guidelines for Transport System Management in Australia, Volume 3 – Appraisal of initiatives, Australian Transport Council, 2006.

[4] In project appraisal, the 'do nothing' option is often used to describe the Base Case or *status quo*. Rarely is it that the 'do nothing' equates to 'spend nothing' because it includes committed projects as well as those expenditures necessary to at least maintain the *status quo* in terms of level of service and system performance.

[5] The expectations with respect to capacity take account of capacity improvements expected to be generated by ARTC's planned upgrades of passing loops on the Melbourne to Adelaide line between June 2009 and December 2011. More detail on the program of works is provided in Section 6.1.1.

2025 and 2030. The current alignment can handle 10.7 million tonnes of freight per year, which is more than double the 4.8 million tonnes per year that is currently carried on the rail line.

Nevertheless, there are numerous characteristics of the Adelaide Hills section of the corridor, between Murray Bridge and Salisbury, that are a constraint on more efficient movement of freight. Steep grades and tight curves force trains to travel more slowly and to use 50% more locomotive power per tonne than on other interstate rail freight corridors. They also restrict trains to a maximum of 3500 tonnes (gross). The terrain of the Adelaide Hills causes greater locomotive and wagon 'wear and tear' and higher maintenance costs than would be incurred with a straighter, flatter alignment[6].

- **Social and environmental impact of the railway**

The Adelaide Hills track passes through six Local Government jurisdictions. As is the case for most Australian capital cities, the existing line runs through urban areas. In the case of Adelaide, this is for a distance of about 50 kilometres between Islington and Nairne where the line runs through the centre of, or backs onto, towns and residential properties.

The existing rail alignment was opened in January 1887 and as such was constructed at a time when the Adelaide Hills was only sparsely populated. Urban development has increasingly surrounded the corridor and has not always been subjected to planning controls for such development that prevail today.

Train noise was the most frequently mentioned issue in the public submissions to the Study, figuring in 42 (55%) of the submissions. Other social and environmental amenity issues raised in the submissions were the impacts of freight train operations on road traffic delays at level crossings[7], the risks to public safety including those associated with freight operations in terms of issues for evacuation in the case of a bush fire, and the generation of pollution. Eighty percent (39 of 49) of Discussion Paper submissions from the Local Government, residential and community submissions contend that the future growth of rail freight will exacerbate these concerns.

- **Appraisal of the options**

Four options ranging in estimated value from $0.7 billion to $3.2 billion were evaluated in terms of achieving strategic fit against project objectives including economic, social and environmental outcomes.

- **Community response**

There were 76 submissions received in response to the Discussion Paper. The Discussion Paper identified the options considered to be a strategic fit under a number of economic, social and environmental criteria. The options are shown in Figure 2.

Of these, 49 (64%) were submissions from community residents and Local Government organisations and focused on community needs. Twenty-seven (36%) submissions were from freight rail operators, infrastructure owners and universities focused on transport operational efficiency issues.

- **Benefit cost analysis**

The benefit cost analysis was conducted in order to inform strategic level decisions about indicative economic viability of the options to the existing rail alignment. It considered three types of costs and benefits of strategic importance: economic, social and environmental.

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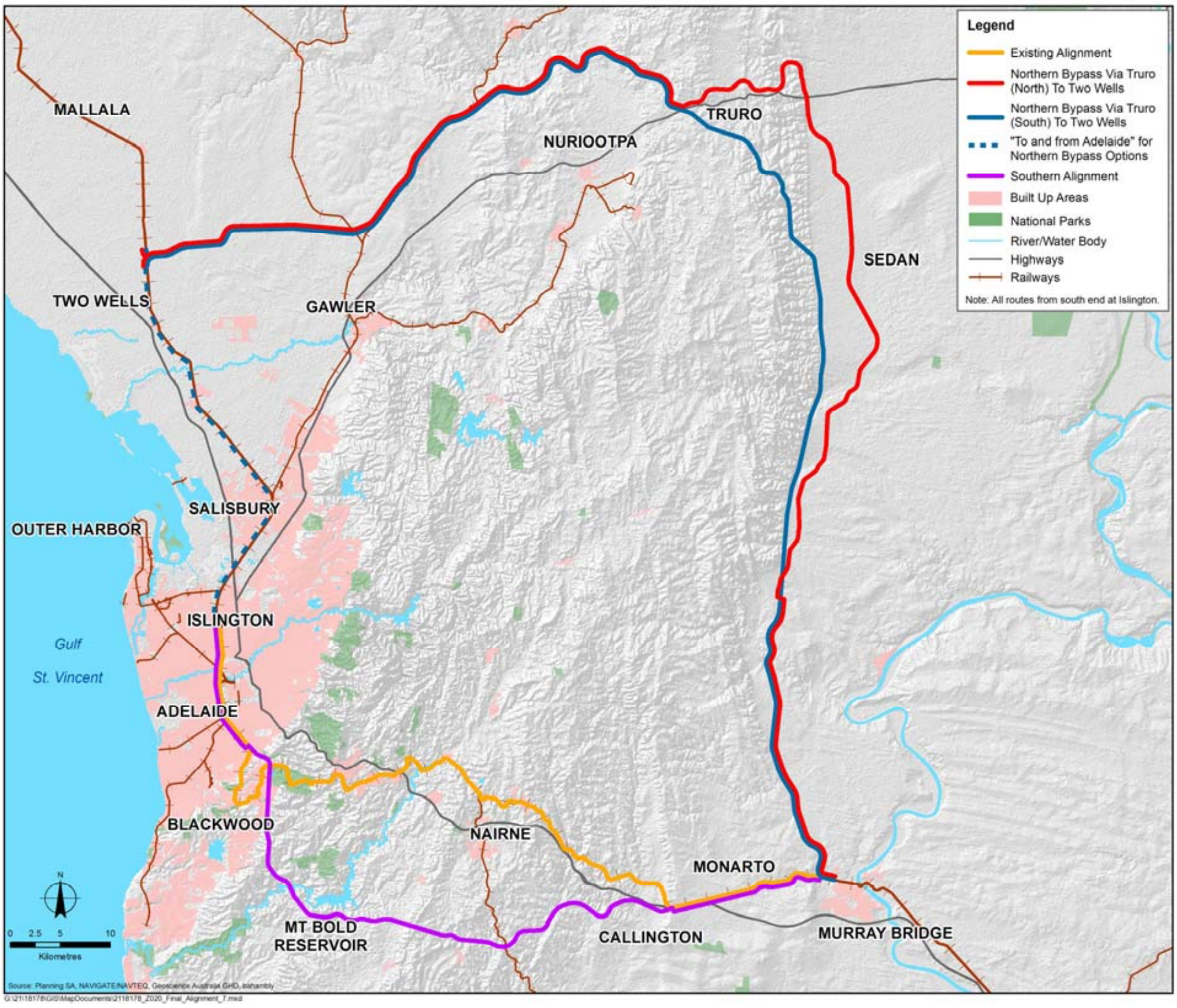
[6] Australian Rail Track Corporation (ARTC) 2005, Melbourne to Adelaide Corridor, Adelaide page 6.

[7] There are 41 level crossings along the rail line between Murray Bridge and Adelaide, which handle a total of about 135,000 vehicle movements per day.

Figure 2: The existing rail alignment and possible options



Source: GHD, 2010

Table 1 outlines the capital cost and net present value of the alternative options to the existing rail alignment. The net present value is the primary summary measure of economic viability of the options to the existing rail alignment, while capital costs play an important role in determining net present value.

Table 1: Summary of capital cost and net present value outcomes of the options

The Options	Description	
	Total undiscounted preliminary estimate of capital cost ($m)	Net present value ($m) based on most likely freight growth assumptions
Option 1: Upgrade Existing Adelaide Hills Alignment (orange route in Figure 2)	700	-470
Option 2: Northern Bypass via north of Truro (red route in Figure 2)	2,900	N/A
Option 3: Northern Bypass via south of Truro (blue route in Figure 2)	2,400	-1,633
Option 4: Southern Alignment (purple route in Figure 2)	3,000	-1,805
Option 5: Upgraded Existing (orange route in Figure 2) and Northern Bypass via south of Truro (blue route in Figure 2)	3,200	-2,145

Source: GHD, 2010

The conclusions of the benefit cost analysis were that:

– **Capital costs will outweigh benefits**

The economic evaluation indicates that the capital outlay[8] required to improve the existing rail line or construct a new line is far greater than the benefits derived from such an outlay. This is reflected in Table 1, where each option has a significant negative net present value compared to the Base Case. While there are benefits flowing to rail track managers, train operators and the communities that surround the rail line, the size of these benefits is modest and the size of the capital outlay required to generate such benefits is large, particularly in the new alignment options.

– **Operational benefits will be modest**

Each of the options will deliver operational efficiency benefits in terms of reduced 'below rail' costs, reduced land transport costs and reduced transit times The Southern Alignment (Option 4) provides the highest benefits of $190 million and Upgraded Existing Alignment (Option 1) generates the lowest operational benefits of $95 million over the Base Case, over the 30-year evaluation period.

– **Social benefits will be marginal**

The benefit cost analysis suggests that, at best, only modest social and environmental benefits will be achieved by upgrading the Existing Alignment or by building one of the proposed alternative alignments[9]. The Southern Alignment (Option 4) generates the highest social benefits — an estimated $14 million, and the Upgraded Existing Alignment (Option 1) generates benefits of less than $1 million relative to the Base Case over the 30-year evaluation period. Despite travelling through sparsely populated areas that

[8] The capital costs reflect the engineering standards adopted in the estimation process.

[9] In addressing some externality parameters a default needed to be adopted. A sensitivity analysis of these externalities is addressed in Section 6.

are much flatter than the Existing Alignment, the Northern Alignment that travels south of Truro to Two Wells (Option 3) would generate externality costs that are $39 million higher than the Base Case, largely because this alignment would be 90 kilometres longer than the Existing Alignment.

– **A change to the *status quo* will not deliver a net economic benefit**

Although all of the alignment options that were designed by the Study Team would be technically feasible, none were economically justifiable. Over the 30-year evaluation period (2009 to 2039), the combination of modest social and environmental benefits and the operational efficiency benefits are not high enough to outweigh the capital costs that would be required to build any of the alternative alignments or to upgrade the Existing Alignment. Therefore, there would be no net economic benefit compared to the Base Case in upgrading the existing rail line and/or constructing a new line. This is because all the options result in significant negative net present value outcomes relative to the Base Case.

Section 1
Introduction

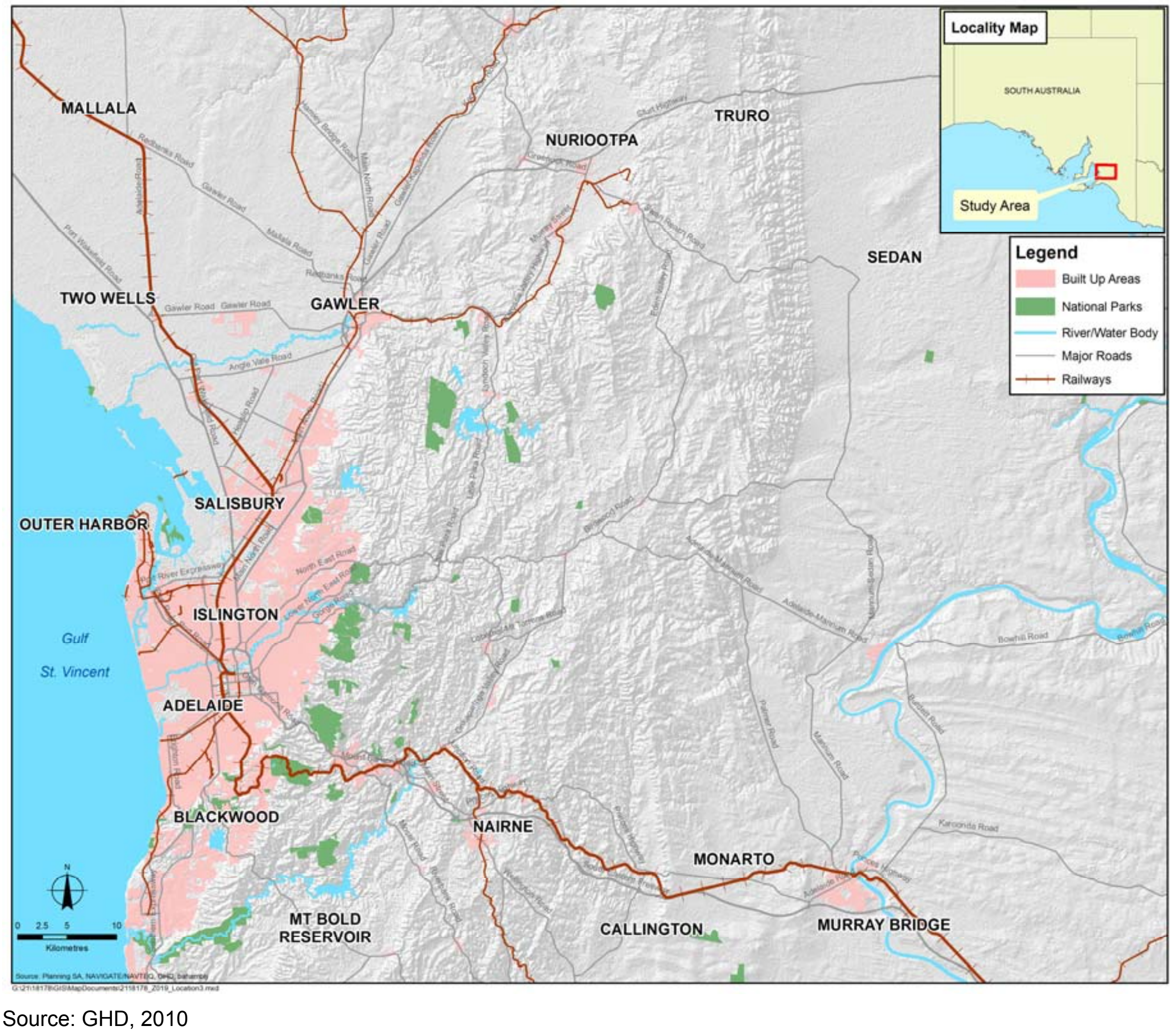
1. Introduction

1.1 Background

The Adelaide Hills rail alignment is part of the interstate freight rail corridor that connects Melbourne, Sydney and Brisbane with Adelaide, Perth and Darwin. The interstate track runs parallel to the urban passenger rail network from Belair to Salisbury. Although a well-used route, the characteristics of the Adelaide Hills section of the corridor, between Murray Bridge and Islington (see Figure 3), constrains the more efficient movement of freight between these key centres. Steep grades and tight curves force trains to travel more slowly, and to use 50% more locomotive power per tonne than on other interstate rail freight corridors. Trains are also restricted to a maximum of 3500 gross tonnes[10]. The terrain of the Adelaide Hills causes greater locomotive and wagon 'wear and tear' and higher maintenance costs than would be incurred in a straighter, flatter alignment[11]. As with other Australian capital cities, the Adelaide Hills freight rail line passes through residential areas.

In September 2008, the Australian Government announced the commencement of the Adelaide Rail Freight Movements Study. In early 2009, GHD was appointed to carry out the Study.

Figure 3: Melbourne-Adelaide rail route through the Adelaide Hills



Source: GHD, 2010

[10] This is for the current operations. Australian Rail Track Corporation (ARTC) is targeting 5000 gross tonnes for the entire network.

[11] ARTC 2005, Melbourne to Adelaide Corridor, Adelaide page 6.

1.2 Study Purpose and Scope

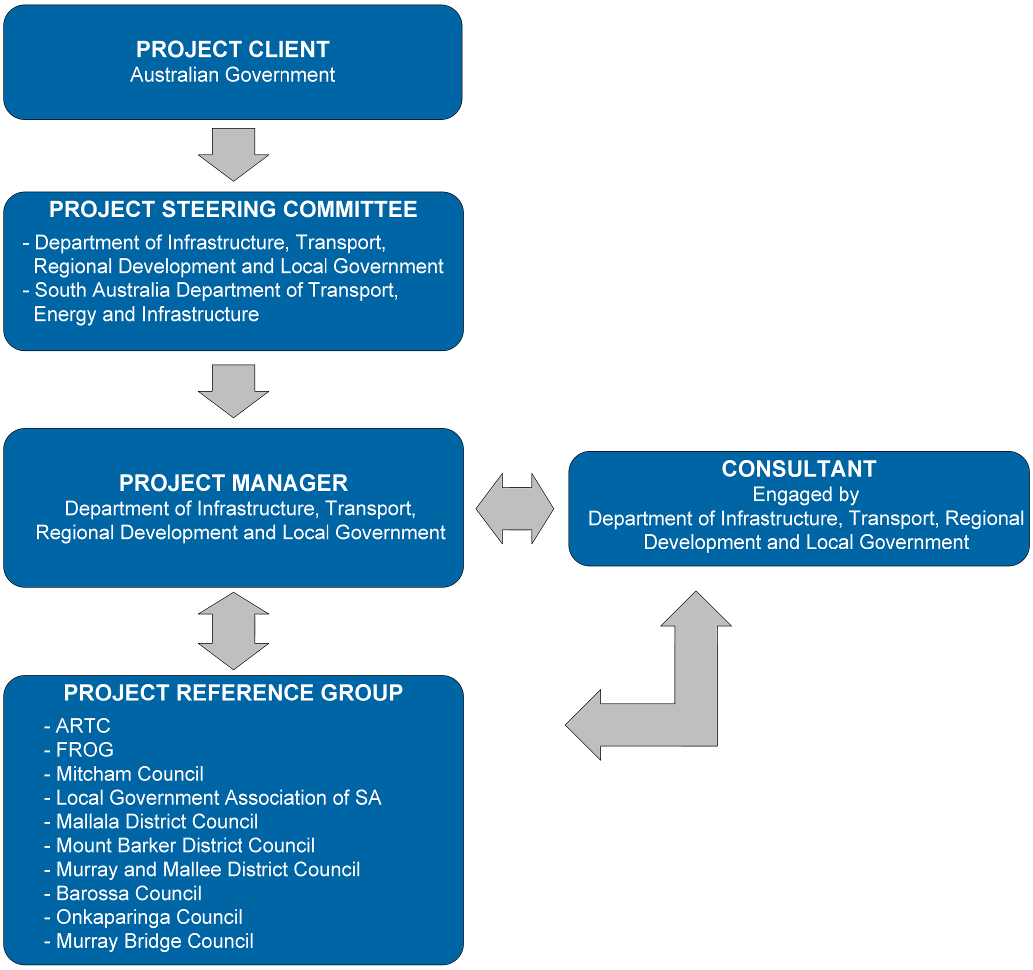
The key purpose of the Study was to examine the feasibility of improving the capacity and efficiency of the interstate freight rail line between Murray Bridge and Islington to meet current and future demand needs while also taking account of likely impacts on community amenity. The specific objectives of the Study Terms of Reference were to:

- *Provide an analysis of both current freight rail movements and the forecast growth in freight movements to and through Adelaide (this includes freight moving east and west).*
- *Provide an analysis of capacity of the line to meet this demand both now and in the future.*
- *Provide an analysis of the impact of the current alignment of the main interstate freight rail line on community amenity (economic, social and environmental impacts).*
- *Identify options to ensure the forecast growth in demand can be met along with an assessment of their feasibility in terms of costs and benefits (in this context, costs will take account of the likely impact on community amenity).*

1.3 Study Approach

The Study consisted of three phases. The relationships between the parties involved in the Study are illustrated in Figure 4. A full list of the membership of the Project Steering Committee and Project Reference Group is provided at Appendix B .

Figure 4: Relationships between parties involved in the Study



Source: Adelaide Freight Movements Study Project Brief. GHD, 2010

The Study involved a combination of field observations and desktop research to assess the performance of the existing Adelaide Hills alignment and to identify and assess potential alternatives. Field observations were conducted to appreciate the physical conditions in which the existing alignment through the Adelaide Hills operates. These conditions include the topography of the area along the alignment, the proximity of the alignment and the freight rail operations to population centres, and the nature of the 'wheel squeal' noise that is generated by the trains moving on the rail line.

Research included:

- Estimates of current rail freight volumes based on a range of economic and freight market factors.
- Technical investigations into the operational performance of the existing alignment.
- Engineering design of possible upgrades to the existing alignment and construction of alternative alignments.
- Simulation modelling of likely transit times associated with each of the alignments for Melbourne-Adelaide and Melbourne-Perth freight[12].
- Preliminary estimates of capital costs benchmarked against a variety of major freight rail projects to a level of accuracy of +/- 50%[13].
- Review of DTEI traffic data to understand the potential impact of the existing alignment on delays at level crossings.
- Review of State and Local Government planning documents to understand the potential future impact of the existing alignment on social amenity, public safety and the local environment, and to avoid choosing alternative alignments that would create negative impacts.
- Analysis of heritage and environmental impacts of the existing and alternative alignments[14].

To support and verify the analysis, regular input was gained from the PSC and the PRG. An updated assumptions and issues register was presented to the PSC and the PRG at monthly meetings where these groups assisted the Study Team to test options and the assumptions underlying them. Monthly meetings were generally held on the second Wednesday of each month in February to June (inclusive), October and December.

Risk management techniques were used in two additional workshops attended by the PSC and PRG to consider and resolve risks associated with the freight demand and capacity analysis, and design and assessment of options. As well as these regular formal meetings, the Study Team was in continuous dialogue with FROG and ARTC representatives as well as DTEI and other state government departments and local governments to clarify or validate the analysis.

1.3.1 Assessing the adequacy of the Adelaide Hills rail line

One of the first tasks of the Study involved understanding the current situation by examining the adequacy of the existing Adelaide Hills alignment by investigating:

- Its operating capacity and efficiency.
- Community expectations about the impact of the rail line on amenity standards.
- Expectations about reasonable levels of environmental protection from the rail line.

[12] Plateway Pty Ltd was engaged to simulate transit times for each preliminary engineering design where all train parameters were kept the same for each option.

[13] Currie and Brown (Australia) Pty Ltd was engaged to develop unit costs and apply them to the preliminary engineering design of each option.

[14] ACHM Pty Ltd was engaged to undertake a desktop study of the Aboriginal heritage impacts due to the various alignments.

The technical assessment was supplemented by field observations and information provided by ARTC and FROG. As well as understanding the operational performance of the railway, the technical assessment also considered the environmental and social dimensions of the railway's performance including issues such as 'wheel squeal' noise, the safety of existing level crossings, the visual impacts of the alignment, and the sensitivity of land use adjacent to the alignment.

A brief description of this technical assessment is presented in Section 2 of this Report.

1.3.2 Defining current and likely future freight tasks

Understanding the volume of freight that is currently carried on the rail line, and how this is likely to change in the future, is critical in determining whether and, if so, when significant capital investment in an improved rail line could be required. Information about the volume and type of freight that is currently carried by the railway as well as the critical factors affecting existing demand for freight rail services was developed early in the Study through consultation with freight operators and ARTC.

Three freight forecast scenarios – low, most likely and high – for the 30-year period evaluation required of the Study were developed through analysis of economic and market data and key policy drivers.

1.3.3 Assessing alternatives to the Adelaide Hills rail line

The findings of the technical assessment of the existing alignment, along with the analysis of current and likely future freight demand, informed the required design characteristics of upgrades to the existing alignment and alternative alignments. The technical assessment of alternative alignments included one that was proposed by the Mitcham Community Rail Freight Task Force. Three stages of design and technical assessment were adopted:

- Review of potential alignments previously investigated by DTEI.
- Use of a height contour map with 10 metre contour gradations to identify possible new alignments that avoided residential areas and towns, minimised the lengths of tunnels or viaducts, and provided a balance of 'cut and fill' earthworks[15].
- Assessment of these options against a set of desirable design parameters based on ARTC rail design criteria, and eliminating options that did not adhere to these design parameters.

A brief description of the alternative alignments as well as proposed upgrades to the existing alignment that resulted from this three-stage design process is provided in Section 4 of this Report.

1.3.4 Appraisal of the options

Using a framework that is consistent with the National Guidelines for Transport System Management in Australia (ATC, 2006), the Study subjected the existing alignment, an upgraded existing alignment, and three alternative alignments to two stages of appraisal. A multi-criterion framework – adopting a strategic fit analysis – was used to test the alignments against a set of economic, social and environmental criteria. This process reduced the number of alignment options that were subsequently subjected to a benefit cost analysis which determined the economic merits of the alternative alignments incremental to the Base Case (existing line/'do nothing' option).

Prior to the benefit cost analysis, the findings of the strategic fit analysis were published in a Discussion Paper which invited public submissions in response to the preliminary findings. A summary of the views expressed in these submissions, which were used to inform the benefit cost analysis, can be found in Section 5 of this Report.

[15] 'Cut and fill' refers to the amount of earth engineering construction that will be required to move from high points of a route alignment and fill in of lower points. Ideally, a balance should be achieved between the 'cut' amount and the 'fill' amount.

1.4 Structure of this Report

Section 2 provides a brief description of the current performance of the existing Adelaide Hills rail line.

Section 3 discusses the analysis of current and likely future freight demand on the rail line.

A description of the alternative rail alignment options developed by the Study is presented in Section 4, while Section 5 contains an interpretation of the public submissions. Section 6 discusses the appraisal of the options and Section 7 presents the key Study findings and conclusions.

Section 2
The Current Situation

2. The Current Situation

The existing rail alignment was opened in January 1887 and was built to accommodate the steam engines of the time. The line was constructed at a time when the Adelaide Hills was only sparsely developed, however urban development has increasingly surrounded the corridor. This urban development has not always been subject to the planning controls common today leading in the past to construction adjacent to the freight corridor and within noise exposure zones.

Although train technology has been substantially improved over the years (resulting in increased train speed and load carrying ability), no significant improvements to the rail track alignment have been made to keep pace with these changes. As a result, potential productivity gains have not been fully realised.

2.1 Line Capacity and Operating Performance

One of the reasons the alignment has not kept up with contemporary standards is the difficult terrain through which the alignment passes. Only 38% of the alignment is straight. For a distance of 104 kilometres between Islington[16] and Murray Bridge, the track has many tight curves, with 34% of them having a radius of 400 metres or less, and some of them closely spaced[17]. Much of the track is steep, with vertical grades of approximately 2%; this is double the current desirable grade of 1%. Along the alignment between Islington and Murray Bridge, six tunnels and ten bridges over the railway provide for a vertical clearance of less than 7.1 metres; this is too low to allow trains to carry full height containers double-stacked[18].

The combined effects of these characteristics of the alignment are that:

- The track can only carry trains to a maximum of 3500 tonnes (total train weight) and a maximum length of around 1500 metres.
- Freight trains must travel more slowly through the Adelaide Hills, averaging only 35 kilometres per hour because of the tight curves and steep terrain. This performance compares with a target average speed for the Melbourne and Adelaide corridor of 60 kilometres per hour[19]. On the Sydney to Melbourne corridor, once improvements now under way are completed, the average speed will be approximately 80 kilometres per hour, and on the Adelaide to Perth corridor, approximately 70 kilometres per hour.
- As a consequence of the low average speed through the Adelaide Hills, the average transit times between Melbourne and Adelaide and Melbourne and Perth are at least one hour longer than would otherwise be the case on a flatter and straighter alignment, and therefore result in higher operating costs.
- On the Adelaide Hills section, freight trains need to use three locomotives rather than two to traverse the terrain and thus incur higher operating costs.
- Higher locomotive and wagon 'wear and tear' and therefore higher maintenance costs are incurred by rail operators ('above rail' impacts).
- Greater 'wear and tear' on the track and therefore higher maintenance costs are incurred ('below rail' impacts).

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[16] Islington is the freight rail terminal in Adelaide.

[17] ARTC Network Configuration and Description at http://www.artc.com.au/Content.aspx?p=98. ARTC's Network Interface and Coordination Plan, Appendix III (http://www.artc.com.au/library/TA02a3.pdf) and Appendix XIII (http://www.artc.com.au/library/TA02a13.pdf).

[18] ARTC Track and Civil Code of Practice SA/WA & VIC, Section 7: Clearances at http://extranet.artc.com.au/docs/engineering/cop/sections/sec_7_clearances.pdf.

[19] ARTC Network Configuration and Description at http://www.artc.com.au/Content.aspx?p=98. ARTC's Network Interface and Coordination Plan, Appendix III (http://www.artc.com.au/library/TA02a3.pdf) and Appendix XIII (http://www.artc.com.au/library/TA02a13.pdf).

Much of the alignment is hemmed in either by towns and residential properties or by the Belair National Park, restricting options to reduce the number of tight curves through deviation. Similarly, the hilly topography of the area would make it difficult to reduce gradients without substantially increasing overall track kilometres, and therefore transit time.

At the moment, and at least until 2025, capacity is not likely to be a constraining factor. The current alignment can handle 10.7 million tonnes of freight per year, which is more than double the 4.8 million tonnes per year that are currently carried on the rail line. On the basis of committed works and in light of the freight demand forecasts developed for this Study (discussed in Section 3), line capacity will not be reached before 2025[20].

Notwithstanding this, the alignment is a source of inefficiency for rail freight transport, and particularly for freight moving between Melbourne and Adelaide. This is reflected by the relatively low freight arrival reliability target of 55% for the corridor[21].

2.2 Community Amenity

The track passes through six local government jurisdictions (Rural City of Murray Bridge, District Council of Mount Barker, Adelaide Hills Council, City of Mitcham, City of Unley, and Adelaide City). While land use between Murray Bridge and the Adelaide Hills is predominantly agricultural, the Adelaide Hills and Adelaide Plains regions are primarily residential. For a distance of about 50 kilometres between Adelaide and Nairne, the rail line passes through the centre of, or backs onto, towns and residential properties.

The Adelaide Hills community is concerned about problems of noise, pollution and rail level crossing safety. Official noise complaints have been made in the past to the Environmental Protection Authority (EPA) South Australia prompting action to install a continuous noise monitoring solution (RailSQAD) in December 2005 to enable some of the noise sources to be addressed. Evident in the public submissions (see Section 5) is the community perception that the future growth in the rail freight task on the line through Adelaide Hills will exacerbate the noise levels.

The main safety consideration along the alignment is the rail line interaction with road traffic at level crossings. According to assessments carried out by DTEI, which assesses all level crossings across South Australia, there are sixteen crossings that would benefit from some form of improvement. Over the last few years, DTEI has been upgrading ‘higher risk’ level crossings with measures such as adding boom gates, line-marking, upgrading signage and improving the line of sight[22].

There are 41 level crossings along the rail line between Murray Bridge and Adelaide which handle a total of about 135,000 vehicle movements per day. Typically, it takes between 1.5 to 2 minutes for a freight train to clear a level crossing, but it may take longer; at Cross Road for example, which accommodates 32,000 vehicles per day, freight trains may take about 3 to 5 minutes to clear. In the metropolitan area, three level crossings — at Main Road in Glenalta, Main Road in Belair and Cross Road in Hawthorn — are heavily trafficked and long delays are experienced by road traffic at these locations. Together these three sites account for 63,500 vehicle movements per day or 47% of total traffic crossing the railway at level crossings between Murray Bridge and Adelaide.

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[20] The expectations with respect to capacity take account of capacity improvements expected to be generated by ARTC’s planned upgrades of passing loops on the Melbourne to Adelaide line between June 2009 and December 2011. More detail on the program of works is provided in Section 6.1.1.

[21] ARTC, 2008-2024 Interstate and Hunter Valley Rail infrastructure Strategy Overview, 30 June 2008, page 13.

[22] The Level Crossing Unit within DTEI’s Traffic & Access Standards Section uses the ALCAM model to assess the compliance of all the level crossings in South Australia. A Commonwealth Program made funds available in 2008-09 to 2009-10 for level crossing improvements across Australia.

Section 3

Current and Future Corridor Demand

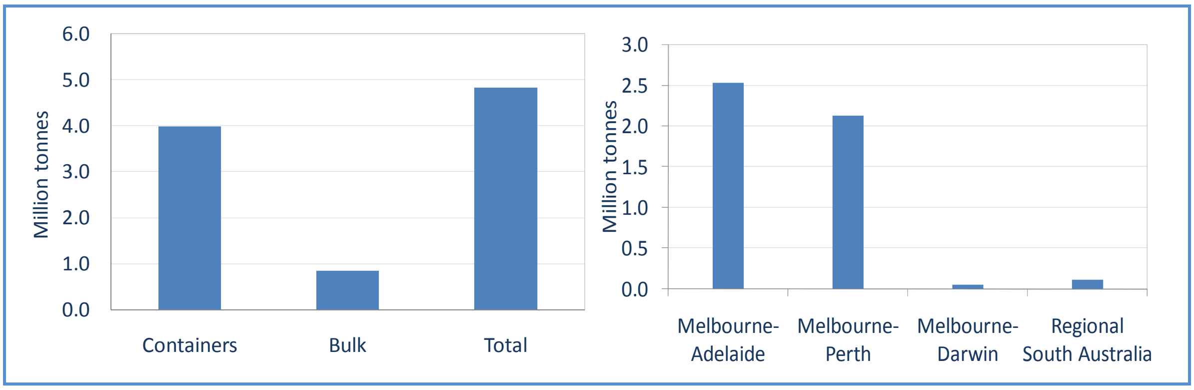
3. Current and Future Corridor Demand

Understanding the volume of freight that is currently carried on the rail line, and how this is likely to change in the future, is critical in determining whether and, if so, when significant capital investment in an improved rail line would be justified.

3.1 Freight Volumes Currently Carried by the Rail Line

The existing rail line has a maximum capacity of 10.7 million tonnes per year. This estimate is based on existing train configurations and available track space and makes allowance for the fact that for commercial reasons not all scheduled opportunities are taken up. Based on the latest available data[23], less than half of this capacity (approximately 4.8 million tonnes of freight) was carried over the existing Adelaide Hills section in the 2007-08 financial year. About 82% of this freight was containerised goods including household whitegoods, clothing, processed food stuffs, beverages (including wine), motor vehicle components, building materials and general consumables. The remaining 18% was bulk goods, including break-bulk steel and bulk commodities such as pulp, hay, grain and mineral sands. These freight volumes are shown in Figure 5 (left side).

Figure 5: Freight flows by type and by origin-destination



Source: FROG and ARTC, 2007-08 origin-destination data

This freight is moving between four origin and destination city pairs/locations:

- Melbourne and Adelaide.
- Melbourne and Perth.
- Melbourne and Darwin.
- Regional South Australia and the Port of Adelaide.

The Melbourne–Adelaide and Melbourne–Perth markets account for the overwhelming majority (96%) of the total rail volume; with 2.5 million tonnes hauled between Melbourne and Adelaide and a further 2.1 million tonnes moving between Melbourne and Perth in 2007 and 2008. This task is serviced using both direct origin-destination trains as well as services stopping off at Adelaide. These total rail volumes by origin-destination are shown in Figure 5 (right side).

The 2.5 million tonnes that move between Melbourne and Adelaide are mainly international exports and imports that are railed to and from the Port of Melbourne. For example, wine from the Barossa Valley is transported to a rail terminal at Port Adelaide then railed to the Port of Melbourne for export.

[23] Based on data provided from Freight Rail Operators Group (FROG) and Australian Rail Track Corporation (ARTC).

Similarly, imports including consumables and vehicle components for General Motors' plant in Adelaide are unloaded from containerships at the Port of Melbourne and then railed to Adelaide. They are then trucked to facilities across the Adelaide metropolitan area.

Most of the remaining 4% of rail volume is bulk grain and mineral sands that are hauled from the east and south-east regions of South Australia over the Adelaide Hills line to Port Adelaide for export.

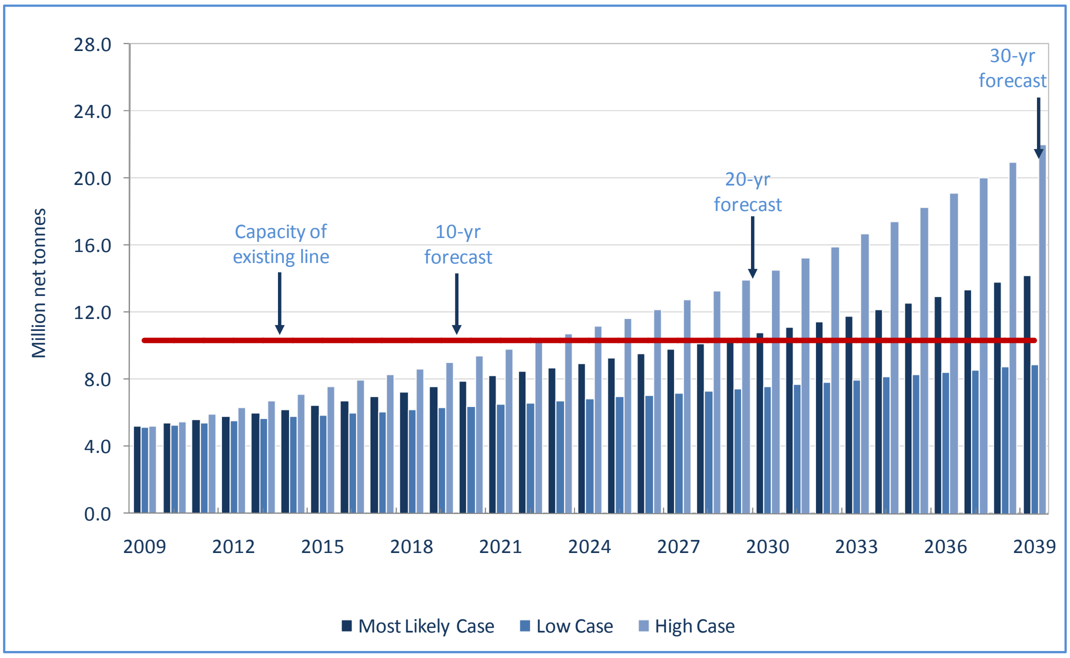
3.2 Likely Future Demand

A scenario-based approach was used to generate a range of forecasts of the rail freight task because of the inherent uncertainties in forecasting. Three distinct scenarios — low, most likely and high case — were specified to capture a range of variations in assumptions for the key future growth drivers and the probable outcomes of the rail freight task. The key future growth drivers include:

- Underlying economic growth (annual growth in Gross State Product (GSP) for Victoria, South Australia, Western Australia and Northern Territory).
- Changes in rail mode share along the east–west corridor (resulting from factors such as the impact of: a carbon pollution reduction scheme on transport mode competition between road and rail; the possible introduction of B-triple trucks on the Melbourne–Adelaide road corridor; truck driver fatigue legislation; ARTC capacity improvements to Melbourne–Adelaide rail corridor; and/or government policies aimed at stimulating growth in coastal shipping between Melbourne and Perth).
- Changes in the relationship between freight and economic growth. These reflect changing supply chain practices such as the rationalisation of manufacturing away from decentralised production towards more concentrated production, creating longer supply chains.

Aggregate forecasts for all three scenarios are shown in Figure 6.

Figure 6: Aggregate forecast growth in rail freight through Adelaide, 2009-2039



Source: GHD, 2010

The most likely case forecasts[24] represents the rail freight task that could arise under economic growth assumptions that reflect current State Treasury forecasts[25] and a relatively stable rail mode share over the forecast period.

[24] The most likely case forecasts prepared by GHD are based on the latest available data obtained from the FROG and ARTC.

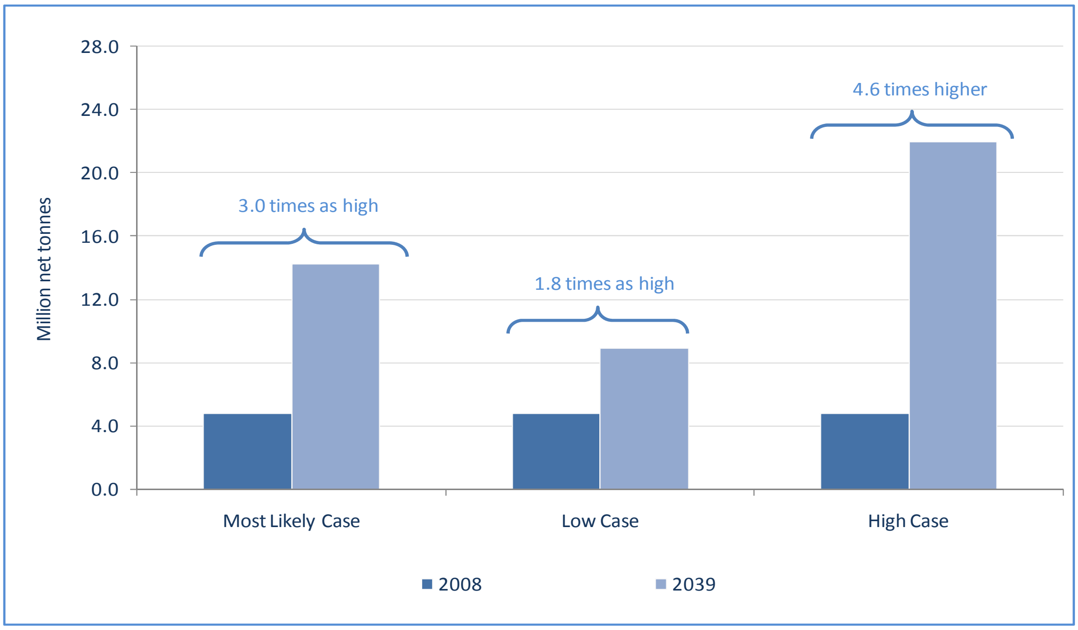
In this scenario, the total volume of rail freight carried on the Adelaide Hills section is forecast to rise from its current level of 4.8 million tonnes to approximately 14.3 million tonnes by 2039. This represents an annual average growth of around 3.6% over the 30-year evaluation period.

The low case scenario represents a conservative view of the size of the future rail freight task — one in which economic, market and policy drivers tend to move against rail (for instance, subdued GSP growth as well as road and sea policy measures that result in a transport mode shift away from rail). Under these circumstances, the total rail freight task is projected to grow modestly over the 30-year evaluation period — from 4.8 million tonnes in 2008 to 8.9 million tonnes by 2039. This represents an annual average growth of 2.0% over the 30-year evaluation period.

In contrast, the high case set of forecasts reflect a future in which economic, market and policy drivers tend to work in rail's favour. These drivers include strong GSP growth and improvements in the competitiveness of rail by comparison with road and sea transportation resulting in transport mode share gains for rail. Under these circumstances, the total rail freight task is projected to grow over the 30-year evaluation period from 4.8 million tonnes in 2008 to 22.2 million tonnes by 2039. This represents an annual average growth of 5.0% over the 30-year evaluation period.

Another way of appreciating the projected change in the rail freight task is displayed at Figure 7. The most likely case forecast implies a threefold increase in the rail freight task between now and 2039. This compares with a less-than-twofold increase in the low growth case, and a just over four-and-a-half times increase in the high growth case.

Figure 7: Forecast growth in rail freight through Adelaide, 2008-2039



Source: GHD, 2010

A key operational aspect associated with the freight forecasting task was to understand the future importance of Adelaide as distinct from Perth (and to a much lesser extent Darwin) as a destination and origin market for railed freight. This is important as options may need to provide rail operators with the opportunity to bypass Adelaide when hauling Melbourne-Perth and Melbourne-Darwin freight. Since this

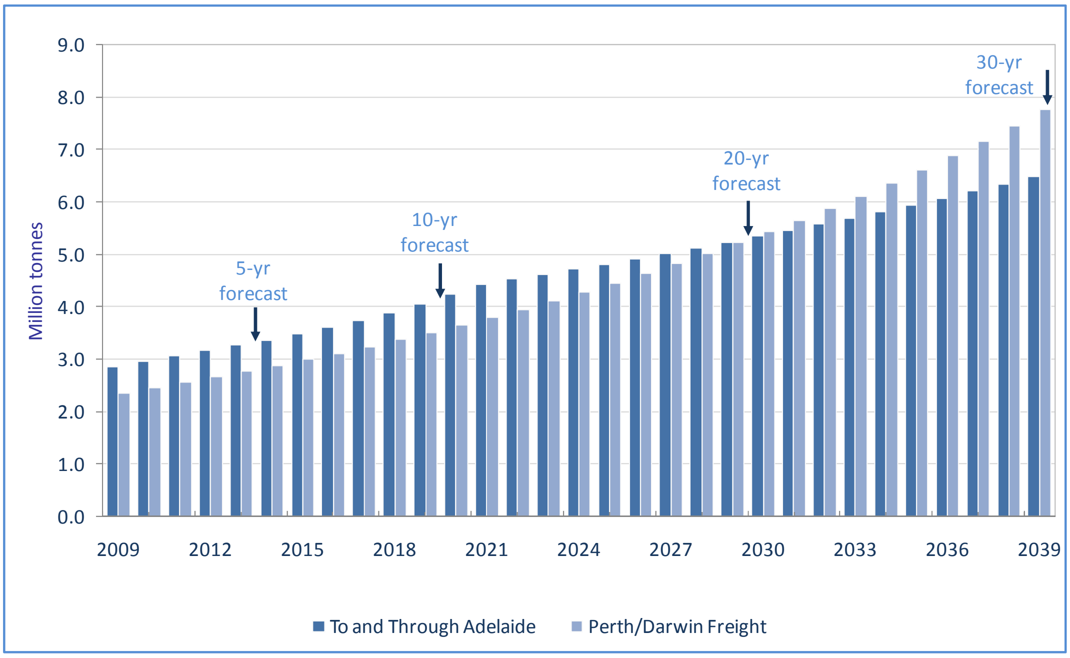
[25] 2008-09 to 2011-12 forecasts are taken from South Australian Government Budget Paper 1 (pg 22) and Victorian Government Budget Strategy and Outlook (pg 23). 2012-13 onwards are GHD forecasts based on long run historical average GSP growth rates. Historical average growth rates calculated using GSP data from Australian Bureau of Statistics publication Australian National Accounts: State Accounts (Catalogue Number 5220.0) 2007-08.

freight would not need to be delivered to or picked up from Adelaide, rail operators could gain train transit time and operating cost benefits by using an appropriate bypass rail route.

Figure 8 shows Adelaide is expected to experience a gradual decline in its relative importance as a rail destination and origin point over the next 30 years in this overall market context.

Cargo bound for or originating in Adelaide currently accounts for around 55% of the total rail traffic moving via the existing Adelaide Hills route. Over the next 30 years, the Adelaide share of the total rail volume is expected to fall by ten percentage points to 45%. This is because Perth's role as a rail freight origin and destination point is expected to grow at a faster rate than that of Adelaide due to the relative rates of GSP growth as discussed below. At 45%, Adelaide will remain an important rail origin and destination point, but Melbourne–Perth (and Melbourne–Darwin) freight will account for the remaining 55% of the freight that will move on this east–west corridor.

Figure 8: Significance of Adelaide as a rail destination and origin point

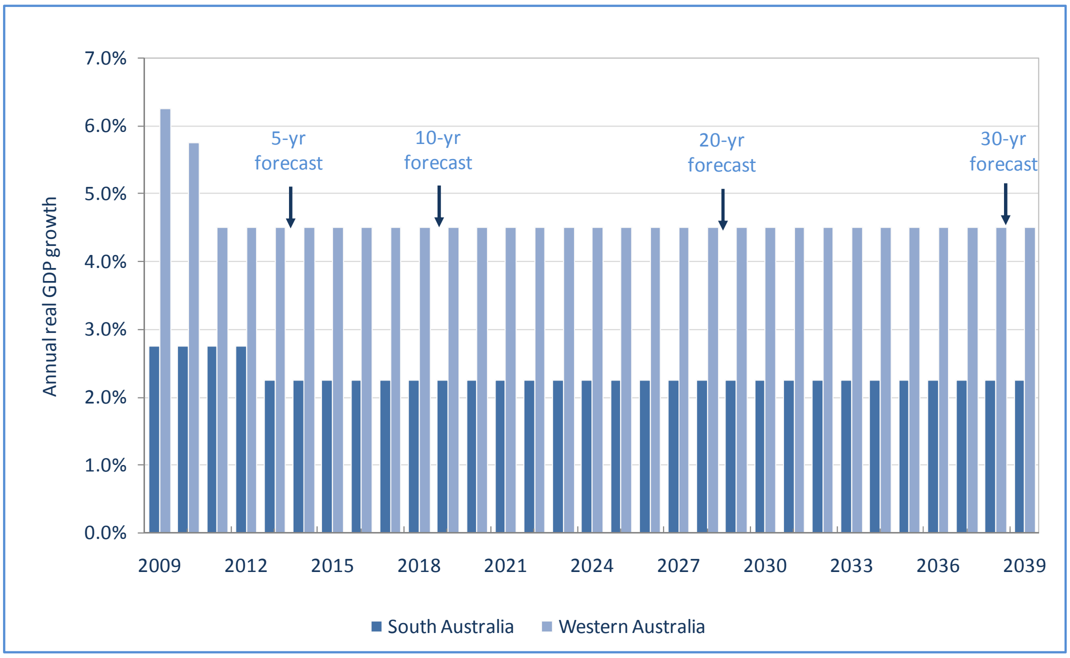


Source: GHD, 2010

The change in the relative importance of these two rail markets reflects the impacts of underlying assumptions made about the relative rates of GSP growth for Western Australia and South Australia. Figure 9 shows that Western Australia is projected to experience consistently stronger GSP growth than South Australia over the 30-year evaluation period.

From 2013 through to 2039, GSP growth for South Australia is forecast to be just over 2% per year while during the same period, the annual GSP growth rate is forecast to be nearly 4.5% for Western Australia. As GSP growth is an underlying driver of rail volume growth, this implies Perth's role as a rail freight origin and destination point will grow at a faster rate than that of Adelaide.

Figure 9: SA and WA GSP growth forecasts - Most Likely Case assumptions



Source: 2008-09 to 2011-12 forecasts from South Australian Government Budget Paper 1 (pg 22) and Western Australian Government Budget Economic and Fiscal, Budget Paper 3 (pg 9). 2012-13 onwards are GHD forecasts based on long run historical average growth rates. Historical average growth rates calculated using GSP data from Australian Bureau of Statistics publication Australian National Accounts: State Accounts (Catalogue Number 5220.0) 2007-08.

3.3 Conclusions

The demand analysis completed as part of this Study indicates that the most likely scenario for freight volumes carried on the Adelaide Hills section of the east-west rail line is an annual average growth of around 3.6% over the 30-year evaluation period. This translates to an increase from the current level of 4.8 million tonnes to approximately 14.3 million tonnes by 2039. These forecasts, which are aligned with the ARTC's budget volume forecasts, suggest that without any expansion of capacity[26], the Adelaide Hills section of the railway would reach its maximum capacity of 10.7 million tonnes per year between 2025 and 2030.

[26] ARTC has included in its current forecasts for some works including passing loops.

Section 4

The Options

4. The Options

4.1 Methodology

The alignment design process involved three stages:

- A review of previously identified alignments.
- Assessment of the alignments against design and other criteria.
- Identification of new alignments using height contour mapping technology.

The first stage of the review included potential alignments summarised by DTEI including those developed by Australian National[27] and ARTC (and consultants to ARTC). Some of these were 'off-corridor' alignments, including those that utilised existing rail corridors between Monarto South and Sedan or between Kapunda and Gawler. However, the majority of the designs, including several between Cross Road and Murray Bridge, followed close to the existing alignment, focusing on modifications to sections of it, with consideration being given to tie-in points to the existing tracks and the potential for future intermodal terminals.

The second stage of the process assessed these options utilising desirable design parameters that were developed on the basis of ARTC design criteria[28] and other social and environmental criteria that also formed part of the strategic fit analysis framework. These design parameters are presented, with additional assumptions agreed with ARTC and FROG, in Appendix C of this Report.

Some alignments were eliminated using this second stage process which considered constructability and operational considerations. For example, some initial options had gradients in excess of 1% or the alignment required 18 to 20 kilometres of tunnels up to 250 metres below ground level, and therefore they were not considered further.

In the third stage of the process, a height contour map with topographical detail with 10 metre contour gradations was used to develop the design for three new alignments. These alignments were identified using the desirable design parameters to avoid residential areas and towns, minimise the lengths of tunnels or viaducts, and provide a balance of 'cut and fill' earthworks.

4.2 Design of Alignments

New alignments were developed using a process of engineering, topographical, environmental and heritage research. These layers of spatial information helped identify alignments avoiding some features and minimising construction costs. Desirable standard track profile requirements were used to produce efficient track alignments where trains could achieve maximum speed limits and load capacities. The alignment corridor thus developed has a width of 100m. It could be refined with more accurate topographical information in a subsequent detailed design. This would allow refinement of land boundaries, further design interaction with roads, streams and heritage places.

One of the alignments followed much of the route proposed by the Mitcham Community Rail Freight Task Force. It avoids the existing Adelaide Hills section between Murray Bridge and Two Wells, by tracking north towards Sedan, then Truro across generally flat land.

A second new alignment was designed to track north from Murray Bridge towards Sedan then Truro across generally flat land and along a generally straight track, but instead of travelling to the north of Truro, takes a more direct route, heading north-west across the ranges north of the Adelaide Hills before approaching Truro from the south.

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[27] Australian National (initially Australian National Railways Commission) was formed in 1975, by the 'nationalisation' of the state railways of South Australia and Tasmania, merged into the Commonwealth Railways.

[28] ARTC Track and Civil Code of Practice; Track, Civil and Electrical Infrastructure Issue 1, Revision 3 – February 2007.

A third new alignment runs to the south of the Adelaide Hills and is the shortest and most direct of the new alignments. However, achieving these desired characteristics requires construction of tunnels, viaducts or bridges, and deep cuts and fills to meet the design criteria. As with all three of the new alignments, bridges and tunnels were designed to have vertical clearance of 7.1 metres to accommodate double-stacking of containers. They were also designed to accommodate two tracks to allow for improved accessibility for maintenance and or incidents.

The Study Team also considered a number of upgrades to the existing alignment that were designed to improve its operational performance and reduce its impact on social amenity. The outcome of these considerations, confirmed by the PSC and PRG, was the identification of five feasible options. Table 2 provides a description of the Base Case — that is the Existing Adelaide Hills Alignment[29] — and the five options. The last option is a combination of upgrading the existing alignment and constructing a northern alignment via south of Truro.

Table 2: Description of the options reviewed by this Study

The Options	Description
Base Case: Existing Adelaide Hills Alignment (orange route in Figure 10)	This is the existing alignment between Murray Bridge and Islington. Apart from ARTC existing plans for improvements such as new and or extended passing loops,[30] the existing alignment remains unchanged. (Base Case)
Option 1: Upgraded Existing Alignment (orange route in Figure 10)	Freight operations would continue to use the Adelaide Hills section but it would be upgraded, including grade separation at level crossings, additional passing loops, and improvements to tunnels and bridges over the rail line, and to the tunnel and bridge at Murray Bridge, to permit double-stacking. Initiatives would be undertaken to reduce the social impact of freight operations on the surrounding communities.
Option 2: Northern Bypass via north of Truro (red route in Figure 10)	This new route would bypass the existing Adelaide Hills section between Murray Bridge and Two Wells by travelling north of Truro. The route would begin just to the west of Murray Bridge and re-join the existing alignment near Two Wells. This route is mostly at ground level and on flat plains area.
Option 3 Northern Bypass via south of Truro (blue route in Figure 10)	This new route would bypass the existing Adelaide Hills section between Murray Bridge and Two Wells by travelling generally in the same alignment as 2 above but south of Truro. The route begins its ascent of the ranges further to the south than Option 2 and passes to the south of Truro. This route is mostly at ground level and on flat plains area with the same design characteristics as Option 2 but it is 18 km shorter and has fewer steep sections than Option 2. As with Option 2, freight operations on the Adelaide Hills section would also cease with this option.
Option 4: Southern Alignment (purple route in Figure 10)	This new alignment would be to the south of the existing rail alignment to avoid the built-up residential areas in the Hills. From Callington it would head west passing Flaxley and Wistow to the south of Mt Bold Reservoir; then it would head north near Kangarilla and Clarendon to the east of Happy Valley Reservoir and would connect with the current freight alignment just south of Cross Road. It would be constructed with the same design characteristics as the other new routes. About 22 km of this alignment is in tunnel (the longest section is 15 km), starting shortly after the Cross Roads level crossing. The tunnelling takes the line to the south away from residential areas, and then comes to the surface near Kangarilla to meet up with the existing alignment near Callington[31]. Option 4 also involves the cessation of freight operations on the Adelaide Hills section, and the construction of a new bypass route.
Option 5: Upgraded Existing Alignment (orange route in Figure 10) and Northern Bypass via south of Truro (blue route in Figure 10)	Option 5 is a combination of Option 1 and Option 3. Like Option 1, it includes improvements to the existing route to increase operating efficiency and reduce social impact. As per Option 3 it includes a new northern bypass on the route to the south of Truro.

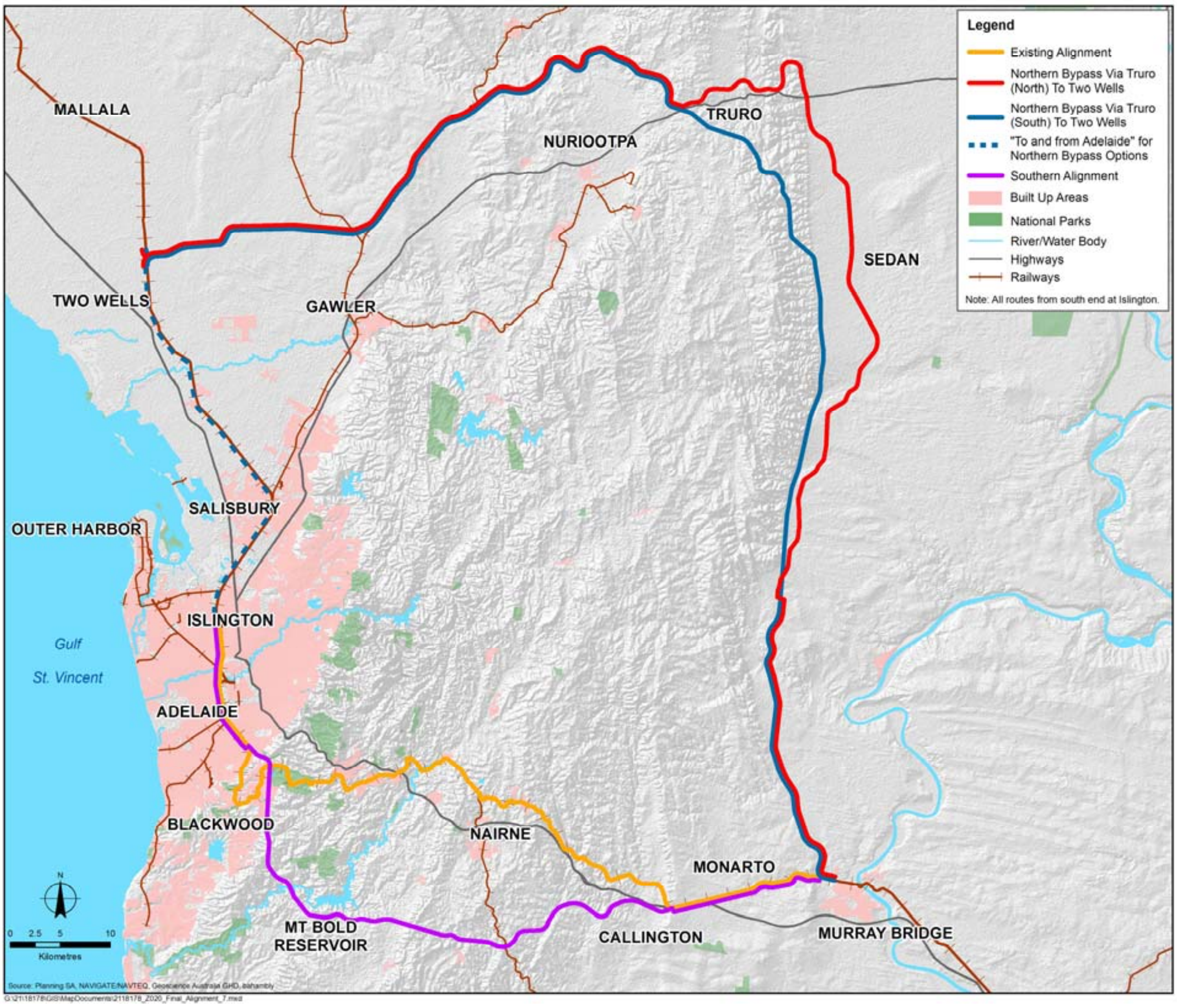
Source: GHD, 2010

[29] Also referred to as the 'do nothing' option which would ensure operation of the railway continues but does not involve a material change in the capability and performance nor radical change in impacts other than existing capital commitments.

[30] http://www.artc.com.au/library/RIS_2.2.pdf, page 39.

[31] While rail tunnels much longer than this operate elsewhere throughout the world, a rail tunnel of this length has not been built in Australia before, and further feasibility work would be required to prove this concept.

Figure 10: The existing rail route and possible options



Source: GHD, 2010

4.3 Options Attributes

The principal performance characteristics of each option are summarised and compared with the characteristics of the 'Base Case' in Table 3. The engineering attributes for each option is summarised in Table 4. The typical bridge/viaduct cross sections developed for the Study are presented in Appendix E.

Table 3: Alignment options attributes

The Options	Attributes						
	Distance (from Murray Bridge)		Capacity	Double-stack	Transit time (from Melbourne)		Total undiscounted preliminary estimate of capital cost[32]
	(kms)		(mtpa[33])	yes/no	(hrs)		($billion)
	Islington	Two Wells			ADE	PER	
Base Case: Existing Alignment	104	141	10.7	no	13	57	0
Option 1: Upgraded Existing Alignment	104	141	23.6	yes	13	57	0.7
Option 2: Northern Bypass via north of Truro to Two Wells	209	172	40	yes	12.9	55.1	2.9
Option 3: Northern Bypass via south of Truro to Two Wells	191	154	40	yes	12.6	54.8	2.4
Option 4: Southern Alignment	96	133	40	yes	11.2	55.2	3.0
Option 5 Upgraded Existing and Northern Bypass via south of Truro	104	154	63.6	yes	13	54.8	3.2

Source: GHD, 2010

The total undiscounted preliminary estimate of capital costs includes the cost of new works, land purchase, preliminary services (design, project management) and additional works on the Murray River Bridge and its access. The costs in Table 3 are different to those in the table in the Discussion Paper

[32] All costs were benchmarked against a variety of major freight rail projects in 2009 Australian dollars and exclude owner's costs, signalling, power supplies, overhead wiring, location factors, modifications to existing line, native title, indigenous heritage, Authority fees, security, planning conditions, relocation of existing services, possession costs, financing, legal, escalation, compensation and GST costs. The level of accuracy of the capital estimates is therefore +/- 50%.

[33] Millions of tonnes of freight per annum.

because they include land purchase, preliminaries and Murray Bridge works. The engineering attributes associated with the options are shown in Table 4.

Table 4: Engineering attributes for each option

Engineering Attribute	Option 1 Upgrade Existing Alignment	Option 2 Northern Bypass north of Truro	Option 3 Northern Bypass south of Truro	Option 4 Southern Alignment	Option 5 Upgraded Existing Alignment and Northern Bypass south of Truro
Total Track Length (km)	104	172	154	96	258
Earthworks (cut & fill) (track km)					
> 0m to ≤ 3m	N/A	39.86	38.57	52.18	38.57
> 3m to ≤ 5m	N/A	32.39	28.47	4.43	28.47
> 5m to ≤ 10m	N/A	40.63	30.26	3.16	30.26
> 10m	N/A	57.33	57.22	4.60	57.22
Rail Bridges & Viaducts					
Total No. (includes Murray Bridge)	1	6	7	18	8
Total Length (km)	0.57	17.06	10.45	22.55	11.02
Length < 100m	N/A	1	1	1	1
Length > 101m to < 150m	N/A	1	1	1	1
Length > 151m to < 250m	N/A	1			
Length > 251m to < 600m	1		1	3	2
Length > 601m to < 1100m	N/A	1	1	5	1
Length > 1101m to < 1200m	N/A	1	2	1	2
Length > 1201m to < 2200m	N/A	1	1	7	1
Road Bridges					
Total No.	N/A	7	6	N/A	6
Total Area (m^2)	N/A	22,320	19,620	N/A	19,620
Tunnels					
Total Length (track km) (includes Murray Bridge Tunnel)	2.34	8.45	8.35	24.18	10.69
Level Crossings (No.)	5^	10	7	5	12
Passing Loops/Lanes (No.)	4	3	3	3^^	7
Other Works:					
Noise attenuation walls / Concrete resleepering / Rail head friction modifiers (track km)	20	N/A	N/A	N/A	1
Existing overbridge / underbridge modifications (No.)	10	N/A	N/A	N/A	1

^ Upgrading of existing level crossings (Cross Road, Main Road at Blackwood and Glenalta, Goodwood and Torrens Junctions).
^^ Excludes approximately 20km of duplicated track in tunnels.

Source: GHD, 2010

Section 5

Submissions Analysis and Interpretation

5. Submissions Analysis and Interpretation

5.1 Public Submissions

Public submissions were invited to respond to a series of questions related to three themes presented in the Discussion Paper. This paper presented preliminary findings of the Study up to and including the strategic fit analysis but before the completion of the benefit cost analysis. Feedback was sought on the following matters:

- **The current situation:**
  - Other features of the alignment that is important for the Study to take into account.
- **Current and future corridor demand:**
  - The economic growth assumptions underlying the freight forecasts.
  - The most likely forecast for the traffic carried on the Adelaide Hills route.
  - The relative shares of freight traffic on the Melbourne-Perth and Melbourne-Adelaide corridors.
  - The extent to which a more efficient rail alignment would improve freight services and lead to a greater use of rail instead of road.
- **Options for further analysis:**
  - The options identified, and whether there are any alternative rail alignments that should be considered.
  - The assumed freight paths, and whether these reflect the choices that ‘above rail’ operators are likely to make.

In total, 76 submissions were received from local governments, rail operators, industry associations and local residents and other interested individuals. This is a numerically small sample of the population of the Study Area and of the stakeholders and therefore it is difficult to draw out specific conclusions to apply as representative.

Many of the submissions answered the questions posed by the Discussion Paper. Common responses were related to amenity, including concerns about noise levels generated by trains operating on the existing railway, the generation of pollution and level crossing delays.

Some suggestions were beyond the scope of the Study. For example, a suggestion was made for the Study to consider the impact of noise on areas outside of the Study boundaries or to assess the impact of each of the options on the broader supply chain. Alternatively, some observations such as one that freight growth ought to take into account population growth in South Australia, have been incorporated into the analysis, as have the potential impact of climate change policies and coastal shipping trends on a shift away from road to rail.

A list of the submissions received in response to the Discussion Paper is presented in Appendix D and the information is summarised in the following sections.

To enable readers of this Final Report to have a framework of reference for consultation, the headings used in the Discussion Paper under which feedback was sought have been used as a basis for analysis. Some comments have also been made separately on the options identification as these were raised in 49 of the 76 (64%) of responses. Not all submissions made comment on the options.

5.1.1 The current situation

Submissions in general fell into two broad groups:

- Community groups, residents and local governments who focused on community needs and issues.
- Freight sector participants and freight interested parties who focused on transport efficiency related matters.

Almost three quarters, 56 of the 76 submissions (74%) noted specifically, support for realignment. Almost two thirds, 49 of 76 submissions (64%) commented that the line is inefficient or that it has some negative impact on some social and environmental amenity for local communities.

Compounding this split was that 49 (64%) of all submissions came from the former group and only 27 (36%) of all submissions from the latter group. The former group clearly had a bias towards amenity issues for the Study's focus.

The following comment by the Blackwood/Belair and District Community Association captures such concern:

"..there is one more question that seems to be missing and that could be expressed as "*What is the impact of each option on the social and environmental amenity along the proposed route, both through the hills and metropolitan area?"*"

The Australian Rail Association (ARA) also acknowledged community sentiments expressing:

"A number of our industry members have specifically stressed that the issue of noise, and safety at level crossings are of high significance and should be taken into consideration."

Train noise was the most frequently mentioned issue in the submissions; figuring in 42, (55%) of all respondents as indicated in Table 5. Submissions also highlighted the impact of freight train operations on road traffic delays at level crossings, the risk to public safety including the difficulties created by freight operations for evacuation in the case of a bush fire, and the generation of pollution.

Table 5: Environmental and social concerns

Submission Groups	Externality Impact				
	Noise	Level Crossing	Safety	Bush Fires	Pollution Levels
Local Government Councils Regional Council Groups Regional Development Board Community Association	4	1	1		4
Rail Operators Industry Associations	3		1		1
Residents Individuals Community Members	35	12	2	4	14
Total	42	13	4	4	19

Source: GHD, 2010 – derived from submissions to the Study

5.1.2 Current and future corridor demand

Most industry submissions, including operator stakeholders, agreed with the freight demand forecasts that underpin the analysis of the capacity of the interstate railway through the Adelaide Hills. One exception to this view was that the Study may have taken account of economic growth forecasts for only South Australia and Western Australia and neglected to include Gross State Product figures for other origin and destination pairs, in particular, Victoria.

An analysis of the east-west rail freight task included a detailed appraisal of the underpinning effects of the economic growth figures of these states on the volume of freight likely to be handled over the next 30 years by rail between the two main origin and destination city pairs, Melbourne and Perth and Melbourne and Adelaide. A related comment expressed a slightly different view about the balance of freight moving along these two freight paths. However, this difference does not materially affect the overall forecasts or when the Existing Alignment is expected to reach capacity.

There was also a concern expressed in one submission that freight volume forecasts may have underestimated bulk grain volumes and may not have taken into account specific mining and other bulk export commodity projects. The Study Team drew on inputs from FROG and the ARTC in developing three alterative growth scenarios which included forecasts for grain exports and other dry bulk commodities including the Penola pulp mill proposal that would potentially make use of the Adelaide Hills railway. Currently, only 4% of rail volumes are bulk grain and materials.

The Study Team took a conservative approach in estimating Melbourne – Adelaide freight volumes because road transport currently dominates the market. Stakeholder consultation with FROG suggested that there was little scope for significant growth in rail mode share for the Melbourne – Adelaide route because most of it (approximately 90%) is land-bridged containers.

For Melbourne – Perth mode share, the assumption made and the view adopted is that sea transport is less likely to impact on rail mode share because of the operational structure and limitations of sea transport.

A few submissions from community and local government stakeholders questioned whether the rail freight forecasts had taken adequate account of the potential effects of climate change policies on likely future modal share. These and other potential changes including the possible advantages to rail that could result from rising fuel prices and the potential advantages to road that could be achieved as a consequence of an increase in the number of B-Triples have been considered.

5.1.3 Options for further analysis

In answer to the question raised in the Discussion Paper about other features that the Study ought to take into account, a number of submissions expressed the view that the freight rail operations have restricted the use of the railway for passenger services. With anticipated population growth in metropolitan Adelaide over the next 30 years, respondents felt that the increasing importance of this potential function of the railway between Adelaide and Mount Barker and Murray Bridge should be included in the evaluation of options.

While the road traffic figures used in the benefit cost analysis took account of population growth forecasts for the affected area, analysis of the impacts on the wider transport system were outside the scope of the Study. The same is the case for the suggestion that the Study should have considered the impact of the Existing Alignment on the broader supply chain and supply chain customers.

5.1.4 Options considered

The clear majority of the submissions (74 of 76 or 97%) which commented on the options expressed a preference for one or more of the options (refer to Table 6). No submissions were in favour of maintenance of the *status quo.*

Four submissions suggested that the Existing Alignment should be upgraded (Option 1). Another submission supported Option 5 which combines the Upgraded Existing Alignment (Option 1) with the Northern Bypass south of Truro (Option 3). Many community, residential and local government respondents were of the view that the Upgrade option (Option 1) would not resolve the operational issues associated with tight curves and steep gradients, nor did they believe that it would completely resolve the social amenity issues.

Half (38 of 76 or 50%) of the submissions expressed a preference for Option 3 - the Northern Bypass south of Truro to Two Wells (refer Figure 3). These submissions included some from those concerned to make sure that the proposed alignment be adjusted to avoid conflicts with existing land uses, and in particular, valuable viticultural lands in the Barossa area.

Almost one quarter (17 of 76 or 22%) of the submissions expressed support for a Northern bypass that would be located to the north of Truro (Option 2). Many of these respondents supported the reasons presented in the Discussion Paper for this option being dismissed in favour of the shorter Northern Bypass (Option 3).

The key reasons for preference for the two northern bypass options were that railway operations would be removed from built-up residential areas and the better terrain would support enhanced rail efficiency. Some submissions suggested that a rail alignment to the north of Adelaide would support economic growth in that area.

Just under one fifth (14 of 76 or 18%) of the submissions expressed support for Option 4 - the Southern Alignment. This group included industry stakeholders attracted to it because of the potential transit time and cost savings with respect to Melbourne–Adelaide freight. Two of the three freight industry submissions favoured this option. These views were balanced by concerns about the high cost of constructing this alignment, its proximity to residential areas even though much of it would be underground, and the perceived risks of underground operations for train drivers.

Proposals for alignments other than those presented in the Discussion Paper were insignificant in number. Apart from suggestions for either deviating one of the alignments proposed by the Study, or including in the proposed alignments old disused railways, the only significantly different proposal was a modification of Option 1 - the Upgraded Existing Alignment. The suggestion was to acquire land in the Adelaide Hills area to realign the existing railway so as to reduce the number of gradients and curves as well as adopting part of the improvements in the vicinity of Blackwood that form part of the Southern Alignment (Option 4). The additional cost required for land acquisition and realignment of the corridor, as well as disruption to property owners, made this proposal a poor strategic fit.

A submission by Wollongong University suggested realignment of 65 kilometres of rail between Murray Bridge and Mount Lofty based on a previous study in the late 1990s[34]. The design criteria adopted in this paper were less stringent than those adopted for this Study (see Appendix C). The criteria adopted for this Study were agreed by operators and rail owners as required for rail operations to 2039. As a result, the estimated costs in the study cited above were substantially less than those proposed for the Upgrade of the existing line (Option 1).

[34] Mount Lofty - a Modern Mountain Railway study, M Michell, 1997.

Table 6: Summary of the preferred options

Submission Groups	Preferred Option				
	Option 1	Option 2	Option 3	Option 4	Option 5
	Upgrade Existing Alignment	Northern Bypass north of Truro	Northern Bypass south of Truro	Southern Alignment	Northern Bypass south of Truro and Upgraded Existing Alignment
Local Government Councils Regional Council Groups Regional Development Board Community Association	1	3	8	1	1
Rail Operators Industry Associations	1			2	
Residents Individuals Community Members	2	14	30	11	
Total	4	17	38	14	1

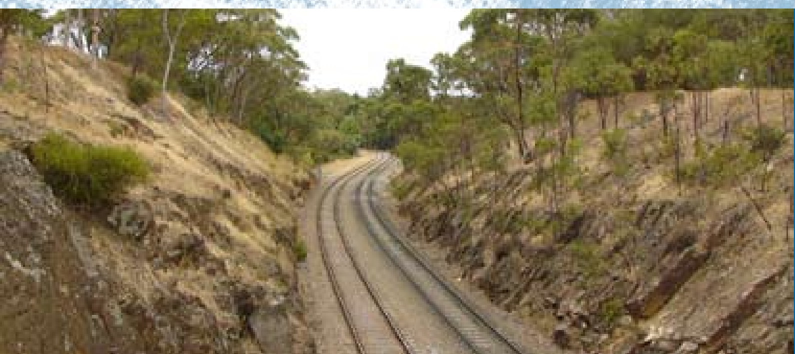
Source: GHD, 2010 – derived from submissions to the Study

Although Option 3 was the most popular choice amongst those that made submissions, a few submissions were concerned that the analysis may not have taken into consideration the impact of alignments traversing private land. For example, the concern of one submission was that the Northern Bypass south of Truro (Option 3) would affect the water supply in one area. A second submission was concerned about the proposed alignment crossing Roseworthy Agricultural College land, and another submission expressed concern that this alignment would be located near or possibly pass through prime vineyards in the Barossa. As the proposed alignments are indicative, adjustments can be made to the alignments to minimise conflicts with other land uses.

One submission questioned whether the evaluation would take account of land acquisition costs. Generic land values were used in the benefit cost analysis to estimate these costs.

A number of community and local government stakeholders suggested that the options could have better reflected the 30-year plan for Greater Adelaide which was released for public consultation in mid-2009. Analysis of the implications of the Greater Adelaide Plan for the future of the Adelaide Hills section of the interstate railway were considered by the Study Team in terms of the potential impact of freight train movements on traffic delays at level crossings, the likely increased exposure to rail noise and other social amenity factors. Also considered was the potential impact of increased passenger rail traffic on freight rail operations.

Separate comments contained in the submissions that the Study should assess the economic and social benefits of increased rail passenger patronage in the absence of freight operations on the Adelaide Hills railway have not been considered. They were not considered because they are outside of the scope of the Study. Similarly, the potential benefits of a Northern bypass for the planned economic growth to the north of Adelaide (including proposals for the development of intermodal facilities) have not been included in the evaluation of the options because this also lies outside of the scope of the Study.



Section 6

Appraisal of the Options

6. Appraisal of the Options

In this Study, appraisal of options has occurred in three stages. In the first stage, the strategic fit analysis was used to make a preliminary assessment of the relative economic, environmental and social performance of all of the options including the existing alignment against the project objectives. The results of the strategic fit analysis were presented in the Discussion Paper and, as part of development of this Final Report, submissions were invited in response to a series of questions about the preliminary findings of the Study. The consultation element was the second stage of the project appraisal process and has already been discussed in Section 5.

In the third stage of appraisal, the options that performed well in the strategic fit analysis were evaluated using benefit cost analysis, with consideration of the inputs received from the public submissions incorporated into the process. This process involved comparing the net costs and benefits of each alternative against the Base Case. In this Study, the Base Case is the existing line as described in Table 2 as well as committed projects on the line. [35]

This section of the Report explains the first and third elements of the appraisal process. These elements are presented in the following sections.

6.1 First Stage: Preliminary Assessment: The Strategic Fit Analysis

The purpose of the strategic fit analysis was to guide the development of a shortlist of options that warranted evaluation using benefit cost analysis. This preliminary assessment was not intended to provide a basis for a firm view on which is the best option, or whether any of the improvement options are economically justified. In particular, it was possible that options that appeared attractive on this preliminary strategic assessment phase could have faired poorly under a benefit cost analysis due to the high cost of implementing them.

Three sets of criteria were used to assess the options - economic, social and environmental - as shown in Table 7.

Table 7: Consideration in selecting the options

Economic	Social	Environmental
Freight capacity	Safety	Risk to flora and fauna
Transit time	Noise levels	Air pollution in the Study Area
'above rail' operating costs	Level crossing delays	Greenhouse gas emissions
Track maintenance costs	Heritage impact	Land pollution
Project investment	Community amenity	Risk to watercourses

Source: GHD, 2010

[35] As part of the Government's Economic Stimulus Plan, ARTC is extending and constructing a total of seven loops between Melbourne and Adelaide to 1800 metres. In combination with the extension and construction of five new loops between Adelaide and Kalgoorlie in Western Australia and the extension and construction of six loops between Crystal Brook (north of Adelaide) and Cootamundra in NSW, this program will accommodate the expected growth in rail freight over the east-west rail corridor whilst maintaining transit times. Work is underway on all three loop upgrade programs, with all eighteen loops to be commissioned into operation by December 2011. This program would see the construction of two new loops between Adelaide and Murray Bridge. Works on a loop at Callington are currently underway and are expected to be completed by March 2011. A second loop, at Ambleside, is currently at the pre-construction stage and is expected to be considered for approval by the South Australia Development Assessment Commission in mid-2010.

All but one of the options that were assessed using the strategic fit analysis approach, were selected for inclusion in the final stage of the appraisal for this Study, the benefit cost analysis. These are:

- Option 1: the Upgraded Existing Alignment.
- Option 3: the Northern Bypass via south of Truro.
- Option 4: the Southern Alignment.
- Option 5: the combination of the Northern Bypass via south of Truro and the Upgraded Existing Alignment.

Option 2, which is the Northern Bypass that would involve an alignment to the north of Truro, was not selected for further analysis, because:

- It is 18 kilometres longer than Option 3 and has more steep sections.
- Construction of this alignment would require extensive bridge and cutting work.

6.1.1 Retain the existing route without major upgrading (Base Case)

With ARTC's currently planned improvements as noted previously, the existing route would have sufficient capacity to meet projected demand until between 2025 and 2030. There has been gradual improvement to train length, a focus on level crossing protection, noise monitoring and mitigation, which has improved the efficiency of the railway. No other improvements are planned under the Base Case.

The physical characteristics of the route do, however, affect the efficiency and reliability of rail operations. They limit the ability of operators to take advantage of economies of scale in train operations. At present, it is not possible to operate double-stack trains on the route, and train length is limited to 1500 metres with a maximum total train weight of 3500 tonnes. Tight curves and steep gradients further increase train operating costs and track maintenance costs.

There are many level crossings on the route, resulting in delays to road traffic and giving rise to safety concerns. Community amenity is also affected by the noise arising from the operation of freight trains through what are now densely populated residential areas.

6.1.2 Upgraded existing alignment (Option 1)

Option 1 (improving the existing route without constructing a new bypass) has a capital cost estimate of approximately $0.7 billion which is significantly lower than the estimated cost of other improvement options. This level of expenditure would allow the redevelopment of the route to make the operation of 1800m, double-stacked trains possible. This would significantly improve track capacity and the efficiency of rail operations.

The investment would also encompass a range of measures to reduce the social impact of freight operations on the route. For example, works would include upgrading of road/rail crossings, noise walls, additional passing loops, tunnels and overbridges. The two most significant rail-rail intersections at Goodwood Junction and Torrens Junction would be grade separated to better facilitate rail freight transit times at estimated capital costs of $150 million and $60 million, respectively.[36]

While this option would reduce road traffic delays as well as residential noise levels, it would not completely eliminate the issues associated with the operations on the Adelaide Hills route. Amenity issues and potential safety risks would continue to exist for the communities that live in close proximity to the route. Trains would also continue to face the steep grades and tight curves of the existing route.

[36] This Study has identified the need to allow for costs associated with the grade separation of the ARTC interstate rail freight corridor from urban passenger trains and road traffic. At the time of this Study, a budget allowance of $240 million for the grade separations at Cross Road, Goodwood and Torrens junctions has been included in options which retain freight train operations over the current route.

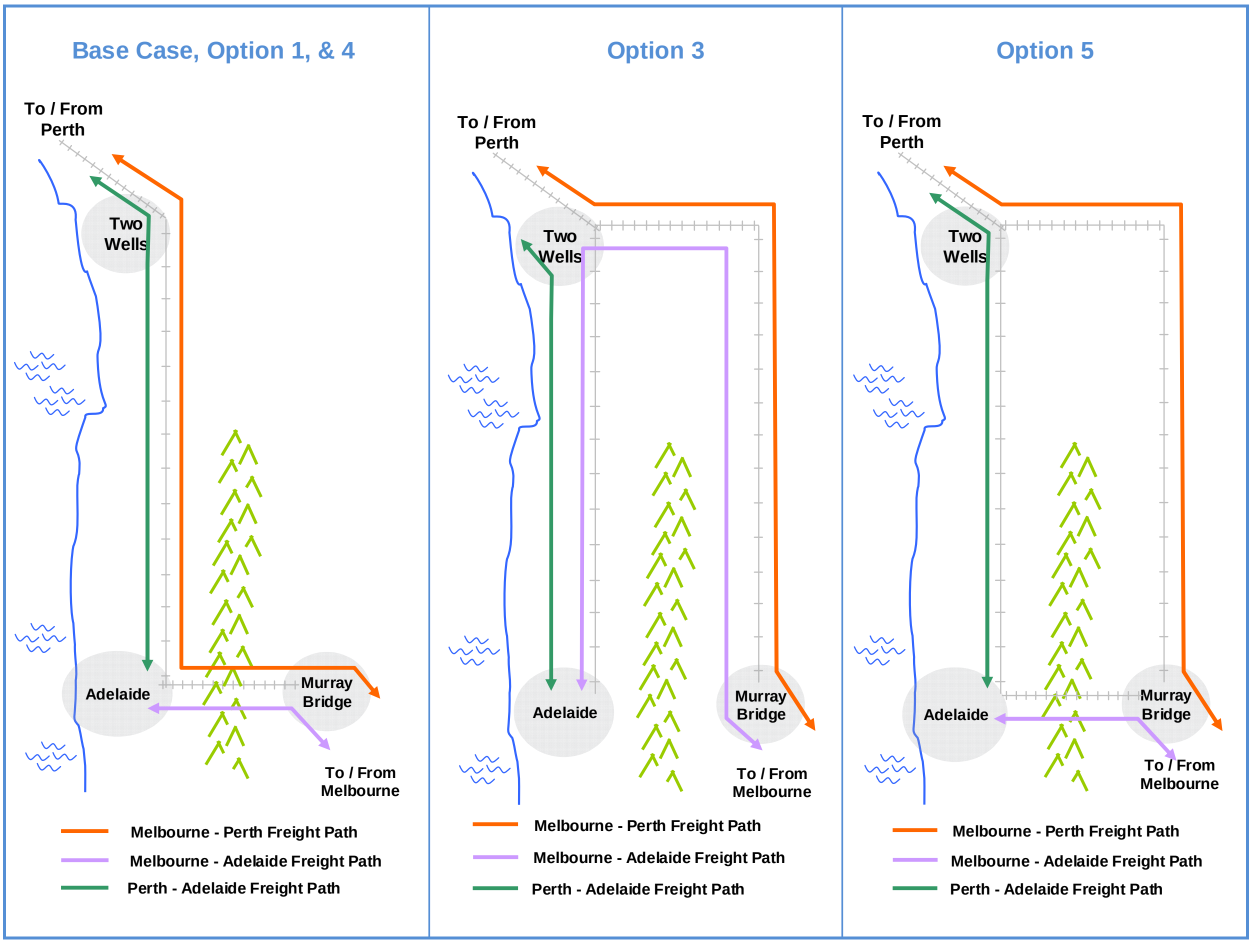
Nevertheless, as the lowest cost option that could be incrementally implemented to increase capacity from 10.7 million to 14.3 million tonnes and to address some of the amenity issues, this option was selected as one of the options to be evaluated using benefit cost analysis.

6.1.3 Northern bypass (Option 3)

Option 3 is mostly at ground level and on flat plains area. However, improvements would be required to the short tunnel and the bridge at Murray Bridge. In total, project investment costs associated with this option would be approximately $2.4 billion. This includes $1.4 billion of construction costs and $1.0 billion for land, preliminary services and Murray Bridge works. This budget allows for the bypass to be developed to a standard capable of handling 1800 metre long double-stacked container trains and it would provide enough capacity to meet the rail freight demand through to 2039.

Under this option, freight traffic on the existing route would cease. This would mean that freight flows to Islington would need to be redirected from Two Wells for 'to and from' Adelaide freight under this option as illustrated in Figure 11.

Figure 11: Freight flows under various options



Source: GHD, 2010

This option would provide a full resolution of the community amenity issues associated with operations currently on the Adelaide Hills route as the Northern Bypass would travel through currently sparsely populated country and poses relatively few new social issues. Preliminary assessments suggest that there are two heritage sites within 100 metres of the alignment that could be affected. However, it is

possible that more detailed investigations would reveal refinements to this alignment that would allow these sites to be avoided.

Although the route taken by freight trains operating to and from Adelaide would be indirect, overall this option allows the use of more efficient trains than can currently be accommodated. Therefore, track operating costs for this option are relatively low. This option also reduces transit time and cost for rail freight between Melbourne and Perth.

Option 3 was one of the options selected for further analysis via benefit cost analysis due to these efficiency gains and the improvements to social amenity and public safety.

6.1.4 The southern alignment (Option 4)

This option is the most expensive of the options in construction terms. It would cost approximately $2.4 billion in construction costs and total $3.0 billion when land, preliminary services and Murray Bridge works are included. The large capital costs are required because of extensive tunnelling and the costs of providing grade separation at Goodwood, Cross Road and Torrens Junctions. However, because it offers a number of advantages, it was included among the options that were subjected to benefit cost analysis.

A major attraction of this option is that it would result in low operating costs, both 'above rail' and 'below rail'. It also has the potential to reduce transit times to a greater extent than any of the other options. The relatively low fuel consumption in this option also means that emission of pollutants is relatively low, and, for most of the route, takes place at some distance from concentrations of population[37].

This option also performed very well against social criteria. Under this option, as under Option 3, commercial freight traffic on the existing route would cease, and this would provide a full resolution of the community amenity issues associated with operations currently on the Adelaide Hills route.

As the bypass route for this option is relatively short and much of it would be underground, the road traffic delays associated with this option would be low. There are also few heritage issues associated with this alignment: only one heritage site — an indigenous site — was identified within 100 metres of the alignment. However, it is possible that more detailed investigations will reveal refinements to the alignment that would allow this site to be avoided.

6.1.5 A northern alignment and upgrading the existing route (Option 5)

Option 5 is the most expensive option at an estimated total cost of $3.2 billion. The construction cost of $2.1 billion includes Goodwood Junction and Torrens Junction grade separation works (Upgraded Existing option).

In addition, Option 5 was not the best performer among the options that were assessed under the strategic fit analysis, as it would require a high level of initial investment and, as the existing route would also remain in service, it would result in high track operating and maintenance costs. However, this dual alignment option offers a number of potential advantages that warranted additional analysis using benefit cost analysis.

Whilst not completely eliminated under this option, the problems associated with the Existing Alignment are reduced by both the diversion of Melbourne–Perth traffic to the northern bypass and by the proposed improvements to the current Adelaide Hills route. Option 5 provides for efficient routings for both Melbourne–Adelaide and Melbourne–Perth freight train services, allows the use of double-stacked 1800-metre trains in both cases, and provides a very good result on 'above rail' operating costs.

[37] The exception is emissions from trains bound for Perth, which would need to travel through Adelaide — as they do now.

In the preliminary analysis, the alternative of combining a northern bypass with maintaining freight operations on the unimproved existing route was also considered. This option did not proceed to benefit cost analysis for a number of reasons. While operating the two lines would reduce the traffic load on the existing route, it would not do anything fundamental to address the operating inefficiencies and social issues associated with the Adelaide Hills route. The reduction in freight traffic levels would bring only limited improvement, and as volumes grow over time even this limited improvement would be eroded.

6.2 Third Stage: Benefit Cost Analysis

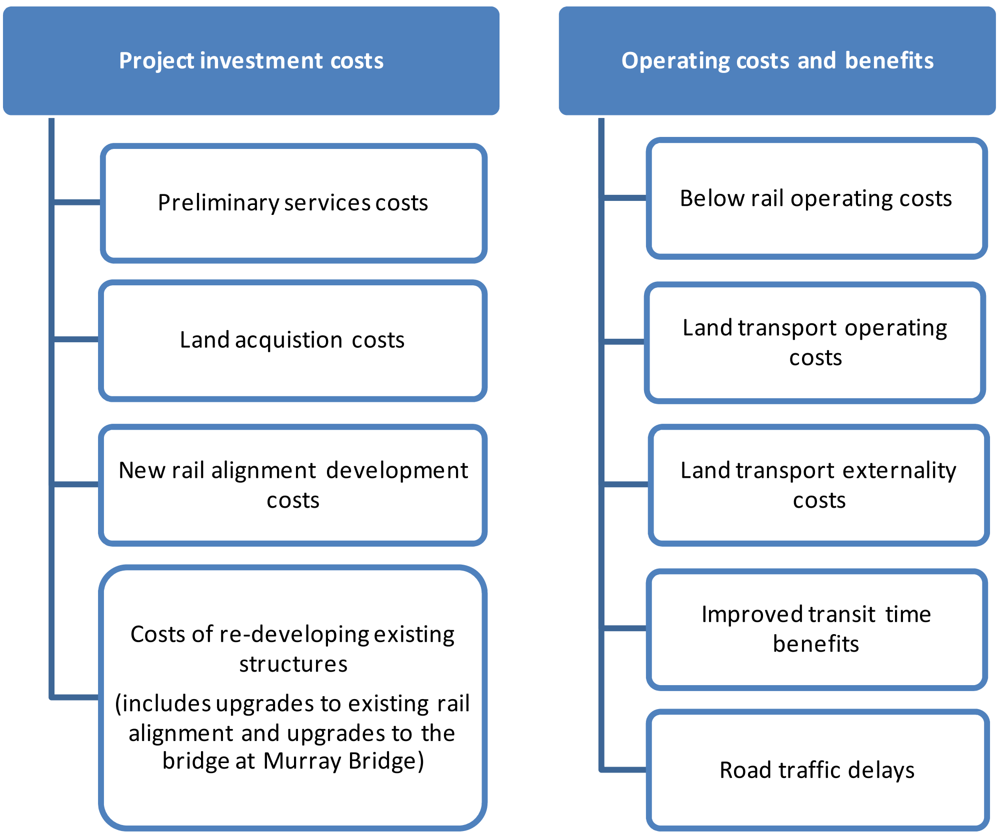
As mentioned in Section 6.1, a number of options emerged from the strategic fit analysis as warranting further evaluation using benefit cost analysis. This phase of the appraisal process also considered relevant insights provided by the public submissions in response to the Discussion Paper.

Benefit cost analysis as recommended by the Australian Transport Council guidelines is appropriate for a study concerned with making strategic investment decisions. The approach involves:

- Focusing on cost and benefit elements that are likely to vary systematically between options or those that clearly highlight differences in fundamental feasibility of the options.
- Working at a level of accuracy necessary to usefully inform strategic decisions. This includes using generic unit data for certain cost or benefit elements unless specific data are readily available.
- Assuming the net economic merit of an alternative alignment option is the difference in net present value (that is, benefits less costs discounted over the evaluation period of 30 years, in this case) between each alternative and incremental to the Base Case (existing line/'do nothing' option).

An overview of the nature of costs and benefits analysed is shown in Figure 12.

Figure 12: Summary of rail alignment option costs and benefits



Source: GHD, 2010

There are a number of different beneficiaries of the benefits outlined in Figure 12. In the main, freight customers (consumers and producers), local residents and taxpayers (in general) would be the main recipient groups across society as noted below.

- Lower ‘below rail’ operating costs would flow to the operator/manager of the alternative rail alignment. This could be the ARTC, and to some extent the taxpayer.
- Reductions in land transport operating costs would flow to train and truck operators. Under an assumption of competitive haulage markets, this would result in lower prices to consumers and producers (i.e. freight customers).
- Reductions in land transport externality costs in the form of lower noise, air pollution and vibration costs would benefit the residents living along and around the Adelaide Hills alignment.
- The benefit of faster transit times would flow through to consumers and producers (i.e. freight customers) in the form of lower prices. For example, warehouses, retail and manufacturing facilities would be able to avoid inventory stock-out costs – something that would benefit consumers and producers.
- Reductions in road traffic delay costs would benefit road users (car drivers and passengers as well as freight/commercial vehicle drivers and passengers). Apart from delivering travel time savings and lower vehicle operating costs, it would also cut the level of accident costs incurred by the community when level crossing accidents occur.

6.2.1 Economic evaluation results

Future costs and benefits of an alignment option are expressed in present value terms. Discounting allows future costs and benefits to be viewed in the dollars of the day. A discount rate of 7% real has been used in this benefit cost analysis. A 30-year evaluation period (2009 to 2039) was used to calculate the measures of net economic worth of the alignment options. This evaluation period also corresponds to the freight traffic forecast period. The benefit cost analysis incorporates analysis of three key categories of costs and benefits of strategic importance: project investment costs, operational efficiency and social/environmental benefits. These are discussed below.

- **Project investment costs**

Project investment costs refer to the capital expenditure incurred for each alignment option. This includes costs of:

- Preliminary services (design and investigation, project management).
- Land acquisition (purchasing tracts of land).
- Upgrade works such as to achieve Upgraded Existing Alignment (noise walls, rail tunnels, passing loops and grade separations) and Murray Bridge and access works for all options.
- Constructing new rail alignments (earthworks, laying of rail track).

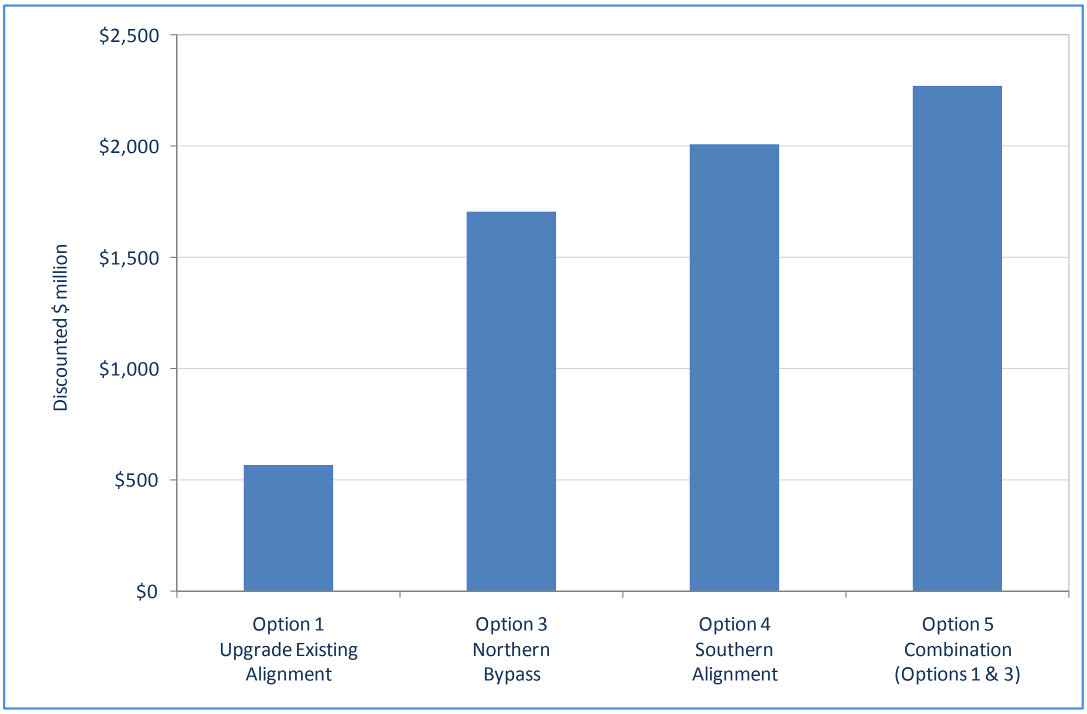
All the alignment options result in additional, or net, project investment costs compared with the Base Case (the Existing Alignment). The smallest additional project investment costs incurred over the Base Case are for Option 1, the Upgraded Existing Alignment, for which present value costs of future investments are estimated at $568 million. This is a present value figure not a capital cost estimate.

The new bypass alignments, Option 3 and 4, result in significantly higher additional project investment costs over the Base Case, with $1.7 billion and $2 billion incurred, respectively. These are present value figures not capital cost estimates.

Of the alternative options available, Option 5 (a combination of a new Northern Bypass and an upgraded existing route) results in the highest additional capital investment outlay. This is estimated to be

$2.3 billion in present value terms. A summary of project investment costs of each alternative option incremental to the Base Case option is displayed at Figure 13.[38]

Figure 13: Project investment costs over Base Case, 2009-2039



Source: GHD, 2010

- **Operational efficiency benefits**

The alignment options were evaluated on their ability to generate operational efficiency benefits over the Base Case. These benefits comprise reductions to track costs ('below rail' costs including both operating and maintenance costs) and land transport operations ('above rail' and road transport costs). There is also an efficiency benefit to freight customers, with faster train transit times contributing to lower warehouse and retail stock-out costs.

– **'Below rail' operating benefits**

'Below rail' operating benefits relative to the Base Case are primarily a function of age followed by length of alignment. New track as envisaged for the proposed Northern Bypass or new Southern Alignment (Options 3 or 4) would be expected to incur less maintenance costs on a per kilometre basis than the much older existing rail infrastructure.

– **Land transport operating benefits**

Land transport operating benefits mainly reflect the economies of scale that train companies obtain from running 1800 metre double-stacked trains in the alignment options compared with 1500 metre single-stacked trains in the Base Case. Apart from train operating benefits, the options generate benefits in terms of avoided road transport operating costs. These occurred later in the (2009-2039) evaluation period.

These benefits reflect the track capacity limitation in the Base Case. That is, the existing track is expected to reach its capacity limit from the mid-to-late 2020s, which means rail cargoes above this limit will instead be transported by road transport to and from intercapital origins and destinations. The

[38] The project investment costs cited, are in present value terms and are therefore different from the undiscounted values which appear in Table 2, pg 19.

resultant road transport operating costs are foregone under each of the options since each alternative alignment has sufficient track capacity to meet the end-of-period (2039) forecast rail freight volume level.

Land transport is the largest contributor to operational efficiency benefits for each alternative alignment. This result is intuitive since the core benefits of an improved or new rail track tend to be reflected in a lower unit haulage cost – that is, a lower cost per tonne of freight hauled by train. The alternative alignments would allow each train trip to be undertaken at a substantially higher payload (due to longer, double-stacked configurations) for a moderately higher locomotive, wagon and fuel cost, providing a lower train operating cost per tonne by comparison with the Base Case.

An important driver of the size of land transport benefits for each alignment option is the distance travelled by trains. The influence of distance is apparent when the land transport benefits of the Southern and Northern Bypass alignment options are compared. Land transport benefits (in present value terms) in the Southern Alignment (Option 4) are $99 million, compared with $46 million in the Northern Bypass (Option 3). This difference is primarily due to the significantly shorter track distance that trains need to travel when accessing Adelaide using the Southern Alignment compared with the Northern Bypass route. This is consistent with the fact that most train cost components vary with distance - the longer the distance travelled, the higher the locomotive/wagon maintenance and fuel costs incurred.

– **Transit time benefits**

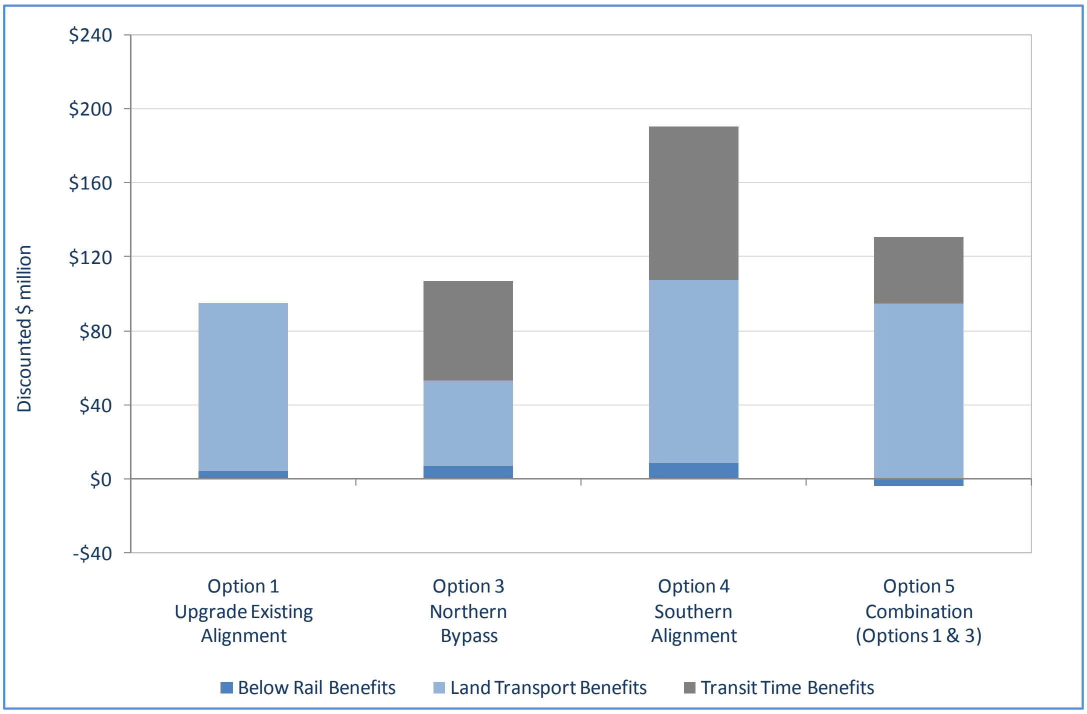
Transit time benefits reflect the value that freight wholesalers and end-customers (retailers) place on rail's contribution to faster door-to-door delivery times. For time-sensitive freight such as containerised electrical or food items, faster train trips can contribute to reduced stock-out costs at retail outlets.

Train transit time benefits account for a notable proportion of operational efficiency benefits, while 'below rail' infrastructure benefits are a very small proportion as shown in Figure 14.

In terms of operational efficiency benefits, the Southern Alignment (Option 4) is the best performer by comparison with the Base Case, with estimated benefits of $190 million over the 30-year period. The next best performing options are Option 5 (Northern Bypass as well as Upgraded Existing Alignment) and Option 3 (the Northern Bypass, south of Truro), with estimated benefits of $128 million and $108 million, respectively.

The Upgraded Existing Alignment (Option 1) generates operational benefits of $95 million over the Base Case. However, this operational benefit is relatively small compared with those offered by the new Southern or Northern bypass options. This is primarily because an improved Adelaide Hills track does not give any train travel time benefits to freight customers.

Figure 14: Net operational efficiency benefits, 2009-2039[39]



Source: GHD, 2010

- **Social benefits**

The impact of rail alignment options and more efficient freight train configurations on communities and the environment is quantified in benefit cost analysis. The social benefits of adopting an alignment option are captured via two channels; reductions in the costs of road/rail level crossing delays and reduced negative externalities. Delay benefits are the value that drivers and passengers of commercial and passenger vehicles place on shorter (or no) time spent waiting at level crossings, while externality benefits represent the lower noise, air and water pollution, nature and landscape impacts that freight movements have on surrounding residents and the environment.

Assumptions were made in estimating road traffic delay hours. These included assuming that 4% of Annual Average Daily Traffic volumes are heavy vehicles, average train speed at level crossings is 60 kph and 1500 metre or 1800 metre trains would operate depending on the option. The number of level crossings for each option was then identified. For example, there were 41 for the Base Case, 36 for Option 1, 28 for Option 4 and 49 for Option 3. The annual road traffic delay costs over the (2009-2039) evaluation period were then calculated. For example, road traffic delay costs are estimated to be $8 million and $6.5 million dollars for Options 3 and 4, respectively over the 30 years.

The net social cost of each alignment option over the Base Case is shown at Figure 15. The operational efficiency benefits of the Southern Alignment (Option 4) also generates the highest social benefits. These are estimated at $14 million over the 30-year evaluation period relative to the Base Case. The Upgraded Existing Alignment (Option 1) delivers small social benefits over the Base Case.

The most striking feature of the data presented in Figure 15 is the externality impact of the Northern Bypass south of Truro (Option 3). The construction and operation of a Northern route is predicted to generate externality costs that are $39 million higher than the Base Case.

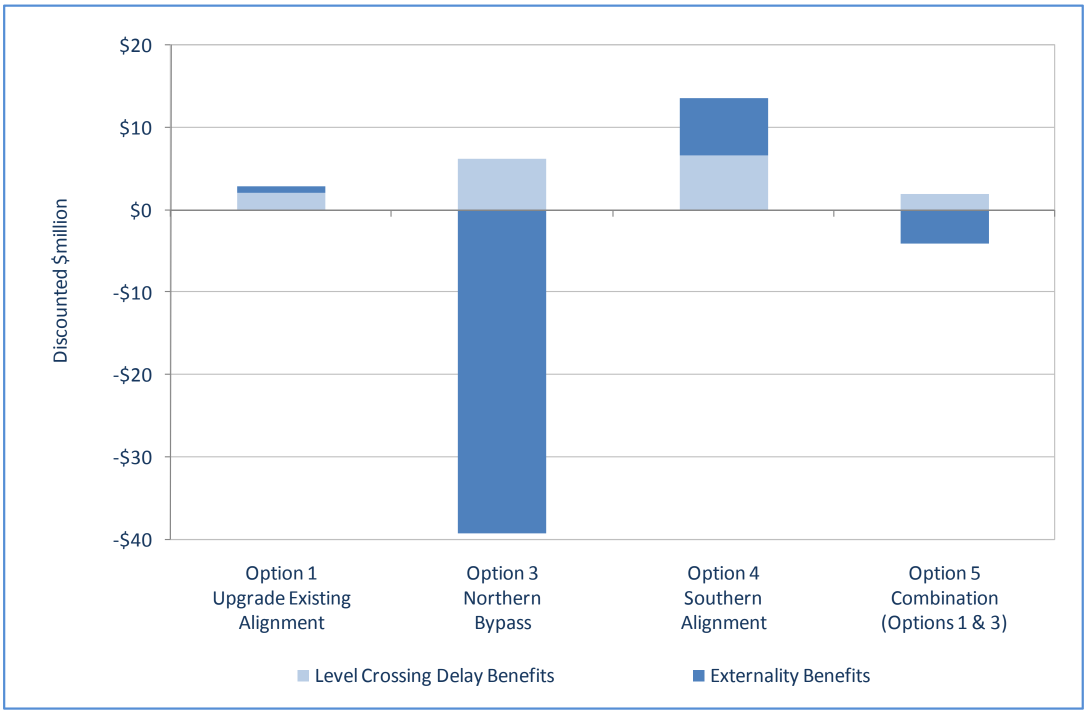
[39] Option 5 'Below Rail Benefits' are negative as two alignments (totalling 258 kilometres) will require ongoing maintenance against a single alignment (totalling 104 kilometres) for the Base Case.

This is surprising given that the Northern Bypass is a relatively flat alignment that mainly traverses small rural townships. The consequent noise intensity and impost of freight train movements on local residents should be markedly lower than the *status quo*.

This outcome is largely explained by the way in which this benefit cost analysis quantifies externalities[40]. The unit values used to calculate externality benefits are distance rather than intensity based values (that is, dollars per train kilometre travelled). This means the magnitude of noise benefit is a function of alignment length as opposed to severity of impost on local residents. Given the Northern Bypass is approximately 90 kilometres longer than the Existing Alignment, calculated externality costs will be higher in the Northern Bypass option than in the *status quo*.

Intensity-based externality values specific to the Adelaide Hills rail operations context are not available. For example, there is no noise exposure forecast for the line identifying the intensity imposed on the local residents in Adelaide Hills. The lack of this location-specific data necessitated a reliance on generic distance-based externality values from the Australian Transport Council guidelines. By adopting a distance-based approach to quantifying noise externalities, it effectively assumes that the intensity (and cost) of noise impact per train movement along the Northern Bypass route is the same as that experienced along the existing route.

Figure 15: Net social benefits over Base Case, 2009-2039



Source: GHD, 2010

6.2.2 Overall results relative to Base Case

The present value of the operational efficiency and social benefits (displayed in Figure 14 and Figure 15, respectively) are summed to give total present value benefits. Total present value costs (displayed in Figure 13) are subsequently subtracted from total present value benefits to determine the net present value of the alternative alignment options compared to the Base Case.

[40] Externalities are defined in the National Guidelines for Transport System Management in Australia (ATC, 2006).

Net present value is the primary summary measure of the net economic worth of a project. A positive net present value indicates that total project benefits exceed total project costs and the project is economically justified. A negative net present value indicates that total project costs exceed total project benefits and therefore the project has no net overall economic merit.

Table 8 outlines the capital cost and net present value of the options incremental to the existing rail alignment. Capital costs play an important role in determining net present value. Table 8 shows that each alignment option has a significant negative net present value compared to the Base Case.

Table 8: Summary of capital cost and net present value outcomes of the options

The Options	Description	
	Total undiscounted preliminary estimate of capital cost ($m)	Net present value ($m) based on most likely freight growth assumptions
Option 1: Upgrade Existing Adelaide Hills Alignment (orange route in Figure 10)	700	-470
Option 2: Northern Bypass via north of Truro (red route in Figure 10)	2,900	N/A
Option 3: Northern Bypass via south of Truro (blue route in Figure 10)	2,400	-1,633
Option 4: Southern Alignment (purple route in Figure 10)	3,000	-1,805
Option 5: Upgraded Existing Alignment (orange route in Figure 10) and Northern Bypass via south of Truro (blue route in Figure 10)	3,200	-2,145

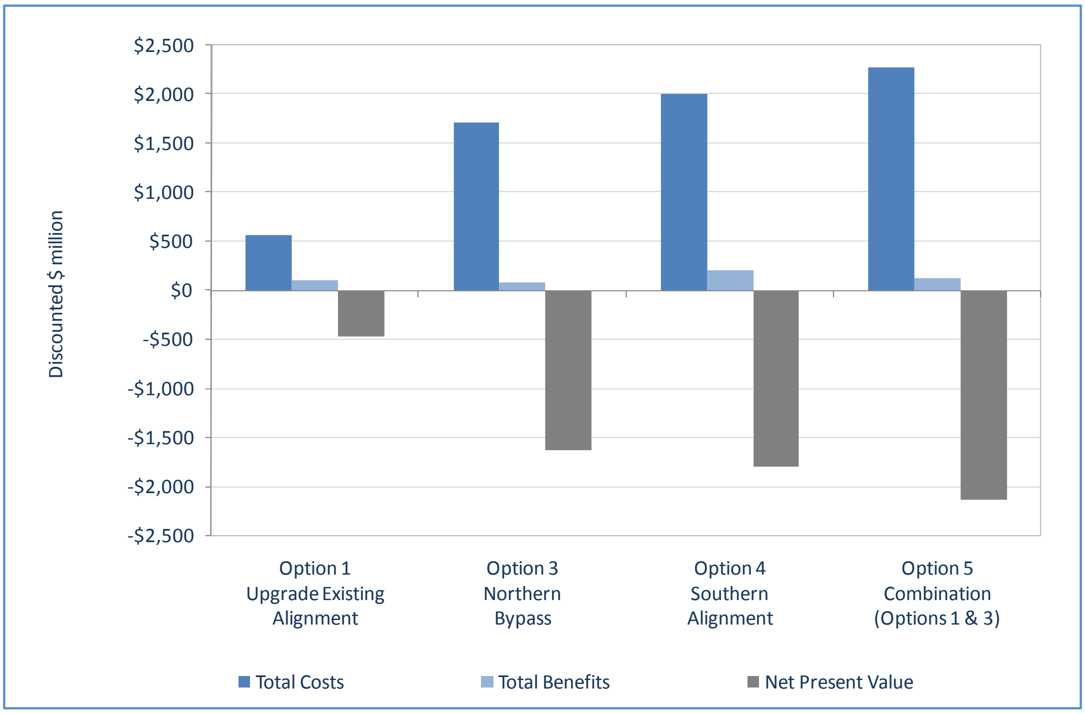
Source: GHD, 2010

Figure 16 displays the graphical version of the net present value outcomes in Table 8. Of the alignment options, the Upgraded Existing Alignment is the best performing option, with the lowest negative net present value outcome of -$0.47 billion compared to the Base Case. In other words, total costs are higher than total benefits by $0.47 billion.

The second best performing option is the Northern Bypass (Option 3) which has a negative net present value of -$1.6 billion relative to the Base Case. This compares with net present value of -$1.8 billion for the Southern Alignment (Option 4). This reflects the higher costs of implementing the Southern Alignment option (i.e. an additional $300 million is required for construction by comparison with the Northern Bypass). This outweighs the higher benefits provided by the Southern Alignment option (i.e. it generates $130 million more in benefits than the Northern Bypass).

The worst performing option is the combination of the Northern Bypass and Upgraded Existing Alignment (Option 5) with the largest negative net present value over the Base Case of $2.1 billion.

Figure 16: Net present value outcomes relative to the Base Case



Source: GHD, 2010

The core finding from this analysis is that the capital outlay required to improve the existing rail line or to construct a new line is far greater than the benefits derived from such an outlay. While there are benefits flowing to rail track managers, train operators and the communities that surround the rail line, the size of these benefits is only modest compared with the size of the capital outlay required to generate such benefits, particularly for the new alignment options. As such, all the alignment options perform worse from an economic perspective than the Base Case.

Sensitivity tests were conducted for the four options to gauge how robust each net present value outcome is to changes in key benefit cost analysis modelling assumptions, cost and demand forecasts and parameter values. A range of alternative values were selected for the discount rate, capital outlays, growth in forecast rail freight volume and road traffics and externalities (specifically, the noise externality value).

As shown in Table 9, the sensitivity tests revealed that the net present value outcomes for the alignment options remain relatively similar under changes in key assumptions and parameters. All the alignment options still give significant negative net present value outcomes compared to the Base Case. As such, all the alternatives perform poorly compared with the Base Case even under sensitivity tests that involve lower capital costs for options.

Table 9: Sensitivity test results - net present value ($m)

Description	Option 1 Existing Adelaide Hills Alignment	Option 3 Northern Bypass via south of Truro	Option 4 Southern Alignment	Option 5 Upgraded Existing Alignment and Northern Bypass south of Truro
Based on central assumptions	-470	-1,633	-1,805	-2,145
Discount rate = 4%: 3 percentage points lower than central assumption	-464	-1,842	-2,031	-2,388
Discount Rate = 10%: 3 percentage points higher than central assumption	-454	-1,442	-1,585	-1,918
Capital costs: 20% lower than central assumption	-356	-1,291	-1,403	-1,691
Capital costs: 20% higher than central assumption)	-584	-1,974	-2,207	-2,599
Rail freight volumes: 20% lower than central assumption	-532	-1,681	-1,870	-2,201
Rail freight volumes: 20% higher than central assumption	-400	-1,576	-1,732	-2,080
Road vehicle traffic: 20% lower than central assumption	-471	-1,635	-1,807	-2,146
Road vehicle traffic: 10% higher than central assumption	-469	-1,631	-1,803	-2,144
Noise externality: 10 times higher in urban areas than central assumption	-470	-1,625	-1,806	-2,144

Source: GHD, 2010

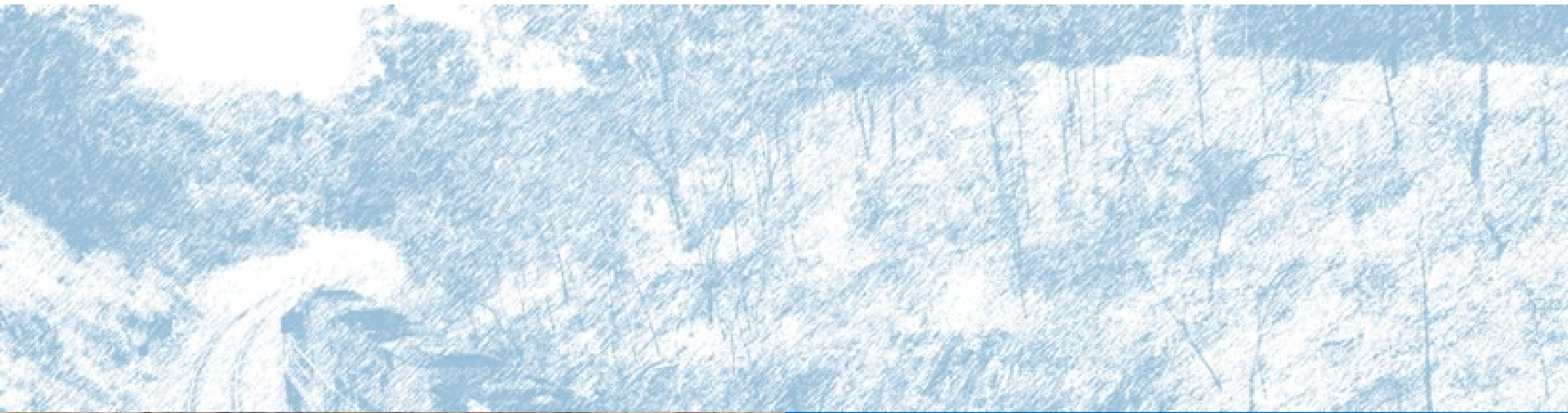
Furthermore, a specific sensitivity test was undertaken on Option 3 in respect of the generic externality unit data that measures the magnitude of social benefits (such as lower levels of noise intensity, air and water pollution). Option 3 is the option most impacted by this issue. Due to the shorter lengths of the other options they were not as significantly impacted by externality measures.

The generic noise externality value used in Options 1, 4, and 5 was set at 10 times higher than that used in the Base Case. The assumed rationale was that noise intensity impact (on residents) per train movement along these options, which passed through urban areas would be 10 times higher than that experienced along the Northern Bypass option (rural route). The resultant impact on the net present value outcome in the Northern Bypass option was marginal – an $8 million improvement in the net present value.

6.2.3 Benefit Cost Analysis Conclusions

The key conclusions from the benefit cost analysis are:

- Over a 30-year evaluation period (2009 to 2039, inclusive) there would be no net economic benefit compared to the Base Case in upgrading the existing rail line and/or constructing a new line to the scale as assessed in this Study. This is because all the alignment options result in significant negative net present value outcomes relative to the Base Case. For example, the Northern Bypass (Option 3) would have a negative net present value of $1.5 billion compared to the Base Case. It is important to recognise that the economic assessment is an incremental one, and as noted earlier, the Base Case does include expenditures currently committed.
- Of the alternative alignments upgrading the existing rail track through the Adelaide Hills (which includes erecting barriers to reduce noise impacts on the surrounding community, grade separating the most critical road/rail intersection points and modifying tunnels to allow double stacking of container trains) returns the lowest negative net present value incremental to the Base Case.



Section 7

Study Findings and Conclusions

7. Study Findings and Conclusions

7.1 Study Findings

7.1.1 Capacity and demand

Although a well-used route, the current configuration and operational characteristics of the Adelaide Hills section of the corridor, between Murray Bridge and Islington is constraining a more efficient movement of freight between these key centres. Steep grades and tight curves force trains to travel more slowly and to use 50% more locomotive power per tonne than on other interstate rail freight corridors. They also restrict trains to a maximum of 3500 tonnes. The terrain of the Adelaide Hills causes greater locomotive and wagon 'wear and tear' and higher maintenance costs than would be incurred with straighter, flatter alignment[41].

At the moment, and at least for the next 15 years, overall capacity is not likely to be a constraining factor for the Adelaide Hills rail line. The current alignment can accommodate 10.7 million tonnes per year, which is more than double the 4.8 million tonnes per year that are currently carried on the rail line. On the basis of the freight demand forecasts (discussed in Section 3) and ARTC's estimates, and in light of committed works on the line, capacity is unlikely to be reached before 2025.

7.1.2 Social and environmental impact of the rail line

The Adelaide Hills track passes through six local government jurisdictions. As is the case for most Australian capital cities, the existing line runs through urban areas. In the case of Adelaide this is for a distance of about 50 kilometres between Islington and Nairne, where the rail line runs through the centre of, or backs onto, towns and residential properties.

Train noise was mentioned in response to the Discussion Paper as an issue in 42 of the public submissions (55%). Other social and environmental amenity issues raised were the impacts of freight train operations on road traffic delays at level crossings[42]. There are 41 level crossings between Murray Bridge and Adelaide. The risks to public safety including the difficulties created for evacuation in cases of a bush fire and emergency because of the level crossings and the generation of pollution are also matters that were raised.

7.1.3 Options and evaluation

Three feasible alternative alignments and an upgraded existing alignment were identified for consideration in a strategic fit analysis. These were:

- Option 1: The Upgraded Existing Alignment.
- Option 3: The Northern Bypass via south of Truro.
- Option 4: The Southern Alignment.
- Option 5: The combination of the Northern Bypass via south of Truro and the Upgraded Existing Alignment.

The evaluation indicates that the capital outlay required to improve the existing rail line or construct a new line is far greater than the benefits derived from such an outlay. While there are benefits flowing to rail track managers, train operators and the communities that surround the rail line, the size of these benefits is only modest at most and yet the size of the capital outlay required to generate such benefits is large, particularly in the new alignment options. As such, all the alignment options do not offer the

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[41] Australian Rail Track Corporation (ARTC) 2005, Melbourne to Adelaide Corridor, Adelaide page 6.

[42] There are 41 level crossings along the rail line between Murray Bridge and Adelaide which handle a total of about 135,000 vehicle movements per day.

community more net benefits than the Base Case (existing line/'do nothing' option), which as noted previously includes committed expenditures.

Each of the options will deliver operational efficiency benefits in terms of reduced 'below rail' costs, reduced land transport costs and reduced transit times, with the Southern Alignment (Option 4) providing the highest benefits of $190 million and Upgraded Existing Alignment (Option 1) generating the lowest operational benefits of $95 million over the Base Case, over the 30-year evaluation period.

Benefit cost analysis indicates that at best, only modest social and environmental benefits will be achieved by upgrading the Existing Alignment or by building one of the proposed alternative alignments. The Southern Alignment (Option 4) generates the highest social benefits of an estimated $14 million, and the Upgraded Existing Alignment (Option 1) generates benefits of less than $1 million relative the Base Case over the 30-year evaluation period.

Despite travelling through sparsely populated areas that are much flatter than the existing alignment, the Northern Bypass would generate externality costs that are $39 million higher than the Base Case, largely because this alternative alignment would be 90 kilometres longer than the existing alignment. This anomaly has been addressed in a sensitivity analysis on the basis that the noise intensity impact on residents per train movement along the Northern Bypass would be 10 times lower than that experienced along the existing route. The result of the sensitivity analysis was a marginal improvement which did not affect the Study outcome.

7.2 Conclusions

Although all of the alignment options that were developed by the Study Team would be technically feasible, none were found to be economically justifiable at this point in time.

Over a 30-year evaluation period (2009 to 2039), the combination of modest social and environmental benefits and the operational efficiency benefits are not sufficient enough to outweigh the much higher capital costs that would be required to build any of the alternative alignments or to upgrade the existing alignment. Therefore, there would be no net economic benefit to the community compared to the Base Case in upgrading the existing rail line and/or constructing a new line on the scale assessed by this Study.

There are a number of issues that, whilst outside the scope of this Study, will need to be considered in future deliberations about rail infrastructure and operations (freight and passenger) in the greater Adelaide region. These out-of-scope issues include consideration to the urban passenger network and the specific impact on freight/passenger junctions. However, governments (State and Federal) will in the future need to consider the implications that arise from:

- A realisation that in many cases where very substantial capital investments are required to deliver solutions sought by the wider community (not just those very directly impacted) the limited quantum of benefits and numbers of direct beneficiaries will make funding problematic.
- A realisation that very major projects may not deliver positive net benefits whilst comparatively small projects can, albeit in quite specific circumstances where beneficiaries are many and benefits such as travel time savings (for commuters, for example) and/or operating cost savings (for car users, for example) are significant.
- A realisation that in order to fully understand and capture all the impacts of a major infrastructure investment, consideration needs to be given to the network-wide impacts.

Appendices

Appendix A

Study Terms of Reference

Australian Government

Department of Infrastructure, Transport, Regional Development and Local Government

Study Terms of Reference

Introduction

The local community has raised concerns about noise levels, safety and inconvenience for road users of this main interstate rail line through the Adelaide Hills and has sought realignment to the north. These concerns and a proposed realignment of the track are reflected in a report that was prepared by the Mitcham Community Rail Freight Task Force in 2007 (the Task Force is an initiative of the City of Mitcham).

The interstate track runs parallel to the urban passenger rail network from Belair and crosses over urban passenger rail lines at Goodwood Junction and Torrens Junction with nine at-grade rail crossings between Belair and the Keswick terminal. Given the proximity of Goodwood Junction to the rail crossing on Cross Road, west-bound freight trains giving way to passenger trains often sit across the road causing road users to experience delays as the boom gates remain down for extended periods.

The rail industry is taking action to address the current noise caused by "squeaky wheels" with the installation of noise monitoring equipment to monitor noise levels. Data from this equipment is utilised in an ongoing program in conjunction with the State Environmental Protection Authority to analyse and identify the causes of wheel squeal, and to develop operational solutions to eliminate or at least minimise the problem. Reports are submitted every three months to the State Environmental Protection Agency showing trends for wheel squeal noise. The ARTC will trial an alternative method of rail lubrication during 2008, and assess the impact this has on wheel squeal. Wheel squeal is not unique to the Adelaide Hills.

The Australian Government has committed funds to undertake a comprehensive study into the feasibility of improving the capacity and efficiency of the main interstate freight rail line between Murray Bridge and Adelaide. The Study will look specifically at the feasibility of a new alignment that would run to the north of Adelaide. It will also identify other options that may involve any of capital investment, further maintenance or improved flow management.

Study objectives

The study objectives are to:

- Provide an analysis of both current freight rail movements and the forecast growth in freight movements to and through Adelaide (this includes freight moving east and west);
- Provide an analysis of capacity of the line to meet this demand both now and in the future;
- Provide an analysis of the impact of the current alignment of the main interstate freight rail line on community amenity (economic, social and environmental impacts); and
- Identify options to ensure the forecast growth in demand can be met along with an assessment of their feasibility in terms of costs and benefits (in this context, costs will take account of the likely impact on community amenity).

Study area

The Study is to include consideration of the current alignment of the Melbourne Adelaide interstate freight rail line and the proposed northern access alignment. This will include two key points where the interstate track crosses over urban passenger rail lines at Goodwood Junction and Torrens Junction.

Other studies

This Study should consider other transport infrastructure studies including but not limited to:

- Transport Sustainability Study in South Australia.
- Northern Connectors Study.
- South Australian Rail Freight – a bypass to save the heart of Adelaide.
- Melbourne-Adelaide Corridor Strategy.
- Adelaide Urban Corridors Strategy.
- Adelaide-Perth Corridor Strategy.

Methodology

In order to fulfil the Study objectives and deliver key outputs, an indicative project methodology, which may be modified and/or refined in consultant submissions, is as follows:

- An analysis of the east-west rail freight task along the Melbourne to Adelaide and Adelaide to Perth and Adelaide to Darwin corridors and the Adelaide Urban Corridors – the analysis will need to consider the current task and forecast growth in the task over the next 5, 10, 20 and 30 years, using previous studies where relevant. The analysis should consider at a minimum:
  - Frequency of freight trains.
  - Origin and destination of freight.
  - Volume of freight moving along the corridors.
  - Value of the freight moving along the corridors; and any significant developments that would have an impact on the freight task (e.g. the proposed pulp mill at Penola, and possible intermodal hub at Monarto).
- A detailed assessment of the current rail alignment from Murray Bridge through the Adelaide Hills into Adelaide, including connections to the Port of Adelaide and intermodal terminals at Dry Creek and Islington. The assessment will need to consider at a minimum:
  - Performance capability of the corridor and train operations requirements – existing and future constraints in terms of 1800 metre trains double stacked, with appropriate speed & axle loading capability, speed, end-to-end journey times and rolling stock and gauge requirements.
  - Connectivity with the Port of Adelaide and existing and proposed intermodal terminals.
  - Interaction with the passenger rail network and road network.
  - Safety issues.
  - Environmental issues, including specifically noise levels through the Adelaide Hills (including wheel squeal).
- The identification of options to ensure the forecast growth in demand in the rail freight task can be met – options will need to consistent with the performance capability of the corridor and may include (but should not be limited to) capital investment options (e.g. alignment options), maintenance options (e.g. reducing cant deficiencies), flow management options (e.g. reduced speed or improved signalling technologies). A Strategic Merit Test and Rapid appraisal, consistent with the National Guidelines for Transport System Management in Australia (ATC, 2006), is to be completed for each option.
  - The Strategic Merit Test is to be used to identify how well each option would contribute to transport system objectives, policies and strategies along with any barriers to its implementation.
  - The Rapid appraisal for each option is to incorporate an indicative assessment of the main benefits and costs associated. It is also to include a high level risk assessment of the financial, engineering and environmental issues for the option.

Appendix B

Members of the Project Steering Committee and Project Reference Group

Members of the Project Steering Committee and Project Reference Group

Project Steering Committee

Department of Infrastructure, Transport, Regional Development and Local Government

Ms	Debra	Robertson	Assistant Director, Rail Investment & Regulatory Reform, Nation Building Infrastructure Investment
Ms	Rowena	Kleiner	Team member, Rail Investment & Regulatory Reform, Nation Building Infrastructure Investment

South Australia Department for Transport, Energy and Infrastructure

Mr	Mark	Williams	Manager, Rail Policy and Investment
Mr	Daniel	Martucci	Engineer, Rail Policy and Investment

Project Reference Group

Australian Rail Track Corporation (ARTC)

Mr	Angelo	Demertzis	General Manager, East-West Corridor
Mr	Andrew	Tonks	East-West Operations

Freight Rail Operators Group (FROG)

Mr	David	Attlee	Manager Strategy & Infrastructure Planning
Mr	Robert	Easthope	Managing Director

Mitcham Council

Cr	Mark	Ward	Mitcham Community Rail Freight Sub-committee

Observers:

Cr	Helen	Dyer	Chief Executive Officer - City of Mitcham
Mr	Charles	Sheffield	Director, Engineering Services - City of Mitcham
Mr	John	Wiley	Manager Contracts - City of Mitcham
Cr	Colin	Campbell	Mitcham Community Rail Freight Sub-committee
Mr	Bob	Hunt	Mitcham Community Rail Freight Sub-committee

Local Government Association of SA

Cr	Allan	Arbon	Mayor - Rural City of Murray Bridge

Mallala District Council

Mr	Henri	Mueller	District Planner

Mount Barker District Council

Cr	Ann	Ferguson	Mayor

Murray and Mallee District Council

Cr	Ian	Mann	Mayor
Mr	Dean	Gollan	Chief Executive Officer

Barossa Council

Mr	Bim	Lange	Chief Engineer

Onkaparinga Council

Mr	Jeff	Tate	Chief Executive Officer
Mr	Britt	Gowing	Team Leader, Asset Management Branch

Murray Bridge Council

Mr	Damien	Moloney	Chief Executive Officer

Appendix C

Alignment Design Parameters

Alignment Design Parameters

Item	Criterion
Train Length	1800 m
Double Stack	7.1 m clearance
Transit Time	Improved
Rail Operation Noise	Maximum at-track noise levels for rail operations - 60 to 85 decibels for existing lines and 55 to 80 decibels for new lines[43]
	Community complaints
Level crossing safety	Conformance to Australian Standard
	Relative Priority
Level crossing road delay	No more than current
Train paths	Meet current requirement
	Meet 2039 requirement
Tonnage	2039 requirement
Curvature	>400 m radius (desirable) but should be >800 m
Gradient	<1% grade (desirable)
Interface with Public Transport	Delay to freight trains
Terminal Interface	Terminals have capacity without affecting other network requirements
Future Residential Growth	No change to impact
Derailments	National average
Potential Incidents	National average
Visual Amenity	Current levels
Risk to Flora	Manageable
Risk to Fauna	Manageable
Pedestrian Incidents	None
Chemical Pollution	Manageable
Fires	Manageable
Operator Train Parameters	As per current train configuration

[43] In the absence of any statutory limits on rail noise in South Australia, and as an interim measure, these maxima are guidelines that have been adopted by the EPA based on maxima that apply in NSW.

Appendix D

Public Submissions Received

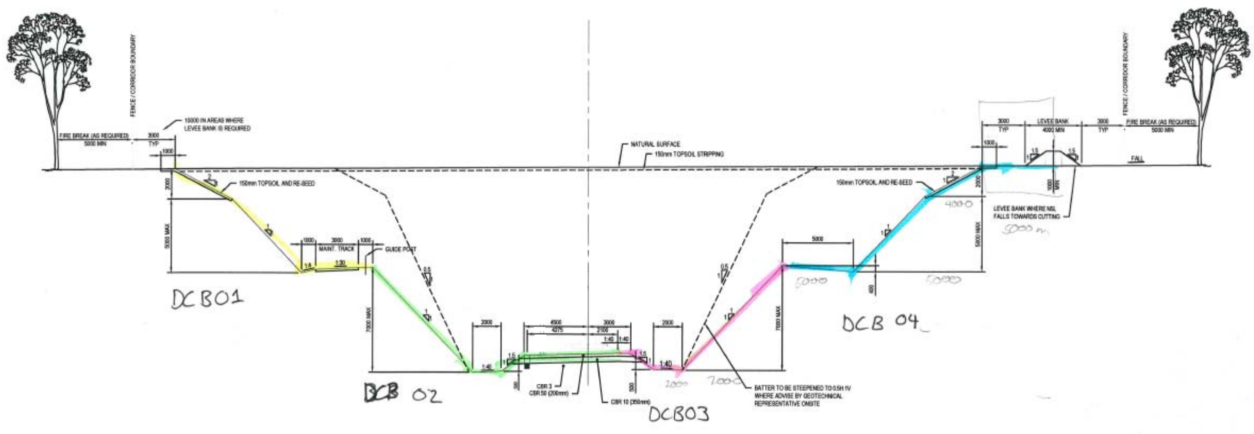
Public Submissions Received in Response to Discussion Paper

Adelaide Hills Council
Asciano Ltd
Australian Rail Track Corporation
Australasian Railway Association
Barossa Council
Blackwood/Belair & district Community Council
City of Adelaide
City of Mitcham
City of Onkaparinga
City of Prospect
City of Salisbury
City of Unley
District Council of Mallala
District Council of Mount Barker
Freight Rail Operators Group
Genesee & Wyoming
Light Regional Council
Monarto Common Purpose Group
SCT Logistics
South Australian Freight Council
Wakefield Group
Wakefield Regional Council
T. Anderson
D. Bardsley
G. Bartlett
S. Bennet
R. Butler
M. Cameron
N. Clark
B. Coomans
B. Donohue
I. Evans
D. Gibson
K. & C. Goodall
I. Grant
M. Guerin
K. Gunn
C. Hampel
R. Heitmann
G. Hickey
R. Hunt
D. Ingram
R. King
P. Laird
D. Laynes
S. & M. Lineham
J. McArthur
B. McCloud
K. McCloud
S. Manoel
Mitcham Hills resident
D. Moffat
J. Mundy
T. Murdoch
M. & M. Paneras
A. Popov
T. Possingham
S. Priestley
M. Prigent
D. Prosser
T. & J. Raison
G. Ross
R. Shearwood
R. Sigston
M. Snell
A. Scholz
J. Terrell
R & P Thiele
J. & T. Tierney
P. & B. Tilbrook
S. Townsend
D. Twining
G. Walker
B. Whibley
C. Wicks
M. Williams/D. DeBats

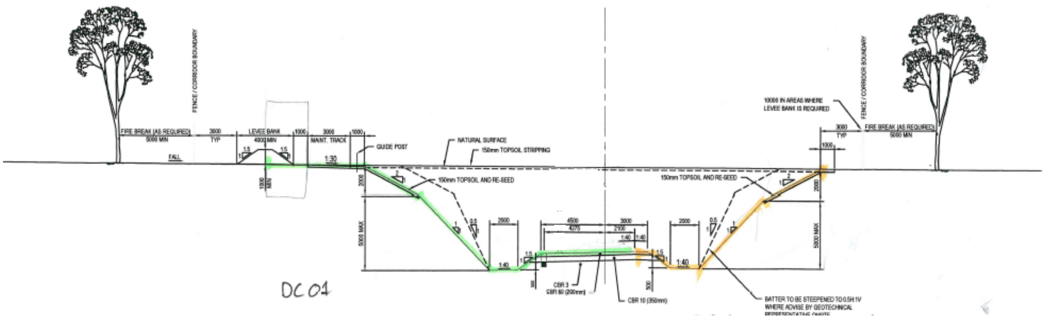
Appendix E

Typical Cross Sections and Bridge Designs

Typical Cross Sections – Deep Cut

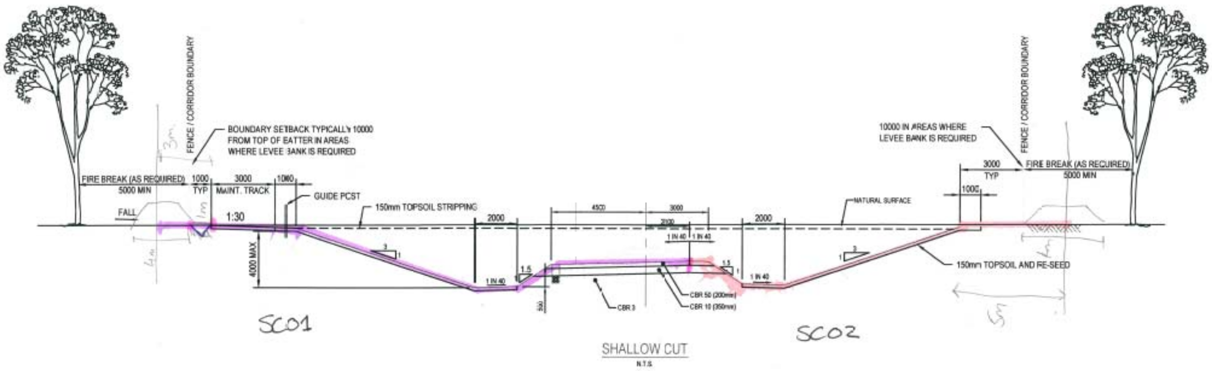


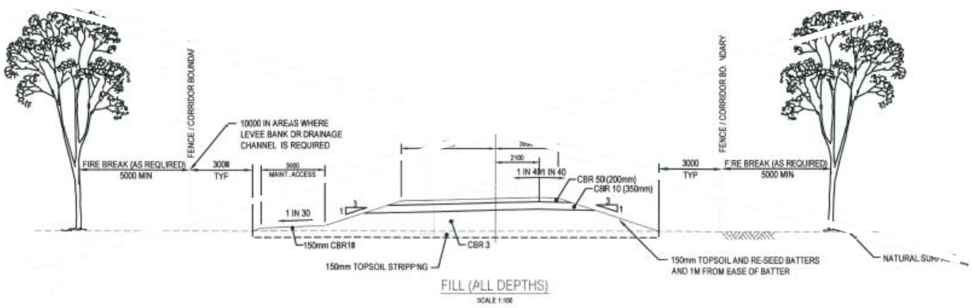
DEEP CUT WITH BENCH > 7m
NTS



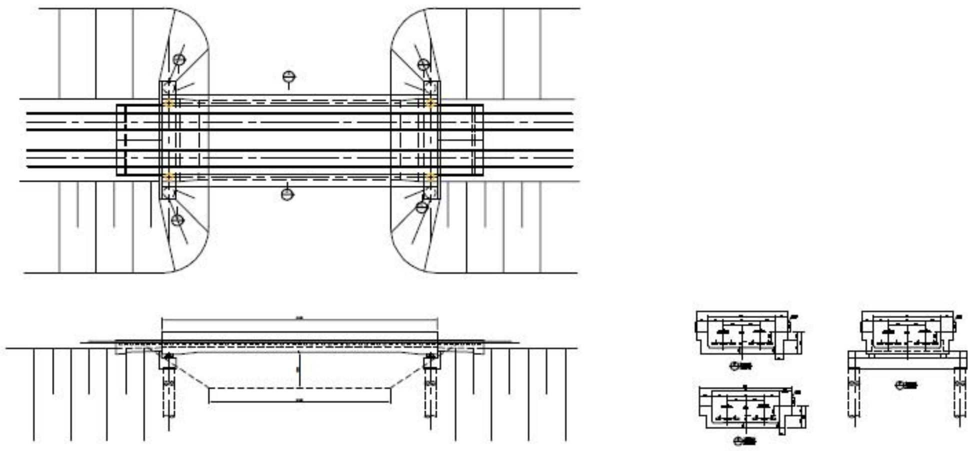
DEEP CUT < 7m
NTS

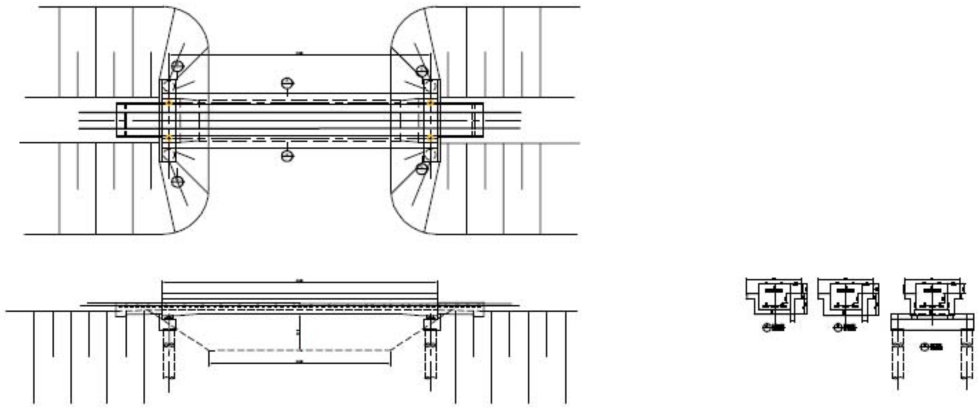
Typical Cross Sections – Shallow Cut and Fill



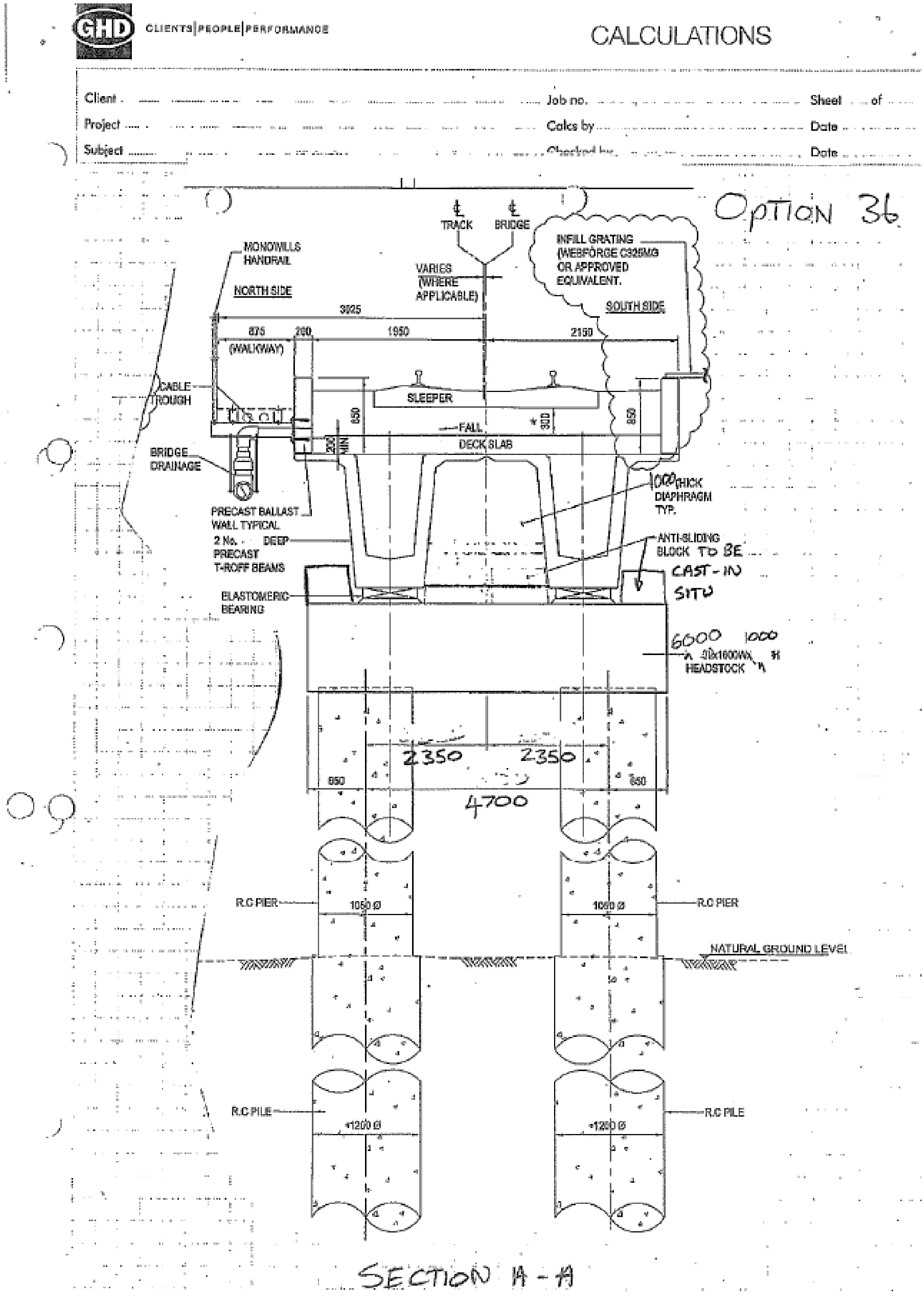


Typical Simple Bridge Design, no piers





Typical Cross Section – Bridge Design



Preferred Bridge Type Construction for Costing Adelaide Bypass

Preferred Bridge Type Construction for Costing Adelaide Bypass

Preferred Bridge Type Construction for Costing Adelaide Bypass

Appendix F

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Louise Meyrick / John Hopman	Steve Kanowski		Martin Baggott		03/06/10