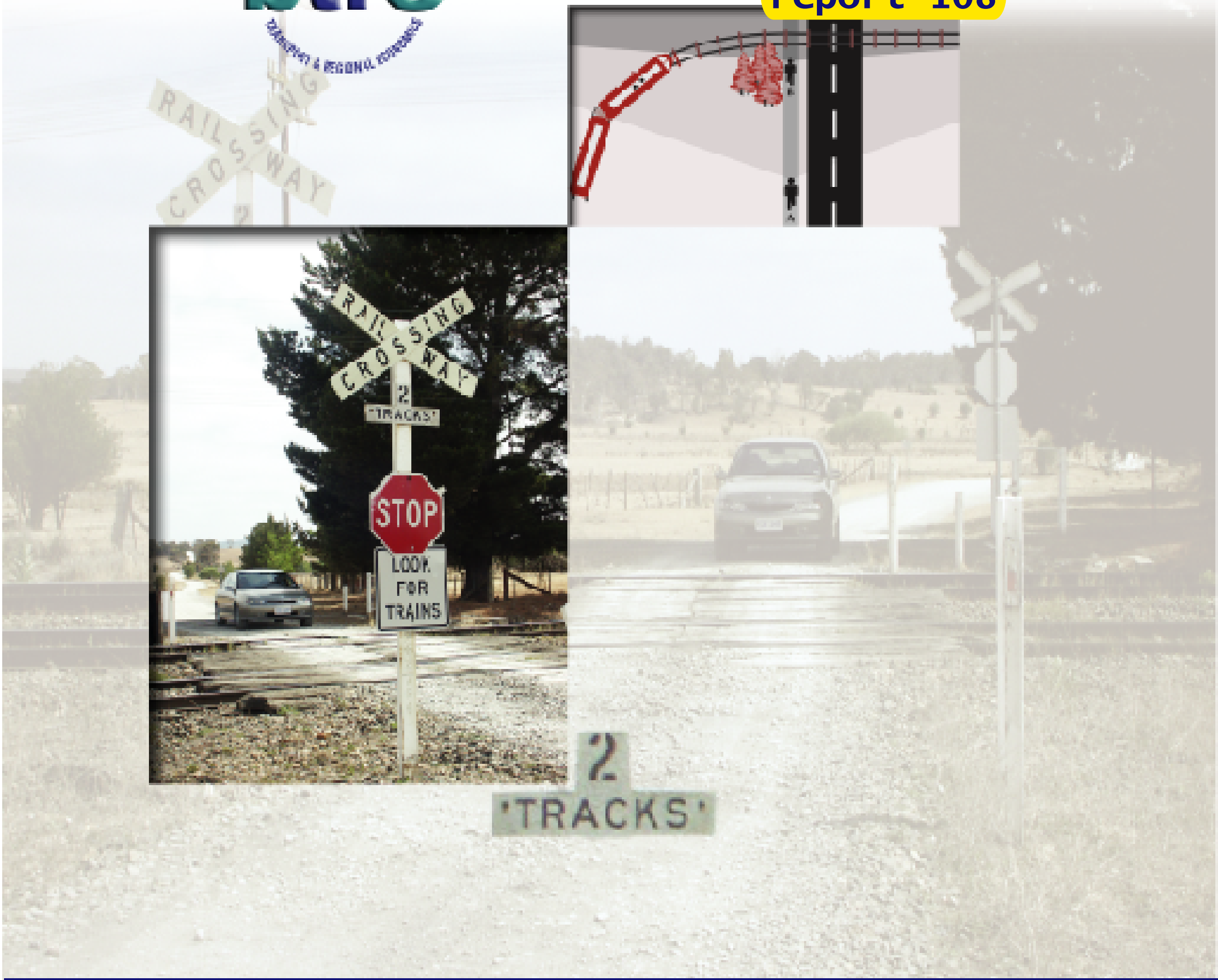
Rail accident costs in *Australia*

report 108



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FOREWORD

This report is the third in a series covering the socio–economic costs of transport accidents in Australia. Transport accidents impose a significant burden on the Australian community. Not all of their consequences can be expressed in financial terms. However, to weigh up options for minimising and dealing with this burden, it is important to know the costs of transport accidents.

Transport accident costs in Australia were quantified in BTCE Report 79, *Social Cost of Transport Accidents in Australia*. Since then the size and distribution of aviation and road accident costs have been dealt with in more detail in BTRE Report 98, *Cost of Civil Aviation Accidents and Incidents*, and BTE Report 102, *Road Crash Costs in Australia*. This analysis covers rail accidents that occurred in Australia during 1999.

The Bureau of Transport and Regional Economics acknowledges with appreciation the assistance of the rail companies, rail operators (especially Queensland Rail and Rail Infrastructure Corporation), rail accreditation authorities, and rail associations (particularly the Australasian Railway Association) that provided data for the study and the Australian Transport Safety Bureau staff who provided advice throughout the study period.

The research team comprised Christine Williams, Team Leader; Johnson Amoako, Principal Research Officer; Michael Simpson, Senior Research Officer; and Elizabeth Berryman, Senior Research Officer. The evaluation was supervised and directed by Dr Anthony Ockwell, Deputy Executive Director.

Tony Slatyer
Executive Director
Bureau of Transport and Regional Economics
Canberra
January 2002

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EXECUTIVE SUMMARY

In this study, a rail accident is defined as a transport accident involving a railway train or other railway vehicle operated on rails, whether in motion or not. It excludes some rail-related incidents, the most important of which are level crossing accidents involving motor vehicles, and rail-related suicides and attempted suicides.

The estimate for rail accidents based on the definition above represents the relevant basis when comparing with estimates for other transport modes, such as road crash statistics. However, rail-related incidents that are not defined as rail accidents have also been discussed in order to provide information to all those concerned with rail safety generally.

The composition of the overall costs of rail accidents and rail-related incidents is set out below.

TABLE E.1 SOURCE OF COSTS IN 1999 ($ MILLION)

Type of cost	*Rail accidents*		*Other rail-related incidents*		*All rail-related incidents*
	Rail accidents excluding level crossing accidents	*Level crossing rail accidents*	*Level crossing accidents involving motor vehicles*	*Suicides and attempted suicides*	
Human costs					
Workplace productivity	20	8	3	19	50
Household productivity	19	8	3	18	48
Medical/ ambulance/ rehabilitation	2	0	1	3	6
Quality of life	11	5	2	12	31
Total	**52**	**21**	**9**	**53**	**135**
Property costs	56	0	1	0	57
Other costs	4	0	0	1	5
Overall total	**111**	**22**	**10**	**53**	**196**

Note All figures are in 1999 dollars, are based on a discount rate of 4 per cent, and are rounded to the nearest million dollars.

Using a real discount rate of 4 per cent, the total cost (including costs that will be incurred in the future) of rail accidents in Australia that occurred in 1999 has been conservatively estimated at approximately $133 million (in 1999 dollars). About $14 million or 10 per cent of this was associated with the accident at Glenbrook, which accounted for 7 fatalities and 57 minor injuries and $5 million of property damage.

The total cost of level crossing accidents was estimated to be $32 million in 1999. About $10 million of this is thought to be due to level crossing accidents involving motor vehicles. Rail-related suicides and attempted suicides were estimated to have cost $53 million. The total cost of all rail-related incidents was estimated at $196 million.

These costs are sensitive to the discount rate selected. The Bureau of Transport and Regional Economics (BTRE) believes that 4 per cent is the appropriate rate to use because it is the long-term real cost of funds to society as a whole. However, the calculations were repeated at different discount rates to facilitate comparisons with other studies. Austroads conducts its evaluations at 7 per cent, and the Commonwealth Department of Finance and Administration has often used a discount rate of 8 per cent. At a discount rate of 7 per cent, the cost of rail accidents would be $112 million, the cost of level crossing accidents involving motor vehicles would be $8 million, and the cost of rail-related suicides and attempted suicides would be $38 million, giving a total cost of all rail-related incidents of $159 million. At a discount rate of 8 per cent, the cost of rail accidents would be $108 million, the cost of level crossing accidents involving motor vehicles would be $7 million, the cost of rail-related suicides and attempted suicides would be $35 million, giving a total cost of all rail-related incidents of $151 million.

Accident costing is an inexact science. Cost estimates depend on the particular costing approaches used, the number of accident cost components that can be estimated, the quality and quantity of available data and the value of key parameters used (such as the discount rate). It should also be noted that the cost estimates in this report are based on the human capital approach. Higher costs would have resulted from the use of the willingness to pay approach.

The quality of the data available to prepare the estimates contained in this report was generally quite low, compared with the quality of data available during the preparation of the costs of aviation accidents and road crashes. As it is anticipated that the establishment of the national rail safety database in January 2001 will progressively resolve at least some of the data quality issues encountered, data quality issues have been discussed in this report where relevant but no recommendations have been made with regard to future data collection.

Rail safety appears to have improved significantly since BTCE (1992) examined the costs of rail accidents in 1988. In 1988, according to rail authorities, there were 96 fatalities, 154 injuries requiring hospitalisation, 61 injuries requiring lesser medical treatment which cost more than $298 (in 1988 dollars), and

1 111 people that suffered injuries that cost less than $298 to treat or who only incurred property damage. (According to the Australian Bureau of Statistics, there were 64 fatalities in 1988. Data quality has been an issue in the rail industry for some time.) In 1999, BTRE estimated that there were 43 fatalities, 47 serious injuries, and 103 minor injuries, on the basis of data from the Australian Bureau of Statistics, Australian Transport Safety Bureau, railway operators and railway regulating authorities.

The average economic cost of a fatality was around $1.9 million, a serious injury about $27 000 and a minor injury about $2 000, including human costs but excluding property and other costs.

TABLE E.2 RAIL-RELATED FATALITIES BY CAUSE IN 1999

Pedestrians hit by trains at level crossings	14
Pedestrians hit by trains at other sites	19
Train passenger falls	2
Other train passenger deaths	8
Total rail accident fatalities	**43**
Motor vehicle occupants hit at level crossings	4
Other persons*	1
Suicides	31
Total rail-related fatalities	**79**

*mode of transport unknown or simply bystanders, killed due to a collision between a train and a car on a public roadway at a level crossing, Australia”

Source BTRE estimates based on ATSB data, unpublished ABS, and railway operator databases.

The principle issues for rail safety are suicides, level crossing accidents, and persons struck by trains. Pedestrians and young males are most at risk. In 1999, of the 43 rail fatalities not including suicides and level crossing accidents involving motor vehicles, 33 were pedestrians, 35 were male, and 18 were male and aged 15 to 29.

In contrast, fatalities and injuries resulting from train collisions and derailments are relatively rare.

The Bureau of Transport and Regional Economics advocates using benefit-cost analysis as a means of determining the priority of alternative measures to improve transport safety. This analysis suggests that measures focused on reducing accidents involving pedestrians at level crossings may warrant further investigation.

INTRODUCTION

Transport accidents affect the whole community, not just the people directly affected, the transport industry and the travelling public. Some costs fall directly on the general public, such as lost productivity due to workplace disruption when someone dies prematurely, is disabled, or is unable to work following an accident. Others are transferred indirectly. For example, part of the costs of accidents to the transport industry may be transferred by means of increased freight costs, which increase the cost of goods purchased by the general public. The revenue raised through taxation may fall as a result of the economic hardship imposed by accidents on injured people, and such people may utilise more health and welfare services. Determining the costs of accidents that are ultimately borne by the general public, the transport industry and the travelling public is quite complex. This report attempts to capture all quantifiable economic costs. The breakdown of costs by different types of incidents is discussed in detail in chapters 3, 4, and 5.

REPORT STRUCTURE

This report builds on previous work (BTCE 1988, BTCE 1992, BTE 1999, and BTE 2000). The executive summary states the main findings of this report. The introduction outlines the structure of this report, and defines a railway accident. Chapter 1 examines the incidence of railway accidents. Chapter 2 gives an overview of rail safety issues. Chapter 3 considers the human costs of railway accidents, chapter 4 the property costs, and chapter 5 all other costs. Appendix 1 gives an overview of the rail industry in Australia. Appendix 2 defines many of the terms and abbreviations used in this report.

DEFINING A RAILWAY ACCIDENT

Understanding what is meant by a railway accident is essential to determining the scale of costs incurred by society. Train accidents may be caused by a single factor or by a combination of many. However, nearly all train accidents result in either collision or derailment. (The term “accident” has been used instead of “crash” as the generic term throughout this report, unlike BTE Report 102, *Road Crash Costs in Australia*, since derailments are not generally crashes. However, it should not be taken to imply that such events are purely chance occurrences.) For the purposes of this study, a railway accident has been defined broadly in accordance with an international standard classification known as the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), published by the World Health Organization. ICD-10 is used by both the Australian Bureau of Statistics (ABS) and the Australian Transport Safety Bureau (ATSB). An Australian modification of this classification system, ICD-10-AM, is used to classify injuries when people are admitted to hospital in Australia.

ICD defines a railway accident as a transport accident involving a railway train or other railway vehicle operated on rails, whether in motion or not. The following accidents are classified as railway accidents:

- a train involved in a collision with another train or object;
- a train derailment;
- a person who falls while boarding or alighting a train;
- a person hit by falling or flying objects within the train;
- a person hit by train doors in the process of closing; and
- a person struck by a train.

In the analysis that follows, where the accident information is disaggregated into the above classifications, the cost of each accident type has been estimated separately. This enables the social and economic consequences of railway accidents to be traced back to their sources.

On the basis of the above definition, the following accidents are excluded:

- an accident on railway premises not involving a train or other railway vehicle, for example a person killed or injured as the result of a fall down stairs at a railway station;
- an accident in a repair shop, for example a person killed or injured while engaged in the maintenance of a stationary train in a repair shop;
- an accident on a rail line not involving a train or other railway vehicle while engaged in track maintenance;
- an accident on a turntable;
- suicide;
- death or injury of a person as a result of a fight on board a train;
- death or injury of a person after being assaulted on a railway station platform;
- death or injury of a person due to a heart attack or drug or alcohol overdose on board a train;
- death or injury of a person on a train due to a landslide which hits the train;

- death or injury of a person travelling on a tram or light rail vehicle involved in an accident on the roadway and a train or other railway vehicle was not involved;
- death or injury of a person travelling in a road vehicle involved in an accident on railway property and a train or other railway vehicle was not involved; and
- level crossing accidents involving motor vehicles.

Two of the classification types excluded from the ICD definition of railway accidents have nonetheless been considered in this report, because of their importance to the rail industry and to society as a whole.

The first of these types is level crossing accidents. Level crossing accidents involving motor vehicles are classified as road crashes. However, they are a significant problem for the railway industry. The costs of level crossing crashes involving motor vehicles are included in the costs identified in BTE Report 102, *Road Crash Costs in Australia*, but are not separately identified in that report. It should be noted that occupants of trains and bystanders, as well as occupants of motor vehicles, killed or injured as a result of level crossing accidents involving motor vehicles are classified as fatalities or injuries resulting from road crashes.

The second of these types is suicide and attempted suicide. Although suicides are not railway accidents, they are of concern to the rail industry, and have therefore been identified and costed in this study.

The following section gives the definitions of rail accidents used in the rail industry in Australia, the United States and Canada. These have been provided to contribute to the debate about and development of an integrated national railway accident definition.

It should be noted that the national statistical agencies and hospitals in these countries use ICD.

Australia

State and Territory rail safety regulators in Australia have agreed to use the following definition of a railway occurrence.

"Any accident or incident involving a railway train or other railway vehicles operated on rails, whether in motion or not, or other event on railway property affecting the safety of persons and property.

Includes:

- Collision, derailment, fire, explosion, act of God, or other event; and
- Slips, trips and falls on trains or railway infrastructure.

Excludes:

- Occurrences in repair shops, not involving a train in motion; and
- Assaults (For national reporting only. Individual State/Territory Rail Safety Regulators may require assaults to be reported. The later definitions of assaults are designed to facilitate consistency between those States/Territories).

Note: The classification of an occurrence by type (collision, derailment, etc) is determined by the 'top event' in the sequence (ie the event with the greatest outcome). This may not necessarily be the final event in a chain of events.

For example, if following a derailment a train strikes another train on an adjacent track, the report will indicate that the occurrence type was a collision, not a derailment, if the collision had the greater outcome. Similarly a SPAD may lead to a major train collision followed by a relatively minor derailment, in which case the collision (second event) would be the top event and therefore reported as the occurrence type." (Rail Safety Regulators 2002). (SPADs are signals passed at danger.)

United States of America

The following definition of a railway accident has been sourced from the Federal Railroad Administration, Office of Safety Analysis, in the US Department of Transport (FRA 2002).

" "*Accident or Incident*" is the term used to describe the entire list of reportable events. These include collisions, derailments, and other events involving the operation of on-track equipment and causing reportable damage above an established threshold; impacts between railroad on-track equipment and highway users at crossings; and all other incidents or exposures that cause a fatality or injury to any person, or an occupational illness to a railroad employee.

Accidents or incidents are divided into three major groups for reporting purposes. These correspond to the following FRA forms:

Train accidents. A safety-related event involving on-track rail equipment (both standing and moving), causing monetary damage to the rail equipment and track above a prescribed amount. The threshold for 1998 was $6,600.

Highway-rail grade crossing incidents. Any impact between a rail and highway user (both motor vehicles and other users of the crossing as a designated crossing site, including walkways, sidewalks, etc., associated with the crossing.

Other incidents. Any death, injury, or occupational illness of a railroad employee that is not the result of a "train accident' or "highway-rail incident." " (This includes any accident in a repair shop, for example a person killed or injured while engaged in the maintenance of a stationary train in a repair shop, unlike the ICD and Canadian definitions.)

Canada

The following definition of a railway accident has been sourced from the Transportation Safety Board of Canada (Transport Canada 2002). It applies to railway occurrences that must be reported pursuant to the *Canadian Transportation Accident Investigation and Safety Board Act* and the associated *Transportation Safety Board Regulations*.

"*Reportable Railway Accident*

a) A person sustains a serious injury or is killed as a result of:
   - i) being on board or getting off the rolling stock,
   - ii) coming into contact with any part of the rolling stock or its contents, or

b) the rolling stock:
   - i) is involved in a grade-crossing collision,
   - ii) is involved in a collision or derailment and is carrying passengers,
   - iii) is involved in a collision or derailment and is carrying dangerous goods, or is known to have last contained dangerous goods the residue of which has not been purged from the rolling stock,
   - iv) sustains damage that affects its safe operation, or
   - v) causes or sustains a fire or explosion, or causes damage to the railway, that poses a threat to the safety of any person, property or the environment."

Comparison of definitions of a rail accident

The ICD definition adopted by ATSB differs in a number of respects from the Australian, United States and Canadian rail industry definitions. ICD focuses exclusively on the act of transport; that is, the transportation of goods and persons. ICD excludes level crossing accidents involving motor vehicles, and excludes accidents indirectly caused by railways, for example accidents caused by fires started by diesel locomotives throwing sparks onto dry grass. The rail industry in Australia records any incident occurring on railway property whether or not a train was involved.

The Canadian definition captures those accidents that are of importance to the rail industry, sets a reportable threshold, and is useful for safety management. The ICD definition excludes level crossing accidents involving motor vehicles, but using it ensures that the costs of accidents across modes can be added without any double-counting.

For the purposes of this report, the phrases “railway accident fatalities” and “railway accident injuries” mean fatalities and injuries resulting from accidents covered by the ICD-definition respectively. The phrases “rail-related fatalities” and “rail-related injuries” mean fatalities and injuries covered by ICD plus all other fatalities and injuries caused by railways respectively, including those from level crossing accidents involving motor vehicles and both suicides and attempted suicides.

chapter 1

INCIDENCE OF RAILWAY ACCIDENTS

Rail is presently one of the safest forms of land transport. There are some differences in the level of safety of rail travel across jurisdictions in Australia. The fatality and accident rates per million train-kilometres are relatively high in Western Australia, and the accident rate is relatively high in New South Wales. The fatality rates are relatively low in Queensland and South Australia, and the accident rate is relatively low in Victoria. These differences between jurisdictions are shown in table 1.1.

TABLE 1.1 RAIL SAFETY BY JURISDICTION, 1999

State	*Number of rail accidents**	*Number of fatalities*	*Train kilometres (in millions)*	*Per million train kilometres*	
				Fatality Rate	*Accident Rate**
NSW	170	21	52	0.41	3.3
VIC	20	10	29	0.34	0.7
Qld	62	2	37	0.05	1.7
SA	35	2	21	0.09	1.6
WA	64	8	14	0.55	4.4
TAS	na	na	na	na	na
NT	na	na	na	na	na
ACT	na	na	na	na	na
Aust	≥351	≥43	≥154	≈0.28	≈2.3

Note The Victorian figures cover only eight months of 1999. These figures do not include suicides or attempted suicides.

'na' means not available to BTRE.

*The number of rail accidents given in chapter 1 and 3 does not match the numbers used in chapter 4, as there were data quality issues with all of the data available and BTRE used that which was thought to be most reliable for each type of calculation. There are two reasons for the differences in figures.

(1) The number of rail accidents recorded for New South Wales was higher than 170. However, RIC's database appears to be more comprehensive than databases kept by other corporations, and includes some types of accidents that others exclude. The original number of 258 was thus not useful in terms of assessing relative risk across jurisdictions, or in calculating human costs where more reliable data sources had to be used. Correcting for this effect by excluding 88 accidents of a kind that others did not report gave a figure of 170 for rail accidents in New South Wales. This figure was deemed to be the most useful for purposes other than the calculation of property costs. However, as reasonable property cost data were available for these 88 accidents, BTRE used them in chapter 4.

(2) BTRE estimates that 8 of the 97 level crossing accidents for which not enough data was supplied to separate out those involving motor vehicles involved pedestrians struck by trains at level crossings. This estimate was made after examining the records from every level crossing accident and dividing those that could not be identified in the same proportions as those that could. BTRE thus estimates that a total of 447 rail accidents were reported in 1999.

Source Railway operators, railway regulating authorities, ATSB, and BTRE estimates.

ATSB (2002a) notes that in 1993 and in 1985–86, in terms of passenger fatalities per distance travelled, rail transport was as safe as bus transport and considerably safer than all other modes except for high and low capacity regular passenger transport by air. In 1993 the number of rail passenger fatalities per 100 million passenger kilometres was only 0.1. The fatality rates per 100 million passenger kilometres, per million passenger hours, and per million passenger trips were roughly four times higher in 1985–86 for all rail fatalities than for rail passenger fatalities.

ATSB (2002a) also compared the figures it obtained for Australia with those published concerning the United Kingdom, to examine how consistent its results were. (The United Kingdom was used for comparison because most countries do not publish enough safety information by mode to enable equivalent figures to be generated.) The results are shown in table 1.2.

TABLE 1.2 FATALITIES PER PASSENGER DISTANCE TRAVELLED—NORMALISED TO CAR OCCUPANT = 1.0

	Australia 1985–86	Australia 1993	UK 1990–99
Air			
High capacity regular public transport	0.00	0.00	0.01
Low capacity regular public transport	0.00	0.33	
General (fixed wing) aviation	6.22	6.83	
Road			
Car occupant	1.00	1.00	1.00
Motorcycles	24.18	26.67	31.52
Bus passengers	0.18	0.17	0.12
Cyclists	4.04		13.33
Rail			
Passenger fatalities	0.23	0.17	0.15
Other			
Pedestrians	15.36		18.79

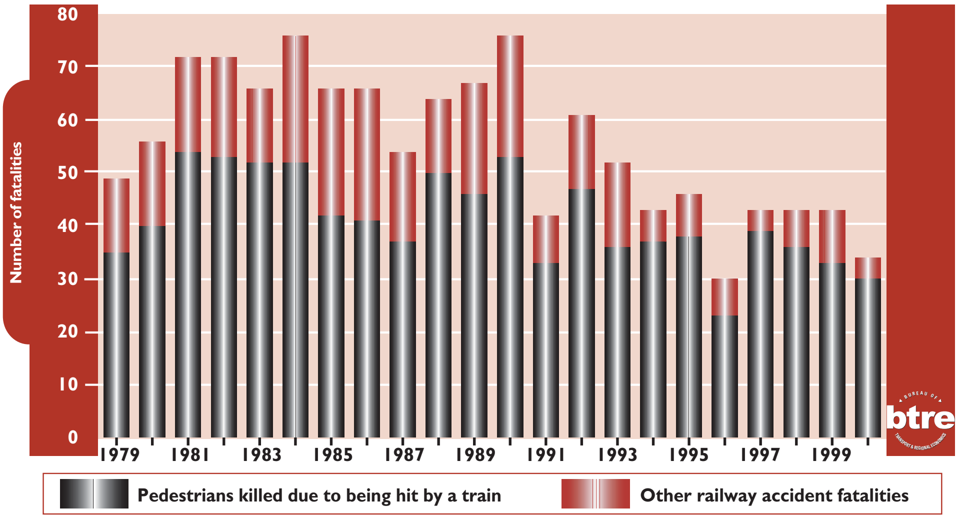
Source ATSB 2002a.

ATSB (2002b, 2002c) analysed some previously unpublished ABS data. The following contains updates of some of the key findings of those papers, incorporating the most recent data available at the time this report was prepared, plus some new material based on the updated ABS dataset.

The number of railway accident fatalities in Australia has fallen in recent years, as shown in figure 1.1, but the variance is relatively high. Pedestrians hit by trains accounted for 74 per cent of railway accident fatalities in Australia in the period 1979–2000 (calendar year).

Pedestrians hit by trains at level crossings accounted for 53 per cent of railway accident fatalities in Australia in 1997–2000 (calendar year). Level crossing

FIGURE 1.1 RAILWAY ACCIDENT FATALITIES IN AUSTRALIA 1979–2000

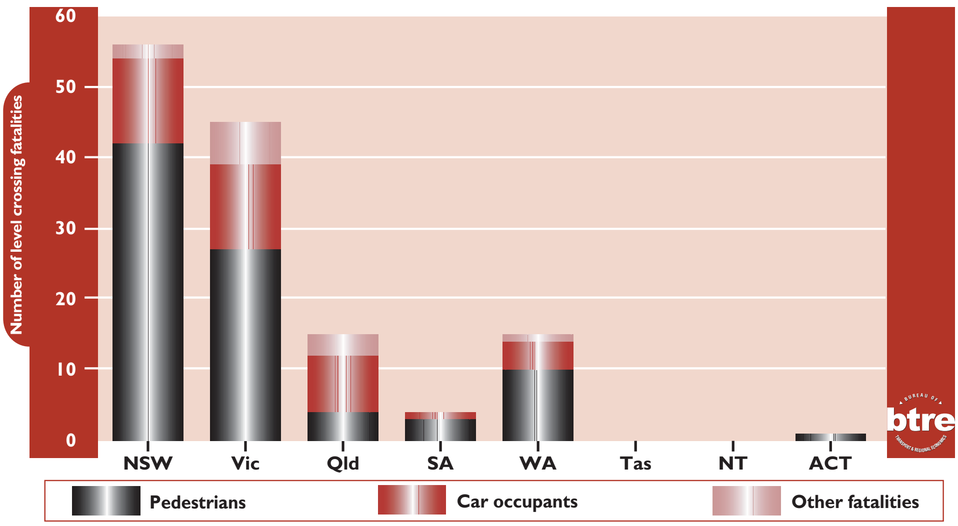


Source BTRE, using ATSB and unpublished ABS data.

accidents are the largest single cause of fatalities from rail activity in Australia, accounting for 136 deaths in the period from 1997–2000. The management of level crossings is thus a key issue for governments, industry and the community.

Pedestrians accounted for 64 per cent of fatalities from level crossing accidents in Australia in 1997–2000, car occupants 29 per cent, and all other categories (cyclists, motorcyclists, three-wheeled vehicles, pick up trucks, heavy trucks, buses, and occupants of trains) accounted for 7 per cent. This is shown in figure 1.2.

FIGURE 1.2 LEVEL CROSSING FATALITIES IN AUSTRALIA 1997–2000



Source BTRE, using ATSB and unpublished ABS data.

ARRB 2002 found that

"Australia appears to have fewer fatalities per 100 000 population at level crossings than New Zealand, the US and Finland, and to have considerably fewer fatal crashes at passively controlled crossings than New Zealand and Finland".

However, given the lack of data available that takes into account other factors such as exposure, it is not clear how well Australia is performing in terms of rail safety compared to other countries.

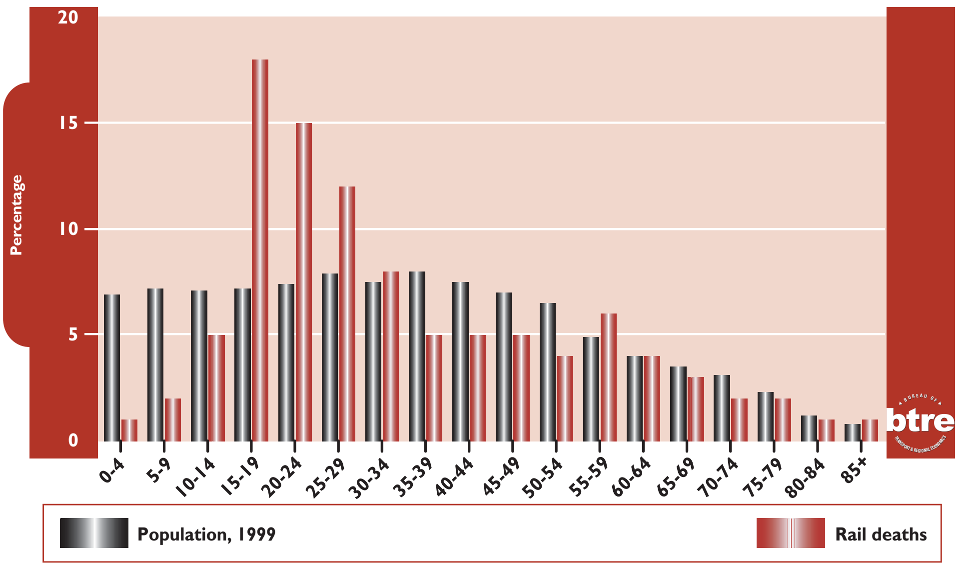
A fall in or from a train was the most common reason for passenger fatalities in Australia in the period 1979–2000, accounting for 15 per cent of railway accident fatalities.

Railway accident fatalities were not evenly spread across Australia's population. The 15–29 age group was disproportionately affected, particularly at the lower end of this age range, and particularly amongst males. Females aged 60 and older were also disproportionately affected, although to a lesser degree. This is shown in figures 1.3 and 1.4. These figures may broadly reflect the differences in risk-taking behaviour across different age groups and sexes, and are a matter for concern and further investigation.

Across Australia 81 per cent of railway accident fatalities in 1979–2000 were male.

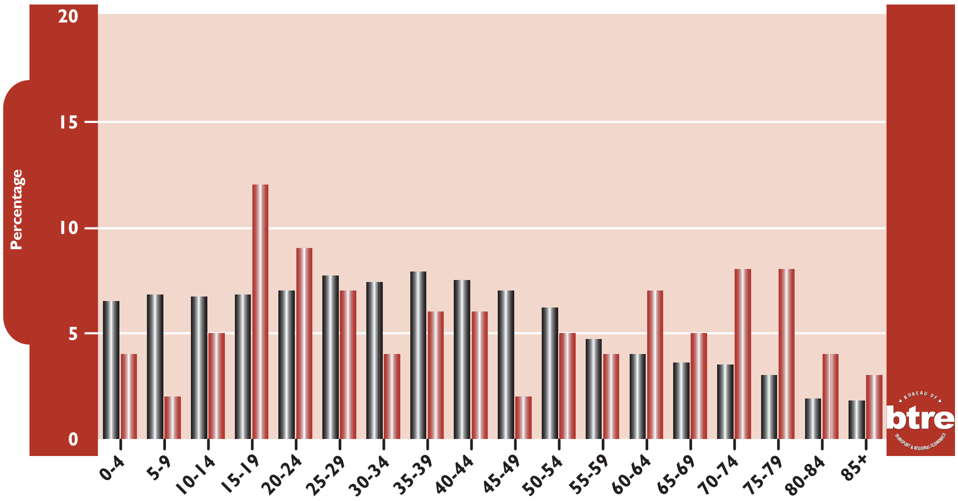
New South Wales has a relatively high share of rail passenger activity and Queensland has a relatively high share of freight activity compared to other jurisdictions in Australia.

FIGURE 1.3 AGE AT DEATH OF MALE RAILWAY ACCIDENT FATALITIES IN AUSTRALIA 1979–2000



Source BTRE, using ATSB and unpublished ABS data and ABS (1999a).

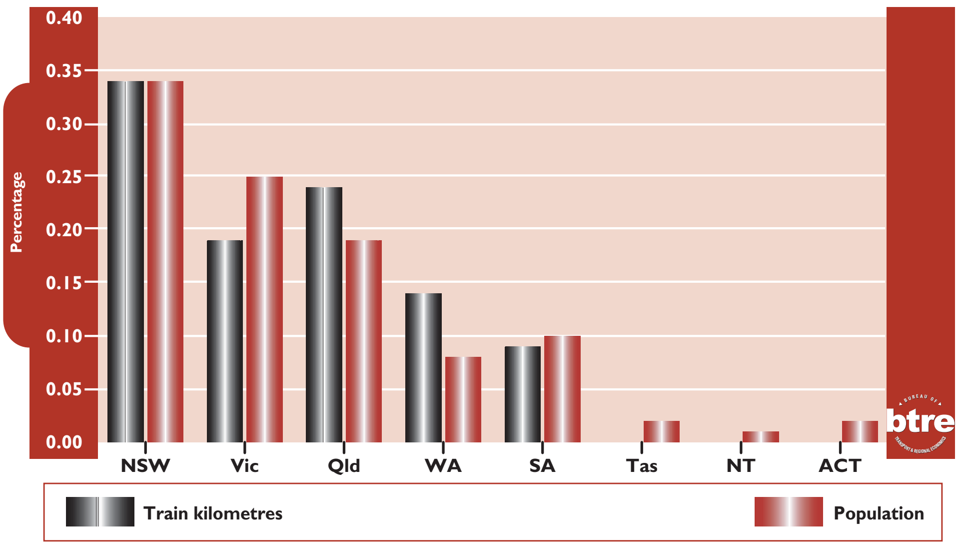
FIGURE 1.4 AGE AT DEATH OF FEMALE RAIL ACCIDENT FATALITIES IN AUSTRALIA 1979–2000



Source BTRE, using ATSB and unpublished ABS data and ABS (1999a).

Most rail transport activity occurs in the eastern seaboard. This is shown in figure 1.5. New South Wales has the largest share of train (freight and passenger) kilometres of any jurisdiction in Australia, followed by Queensland,

FIGURE 1.5 SHARES OF TRAIN KILOMETRES AND POPULATION BY JURISDICTION 1979–2000



Source Unpublished traffic data from State and Territory Governments and ABS data.

Victoria, Western Australia and South Australia. (Reliable data were not supplied for the other jurisdictions.) Queensland has a relatively high share of freight activity relative to other jurisdictions in Australia.

It was estimated that there were 31 deaths resulting from suicide attempts nationally in 1999 where people tried to get run over by trains. The estimation procedure is discussed in more detail in chapter 4. As stated earlier, while suicides are not included in rail accident fatalities, data have been collected on rail-related suicides and the costs associated with them have been calculated separately and presented in chapter 3.

In summary, suicides, level crossing accidents and persons struck by trains are the key safety issues. Pedestrians and young males are most at risk. Safety issues relating to pedestrians are discussed in more detail in chapter 2.

chapter 2

OVERVIEW OF RAIL SAFETY ISSUES

The focus of this report is on costing rail accidents, to provide input into the assessment of proposed future safety measures, rather than making recommendations on how to improve rail safety. However, BTRE was of the view that some brief comments on hazards at level crossings and other factors contributing to rail accidents would add value to the debate about safety. Much of the literature on rail safety discusses either the new high-cost, high technology systems now available or being developed to prevent train collisions, or discusses train and carriage designs that reduce the severity of the effects of train collisions and derailments. In contrast, there is surprisingly little information published on measures to promote pedestrian rail safety, with the exception of public education programs. In Australia, there is only a small amount of data on pedestrian rail safety issues available for analysis, which may have contributed to this lack.

This chapter is not intended to be comprehensive. It aims to stimulate discussion on pedestrian rail safety by looking at analogous issues.

Hazards at level crossings

Passive level crossings have signs and/or pavement markings. Active level crossings have signals and/or boom gates that operate automatically when a train approaches. Many level crossings also have one or more pedestrian rail crossings that are also either passively or actively protected, although there are also many stand-alone pedestrian level crossings in Australia, usually located between railway stations, or at the other end of railway stations to level crossings.

It is estimated that there are 6 060 passive level crossings on public roads in Australia (Ford and Matthews 2002), and there is currently no cost-effective way of converting them into active crossings (ARRB 2002), although research into low-cost warning devices is proceeding.

The risk of a rail accident at a level crossing is different from the risk of a road accident at an intersection, because moving trains require very long distances to stop. If a driver or a pedestrian misjudges how much time is available to cross an intersection safely, but does not misjudge by much, only a small reduction in speed by the other driver is needed to avoid an accident. However, a train driver is not generally in a position to be able to compensate for the misjudgments of pedestrians or drivers, however small. Pedestrians and motor vehicle drivers are generally more accustomed to crossing the paths of other motor vehicles, and may fail to allow for train drivers' inability to compensate.

Different signs are used to give advance warning of passive and active crossings in Australia. However, it appears that not all road users understand the distinction between the different kinds of signs, or are aware that many railway crossings do not have active warning systems. For example, Misopoulos et al (2001) found that the majority of subjects who took part in a driving simulator experiment believed that all or almost all of the railway level crossings in the State of Victoria have active protection, when the actual proportion is less than half. It is thus likely that not all pedestrians are fully informed about level crossings.

To date, most of the literature concerning level crossings has concentrated on crashes involving motor vehicles and trains. However, in Australia, more pedestrians than occupants of motor vehicles die due to train accidents at level crossings.

Little can be said for certain about the kinds of safety measures that may prove effective with regard to increasing pedestrian safety, as this issue has not received much attention from researchers. In Australia, there has been an increase in awareness of the specific safety issues faced by people with disabilities at level crossings. For example, flangeway gaps have the potential to trap wheels, and 25 seconds of warning may be inadequate to enable people with movement disabilities to reach a safe location. These issues are now beginning to be addressed. However, the main response to pedestrian rail safety generally has been the introduction of community education programs. These are discussed later in this chapter. Other responses have included the establishment of the Pedestrian Crossing Protection Upgrade Programme by the Victorian Government, which has been allocated $8 million over the next 4 years (Victorian Department of Infrastructure 2002).

Nonetheless, despite the lack of data about pedestrian safety issues, there are some lessons that can be drawn from attempts to improve the safety of level crossings for occupants of motor vehicles.

Elzohairy and Benekol (2000) looked at a variety of accident prediction formulae. All of these (Peabody-Dimmick 1941, Oregon Highway Commission 1950, NCHRRP Report 50 1968, Coleman Stewart 1976, Mengert Report 1980, Farr 1987) showed that crashes between motor vehicles and trains at level crossings were a function of both train and vehicle traffic per unit of time. The number of crashes at level crossings generally increases as the vehicle traffic per unit of time through the crossings rises. However, the relationship between train traffic per unit of time and the number of crashes was not linear, and more complex than might be expected, particularly for very low train frequencies.

The Federal Railroad Administration in the United States found that

“a low train frequency at crossings is associated with a higher rate of accidents”.

The National Transportation Safety Board (2000) explained this as follows.

“One factor that can affect whether a driver looks for a train is the driver’s expectation of seeing a train. … The driver’s perception that a train is not likely to be at the crossing is reinforced each time that driver passes the crossing without seeing a train. Researchers have reported that a driver’s response to a potential hazard is a function of both the perceived probability of the adverse event occurring and of the driver’s understanding of the severity of the consequence of the event. A person’s perception of the probability of a given event is strongly influenced by past experience, and the frequency with which the driver encounters a train at a crossing will influence the likelihood of that driver stopping.”

Thus on busy lines, where drivers have a high expectation that there will be a train when they approach a level crossing, drivers adopt more defensive behaviour, and the probability of an accident is directly but non-linearly related to train traffic for most of the range of train traffic values. In contrast, when approaching lines that carry only one or two trains a day or less, drivers do not expect to encounter a train, are more likely not to look for one, and thus drive less defensively, leading to an inverse relationship for very low train traffic values.

The expectations of pedestrians may also be important in determining their behaviour. Some who have worked in rail for many years believe that a significant percentage of pedestrian rail accidents occur when two trains pass by instead of one. They believe that pedestrians may see the first train, wait for it to pass, cross, and then be struck by a train coming from the opposite direction. At present there is insufficient data available to support or disprove this theory.

Wigglesworth (1976) conducted an Australian study of human factors in level crossing accidents, in which drivers’ visual searches for trains were examined by observable head movements. This showed that only about thirty percent of drivers approaching an active or passive level crossing looked for trains. Furthermore, many of those that did search looked just before entering the crossing, too late to stop, and a few were still looking as their vehicles crossed the train tracks.

Research is currently underway to consider ways of making trains more conspicuous (SCOT Rail Group 2002), to ensure that road users and pedestrians can see an approaching train (locomotive or carriages, as carriages may be pushed as well as pulled), or a train that is already on a level crossing. The cost effectiveness of such measures is an important issue.

Educating drivers to gauge the arrival time of an approaching train appears to be a complex problem. The parallel lines from the tracks converge toward the horizon, giving an impression of great distance, and the rate of growth of a train's apparent size as it approaches is hyperbolic (increasing very slowly at first and then more and more rapidly), meaning that it is very easy to overestimate how much time is available before the train enters the crossing.

At night, drivers' judgment is usually worse, because they may have difficulty comparing train movement against a dim background with indistinct landmarks. However, there is generally more traffic in Australia during daylight hours. Most vehicle crashes at level crossings in Australia occurred during the daytime (ATSB 2002d).

Drivers are generally much better at judging how much time is available before a train enters the crossing when the train is very close. However, as they have to stop or commit to crossing the rail tracks when the train is further away, this may not be particularly helpful. This problem is illustrated in picture 2.1.

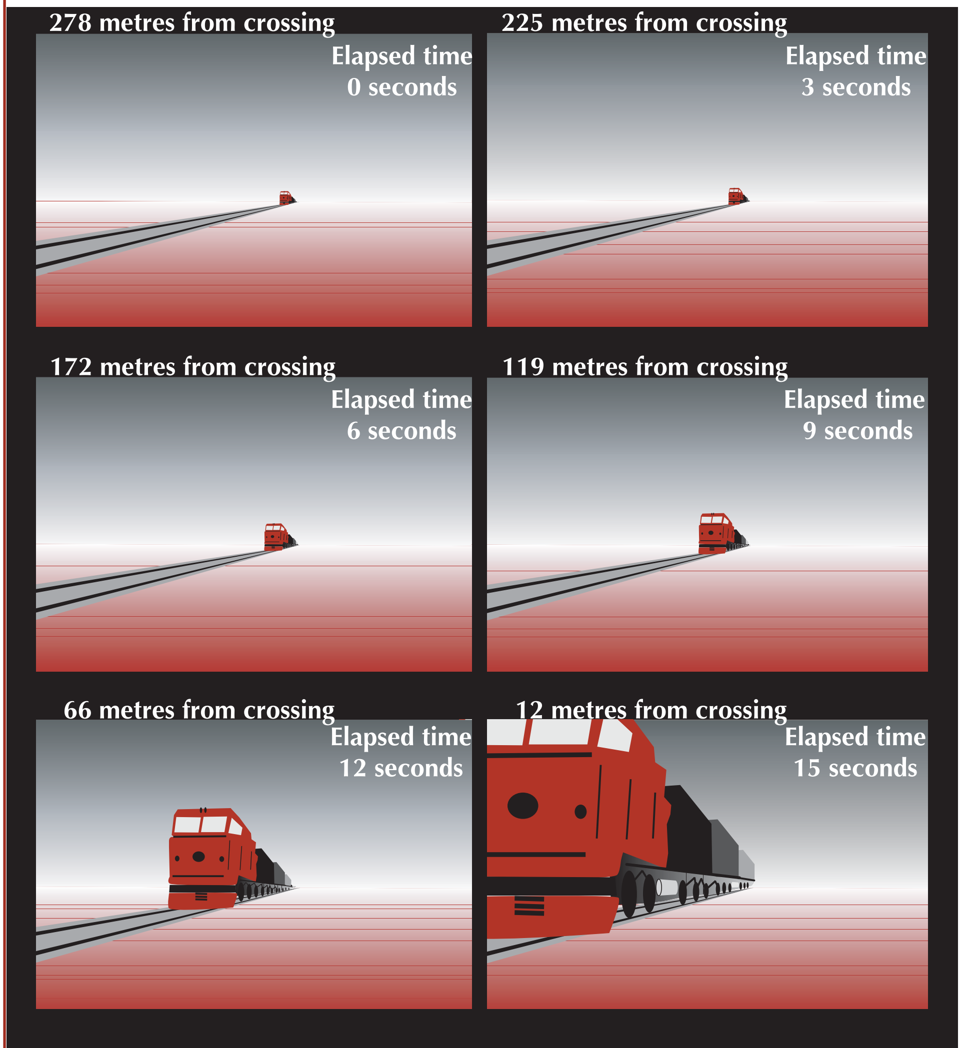
The amount of light available and the presence or absence of various protection factors were also found to be significant in the studies examined by Elzohairy and Benekol (2000). Flashing lights and signage both at and prior to the level crossing that told drivers what actions to take were effective. Boom gates did have a positive safety effect, but not as high as might be expected. Sometimes motor vehicles may be trapped in a level crossing by boom gates, or take longer in the level crossing by driving further in order to go around lowered boom gate arms that block the side of the road it is legal to drive on. The Western Australian Government is currently examining the extent to which drivers enter active crossings when the red lights are flashing (SCOT Rail Group 2002), and the circumstances in which this occurs.

The appropriateness of driver responses is a key issue. A number of Australian rail stakeholders wish to examine the effectiveness of different kinds of driver education programs (SCOT Rail Group 2002).

In the United States, nearly half of all level crossing collisions occur where properly functioning flashing lights or boom gates are in place (*Eriks Rail News*, 2001). The situation is similar in Australia. There are approximately 2 650 active level crossings in Australia (Ford and Matthews 2002), generally located in high traffic areas. These account for around half of all vehicle crashes at level crossings (ATSB 2002d).

Queensland Transport has developed a risk-based scoring system database that has been adopted by the New South Wales Department of Transport and the Victorian Department of Infrastructure, and is being considered in other jurisdictions (SCOT Rail Group 2002). This database considers 38 different treatments that can be applied to level crossings and the situations where each treatment would be effective in reducing risk.

PICTURE 2.1 APPARENT SIZE OF TRAIN AT DIFFERENT DISTANCES



Source **BTRE based on NTSB data.**

Train horns help to prevent accidents. The benefit is partially offset by vehicles being designed to reduce the amount of external sound penetrating the vehicle, and noise from stereos, passengers and road traffic may mask any remaining sound or distract drivers enough for them not to hear and identify a horn sound as coming from a train. There are also environmental noise issues associated with using train horns in urban areas.

ARRB (2002) examined the literature on the pros and cons of audible signals. Aurelius and Korobow (1971), Wigglesworth (1976), and Laffey (2000), have found various reasons why the loudness of train horns should not be increased, including noise pollution, pain and noise-induced hearing loss for train crews and trackside communities. Laffey (2000) also found that nationally in the US, crossings covered by whistle bans experienced 84 per cent more accidents than those without bans, and that there was a 38 per cent reduction in crashes after whistle bans were cancelled. He also found that after a night-time only train whistle ban in Florida was removed, there was a 68 per cent reduction in accidents.

The visibility of the train track to drivers approaching the intersection was a key issue. The NTSB (2000) examined the physical characteristics at passive crossings in the United States of America that affect a driver's ability to see a train, and concluded:

"Sight distance is the technical term describing the set of distances along the highway and along the railroad tracks needed by a motorist to detect the presence of a train in time to stop. …the interior of which should be clear of any visual obstructions. For a vehicle stopped at the crossing, the driver must be able to see the train far enough along the tracks to have time to accelerate the vehicle and clear the crossing before the train's arrival".

NTSB (2000) showed

"a strong association between inadequate sight distance and accident occurrence".

This study also found that

"the angle at which the roadway meets the railroad tracks may also affect the driver's ability to see an oncoming train" (the train may essentially approach from behind if coming from an acute enough angle),

"the distance a highway vehicle must traverse in order to clear the intersection is greater when the angle is skewed, and therefore the time it takes to safely cross is greater",

"when the angle of intersection deviates from 90 degrees, safety may be compromised".

Curvature of the road or the railtrack may also affect a driver's ability to see an oncoming train. Even if the curvature does not impede visibility, NTSB (2000) noted that research into human perception shows

"when a driver's trajectory includes a curve, the task of determining the speed and distance of another vehicle is much more difficult. Further the highway vehicle driver may be distracted by the effort to correctly negotiate the curve."

These findings are obviously of importance with regard to crashes between motor vehicles and trains. However, they also have important implications for managing risks to pedestrians.

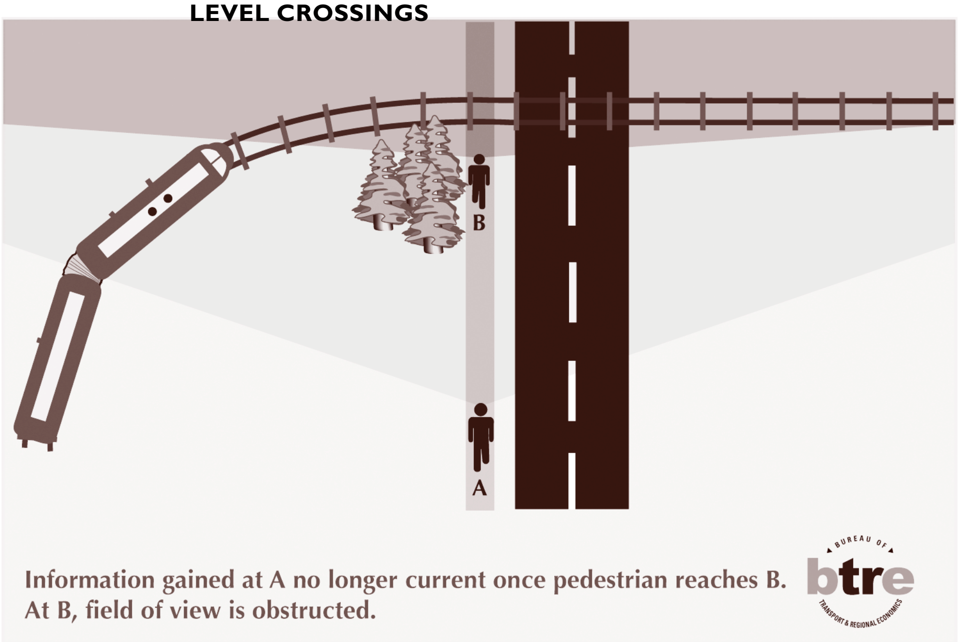
Pedestrians do not have the advantage of a wide field of view to help them detect trains as they approach a level crossing. There are three specific reasons why the narrow field of view from close to the line may be disadvantageous.

Firstly, from close to the line an approaching train can only be seen end on, rather than side on, making it more difficult to judge how far away it is. Secondly, some pedestrians may not turn to look properly. Finally, the view from close to the line is more easily obscured by obstructions.

Given the relatively slow rate at which pedestrians travel, any information a pedestrian gleans about the presence or absence of a train at a distance where the pedestrian has a wide field of view is long out of date by the time the pedestrian is ready to decide whether or not to enter the level crossing. At this point the pedestrian has only a narrow view. The pedestrian is in an equivalent state in terms of information available as a driver that has been stopped just outside a level crossing for a long time, or a driver that has approached with radically obscured visibility due to obstructions. This is important because it means that pedestrians are even more likely than drivers not to detect an approaching train until it is very close. This is illustrated in picture 2.2.

It is important to ensure the design of a passive level crossing is such that pedestrians and drivers are always able to judge whether or not it is safe to enter. It may be that for some crossings this is already beyond human abilities. Higher train speeds and the use of larger vehicles that take longer to stop would exacerbate this problem.

PICTURE 2.2 INFORMATION AVAILABLE TO PEDESTRIANS AT LEVEL CROSSINGS



Source **BTRE**

Pedestrians may also suffer from all the problems raised above in connection with drivers, but in addition have a lower maximum speed.

Given this, it may be appropriate to examine the adequacy of warning systems for pedestrians. Warning systems that are located in optimal positions for drivers may be in suboptimal positions for pedestrians, as they are not at eye-level and may be set too far back from level crossings for pedestrians approaching parallel to the train tracks to observe.

Signage for drivers that told the drivers what to do (for example "look for train" just before the optimum point for drivers to search for a train, and "yield to train" just before a reasonable braking distance) has proven to be more effective than other kinds of signage. It is thought that Australian signing practice at passive crossings gives better guidance to motorists than do typical treatments in the United States (ARRB 2002). This principle of telling the target group what behaviour to adopt should be considered when developing signage for pedestrians.

Limiting the number of level crossings may be worthwhile. Savage (1998), after examining British, Canadian and United States pedestrian casualties at level crossings, commented that

"The most striking difference between the countries is the risk of grade crossing fatalities. The fatality risk per vehicle registered in America and Canada is five times higher than in Britain. Unlike North America, the British system was built with extensive grade separation, which reduces the exposure to highway-rail collisions".

Hazards to pedestrians crossing tracks at other locations

Whilst there are less pedestrian fatalities from crossing rail tracks at sites other than level crossings, this is still a significant issue for rail safety. There are no obvious solutions to this problem. Savage (1998), after examining British, Canadian and United States pedestrian casualties from crossing tracks other than at level crossings, remarked that

"There is a quite remarkable similarity among the three countries in the propensity of the population to trespass on the railroad, and get struck by a train. This similarity is despite the fact that Britain's railways are largely fenced."

Preventing train passenger falls

The data available on train passenger falls is limited. Older carriages without power doors that automatically close before the train begins moving and cannot be opened before it stops may be a potential hazard. However, as the passenger falls data available do not give sufficient detail about the circumstances in which the falls occurred, BTRE is unable to present a statistical analysis of the key risk factors.

Other safety issues

Some stakeholders in the rail industry have raised the lack of nationally consistent standards for the education of train-drivers and the health and fatigue levels of train-drivers as an issue. The data available to BTRE on this issue at present is insufficient for BTRE to assess these issues in terms of quantifiable risks.

Education measures

A variety of community education programmes are in place both internationally and in Australia to try to change driver and pedestrian behaviour. One of the best known is "Operation Lifesaver", operated in the United States of America and Canada. The focus of this programme is on:

"educating people of all ages about the dangers of highway/railway crossings and the seriousness of trespassing on railway property" (Transport Canada 2002). Its particular strength compared to other such programmes elsewhere lies in the degree of cooperation achieved across different levels of government, railway companies, public safety organizations, police, unions and community groups to promote rail safety.

However, whilst there has been a significant reduction in the number of rail accidents and other level crossing accidents in the United States of America and Canada over the last thirty years, there has also been a substantial improvement in rail safety in Australia over the same period. It is difficult to separate out the effects of improvements in technology and infrastructure from those due to behavioural changes. There have been line closures in Australia that may have contributed to the Australian rail safety result. In Australia, community education programmes relating to transport safety have tended to be more fragmented and less focussed on rail. For example, "Travel On", a Victorian Government programme, is aimed at primary school children and promotes the "safe and responsible use of public transport". One of the components of this programme aims to teach children how to identify marked railway crossings, how to cross a track safely and why it is important to use marked crossings (Victorian Department of Infrastructure 2002).

In summary, it is difficult to assess the cost-effectiveness of measures to promote pedestrian rail safety without more data.

chapter 3

ANALYTICAL APPROACH AND HUMAN COSTS

Some means of assessing the benefits and costs to society of the various options available to reduce transport risks is required before rational transparent decisions can be made with regard to the expenditure of public funds. The assessment method used needs to be able to be applied to different modes and approaches, as risk management options are often competing for the same funds. The benefits of safety are measured in terms of accidents prevented, as accident costs are avoidable if the accidents that gave rise to them can be prevented. The costs of safety measures are usually easier to identify. In the railway industry, managers and regulators need comprehensive information on the types and causes of accident costs to enable them to determine which safety measures are most appropriate.

This chapter focuses on the approach used to estimate the human costs to society of railway accidents in 1999. Chapter 4 looks at the estimation of property costs, and chapter 5 at other costs. This information can be used by analysts and decision-makers to estimate the benefits of rail safety measures. The approach adopted is the same in principle as the methods used by the former BTE to estimate the costs associated with road crashes and air transport accidents. There are some minor differences due to the different data sources available for the different modes, and the need to provide information that is useful to the rail industry whilst remaining consistent with the ICD classification system used in other transport safety studies. Some accidents arising from rail-related activity, such as level crossing accidents involving cars, are not defined as rail accidents. However, they are of interest to the rail industry, and calculating their costs separately enables the cost of all transport accidents to be determined without double-counting. The cost of rail-related suicides has also been calculated separately.

These accident costs may be used as a basis for intermodal safety comparisons. As some modes are safer than others, safety issues should be considered when comparing infrastructure investments in different transport modes. Failure to consider the different externalities that arise from transport in different modes may lead to a suboptimal result for society, such as over-investment in roads compared to rail infrastructure.

In this report, a rail fatality is defined as a death occurring on the spot or within 12 months of the rail accident, as ABS and ATSB data is based on a time period of 12 months. ICD road data is also based on a time period of 12 months. However, the time lag used by BTRE has not been applied consistently as the data from Australian rail operators is based on a time period of 30 days, which is consistent with the 1968 Vienna Convention on road deaths. BTRE has not attempted to correct for any inconsistencies from this difference in definition, as very few people who were seriously injured in a rail accident that die from their injuries die later than a week after the accident.

ESTIMATING THE COSTS OF ACCIDENTS

There have been fewer studies on the costing of railway accidents than on the costing of road crashes. However, Brell (1999), Porter et al (1995), Jones-Lee and Looms (1995), Miller et al (1994), Read (1992), BTCE (1992), and Dubus (1988) have all made useful contributions in this area. The methodology used to estimate the costs of accidents does not vary much across modes, so this study also draws on work done in the roads sector, for example by Persson et al (2002).

Not all of the consequences of accidents can be measured in financial terms. However, those that can may be grouped under two headings: direct costs and external costs (Porter et al 1995). Direct costs are those that are borne by the parties directly involved in an accident. External costs are those borne by third parties not directly involved and by society as a whole (for example, costs resulting from delays, and costs to government health budgets).

Accident costs may also be grouped into human costs, property damage costs and other costs (BTE 2000, Persson et al 2002, Miller et al 1994). That approach has been followed in this study.

Human costs

Estimates of human costs may vary considerably depending on the method of estimation. The human capital and willingness to pay approaches are the two most commonly used methods to value the fatality and injury cost components of transport accidents. The principles that lie behind the human capital and the willingness to pay approaches are quite different, and generally result in substantially different figures. Past studies such as BTE (2000), Miller et al (1994) and Dubus (1988) have found that the values placed on life and injury tend to be a very substantial component of accident costs, making the method chosen to estimate these values important in determining the magnitude of the overall total.

Economists do not value the intrinsic worth of human life. The following section explains what is really being valued, and largely consists of the arguments stated in BTRE (2000 and 2001) with minor modifications to update them and make them appropriate to rail.

Box 3.1 provides a brief discussion of what is meant by value of 'life' and whose life is valued.

BOX 3.1 WHOSE LIFE IS BEING VALUED?

People generally value their own lives very highly, and often the same can be said for the lives of family and close friends. Indeed, life can be argued to be priceless, as without life money would be of no use. This view is supported by the many publicised incidents where large amounts of money have been spent to save the life of an identified person.

However, at the other end of the spectrum, much lower implicit values are placed on lives every day. Each time a decision is made regarding the allocation of funding to health and emergency services, to workplace occupational health and safety projects, and indeed to any activity which aims to save lives or prevent injuries, life has an assumed implicit value.

A particular life may be regarded as priceless, yet relatively low implicit values may be assigned to life because of the distinction between identified and anonymous (or 'statistical') lives. When a 'value of life' estimate is derived, it is not any particular person's life that is valued, but that of an unknown or statistical individual. The concept relates to the probability of a fatality in a given population.

This is an important distinction when examining safety improvements, as it is not known which particular lives will be saved due to a change in the statistical probability of an accident or death/injury in an accident.

"Valuing an unknown (or statistical) life eliminates subjective assessments of the worth of particular individuals. A statistical life is unidentified and so does not have the emotional and moral overtones associated with a known life. In practical terms, the distinction means that much smaller sums are allocated to saving statistical lives than may be spent in saving identified lives.

The human capital approach characterises people, and therefore life, as a labour source and input to the production process. This approach argues that the value to society of preventing a death or injury is the saving in potential output or productive capacity. It is an ex-post accounting approach that uses the discounted present value of a dead or injured person's future earnings as a proxy for the opportunity cost associated with death or injury. The human capital approach can also be used to value non-paid work in the form of service to family and the community.

The human capital and willingness to pay approaches are different in concept and, in terms of the value of 'life' issue, produce two different measures. As stated above, the human capital approach measures human output or productivity, while the willingness to pay approach attempts to capture trade-offs between wealth and risk. In other words, the willingness to pay approach estimates the value of life in terms of the amounts that individuals are prepared to pay to reduce small risks to their lives. For example, suppose a thousand people each face a one in a million chance of dying from a particular cause per year, and are willing to pay on average $5 000 each to eliminate that risk. The value of 'life" would be equal to $5 000 multiplied by 1 000 000 divided by 1 000, namely $5 000 000. The approach uses people's preferences (either stated or revealed) to ascertain the value they place on reducing risk to life and reflects the value of intangible elements such as quality of life and joy of living. Both the human capital and willingness to pay approaches are imperfect in estimating the value of 'life'. Fundamentally, the human capital approach has theoretical problems in regard to its application to the economic valuation of life, while the willingness to pay approach involves various empirical difficulties.

The two approaches have some common deficiencies. For example, both approaches involve 'partial equilibrium' in the sense that they ignore the wider consequences of extending life. The willingness to pay approach may approve of measures to prolong the life of a person provided the cost was met by those interested in that person's welfare. However, there may also be social costs involved. For example, the consumption of the elderly may be financed by members of the labour force. Both approaches ignore inter-generational costs, such as a heavier social security burden on younger members of society.

Social equity issues arise in the application of both the human capital and willingness to pay approaches because richer members of society can have a disproportionate influence on policy outcomes. Different programs can be valued differently depending on whether human capital or willingness to pay is used. Human capital is associated with the utility of lifetime consumption (to the extent that consumption is the major objective of production) whereas willingness to pay is related to the utility of life per se. The willingness to pay approach is favoured by some countries because of its more comprehensive nature. The human capital approach, however, provides a fairly reliable lower bound estimate of the social value of accident costs.

Table 3.1 provides a summarised version of the arguments for and against the use of these two approaches. BTE (1998) provides a detailed and comprehensive review of the theory and practice of willingness to pay methods.

As the willingness to pay approach includes elements that the human capital approach has difficulty in costing, the former will generally give higher values than the latter. This is particularly the case for fatalities. Higher values for safety can be expected to increase the relative priority given to safety in rail projects and to also increase the priority given to rail safety vis a vis other areas of government expenditure. Hence, using the willingness to pay approach would have a range of policy implications that warrant careful consideration.

Persson et al (2002) provides a comprehensive discussion of the value of statistical life (VOSL) for both countries that use the willingness to pay approach and those that use the human capital, which include Australia. The study

TABLE 3.1 COMPARISON OF APPROACHES TO VALUING HUMAN LIFE

Advantages	*Disadvantages*
Human capital	
• Data reliable and readily available. • Consistent and transparent results. • Simple to use. • Provides a reliable lower bound estimate of the social cost of accidents.	• Values some lives higher than others due to labour market imperfections, such as wage discrimination. If simplistically applied, the very young and old are undervalued. • Overestimates costs in an economy with less than full employment. • Does not reflect a key reason for investment in safety: aversion to death/injury rather than solely income protection. • Ignores the loss of 'joy of life', while values for pain, suffering and grief are often arbitrary. • There are actuarial uncertainties regarding life expectancy and earnings. • Selection of the appropriate discount rate is controversial. • Ignores inter-generational effects.
Willingness to Pay	
• Comprehensive. • Incorporates subjective welfare costs. • Reflects individual preferences.	• People have difficulty understanding and valuing small risks (generally less than 1 in 10 000). • Individual perceptions of risk may differ. • Willingness to pay does not necessarily imply ability to pay. • Differences exist between people's expenditure patterns/actions and their real preferences. • Aggregating individuals' willingness to pay may not produce social willingness to pay, as individuals may ignore external social costs. • Difficulty in applying concept of a statistical life rather than a particular life. • Methodological difficulties (such as inaccurate responses) and strategic behaviour in surveys. • Equity is not taken into account, as results are income-related. • Discrepancy in results using willingness to pay and willingness to accept approaches. • Value will change with incomes and variations in rail safety. • Ignores inter-generational effects.

Source BTE (1998).

confirms that the human capital approach tends to generate values at the lower end of the scale.

The wide variation in willingness to pay estimates of value of statistical lives is, in part, due to the fact that the value depends on circumstances and individual preferences in avoiding physical risk. This can be viewed either as a complicating and inconsistent factor, or as a strength of the willingness to pay approach in more precisely recognising people's preferences for particular accident prevention activities. The variation is also partly due to country differences. Willingness to pay is country-specific and inter-country comparisons of willingness to pay values are difficult to make as social, cultural and income factors confuse the picture.

Like previous studies prepared by this Bureau, this study uses the human capital approach. In recognition that life is more than labour, a non-economic loss has been incorporated to represent pain and suffering and lost quality of life. The values obtained for rail accident costs should thus be broadly comparable with the estimates previously produced in relation to other transport modes.

In this report, human costs include lost labour (lost production in the work place, household and community), the value of quality of life lost, injury-related medical and health costs, legal and investigation costs. Human costs thus include actual expenditures and valuations for lost opportunities and services.

Value of lost labour

When individuals are killed or severely disabled, their potential labour output over their expected remaining years of life is lost to society. Only the value of the labour is considered foregone, as income from non-labour sources (such as dividends and rental income) will continue regardless of the death or health of individuals. The loss of labour services is felt in the workplace, the household and the community and their worth to these areas must be calculated.

Labour in the workplace (lost income)

The total value of labour in the workplace depends on the amount of working life a person would reasonably expect to have and the worth of the labour to the workplace. An alternative viewpoint is outlined in box 3.2.

Age and gender-specific life expectancy tables have been used to estimate the probable length of life if the death or incapacity had not occurred prematurely (ABS 1998a). For statistical purposes, death or incapacity is modelled as occurring at the mid-point of the year. Life expectancy data have been combined with similarly detailed employment rate data to model typical periods of working life.

Before a value is placed on labour, an important point regarding terminology needs to be made. The value of labour can be estimated in a number of ways and is sometimes referred to as a measure of 'labour productivity'. However, true labour productivity is a measure of the contribution to output by a unit input of labour. Care must be taken to separate the contribution of labour from that of capital and other factors, such as managerial efficiency or economies of scale. This report does not use an output-based value of labour; instead, it uses the dollar amount an employer pays for a unit of labour as an input to production.

Average wage and salary data from the *1995–96 Survey of Income and Housing Costs* (ABS 1996) were inflated to 1999 values using the Consumer Price Index and were used as the basis for measuring the value of labour in the workplace. This provides a measure of gross income from all jobs weighted to reflect the split between full-time and part-time workers. A further advantage of this survey is that it provides age and gender differentiated data.

Those fatally or permanently incapacitated are unable to rejoin the workforce. Those with serious injuries (excluding those with permanent disabilities) are assumed to have lost 25 working days, as in BTRE 2000. This figure is based on the ratio developed by Collins and Lapsley (1991) in their work on production lost due to drug abuse of two days of recuperation for each day of hospitalisation, and a figure of 8.3 hospital bed-days per serious injury. More recent work relating to these costs could not be found.

The loss of labour from minor injuries has not been estimated, as reliable data are not available. Based on the observed profile of rail accidents, accident cost studies for other modes, and the relatively small contribution that workplace disruption makes to the total cost of accidents, BTRE believes that this omission is not crucial.

BOX 3.2 THE FRICTION METHOD OF VALUING LOSS OF LABOUR

Koopmanschap and van Ineveld (1992) argue that labour should be valued using only the lost production during the time taken to replace a missing worker (the friction period), rather than the worker's future stream of income. Real production losses are believed to be much smaller than the potential losses, as labour may be replaced by the unemployed or from labour reserves within the firm, or there may be possibilities for restructuring the organisation of production and using labour saving devices. Therefore, production may be lost only until the firm adapts to the situation. Lost labour is valued from the perspective of the workplace, rather than from the perspective of the whole of society.

This study recognises the existence of frictional costs in the workplace—such as lost output from remaining workers and recruitment and training costs—but argues that, from the social viewpoint, these are incurred in addition to the lost income stream. As such, they are examined separately later in this chapter. From a social standpoint, how soon the fatality or incapacity is replaced in the workplace will not have an impact on the value of the potential labour resource lost. This value is only affected by the probability of being without paid employment at some stage of life.

There has been considerable debate on the use of gross versus net earnings in valuing output (see BTCE 1992, appendix I for a discussion of this issue). Australian studies have mostly used gross earnings. Gross earnings are a measure of the amount an employer pays for employees—some funds go directly to the employee (net earnings) and the remainder goes to bodies such as government (taxes) and superannuation funds. This study also uses gross earnings, as it accurately reflects the full cost (and value) of labour.

ABS gross wages and salaries data (age-specific and gender-specific) were used as the basis for the estimation of the cost of labour to the employer. The gross wages and salaries data were adjusted to incorporate on-costs (such as employer payments for superannuation, payroll tax, workers' compensation and fringe benefits tax), producing a closer approximation of the cost of labour to the employer. ABS (1998b) estimated on-costs to be a weighted average of 14.8 per cent of earnings in 1996–97. These on-costs have been inflated to 1999 levels using the Consumer Price Index. The weighting accounts for the differences in earnings between full-time and part-time labour. In addition to on-costs, an adjustment for training costs of 2.9 per cent of gross wages and salary was made (BTE 2000). The cost of welfare services and recruitment are two other costs borne by the employer. However, ABS (1995) considers that these costs are not significant contributors to total labour costs and hence they have been excluded and the 1996 update has not been used. The sum of these adjustments represents a 17.7 per cent increase in the base wages and salaries data.

For ease of later calculations, weekly earnings figures were annualised using 52.18 weeks per year. A 2 per cent annual growth rate was applied to take account of real increases in labour costs over time. The resultant figure represents the overall value of labour. Only one age group was treated differently. Fatality or incapacitation between 0 and 14 years of age was assigned a zero value of labour until the time when the legal working age of 15 would have been reached.

The value of labour at each age was applied to the potential remaining working life of the fatalities or incapacities. At each age only a proportion of people have the potential to hold paid positions. The remainder is comprised of voluntary workers, unemployed persons or those who choose not to be part of the labour force. To represent this phenomenon, the present value of the earnings stream was adjusted using age-specific and gender-specific employment and participation rates (ABS 1999b). This adjustment is important in estimating the actual, rather than potential, labour loss due to rail accidents.

Discount rate issues

Benefit-cost analyses use discount rates in project assessment to compare the value of benefits and costs in the future with those in the present.

The discount rate for a project should reflect the opportunity cost of using resources in that project and alternative means of obtaining equivalent benefits. That is, it should look at what could have been achieved by investing the resources according to the best option available other than the project, and at the minimum alternative investment necessary to achieve equivalent benefits.

When investment is involved, the marginal real rate of return on capital must be considered. However, when lost consumption is involved, the appropriate measure is the rate at which society is willing to trade off future for current consumption. This is called the social rate of time preference. The human capital approach to accident costing, to a large extent, represents lost lifetime consumption, to the extent that consumption is the major objective of production. Hence, the appropriate discount rate is the social time preference rate.

In 2002, the Commonwealth Government indexed bond rate was around four per cent. The BTRE believes that a discount rate of four per cent generates the most meaningful result. However, to facilitate comparability with the BTCE 1992 report, which used a discount rate of seven per cent, and as AustRoads has been publishing its analyses at seven per cent since 1996, the analysis was also completed using a seven per cent discount rate. (Treatments to increase the safety of different modes may compete for the same funds, so being able to compare different treatments easily is important.) The Department of Finance and Administration often uses a discount rate of eight per cent, and hence the analysis was also completed using this discount rate, to facilitate benefit-cost comparisons of rail safety measures with non-safety related proposals.

The formulas below summarise the foregoing discussion:

$$P_x = A_x V_x[(\frac{l_{x+1}}{l_x})/(\frac{l_x}{l_{x-1}}]$$

with

$$V_x = W_x E_x$$

where P_x is value of the lost labour for the year the fatalities and incapacitated people would have been age x; A_x is the total number of people at age x who have died in rail accidents and who would statistically otherwise have been alive at age x; l_x is the number of people who statistically survive to age x in a birth cohort of 100 000 (ABS 1998a); and V_x is the employment rate (E_x) at age x multiplied by average earnings (W_x) at age x.

The result, P_x, for each year of statistical survival was discounted to present values 1999, which is the base year for the analysis. That is,

$$PV = \sum_{x=i}^{\infty} \frac{P_x}{(1 + rate)^{x-i}}$$

where PV is the present value of the lost value of labour over the relevant period, *rate* is the discount rate and i is the age at death from a rail accident.

Labour in the household and community (lost unpaid work)

The loss of a person in a rail accident means that their contribution to the home, such as child care and housework and to the community, including voluntary assistance to school, sporting and community groups, is foregone. Although such work is unpaid, it is essential to the quality of life of individuals, their families and the wider community.

In this study, average hours of unpaid work outside the workplace were obtained from time use data, and wage rates derived from the *1995–96 Survey of Households and Income* (ABS 1996) and updated to 1999 using the Consumer Price Index. These were used to obtain estimates of the total value of unpaid work. The level of earnings per hour for those in the formal workforce has been assumed to be equivalent to the loss of potential earnings while performing these functions.

Age, gender and employment status are three important factors in determining a person's level of productive activities. The influence of these factors on productivity should be fairly obvious and a few explanatory examples should suffice:

- People with children may be involved in a number of community groups, and have added housework, because of the children.
- As those not in the workforce have more time at home, they may tend to do more around the house.
- Traditionally, women have been the major bearers of domestic duties.

The *1997 Time Use Survey* (ABS 1998c) provides average hours per week spent in work in the home and work for the community by age-group, gender and employment status for 1997. These values were annualised using an equivalent of 52.18 weeks, on the assumption that work is carried out throughout the year.

The computational method used for valuing labour in the workplace was also used for the estimation of household and community workplace labour losses. In short, for each potential year of life, the amount of household work specific to a ten-year age group was calculated and valued using the average income for that group.

This was done for employed and unemployed males and females. Employment status clearly affects the number of hours in any given week available for household and community work.

Lost household and community labour for those with permanent injuries were estimated using the same approach as that adopted to estimate workplace labour losses. Those with serious injuries will also be unable to contribute labour to the household or the community for the average 25-day recovery period discussed earlier in relation to workplace labour losses. The value of this labour loss was estimated assuming an average age and taking into account the variation in labour output according to employment status.

As with workplace labour, there were no reliable data available on the loss of household and community labour due to minor injuries. BTRE believes that the impact of the omission on the analysis is likely to be relatively small.

In this report, human costs include lost production in the work place, household and community, the value of quality of life lost, injury-related medical and health costs, legal and investigation costs. Human costs thus include actual expenditures and valuations for lost opportunities and services.

The next section presents and discusses the human cost estimates.

Human cost estimates

Value of productivity losses

The human costs of rail accidents in this report are comprised of lost production from both formal (paid) employment and informal employment (in the household and the community) and other costs arising as a result of human injuries resulting from railway accidents. Table 3.2 shows the number of persons killed or injured and the severity of injuries as a result of railway accidents in Australia in 1999. These figures exclude those involved in accidents at level crossings and suicides and attempted suicides, which are discussed later in this section.

TABLE 3.2 NUMBER OF RAIL ACCIDENTS AND INJURY LEVELS IN 1999

State	*No of accidents**	*Fatal Injuries*	*Serious Injuries*	*Minor Injuries*
NSW	170*	21	18	67
VIC	20	10	5	3
Qld	62	2	3	na
SA	35	2	1	3
WA	64	8	20	30
TAS	na	na	na	na
NT	na	na	na	na
ACT	na	na	na	na
Australia	≥351	≥43	≥47	≥103

Note The Victorian figures cover only eight months of 1999. These figures do not include suicides or attempted suicides.

'na' means not available to BTRE.

*The number of rail accidents given in chapter 1 and 3 does not match the numbers used in chapter 4, as there were data quality issues with all of the data available and BTRE used that which was thought to be most reliable for each type of calculation. There are two reasons for the differences in figures.

(1) The number of rail accidents recorded for New South Wales was higher than 170. However, RIC's database appears to be more comprehensive than databases kept by other corporations, and includes some types of accidents that others exclude. The original number of 258 was thus not useful in terms of assessing relative risk across jurisdictions, or in calculating human costs where more reliable data sources had to be used. Correcting for this effect by excluding 88 accidents of a kind that others did not report gave a figure of 170 for rail accidents in New South Wales. This figure was deemed to be the most useful for purposes other than the calculation of property costs. However, as reasonable property cost data were available for these 88 accidents, BTRE used them in chapter 4.

(2) BTRE estimates that 8 of the 97 level crossing accidents for which not enough data was supplied to separate out those involving motor vehicles involved pedestrians struck by trains at level crossings. This estimate was made after examining the records from every level crossing accident and dividing those that could not be identified in the same proportions as those that could. BTRE thus estimates that a total of 447 rail accidents were reported in 1999.

Source Railway operators, railway regulating authorities, ATSB, BTRE estimates.

Using the methods described earlier in this chapter, it is estimated that the productivity losses that occurred in 1999 as a result of the 43 rail fatalities amounted to about $51 million. The calculation is shown in table 3.3.

TABLE 3.3 ESTIMATED VALUE OF PRODUCTIVITY LOSSES ($ MILLION) DUE TO RAIL ACCIDENT FATALITIES IN 1999

	Males	*Females*	*Total*	*Males*	*Females*	*Total*	*Males*	*Females*	*Total*
Discount Rate		0.04			0.07			0.08	
Workplace Productivity	22.5	3.1	25.7	14.5	2.1	16.6	12.7	1.8	14.6
Household Productivity	21.3	3.7	25.0	12.0	2.1	14.1	10.3	1.8	26.7
Total Forgone Productivity	43.8	6.9	50.7	26.5	4.2	30.7	23.0	3.6	26.7
Total Number of Fatalities	37	6	43	37	6	43	37	6	43
Average Value per Fatality			1.2			0.7			0.6

Source BTRE estimates.

In addition to these productivity losses associated with fatalities, those who suffered serious injuries as a result of rail accidents in 1999 are also assumed to have lost time away from formal (paid) work and informal (household and community) work. Some victims would only be unable to work temporarily, whilst others would be affected permanently as their disabilities would prevent them from re-entering the work force. It is estimated that the value of productivity losses associated with the 43 victims that sustained serious injury (excluding those who sustained permanent disabilities) amounted to around $130 000. (Four of those 47 who were seriously injured were thought to have suffered permanent disability, and their costs have been estimated separately.) The loss of productivity in the household and community accounted for 29 per cent of this total. Losses associated with those sustaining permanent disabilities amounted to $4.7 million. The loss of productivity in the household and community accounted for 49 per cent of this total. The productivity losses from all those who suffered serious injuries thus totals around $4.8 million.

Overall, productivity losses in 1999 associated with fatalities and serious injuries from rail accidents totalled around $55.51 million. These costs are of concern to both rail operators and the public.

During 1999 it was reported that 19 persons died and 13 were seriously injured as a result of level crossing accidents. Of these, 5 of the fatalities were involved in train and road vehicle collisions, and hence were excluded from the ATSB's figures in table 5.2 and the productivity losses in table 3.3. It is estimated that the value of productivity losses associated with level crossing accidents in 1999 amounted to $22.42 million, of which about $6 million was associated with those involved in road crashes and thus excluded from table 3.3.

There were also 31 fatalities as a result of persons committing suicide by choosing to be killed by a train. In addition, it has been estimated that about 64 attempted suicides resulted in serious injuries. This estimate is based on data obtained from rail agencies, not hospital admissions, as hospitals count a person each time that person is admitted to a different ward for a different care type, not once per incident causing a need for treatment. These suicides were excluded from the ATSB's figures in table 3.2. The value of productivity losses for rail-related suicides amounted to about $36.52 million. The costs of suicides involving rail are generally viewed as external costs. Suicides are seen as an issue which society rather than rail operators should deal with. They are nonetheless of concern to the rail industry in that train drivers may be psychologically traumatised by such events, regardless of their lack of ability to prevent them, and may ultimately seek alternative employment as a result. BTRE has not attempted to place a value on this.

In total, losses through foregone productivity from rail accidents totalled $55.51 million, which includes the foregone productivity of pedestrians struck by trains at level crossings. Losses through foregone productivity for all level crossing accidents totalled $36.72 million, and those from suicides and attempted suicides totalled $36.72 million. In total, around $98 million was lost through foregone productivity from rail-related incidents.

The values for level crossing and suicide fatalities have been derived using the average costs shown in table 3.3. Unfortunately, the age and gender distribution of those affected was not available so the more refined calculation methods discussed above could not be used.

Medical costs

Although not everyone involved in a rail accident or rail-related incident receives or needs medical attention, the majority that sustain an injury will require medical attention. The medical costs of rail accidents comprise charges arising from the use of ambulance, hospital in-patient, outpatient and casualty/emergency services, general practitioners, specialists and allied health services such as radiography and physiotherapy. In addition, there is the cost of rehabilitation and long-term care, which is not always a purely medical cost, associated with ongoing medical problems.

This report considers three levels of injury arising from rail accidents – fatal, serious injury, and minor injury. A rail accident fatality, as stated earlier, is defined as a death occurring on the spot or within 12 months of the rail accident. A serious injury is defined as an injury resulting in hospital admission with an average length of stay of more than one day. A minor injury is defined as any lesser injury that required medical attention. Those with injuries that did not require or receive medical attention were regarded as uninjured and were not considered further. Table 3.4 highlights the number of people in each category.

TABLE 3.4 PEOPLE KILLED OR SERIOUSLY INJURED BY RAIL ACCIDENTS IN 1999

Injury severity	*Cause of injury*				
	Rail accidents (excluding level crossing accidents)	*Level crossing accidents*		*Suicides and attempted*	*Rail-related incidents suicides*
		rail accidents	*accidents involving motor vehicles*		
Fatal	29	14	5	31	79
Serious	47	13		64	124
Total	76	32		95	203

Note The figure for the number of attempted suicides resulting in serious injury is an estimate.

Source BTRE estimates, based on ATSB data, and unpublished data from the ABS and railway operator databases.

Those that die at the scene of an accident are transported to a morgue or to another appropriate location for post-mortem examination. In these instances only the ambulance costs have been estimated.

Medical costs are predominantly determined by the type and severity of injury and the place of treatment. All of these factors have been considered in this report when compiling medical costs. There are some other factors that have not in all cases been considered due to lack of available information, but which may influence the true medical costs. These factors are the jurisdiction in which treatment occurs and the age of the patient. As medical costs differ slightly between States and Territories, average Australian costs have been used. The age of a patient is particularly important when it comes to determining the amount of time spent recovering from an injury, and hence the level of ancillary medical services consumed.

A proportion of the injuries sustained in rail accidents in any particular year will require ongoing medical treatment in future years. It is assumed that an element of such costs is implicitly included via the inclusion of the costs of re-admitted people who were injured in previous years.

Hospital in-patient costs

The cost of hospital in-patient services used by those injured in rail accidents, including usage by some that are ultimately fatally injured, is a major component of rail accident costs. To estimate this cost, it was necessary to establish how many people involved in rail accidents were admitted to hospital and their level of injury (fatal or serious). To derive hospital costs by injury level, BTCE

(1988) used a multiplier, developed from insurance claims for medical costs, based on a 1978 cost estimate (Atkins 1981). In this study, data collected by hospitals and collated by the Australian Institute of Health and Welfare (AIHW) was used to derive this information.

Injury level was determined using the average length of hospital stay, with a serious injury defined as one requiring an average length of stay in hospital of more than one day.

The AIHW dataset provides data on episodes of care for admitted patients by principal diagnosis. For the purpose of costing hospital in-patient services, this study analysed episodes of acute care. As the AIHW dataset counts episodes of care and not individual patients, a patient is counted each time the patient is statistically discharged from one treatment to another treatment in the hospital system. This means that the number of people receiving hospital in-patient services as a result of rail accidents may be overestimated using the AIHW dataset. The AIHW dataset was thus not used to estimate the number of people that went into hospital. The data provided by the ATSB and by States and Territories were used for this purpose instead. However, the AIHW dataset was used to estimate the number of people that attempted to commit suicide, as there were no other sources for this information. The number of attempted suicides has been derived by comparing the AIHW dataset, adjusted for double counting, with the ATSB dataset. It has been assumed that on average someone attempting suicide involving rail will have two hospital episodes (that is, two statistical in-hospital discharges) before being discharged home. Notwithstanding the above limitations, the AIHW dataset is the best source available with regard to medical costs.

The treatment a patient receives and the length of stay determine the hospital-generated medical costs. There are a number of factors influencing these costs, such as patient age and gender, whether the treatment is in a public or private hospital, and in which State or Territory a patient is located. All of this information is collected for each patient by the AIHW and is reflected in the average cost for a diagnosis-related group (DRG).

The AIHW dataset indicates that in 1999 two persons died in hospital as a result of injuries sustained in a rail accident, and there were 221 other statistical admissions pertaining to rail accident injuries of which 207 were for acute care. Each DRG consists of a class of patients with similar clinical conditions requiring similar hospital services. The costs associated with the two people that died from their injuries in hospital amounted to about $58 000. Summing the costs across DRGs provided a total cost of all admissions (excluding those that subsequently died) for accident-related reasons as in-patients in 1999 of around $1.16 million (AIHW 2000). Of the $1.16 million associated with serious injury treatments, $490 000 (42 per cent) was allocated to defined rail accidents and $670 000 (58 per cent) was allocated to attempted suicides.

This approach recognises the base cost of a bed-day and also assumes that the period in hospital reflects the level and costs of treatment received. This top-down approach also avoids the problem where the medical costs of multiple injuries are estimated separately and then summed, which overestimates bed-days and therefore also total medical costs when these injuries are treated simultaneously (Ryan, Hendrie and Mullan 1998).

In 1999, there were 42 additional admissions related to in-patient hospital treatment as a result of injuries sustained from level crossing accidents and two fatal injuries from level crossing accidents. The costs associated with the fatalities totalled around $6 000. The cost associated with the treatment of those who were seriously injured was around $180 000. It is likely that some of those who were seriously injured had attempted to commit suicide. However, BTRE has been unable to source enough data to separate out those who were accidentally hurt from those who attempted suicide, so these figures have not been adjusted or accounted for separately.

The number of attempted suicides was estimated to be 64, based on information from the AIHW dataset after allowing for multiple admissions as described above. The cost of these attempted suicides was estimated to be 58 per cent of the total cost of serious injuries. This estimate was based on the proportion of the total persons injured who were thought to have attempted suicide. This gives a total cost of hospital care for suicides and attempted suicides of $670 000.

In summary, the estimated in-patient cost of rail accidents, excluding level crossing accidents and suicides, was $0.55 million. The estimated in-patient cost of level crossing accidents and attempted suicides was $0.186 million and $0.674 million respectively. The total estimated in-patient cost of rail-related incidents was $1.4 million.

Other medical costs

There are a number of other providers of medical services to people injured in rail accidents—hospital accident and emergency departments, outpatient clinics, general practitioners, specialists and allied health services (such as occupational therapy and physiotherapy). Rail accident victims also use pharmaceutical products.

Emergency departments deal with a range of admitted and non-admitted patients, but focus on short-term care for urgent conditions. The key function is the initial reception and early management of patients who present themselves to the department.

Outpatient clinics in hospitals provide care to non-emergency patients not formally admitted to hospital. To attend a hospital outpatient clinic, a referral is required from either the hospital itself (an in-patient referral) or from a primary-care physician. The services provided overlap with those provided by general practitioners, as well as substituting for some in-patient services. There is also some substitution for services provided by specialist medical practitioners in private practice (Duckett and Jackson 1993).

Assessing the extent of the range of medical services provided to people involved in rail accidents, and allocating these services among those with fatal, serious and minor injuries was hampered by a lack of information on medical service usage by people involved in rail accidents.

In 2000, the BTE estimated the total medical costs arising from road crashes and the utilisation of medical services in 1996, based on a study by AIHW (Mathers and Penm 1999). In the absence of updated information, estimates from the BTE study have been used to generate an estimate of the total value of other medical services for rail accidents in 1999. To use this approach, it was necessary to assume that people injured in rail accidents have the levels and patterns of usage of medical services of people injured in road crashes.

In order to calculate the total value of other medical services for rail accidents, BTE's (2000) estimates of other medical services costs by injury category were inflated to average 1999 levels, using the Consumer Price Index. The resultant value was then multiplied by the number of people injured in rail accidents estimated to have received these additional services. Using this approach, the total value of other medical services for rail accidents was approximately $1.20 million. This amount has been assigned to people who were seriously injured. It has also been assumed that amounts equivalent to 10 per cent and 52 per cent of this total respectively should be attributed to people injured in level crossing accidents and attempts at rail-related suicide. That is, the total value of other medical services for level crossing accidents should be around $0.13 million and that for attempted suicides around $0.62 million.

Long-term care

For a proportion of people injured in rail accidents, the type of injury sustained necessitates long-term care outside the hospital system, either in a nursing or community home or in private homes. The duration of this care (and cost) varies with the severity of the disability. For some the disability will be permanent and prohibit any future employment, while others will be able to work but will only be able to undertake limited duties or work part-time.

There are no data available on the number of people requiring long-term care as a result of rail accidents. To estimate the number of people injured in rail accidents who have, or are likely to have, injuries requiring long-term care, data from the National Hospital Morbidity Database and the Australian Spinal Cord Injury Register (ASCIR) were used in conjunction with studies into the prevalence of long-term disability. Studies into the costs of disability were used to determine the cost of caring for people needing long-term care.

In the absence of any better information, it was assumed that a person who sustains a traumatic brain injury or multiple significant trauma or becomes a tetraplegic or paraplegic as a result of their injuries will require long-term care.

According to the ASCIR, in 1998–99 four people were discharged from spinal units with a neurological deficit such as tetraplegia or paraplegia resulting from injuries sustained from rail accidents (O'Connor 2001). Of these people, two were tetraplegics and two were paraplegics. In 1999–2000, there were no rail accident related spinal cord injuries.

According to a study by Coopers & Lybrand Actuarial and Superannuation Services (1999), the annual cost of caring for a person with tetraplegia ranges from $34 500 up to $332 300 for a ventilator-dependent person.

Estimating the number of people with traumatic brain injury was more complicated. Significant improvements commonly occur in the first few months after a brain injury. As a result, information collected at the time of discharge from hospital is limited in its ability to predict the proportion of people who will experience long-term disability and need long-term care following a brain injury (Fortune and Wen, 1999). However, in the absence of actual information, data from the National Hospital Morbidity Database was used to determine the number of brain injuries sustained from rail accidents. Classification of a brain injury was based on ICD codes indicating skull fracture and concussion or intracranial injury (Fortune and Wen, 1999). From this process it was estimated that four people sustained a brain injury.

To determine the number of these people that will experience long-term disability, it was predicted that 16.4 per cent of people with new incident cases of traumatic brain injury who are discharged from hospital will experience long-term disability, in line with Kraus' (1987) study. Given the medical data available for 1999, this generated an expected figure of 0.64 of a person. It was assumed that 1 case in 1999 suffered a brain injury that will require long-term care as a result of a rail accident.

The number of people reported to have tetraplegia, paraplegia and traumatic brain injury in this study is consistent with a study into the costs of motor vehicle crashes in America by Miller and Moffet (1993). The study reported findings by Miller et al (1985) indicating that about two per cent of all serious injuries result in permanent disability such as paraplegia, quadriplegia (tetraplegia) or serious brain damage.

The number of people sustaining multiple significant trauma was also calculated from the National Hospital Morbidity Database. A total of 14 people sustained injuries classified as multiple significant trauma. It has been assumed that only a portion of these people will require long-term care. If the same percentage of new incident cases of multiple significant trauma experience long-term disability as do new incident cases of traumatic brain injury, then the medical data available for 1999 gives an expected figure of 2.8 people that will require long-term care as a result of multiple significant trauma. It was assumed that 3 cases in 1999 suffered multiple significant trauma that will require long-term care as a result of a rail accident.

Overall, it is estimated that in 1999 about 4 people injured in rail accidents would have suffered permanent disabilities requiring long-term care as a result of a rail accident. This estimate is of the same order of magnitude as the estimate in BTE (2000), which estimated that about 4.7 per cent of all those seriously injured in road crashes in 1996 suffered permanent disabilities. Applying that ratio to the rail figures gives an estimate that about 6 people would have suffered permanent disabilities requiring long-term care as a result of a rail accident.

The national annual average level of government support for the disabled encompasses expenditure on accommodation, community support and access, respite care and employment services, and was estimated at $33 435 per disabled person supported in 1999 (Steering Committee for the Review of Commonwealth/State Service Provision 2000). This figure is the average for those with all levels of disability.

The net present value of this cost over an assumed average remaining lifespan (from age 29), taking into account mortality rates and disability life adjusted years, was derived using an annual growth rate of 0.3 per cent and discount rate of 4 per cent. The annual real growth rate of 0.3 per cent is very conservative, and is based on the belief that, in the long-term, care will become more efficient and cost-effective given the rate of medical advances. The net present value of care for those disabled in rail accidents in 1999 amounted to $2.9 million ($1.9 million at a discount rate of 7 per cent). This value excludes the lost value of labour for those whose disability prohibits them from working, as this cost has been estimated and reported in the section above. The cost is net of other old age and normal medical costs.

Using the same ratios discussed above for level crossing accidents and attempted suicides, it was estimated that the long-term care costs for level crossing accidents and attempted suicides were 10 and 52 per cent respectively of the costs obtained for rail accidents.

Ambulance costs

Ambulances are used to transport the injured to hospital, treat the injured on the spot, and remove fatalities, so ambulance costs need to be included.

The number of ambulances initially dispatched to a rail accident varies between States and Territories and is dependent upon the nature of the accident and the details provided to the ambulance service about the accident in the initial report. In New South Wales, Victoria, Queensland and Tasmania, when a motor vehicle or person has been hit by a train, or there is minimal information on the number or nature of injuries, one ambulance will be dispatched initially. If a bus and a train or two commuter trains have collided, or a passenger train has derailed, a number of ambulances will be dispatched initially. In South Australia, on the other hand, two ambulances are sent automatically to all rail accidents. In all States and Territories, additional ambulances will be dispatched to the accident scene if necessary, following an assessment of the scene by ambulance personnel.

In New South Wales, if the rail accident occurs in the Sydney area, and the ambulance service is called, an ambulance and a motor cycle will be dispatched, as the motor cycle will generally be able to get to the accident scene quicker than the ambulance, and will be able to report if more ambulances will be required.

Calls for ambulance services to attend rail accidents will either be made by the railway company involved or members of the public. A number of States have a dispatch system which identifies if jobs are reported in the same area at about the same time, therefore preventing the possibility of more than one ambulance arriving at the accident except when more than one is needed. In remote areas another train may be used to transport the injured to another station where an ambulance will be waiting, or if the case is very serious, a helicopter may be used.

BTRE has assumed that all reported cases of fatalities and serious injuries required the attendance of an ambulance. In the case of a major accident such as Glenbrook, which occurred during the period this study covers, a fleet of ambulances is required. Rather than attempt to estimate the number of ambulances that attended each accident scene, it was assumed that each of the 79 reported fatalities and 124 reported serious injuries required an ambulance. These estimates are further inflated by the use of ambulances for inter-hospital transfer of the injured. This inter-hospital transfer constitutes about 4.2 per cent of additional ambulance services (derived from AIHW 2000).

Using an average ambulance cost per actual attendance of $350 (see BTE 2000), the estimated total cost of ambulance services attending rail accidents in 1999 was around $32 000, made up of $15 000 for fatalities and $17 000 for the seriously injured. It is estimated that the total cost of ambulance services attending level crossing accidents and suicides/ attempted suicides in 1999 was $11 000 and $33 000 respectively. This gives a combined total for ambulance services for rail-related incidents of about $76 000.

It was not possible to split the assorted medical care costs of level crossing accidents cleanly between rail accidents and level crossing accidents involving motor vehicles due to data quality problems. Some serious jury data that should have been recorded was not. However, for the subset of serious injuries for which information was available, all of the costs identified were due to level crossing accidents involving motor vehicles. For the purposes of estimating the total cost of rail-related accidents, these assorted medical care costs have been assumed to be wholly due to level crossing accidents involving motor vehicles.

Quality of life

The following section differs substantially from previous discussions by this Bureau on the same topic, as increasing government control of compensation payments to people injured in accidents has impacted on the valuation of 'quality of life'.

People who have been injured or who have undergone any kind of traumatic experience sustain costs in forms that cannot be readily given monetary value. Apart from the pain and fear associated with the injury itself, people injured may be left with long-term disabilities. A person who becomes a quadriplegic will lose the great majority of the freedoms and abilities available before the injury.

Losses of this kind are referred to as pain and suffering, loss of amenity of life and non-economic loss. In this report, the term 'quality of life' is used to encompass all such losses. Assigning a monetary value to quality of life loss is a difficult procedure. There is no market value for pain, or for the emotions that arise from dependence on others, or the loss of the ability to play with children.

Economists have explored a variety of methods for valuing quality of life losses. These include non-economic court awards (Viscusi 1988, Cohen 1988), a variant of court awards that accounts for legislated restrictions on the amounts awarded, willingness to pay (BTE 1998) and disability adjusted life years (DALYs) (Mathers, Vos & Stevenson 1999). As the name suggests, DALYs are not a monetary measure of loss, but they can be given monetary value.

Non-economic court awards value only the quality of life aspect of human life. This makes them naturally suited to complement the human capital approach. The justification for using court awards is that society has chosen the court system to determine appropriate monetary compensation for accident injuries.

Court awards were used by this Bureau in its early estimates of transport accident costs (BTCE 1992, BTCE 1988). More recently, the Bureau's reports on transport accident costs have begun to take account of increasing government control of compensation payments to people injured in accidents (BTE 1999, BTE 2000). The most recent report on road crash costs contains a discussion of the economic issues surrounding this change (BTE 2000).

The willingness to pay approach has a more complex relationship with quality of life loss than the court awards method. In principle, willingness to pay encompasses all aspects of the value of a life, economic as well as non-economic. It has been proposed that the quality of life loss for a fatality could be estimated by subtracting productivity loss estimates from a willingness to pay estimate for the value of a life (Miller et al 1998). In practice, the exact scope of a willingness to pay valuation may depend on the method used to establish it. For example, one common means of estimating willingness to pay is to conduct a stated preference study, in which a representative sample of people are asked questions about how much they would pay to achieve some end, such as improving transport safety. When people answer survey questions of this kind, they may not take explicit account of all the economic costs, such as loss of income, even assuming they interpret the questions as intended by the survey authors (BTE 1998). Consequently, a willingness to pay valuation of life may require the addition of some elements of the human capital approach, depending on the construction of the survey used to develop it.

At present it is not possible to use the willingness to pay method for Australian transport accidents because no survey has been conducted to establish a valuation.

Disability adjusted life years (DALYs) estimate the human loss caused by injuries in terms of years of life lost due to mortality (YLL) and years lost due to disability (YLD). YLD for a given disability is estimated by adjusting the number of years lived downwards to reflect the estimated partial loss of the value of those years. The adjustment for each disability is established by survey. Like willingness to pay, DALYs are intended to value all the losses associated with disability, but the true scope of the valuation may depend on the exact form of the survey questions and how respondents interpreted them. It may be that DALYs do not take full account of economic costs such as lost income.

DALYs are not at present a practical method for valuing quality of life loss caused by rail accident injuries in Australia. Mathers, Vos & Stevenson (1999) includes rail accidents only as part of the 'other transport accidents' category, and there does not appear to be any source of data specific to rail accidents.

Compensation awards for people injured in rail accidents were not limited in most jurisdictions in Australia in 1999. The exception was Victoria, where the Transport Accident Commission (TAC) deals with injury compensation for all modes of transport, and where accident compensation payments are strictly limited by law. At the time this report was being prepared, the Australian insurance industry was in crisis, and personal injury compensation awards were under review.

There is little data available regarding quality of life losses due to injuries in railway accidents. Because of this, quality of life loss calculations have been based on the estimates made in BTE 2000. These estimates derive from the Victorian Transport Accidents Commission. The use of the BTE 2000 figures has the advantage of consistency: it gives injuries sustained in rail accidents the same status as those sustained in road accidents.

It can be argued that it is inappropriate to attribute loss of quality of life to people who take their own lives. This stems from an assumption that a person who commits suicide must feel that they have no quality of life to lose. The BTRE takes the position that the issue of suicide is not always as simple as this, and so has included the figure for loss of quality of life by suicides. A person who sustains a serious injury as a result of a suicide attempt clearly has a lower quality of life than before, and so the figure for this loss has be included.

The estimated value for lost quality of life was about $327 000 per fatality and $35 000 per serious injury. These are the figures used in BTE 2000, adjusted for inflation between 1996 and 1999. The estimates for the quality of life lost were: $14 080 000 for fatalities and $1 650 000 for serious injuries due to railway accidents, which includes $4 580 000 for fatalities and $70 000 for serious injuries in level crossing rail accidents (persons struck by trains at level crossings); $1 640 000 for fatalities and $390 000 for serious injuries due to level crossing accidents involving motor vehicles; and $10 150 000 for suicides and $2 250 000 for serious injuries resulting from attempted suicide.

Minor Injuries Costs

While some data was available on minor injuries, it was not available for every State and Territory, and some of that available was not of good quality. The best available minor injuries data were from New South Wales. However, the New South Wales data were atypical because of the large number of minor injuries (57) in the Glenbrook accident in 1999. Costs for minor injuries were based on those estimated for road accidents for the year 1996 in BTE (2000). Although it is clear that the distribution of fatal, serious and minor injuries in rail accidents is completely different from that in road accidents, it seems reasonable to assume that within the category of minor injuries the costs should be similar. The cost categories included were hospital in-patient, other medical, ambulance, workplace disruption, and legal costs arising from insurance claims. The value of lost labour caused by minor injuries was assumed to be negligible. Legal costs arising from criminal prosecutions were excluded because the situation for railway accidents may be very different from that for road accidents. The costs were adjusted from 1996 to 1999 using the Consumer Price Index.

In 1999, New South Wales had 57 minor injuries in the Glenbrook accident, plus 11 in other accidents. The total cost of minor injuries was therefore $117 000 for the Glenbrook accident and $23 000 for other accidents in New South Wales. It is estimated that there were 110 minor injuries in Australia in 1999, leading to costs of $227 000.

Table 3.5 summarises the human costs discussed in this chapter.

TABLE 3.5 SUMMARY OF HUMAN COSTS ($ MILLION) 1999

	Rail Accidents Excluding Level Crossing Accidents	*Level Crossing Rail Accidents*	*Level Crossing Accidents Involving Motor Vehicles*	*Suicides and Attempted Suicides*
Work place productivity	19.7	8.4	3.0	18.6
Household productivity	19.2	8.2	2.9	18.1
Medical, ambulance & rehab	2.3	0.0	0.6	2.8
Quality of Life	11.0	4.7	2.0	12.4
Total	**52.3**	**21.2**	**8.6**	**51.9**

Source BTRE estimates.

chapter 4

PROPERTY DAMAGE COSTS

Most railway accidents produce damage to both railway and non-railway property. A collision or derailment may damage locomotives and rolling stock, as well as fixed infrastructure such as signalling equipment, and may destroy a section of track, making the line unusable until it is repaired. (Rail accidents differ from road crashes in that road accidents are much less likely to cause extensive damage to the road or road furniture in the vicinity of the crash.) Rail accidents may also result in damage to buildings, bridges, and other non-railway property.

Property damage costs include the replacement or repair costs of accident-related damages to all fixed structures and rolling stock affected.

The lost value resulting from property damage is very difficult to estimate directly. Technological change and changing customer requirements mean that the value of an item in use may differ from its historical cost and from its replacement cost. Repair and replacement costs are thus proxies for lost value resulting from property damage rather than direct measures of it. However, they are the best proxies available. If an owner pays repair and replacement costs, the value lost will in general have been at least as great.

The social cost of rail accidents is a matter of economic costs, rather than accounting costs. This means that the cost is estimated in terms of losses to the whole of society, rather than costs incurred by individual people or firms. Property loss and damage is concerned with the lost value caused by damage to equipment, rather than with the amount of money railways spend on repairs. The cost of repairs and replacements is not in itself a loss to the economy. For example, the cost of repairs and replacements may include some taxation, which from society's perspective is a transfer rather than a cost. The loss to society is the opportunity cost of the damage, namely the creation of new wealth that is forgone when resources must be utilised performing repairs and building replacements.

Data

An estimate of the value of property damage was made using incident databases and data summaries supplied by a number of railway operators and authorities. Most of the databases included estimates of the value of property damage, or the expected cost of repairs. In some cases, summaries of actual repair accounts were supplied. However, none of the data sets related records of repair costs with the accidents that caused the damage, nor did they allow accident repairs to be distinguished from other repairs.

The most useful data sets were those that listed accidents by type. These data sets used categories equivalent to 'collision', 'derailment' and 'person struck' (that is, a person hit by a moving vehicle). Some also used categories equivalent to 'falls' that include people who fell while boarding, alighting or travelling on trains.

Unfortunately, the data supplied to the BTRE were not generally structured in a way that enabled railway accidents to be distinguished from other types of incidents. Most were structured on the lines of industrial safety, rather then railway safety. The data did not distinguish railway accidents from other rail-related incidents, or incidents that occurred on railway property. Some sets of data went further than industrial safety, being more akin to operational incidents databases. These included, for example, locomotive defects that were not safety related.

The data quality issues were such that the final result obtained may be imperfect. Any data classified in the category 'derailment' relates to an incident involving a moving train, so any derailment is a railway accident. However, sorting the data in other categories was less straightforward. The 'trespasser' or 'person struck' category may include people run down by motor vehicles, or passengers injured by station equipment, such as ticket barriers. A crash between two trains, and a road crash involving a car owned by a railway operator, may both be classified as 'collisions'. A passenger who fell whilst boarding a train, and a pedestrian who fell on a station concourse, may both be classified as 'falls'. In many cases it was necessary to look at individual written descriptions of incidents in order to separate out those that were not railway accidents.

The relationships amongst the organisations supplying data, and the differences amongst the types of data supplied, further complicated the data sorting process. Some organisations only supplied estimates of 'below rail' costs; namely those arising from damage to track, signalling plant and other fixed property. Some organisations only supplied estimates of 'above rail' costs; namely those arising from damage to locomotives and rolling stock. Other organisations supplied estimates that covered both types of costs, but did not provide data that enabled 'below rail' and 'above rail' costs to be distinguished. In some jurisdictions, the combination of all three problems made it difficult to be certain of including all costs without double counting. In addition, some databases appeared to be more comprehensive than others.

The casualty figures shown are derived from the same railway operator databases as the property loss estimates. These do not display good agreement with the ATSB fatality figures on which this report is based. The reason for this appears to be differences in classification of fatalities, especially level crossing accidents of all kinds and suicides and attempted suicides. Railway operators and railway regulatory authorities use the definition of a railway occurrence stated on pages xv and xvi rather than the ICD definition of a rail accident.

The loss of value that occurred due to damage to rolling stock and property was estimated using market prices for the cost of repair or replacement derived from railway safety databases. The total cost for repair and replacement of property damaged in accidents clearly identified as railway accidents during 1999 was about $55.9 million, as shown in table 4.1. Property damage associated with level crossing accidents involving motor vehicles accounted for a further $1.2 million, as shown in table 4.2. The railway operator databases did not include data in relation to suicides and attempted suicides that railway

TABLE 4.1 PROPERTY COSTS OF RAIL ACCIDENTS BY ACCIDENT TYPE, 1999

	Number of rail accidents	*Cost ($'000)*	*Average Cost ($'000)*	*Fatalities*	*Serious injuries*	*Minor injuries*
Collision	64	25 641	401	8	3	94
Derailment	165	29 333	178	0	1	7
Trespasser	122	429	4	65	36	0
Other	88	480	5	1	7	2
Pedestrian level crossing	8	17	2	0	2	7
Total	**447**	**55 900**	**125**	**74**	**49**	**110**

Note The figures in this table, and all other tables in chapter 4, were derived from railway operator databases. The fatalities figures are believed to include 31 deaths classified as suicides by the ATSB. Most of these are likely to have been classified under 'trespasser'. However, the information available did not enable BTRE to determine which records from railway operator databases related to suicides, and hence to segregate them. BTRE believes that the serious injuries figures may also include some attempted suicides. The railway operator databases are the only sources available of the rest of the data presented.

Sources Railway operators, railway regulating authorities, ATSB, BTRE estimates.

TABLE 4.2 PROPERTY COSTS OF LEVEL CROSSING ACCIDENTS INVOLVING MOTOR VEHICLES, 1999

Type of level crossing accident	*Number of level crossing accidents*	*Cost ('000)*	*Average cost ('000)*	*Fatalities*	*Serious injuries*	*Minor injuries*
Motor vehicle	89	1 266	14	11	11	14

Note See note to table 6.1. Level crossing fatalities data derived from railway operator databases does not agree with ATSB data.

Sources Railway operators, railway regulating authorities, ATSB, BTRE estimates.

operators could identify as such, although it is likely that at least some of these have been included under 'trespasser'.

It should be noted that not all jurisdictions separated their level crossing accidents data into pedestrians struck by trains, which are defined as rail accidents, and motor vehicle related accidents, which are defined as rail-related incidents. The data from those sources which did not separate these categories have been assumed to be separated in the same proportions as the data from those jurisdictions that made the separation. BTRE believes that this is a reasonable assumption for property costs, but the split in the numbers for fatalities, serious and minor injuries for pedestrian and motor vehicle related level crossing accidents should be treated with particular caution.

Tables 4.3 through to 4.6 provide property cost estimates for different kinds of rail accidents.

TABLE 4.3 PROPERTY COSTS ATTRIBUTABLE TO COLLISIONS BY JURISDICTION, 1999

Jurisdiction	*Number of collisions*	*Cost ($'000)*	*Average Cost ($'000)*	*Fatalities*	*Serious injuries*	*Minor injuries*
NSW	50	7 012	140	7	0	61
VIC	2	12 000	6 000	0	2	3
QLD	2	13	6	0	0	0
SA	4	540	135	1	0	0
WA	6	6 076	1 013	na	1	30
TAS	na	na	na	na	na	na
Australia	**64**	**25 641**	**401**	**8**	**3**	**94**

Note 'na' means not available to BTRE.

Sources Railway operators, railway regulating authorities, ATSB, BTRE estimates.

TABLE 4.4 PROPERTY COSTS ATTRIBUTABLE TO DERAILMENTS BY JURISDICTION, 1999

Jurisdiction	*Number of derailments*	*Cost ($'000)*	*Average Cost ($'000)*	*Fatalities*	*Serious injuries*	*Minor injuries*
NSW	35	9 320	266	0	1	4
VIC	8	1 040	130	0	0	0
QLD	45	5 097	113	0	0	0
SA	29	5 226	180*	0	0	3
WA	48	8 650	180*	na	na	na
TAS	na	na	na	na	na	na
Australia	**165**	**29 333**	**178**	**0**	**1**	**7**

Note 'na' means not available to BTRE.

*The South Australia and Western Australia costs were estimated using the average costs for Queensland and New South Wales.

Sources Railway operators, railway regulating authorities, ATSB, and BTRE estimates.

TABLE 4.5 PROPERTY COSTS ATTRIBUTABLE TO TRESPASSERS BY JURISDICTION, 1999

Jurisdiction	*Number of trespassers*	*Cost ($'000)*	*Average Cost ($'000)*	*Fatalities*	*Serious injuries*	*Minor injuries*
NSW	85	210	2	34	10	0
VIC	10	50	5	10	3	0
QLD	15	161	11	10	3	0
SA	2	7	4	1	1	0
WA	10	na	na	10	19	na
TAS	na	na	na	na	na	na
Australia	**122**	**428**	**4**	**65**	**36**	**0**

Note 'na' means not available to BTRE.

Sources Railway operators, railway regulating authorities, ATSB, and BTRE estimates.

As noted earlier, table 4.5 includes data on trespassers, suicides and attempted suicides, as insufficient information was available to segregate suicides and attempted suicides.

TABLE 4.6 PROPERTY COSTS ATTRIBUTABLE TO LEVEL CROSSING ACCIDENTS BY JURISDICTION, 1999

Jurisdiction	*Number of level crossing accidents*	*Cost ($'000)*	*Average Cost ($'000)*	*Fatalities*	*Serious injuries*	*Minor injuries*
NSW	13	339	26	5	1	1
VIC	8	102	13	2	0	16
QLD	27	198	7	0	11	4
SA	6	81	13*	0	1	0
WA	41	550	13*	4	na	na
TAS	2	14	7	na	na	na
Australia	**97**	**1 284**	**13**	**11**	**13**	**21**

Note This table includes all level crossing accidents, including those involving motor vehicles.

*The South Australia and Western Australia costs were estimated using average costs for Queensland and New South Wales.

Sources Railway operators, railway regulating authorities, ATSB, BTRE estimates.

Accuracy of cost estimates

The safety incident data used in this analysis almost certainly understates the cost of property damage caused by rail accidents and rail-related incidents. Most database property cost entries were estimates made on the spot, and were not checked against the actual repair costs, which were recorded in separate databases. Although the estimates were made by people with experience in the field, an examination of the high quality costings available for a small number of major accidents suggests that the estimates were conservative. There were also some insurance data available that implied repair and replacement costs were understated by the safety databases.

In addition, the safety databases used did not take account of all the long-term indirect costs of damage to railway equipment. A derailment can cause damage to track that may take hours or days to repair. The costs arising from traffic delays are estimated in chapter 5.

Rolling stock that is damaged or destroyed takes time to replace, and railways do not keep much in reserve. Consequently, the cost to the railway operators of traffic forgone may be high, especially if contracts are lost because of temporary lack of capacity. BTRE was unable to estimate this cost because of lack of data. Anecdotal evidence suggests that the opportunity cost to the railway operator may be more than double the direct cost of property damage, at least for major accidents. However, not all of this opportunity cost to the railway operator is likely to be a cost to society.

The figures by jurisdiction given in tables 4.3 to 4.6 show considerable variability that does not appear to be related to differences in traffic levels. This may be an indication of varying conditions in the different jurisdictions, but it may also indicate differences in standards applied when recording incidents in each jurisdiction.

Property loss in fatal accidents

Fatal railway accidents are on average associated with lower property damage costs than non-fatal accidents. This is because the majority of fatal accidents arise from people on the track being run down by trains. The property damage resulting from these 'person struck' accidents is frequently negligible.

The data include the major collision at Glenbrook in New South Wales, which occurred on 2 December 1999. BTRE considered this collision carefully to determine whether 1999 was a typical year with regard to rail accidents. Table 4.7 shows the casualties and estimated property cost caused by the Glenbrook accident. Glenbrook accounted for less than ten per cent of the total $55.9 million in property damage costs definitely attributable to rail accidents, and 7 of the 43 fatalities attributed to rail accidents by the Australian Transport Safety Bureau. Its contribution is significant, but not dominating.

Glenbrook was, however, a major exception to the general rule that fatal accidents have low property costs.

TABLE 4.7 COLLISION AT GLENBROOK, DECEMBER 1999

Fatalities	*Serious injuries*	*Minor injuries*	*Cost($'000)*
7	0	57	5 250

Source Rail Infrastructure Corporation.

From the data available, the average property cost for a fatal accident was around $118 000, and the average property cost per fatality was about $105 000. Excluding the Glenbrook accident from the data available gives an average property cost of about $4 300, both per accident and per fatality. All fatal accidents other than Glenbrook in 1999 were single fatality accidents. The property cost associated with fatalities was calculated as the total cost of the Glenbrook accident, plus the total cost of other fatalities based on the average of $4 300 per fatality. This implies that the 43 fatalities recorded for 1999 had an associated property cost of $5.4 million.

Suicide and attempted suicide

Of databases that contain death and injury information, most make some attempt to distinguish suicides from accidental deaths and attempted suicides from accidental injuries. As stated earlier, the ICD definition of a rail accident excludes suicides and attempted suicides, on the grounds that they are not a railway safety issue. The causes of, and appropriate public policy responses to, railway accidents are very different from those for suicides and attempted suicides, and confusing the statistics of the two will not improve the policy response to either. The statistics for suicides and attempted suicides have thus been presented separately wherever possible.

The decision to place an incident in the suicide or attempted suicide category is based on investigations carried out by railway safety authorities and by the police. The evidence used includes statements by the train driver and any other eyewitnesses, physical evidence such as the stopping position and known stopping performance of the train, data from recording devices, and evidence about the person's personal circumstances.

As a general rule, if a person is truck by a train, the train driver will usually not be at fault. A train driver cannot avoid the particular section of track a person is on. The only actions available to a train driver are to sound the horn as a warning, and to make an emergency brake application. Emergency brake applications are likely to lead to delays, and can occasionally lead to damage, derailment of rolling stock, or even injury to people riding on the train. Even under emergency braking, a train requires a much greater distance to stop than any road vehicle travelling at equivalent speed. One accident investigator's report noted that 450 metres was a reasonable stopping distance under emergency braking for a train initially travelling at 80 kilometres per hour for the type of electric suburban passenger train in question. Freight trains normally require still more distance. This long stopping distance means that once the driver sees a person on the line, it is frequently too late for the train to stop. If it is not too late, the decision must be made when the trespasser is still half a kilometre away or more. At this point, the person on the line is highly likely to clear the track when they hear the horn, and has ample time to do so.

Coroners' verdicts have not been used to sort accidents arising from trespass from suicides and attempted suicides. The social stigma associated with suicide and attempted suicide in Australia is such that coroners may prefer to return a verdict of suicide only if they have strong evidence for it. This would be an inappropriate standard of proof if used in a statistical analysis intended to guide policy decisions. It is more valuable to estimate the correct proportion of suicides, even if some individual cases are misclassified.

The number of suicides was estimated from the difference between the number of fatalities given in the ABS data, and the number of fatalities derived from rail operator databases. Even after culling events that are not rail-related, the operator databases contained significantly more fatalities than the ABS data. Since the ABS does not record suicides, while operators record all deaths on their property, it was assumed that the difference represented the number of suicides.

The estimated average property cost per suicide was $6 100. The total property cost for the 31 suicides was $189 000.

chapter 5

OTHER COSTS

Other costs have been defined as costs other than human and property damage only costs. They include costs associated with delays to freight and passengers, environmental costs (for example, those arising from dangerous goods spillage), investigation costs both within rail agencies and external agencies, emergency services (such as the cost of fire brigade and police responses), and lost cargo.

Delay costs

Train accidents can result in delays to owners and customers of the system. Such delays impose costs.

An accident may render a rail line completely unusable, particularly in the case of a major accident. The rail line may be closed for days. The economic consequences can be significant, particularly if the rail line is a single line. On the other hand, there are many accidents that leave the rail lines involved intact and operational. However in almost all cases the trains involved in the accidents and other trains that use the rail lines affected are subject to delays while safety personnel seek to establish the causes of the accidents and take precautionary measures. Sometimes road traffic is affected too. This usually occurs when accidents occur at level crossings.

The value of time lost by train crew members killed or injured in accidents has not been included in the delay costs total, as it is implicitly included in the lost productivity value reported in chapter 3 of this report. Where the train crew members have been stood down, the value of the time lost has been estimated and included under 'additional operating costs'.

Value of time

Transport analysts routinely place values on travel time saved and lost for use in policy formulation and decision-making with regard to investment in capital works. Time lost to passengers and freight has an economic and financial value. There have been many empirical studies and reviews regarding the valuation of travel time savings (Hensher 1994, Walters 1995, Bradley 1995, Miller 1996, and Wigan 1998). Miller (1996) provides a recent comprehensive review of the literature including cross-country travel time values.

The value of travel time saved is not necessarily the same as the value of travel time lost. Miller (1996) and Hensher (1994), in their work on road crashes, pointed out that crash-related delays are unexpected, and travellers are generally prepared to pay a premium to avoid the unplanned delay. Time lost is thus worth more than time saved. Hensher (1994) derives the values of 44 to 68 percent of the wage rate for travel time lost and 35 to 41 percent for travel time saved.

The ranges of values calculated by Hensher indicate that different road users value time differently. Miller (1996) suggested a time lost value of 55 percent of the wage rate for passengers and 75 percent for drivers, whom he assumed to be working. It has been assumed that the value of time lost of rail passengers equates with that of bus passengers. However, users may attach different values to each mode of travel. For example, urban commuter trains cover distance more quickly than buses, but their closest point of approach to the intended destination will on average be further away.

One further consideration when valuing time lost is the determination of whether every minute is accorded the same value by every person. Small (1982) demonstrated that one minute lost or saved can be valued minimally or very highly, depending on the situation of the traveller. The same person may value time lost on a long trip differently from that lost on a short journey. The amount of time lost may also affect its value. For example, the first minute lost may be assigned a lower value than the thirtieth minute lost. This raises the question of whether there is a pattern in the valuation of time in certain circumstances or for particular people. Miller (1996) reviewed the literature on this subject but did not find consistent patterns. Thomas and Thompson (1970) estimated that the value per minute saved was minimal for the first five minutes, then increased rapidly until savings reached about 15 minutes, then decreased. Lee and Dalvi (1969), on the other hand, found that the value of time saved consistently decreases as more time is saved. Horowitz (1978, 1980) and Hensher (1976) found that the value of time saved consistently increased, although at a decreasing rate, and is a function of percentage reduction in trip length.

Although the value of time lost varies with both the amount and the situation, the uncertain nature of this relationship has meant that this study does not attempt to model any of the possible scenarios. As in BTE 2000, the value of time lost by rail passengers is assumed to be constant. Hensher's estimate equates to $8.80 per hour per bus passenger in 1999 dollars after adjustment in line with the Consumer Price Index. This figure has been used as a proxy for the value of time lost by train passengers.

The BTE Rail Operating Cost Model was used to estimate the opportunity cost of time lost per freight train per hour. The value derived was about $1 000. The simulation was based on a train with 25 wagons travelling from Sydney to Melbourne.

The severity and location of rail accidents are the prime determinants of the length of any delays. When an accident occurs rail operators explore ways to re-route trains around the site to minimise delays and inconvenience to customers. Such re-routing is often feasible in urban areas. On single rail lines re-routing may not be an option. Services yet to start may have to be cancelled and ticket holders diverted to other modes of transport.

Most rail operators have contractual arrangements in place with bus operators so that in the event of a passenger train accident stranded passengers are transported by bus. The buses provide a link to the origin and destination of the train service until the line is cleared. Other trains affected normally transport passengers to the nearest accessible station. Buses are then used either to transport the passengers for the remainder of their journey or to serve as a bridge between trains at either side of the incident site. The ability of all passenger train operators to put alternative services in place immediately reduces the length of delays. However, train services are operated as a network. When a link in the network is broken, much of the network may be affected and the flow-on effects may last longer than the incident that caused them. The train drivers involved are usually relieved by a fresh train crew and train schedules are altered. Not all of the customers inconvenienced by an accident will be located close to the accident. In the short term some patronage may be lost to other modes of transport.

In the case of freight train accidents, the options available usually involve diverting trains or terminating services, at least for a time. The quantities moved by freight trains are so large that providing substitute services using other transport modes is generally infeasible. As a result, most of the economic losses associated with delays occur when freight is subject to long delays. Although freight train loads are generally less time sensitive than passengers or road freight, they nonetheless have time value. Even the re-positioning of empty containers for shipping can generate a major loss if containers do not arrive on time to be loaded and the cargo misses its shipping schedule. In Sydney, because there is a curfew for freight trains during morning peak-hour commuter traffic, a delay of an hour could translate into a much longer delay.

Delay values

Detailed data on the delays generated by each rail incident were not available. Trains run to a schedule so rail operators are able to capture the total delay on the rail network when an accident occurs. This information is collected by rail operators for internal use, but some rail operators are reluctant to share it, and where such information is available it is not in a form that permits easy analysis. A number of case studies were examined and advice taken from rail operators to determine what assumptions should be made to enable the value of delays to be estimated. Some examples are given below.

BOX 5.1 CASE STUDIES

On 22 April 2000 a Queensland Rail train was involved in a level crossing accident with a motor vehicle. The incident was estimated to have affected 9 trains with a combined passenger total of 674. The total delay of all the services was 73 minutes. The longest passenger delay was 18 minutes. The track was not damaged.

In one incident involving a person being struck by a train, 5 train services were diverted around the site, and 3 other services were affected. In another incident involving a person stuck by a train, 5 train services were affected, involving 111 passengers. The affected services terminated prior to reaching their destinations, and the passengers completed their journeys by bus.

In June 1998 an empty 8-car train was derailed in Sydney from the Strathfield–Hornsby line, affecting commuter traffic. Central coast trains were diverted with delays of about 15 minutes per train. Commuters between Strathfield and Hornsby were transported by 55 buses from where the train journeys terminated to passenger destinations.

In August 1999 the Indian Pacific train collided with the rear end of a freight train on the rail line between Adelaide and Perth. A special train service was used to transport the 170 passengers about 200 kilometres to Kalgoorlie.

In June 2001 two trains collided during peak hour traffic in Melbourne. Buses were used to take passengers from Footscray to Newport where they continued by train. The maximum delay to passengers was about an hour.

In November 1999, there was a collision in Ararat in Victoria, delaying 27 trains.

These case studies show that incident related delays are kept to minimum, particularly in the case of passengers. In the absence of detailed data on the delays resulting from each incident, this study has assumed an average delay time of 20 minutes for all accidents affecting urban passenger commuter trains and an hour for inter-urban trains. Whilst rail lines have been known to close for days following an accident, most transport problems are resolved very quickly when alternative transport services are deployed.

The estimate of the value of delays was obtained by multiplying the estimated value of time and the estimated number of people affected. A number of further assumptions were made to estimate the number of people affected. For example, where the number of passenger trains and the number of passengers affected were not available, it was assumed that, outside of Sydney and Melbourne, trains would have 80 passengers. In Sydney and Melbourne, it was assumed that trains would have 400 passengers based on State Rail Authority movement of about 900 000 passengers per week-day using about 2 300 train services in 1999. It was also assumed that each derailment and collision would affect two passenger trains. This is a conservative assumption because in peak hours in cities it is most likely several trains would be affected. Delays associated with trains striking people, and level crossing accidents, have not been factored into the estimates. It is acknowledged that these kinds of accidents do cause delays. An examination of case studies from Queensland supports this conclusion.

In aggregate, the assumptions made when estimating the value of delays generate very conservative figures, which should be considered as lower bounds.

For 1999 it is estimated that the economic losses incurred by passengers due to train accident induced delays totalled around $310 000. No estimate was derived for the cost of passenger delays caused by level crossing accidents involving motor vehicles or suicides and attempted suicides. Additional operational costs of about $120 000 were incurred by using buses, replacing train crews, providing crew trauma counselling, and so on. Since the contractual arrangements between rail and bus operators allow for fixed payments regardless of whether or not accidents occur, only the avoidable costs have been taken into account. Level crossing accidents involving motor vehicles and suicides and attempted suicides accounted for an additional $25 000 of operational costs each.

In cases where train accidents affect the rail lines used by freight trains, it has been assumed that on average freight trains would be delayed by 6 hours. Where data are not available it was assumed that 50 per cent of train derailments and collisions would affect one freight train. The costs of freight train delays associated with trains striking people, and level crossing accidents, have not been estimated, for the reasons described above.

The estimate of the value of freight delays was obtained by multiplying the opportunity cost per hour per freight train by the estimated number of freight trains affected and by the assumed delay time.

For 1999 it is estimated that the economic losses associated with freight delays due to train accidents amounted to $1 310 000. Equivalent figures were not estimated for level crossing accidents involving motor vehicles or suicides and attempted suicides as the data necessary to do so was not available. However, as suicides and attempted suicides generally cause minimal property damage, it is expected that the delay costs for these incidents would be negligible.

Environmental and recovery costs

Rail is often the preferred mode for transporting dangerous and toxic cargoes such as radioactive material, chemicals, fuel and so on. In the event of an accident, such cargoes may spill, setting bushland on fire or leaving toxic residues. Expenditure may be needed to control the problems created and restore the affected sites. There were a number of spills of dangerous goods in 1999, according to the Australian Incident Reporting System. However, the time spent by providers of fire services at each of the affected sites suggests that most spills had only minor consequences. It has been assumed that the costs of restoring the sites were partly subsumed in the fire brigade costs and partly in the site recovery costs shown below. The site recovery costs are the costs associated with restoring the sites excluding track repair costs. They include the costs of crane hire to lift rolling stock and the costs of cleaning the sites affected. In 1999 these recovery costs totalled about $230 000. This total may include some costs associated with level crossing accidents involving motor vehicles. However, as these could not be separated out, the total was attributed to rail accidents.

Lost cargo

In the event of a freight train accident, cargo may be spilt or spoilt in such a way that it is not practical to recover some or all of it. Usually these instances are covered by insurance. Queensland Rail commented that these costs typically ranged from $30 000 to $300 000 depending on what was in the wagons. However, derailments and collisions often do not cause wagons to tip over. No attempt was made to estimate the value of lost cargo as insufficient data were available to develop a defensible estimation procedure.

Investigation costs

Railway agencies have safety personnel that investigate train accidents. Sometimes an external investigator such as the Australian Transport Safety Bureau (ATSB) may be brought in as well. The Australian Transport Safety Bureau may investigate rail accidents on the request of the appropriate regulatory authority, the track owner/manager or rail operator. These investigations seek to determine the causes of accidents and any precautionary or remedial safety actions that need to be taken in the short and long-term to help prevent future accidents. In the case of rail staff, the relevant costs are the additional costs incurred such as travel and overtime expenses. For external investigators the full costs have been included. Each accident is deemed to have an investigation cost. Where the cost was unknown an average cost of $1 200 derived using sample accident investigation costs by one rail operator was applied.

It is estimated that during 1999 rail accident investigation costs totalled around $370 000, the cost of investigating level crossing accidents involving motor vehicles was about $30 000, and the cost of investigation suicides and attempted suicides totalled was about $110 000. This gives investigation costs of about $510 000 for all rail-related incidents. (Most of the costs associated with investigating Glenbrook were not incurred in 1999.)

Emergency services costs

Police costs

An attempt was made to cost police work undertaken in relation to rail accidents directly. However, State and Territory police forces do not tag rail accidents as accidents involving that mode. They code according to the nature of the accident. For example, a level crossing accident may be coded as a motor vehicle accident, and a person falling on a rail track may be coded as an accidental death. The costing presented here thus draws on BTE (2000).

The cost of police work includes police time expended at the scene of the incident, the time taken for criminal investigation, and the time taken to prepare information for and to attend coronial hearings. Police do not attend all rail accidents, but always attend rail accidents involving fatalities or serious injuries. Police may also attend rail accidents where there has been a derailment and no injuries have occurred. In these instances police may be required to direct traffic flow, or to breath-test the train driver in NSW and Tasmania. Breath testing at a rail accident is only conducted at the request of the State Rail Authority in NSW or if requested by the train driver involved in Tasmania.

The number of police sent to a rail accident depends on the severity of the injuries incurred, where the accident occurred and how many people were involved. A team of specialist personnel attends fatal accidents. This team may include a crime scene examiner, a forensic expert, a pathologist, a coroner's clerk, and regular police officers. A level crossing accident in a small town may only be attended by one or two police officers, whereas a rail accident involving a suburban passenger train at peak-hour may require a number of police to attend to take down particulars of witnesses and/or statements.

Police deal with either the relevant rail authority or the public when any rail accident is reported. This information must be processed, so some police time has to be allocated to this task. It has been assumed that on average 20 minutes is expended per accident on recording information. When a death occurs as a result of a rail accident, police must recover the body, arrange transportation of the body to the morgue, determine the identity of the fatality, notify the next of kin, and arrange for the next of kin to formally identify the body. Police are also required to notify the relatives of people seriously injured in rail accidents. Police also determine whether there was criminal activity, interview witnesses, revisit the scene of the accident, attend court if necessary, and process photographs.

It has been assumed that police attend all accidents involving one or more fatalities or serious injuries. Some accidents involve more than one injured person. However, accidents involving multiple injuries are generally attended by larger than normal-sized police teams. This tends to reduce any economies of scale in the cost of attending such accidents.

The costing presented here draws on the police costs in BTRE (2000). Using police costs of $6 372 for attendance at an accident involving a fatality and $2 189 for attendance at an accident involving a serious incident, it is estimated the cost of police attendance at railway accidents in 1999 totalled about $320 000. The cost of police attendance at level crossing accidents was estimated to be about $160 000 and that for suicides and attempted suicides about $310 000.

Fire services costs

Fire services attend rail accidents whenever there is a need for their specialised fire control, hazard management and rescue assistance. The fire crew remains at the scene of an accident until it has been cleared and there is no further hazard to the general public.

The method of providing fire services differs significantly between metropolitan and rural areas. Metropolitan fire services are provided by paid, professional fire control officers in capital cities and in regional centres. Full-time fire services are not economically viable outside of these areas as rural and remote areas require fire services relatively infrequently. In rural and remote areas, the Country Fire Authority, Bush Fire Brigade or State Emergency Services may need to assist or provide fire services. However, all of these organisations use resources.

Fire brigades code attendances at rail accidents under the general code 'on railway land'. This data is included in a national database of fire brigade statistics, maintained by the New South Wales Fire Brigades, called the Australian Incident Reporting System (AIRS). The Australian Incident Reporting System database provided the statistics used to calculate the cost of fire services. It may under-report responses by fire brigades to some degree because of agency specific reporting procedures and systems, and industrial disputes experienced by some fire services during the reporting period. In addition, the brevity of the description of each incident in the database made identifying attendances at rail accidents difficult. In the smaller jurisdictions it was possible to obtain information on each incident, but this was not the case with larger states such as NSW and Victoria. Given the above, the estimate derived for the cost of fire services is likely to be too low. However, as there was no information available on the scale of the problems identified, this estimate has not been adjusted.

State Emergency Services (SES) also become involved in rail accidents. The role of the State Emergency Services varies between and within jurisdictions and with the severity and scale of the accident. For example, in Victoria, Queensland, South Australia, Western Australia and the Northern Territory, the State Emergency Services may assist with rescues, whereas in New South Wales only those State Emergency Services units that are accredited rescue units may conduct rescues at rail accidents. The State Emergency Services may also provide welfare services in Victoria, Western Australia and the Northern Territory; emergency lighting in Victoria, South Australia and the Northern Territory; road closures or crowd control, at the direction of the police in Victoria, Queensland, Western Australia and the Northern Territory; and first aid in Victoria and the Northern Territory. The State Emergency Services in Victoria and the Northern Territory may also assist the ambulance service at an accident scene by locating equipment in the ambulance and setting this equipment up for the ambulance service, and may drive ambulances, if required.

In country Victoria, the State Emergency Services go to most, if not all, rail accidents. In Western Australia it is more common for the State Emergency Services to become involved in rail accidents in country areas where there is a shortage of other Emergency Services personnel and in large-scale rail accidents.

Although the State Emergency Services is a volunteer organisation, an average wage rate has been applied to this work, as there is an opportunity cost involved.

Each rail accident is different, requiring fire services personnel to attend for different periods of time using different equipment and sizes and compositions of crew. The costing used was very general in nature as insufficient information was available to derive a more detailed model. The cost of fire services per attendance in 1999 of $499 was obtained by scaling the 1996 figure used in BTRE (2000) using the Consumer Price Index. This figure was then applied to the number of fire services call-outs reported in 1999.

The Australian Incident Reporting System database suggests that the fire brigade attended 385 incidents across the country at railway properties in 1999. The detailed descriptions indicate that over 90 per cent were to some sort of train accident as opposed to an industrial accident. Of these call-outs 23 involved fatalities, 69 involved injuries and 2 391 involved evacuations. It has been assumed that all the reported call-outs to railway properties were in relation to train accidents.

Using the information presented above, it is estimated that the costs associated with the attendance of fire services at railway accidents, level crossing accidents involving motor vehicles, and suicides/attempted suicides were around $80 000, $30 000, and $82 000 respectively, giving a total for all rail-related incidents of about $192 000.

Coronial costs

Every fatality for which the cause is violent, suspicious or unknown requires a coroner's report. Most railway accident deaths fall into this category. It has been assumed that all railway accident deaths in 1999 would have been the subject of a coronial inquiry. Reports are compiled by the police and the medical profession and forwarded to the coroner. In many instances the procedure is purely an administrative matter, with the coroner examining the submission of reports. However, in some cases, there may be a coroner's inquest with a full hearing. The cost per lodgement in the coronial court in 1999 of $483 was obtained by scaling the 1996 figure used in BTRE 2000 using the Consumer Price Index. The use of this figure gives an estimated upper bound for the cost of coronial investigations into railway accident deaths, deaths arising from level crossing accidents involving motor vehicles, and suicides of $20 000, $10 000 and $13 000 respectively, giving a total for all rail-related incidents of about $43 000.

Insurance administration and legal costs

The figures included here relate to the net cost to society. Transfer payments from one party to another are excluded.

Legal costs may arise from rail accidents in a number of ways. They are incurred when those injured, or those who have had property damaged, obtain legal assistance in either making an insurance claim or in contesting the ruling on such a claim. These costs are initially borne by the claimant, but are later reimbursed by the insurance company. Legal costs are also incurred when charges are laid against a party as a result of a death. There may also be civil damage cases where the party at fault was not insured. The latter costs are not included in these estimates, because the defendant's costs will not appear in insurance company statistics.

Unlike the road transport industry, the rail industry often operates and manages its own insurance. For example, Queensland Rail's insurance is managed by On Track Insurance Pty Ltd, which is a division of Queensland Rail, although it operates independently. Anecdotal evidence suggests that the industry insurers make every effort to settle claims rather than allow claims to be pursued through the court system. Data on cases with involvement by lawyers have been difficult to obtain. However analysis of the insurance claim data available suggests that legal costs from the operator's side are internalised in their administrative costs. Legal costs for or on behalf of people killed or injured have not been estimated.

Some industry analysts believe that rail insurance administrative costs generally account for about 7.5 per cent of gross claims. Based on confidential data obtained from one insurer, the average administrative cost per claim may range from $16 000 to $60 000 with an average of about $32 000, depending largely on the number of claims received per year. This is much higher than for general insurance. Rail insurance is highly specialised and rail insurers are not expected to handle as many claims as general insurers.

Using an average administrative cost per claim of $14 615 and assuming that a claim or insurance payout would be made with regard to all fatalities and serious injuries (excluding those that occurred at level crossings and suicides and attempted suicides), it is estimated that the associated administrative cost amounted to $600 000 for fatalities and $690 000 for people who incurred serious injuries in 1999. For level crossing accidents involving motor vehicles and suicides/attempted suicides, the rail operator would generally lodge claims against the people killed or injured on the basis of trespass and that these people were at fault. Some administrative costs would be involved in such cases, but they have not been estimated in this report.

To estimate the other costs for level crossing rail accidents, it was assumed that these involved only fatalities, and included investigation, police attendance, coronial, and administrative costs in proportion to their share of the fatalities total. This gave a figure of about $410 000.

TABLE 5.1 SUMMARY OF OTHER COSTS ($ MILLION)

	Rail Accidents Excluding Level Crossing Accidents	*Level Crossing Rail Accidents*	*Level Crossing Accidents Involving Motor Vehicles*	*Suicides/ Attempted Suicides*
Value of trip delays				
Passengers	0.3	na	na	na
Freight	1.3	na	na	na
Additional operating	0.1	0.0	0.0	0.0
Environmental/recovery	0.2	0.0	0.0	0.0
Investigation	0.4	0.0	0.0	0.1
Emergency services	0.3	0.1	0.2	0.4
Insurance admin & legal	1.1	0.2	0.1	0.1
Coronial	0.0	0.0	0.0	0.0
Total	**3.6**	**0.4**	**0.3**	**0.7**

Note ‘na’ means not available. These costs have been assumed to be negligible.

Source BTRE estimates.

Appendix i

OVERVIEW OF THE RAIL INDUSTRY IN AUSTRALIA

BACKGROUND

In 2000–01, rail carried 26 per cent of Australian freight if measured in tonnes and 35 per cent if measured in tonne-kilometres. Rail has consistently carried around a third of Australia's domestic freight in terms of tonne-kilometres over the last quarter of a century. It has maintained its freight market share because of the relatively high tonnages of commodities transported in bulk compared to tonnages of other goods in Australia. Minerals, ores, coal and grain account for much of this commodity tonnage. Most freight carried by rail comprises intrastate bulk commodities, being moved from the location of extraction or production to a processing location or seaport. Bulk freight activity is expected to increase as bulk production grows.

Increased competition from road transport and lack of investment in rail infrastructure has led to a steady decline in the proportion of non-bulk interstate freight transported by rail. In 2002, the Department of Transport and Regional Services estimated that rail carries only 15 per cent of the non-bulk freight on the eastern seaboard, in contrast to 80 per cent of the non-bulk freight on the east-west (Sydney to Perth) corridor. Interstate non-bulk rail activity is expected to grow to 96.3 billion tonne-kilometres by 2020, up 171 per cent from 35.5 billion tonne-kilometres in 2000. However, based on historic trends, rail's overall share of interstate non-bulk freight in terms of tonne-kilometres is expected to continue to fall to just over 20 per cent by 2020 (BTRE 2002). The rail industry anticipates that this falling trend in its share of interstate non-bulk freight measured in tonne-kilometres will be reversed by the efficiency gains expected to result from the restructuring and privatisation of the rail industry. There have been measurable effects on rail's market share in some areas. Some capital city ports are endeavouring to increase their use of rail to enable them to deal with the forecast growth of 73 per cent in container traffic from 2.2 million containers imported and exported in 2000-01 to 3.8 million in 2010–11, given their limited port land and congested access for road transport. For example, rail's modal share of Sydney Port container freight has increased from 8 per cent in 1993 to 23 per cent in 2001 in terms of twenty-foot equivalent containers (TEUs) carried (Matthews and Hoffman 2002). However, continued improvements in reliability of service and reduced terminal delays are also likely to be necessary if the rail industry is to retain more market share than projected on a broader scale. Investment in higher quality track is needed if transit times are to be reduced and reliability in terms of on-time delivery increased.

Rail accounted for 4.6 per cent of urban passenger kilometres travelled in 2000. While this proportion is not particularly high, rail is important in transporting commuters to and from central business districts during peak times, as small increases in road traffic can cause disproportionately large increases in congestion effects. In Sydney, CityRail provided approximately 2 500 train services carrying about 900 000 people per week day in 2002 (StateRail 2002), up from 2 300 in 1999 (Productivity Commission 1999). Rail is less important in terms of passenger transport outside of major population centres, accounting for 1.6 per cent of non-urban passenger kilometres travelled in 2000. Rail also accounts for only a small proportion of interstate passenger trips, accounting for around 2 per cent of the total in 2000 (BTR 2000 and BTRE unpublished estimates).

Rail reform in Australia

Rail transport has undergone substantial reform since the early 1990s. The process was triggered by both competition from road transport and government activity. The former Industries Assistance Commission's case studies of government business enterprises included railways and highlighted the potential gains to be made from rail reform (IAC 1990). This was explored in more depth in the Industry Commission's 1991 rail report (Industry Commission 1991). The 1991 Special Premiers' Conference considered the draft of this report, and agreed to establish the National Rail Corporation as a commercially-run body to be Australia's sole interstate rail freight operator. This eliminated the need for customers to deal with up to five separate rail authorities to transport freight across Australia. The 1991 Special Premiers' Conference also agreed to transfer Australian National's interstate freight operations to the National Rail Corporation (COAG 1991). Australian National retained the Tasmanian and South Australian internal freight and interstate passenger operations.

Prior to the 1990s, most railways used a vertically integrated structure and were government-owned. Ownership has since been diversified and some railways are now vertically separated in terms of ownership. Rail access regimes have been introduced in most States. Initiatives to improve rail safety regulation and the regulation of operating requirements have been progressed in accordance with the 1996 Intergovernmental Agreement on Rail Safety which required signatories to pass legislation that provides for regulation (clause 4) and also provides for independent investigation (clause 8). Railways now employ less staff. There have also been productivity improvements in government-owned railways (Productivity Commission 1999, Webb 2000). These developments are discussed in more detail by jurisdiction below.

Commonwealth and State Transport Ministers agreed to further major reforms to interstate rail at a National Rail Summit in 1997. These commitments were incorporated into an Intergovernmental Agreement signed later that year. The reforms included:

- the establishment of the Australian Rail Track Corporation (ARTC) as a national infrastructure manager and one-stop shop access provider;
- the designation of a national interstate track system;
- acknowledgment of the need for the interstate rail network to be operated as a single network with respect to investment, access and pricing; and
- proposals to make arbitration binding and to accelerate the resolution of disputes (ATC 1997a).

Commonwealth and State Transport Ministers also agreed to commission a study of rail standards and operation requirements, which was released in February 1998. It documented safety, technical and operational standards and requirements in use on the national rail system with an emphasis on standards and operational procedures that impede interstate operations. This emphasised the lack of uniform operating standards (Maunsell 1998).

In April 1999 the Australian Transport Council (ATC) agreed that the Standing Committee on Transport would establish an independent review of rail safety arrangements in Australia, focusing particularly on the interstate system. The review was to include a review of the 1996 Intergovernmental Agreement on Rail Safety and have input from the self-review being undertaken by the Rail Safety Committee of Australia. The Standing Committee on Transport Rail Group was asked to develop a strategy to address other issues identified in the Rail Safety Committee report, prepared by Booz-Allen & Hamilton, such as responsibility for risk and questions about the efficiency of mutual recognition for accreditation. The report was considered by the Australian Transport Council in November 1999, and it agreed that:

- the report's main recommendation of two new statutory bodies for interstate and intrastate rail safety regulation and investigation respectively not be progressed at that time; and
- the Australian Transport Safety Bureau (ATSB) develop a national rail safety statistical database to better identify safety trends in the rail industry.

Australian Transport Council Ministers also agreed to sign an Intergovernmental Agreement (IGA) on Rail Operational Uniformity. This IGA provided for the establishment of the Australian Rail Operations Unit (AROU) as a non-statutory unit within the Commonwealth Department of Transport and Regional Services (DOTARS) to facilitate the finalisation and implementation of the Code of Practice for the Defined Interstate Rail Network. The IGA also provided for the establishment of an industry-based Advisory Committee to provide advice to the Australian Rail Operations Unit on the finalisation and implementation of the Code.

The Productivity Commission's Inquiry into Australia's railway systems identified a range of problems with Australia's railways at the time, including:

- the pricing of rail services;
- the quality of rail freight and passenger services;
- a lack of commercial focus by government-owned railways;
- deficiencies in rail infrastructure investment; and
- the lack of competitive neutrality between transport modes (Productivity Commission 1999).

The report made a number of recommendations for reforming Australia's railways.

In April 2000, the Commonwealth Minister for Transport and Regional Services announced the Commonwealth Government's response to four reports on land transport issues. He said

"…rail safety is a priority and the Government will legislate to enable the Australian Transport Safety Bureau (ATSB) to independently investigate accidents and incidents on the interstate rail system. The reports of such systemic, 'no-blame' investigations will be publicly released by the ATSB to allow the rail industry to benefit from the lessons learned.

The proposed legislation will be consistent with the provisions of the 1996 Rail Safety IGA (Intergovernmental Agreement) and is in accordance with the rail safety recommendations of the Neville Report from the House of Representatives Standing Committee on Communications, Transport and Microeconomic Reform, *Tracking Australia* (July 1998) and the Smorgon Report, *Revitalising Rail* (April 1999)."

Since then, the Australian Transport Safety Bureau has assisted the Minister to develop the legislation, and set up a rail safety database that includes data from January 2001. Codes of Practice for the Defined Interstate Rail Network were released in September 2001 by the Commonwealth Department of Transport and Regional Services.

Rail safety in Australia is still regulated by State and Territory governments, by the following agencies and legislation.

New South Wales

Department of Transport, Transport Safety Bureau

Rail Safety Act 1993, Rail Safety Regulations 1999.

Victoria

Department of Infrastructure, Safety and Technical Services Branch

Transport (Rail Safety) Regulations 1998, Public Transport Competition Regulations 1999.

Queensland

Queensland Transport, Rail Safety Accreditation Unit

Transport Infrastructure Act 1994

Western Australia

Department of Transport, Office of Rail Safety

Rail Safety Act 1998

South Australia

Transport South Australia, Rail Safety Unit

Rail Safety Act 1996, Rail Safety Regulations 1998

Tasmania

Department of Infrastructure, Energy and Resources, Infrastructure Policy Division

Rail Safety Act 1997, Rail Safety Regulations 1999

Northern Territory

Department of Transport and Works, Rail Safety Unit

Rail Safety Act 1998

At the time this report was being prepared, the Australian Transport Council was progressing the development of a more national approach to land transport regulation. Subject to all Heads of Government agreement, Ministers agreed at their meeting in August 2002 to replace the National Road Transport Commission (NRTC) with a National Transport Commission (NTC) to cover road, rail, intermodal regulation and operations.

Progress has been slow in relation to achieving competitive neutrality in the conditions affecting competition between different transport modes, especially road and rail; the need for better management of, and access to, the national track; and additional investment in the interstate track (Webb 2000). Whilst rail standardisation between capital cities is now complete, there are still areas where gauge differences are an issue. Interstate rail is still affected by jurisdictional issues. For example, the accreditation requirements in each State and Territory often include different reporting requirements and fee structures (Rail Projects Taskforce 1999). Without further reform, particularly in relation to access interfaces and infrastructure investment, rail's share of Australia's transport task is likely to continue to decline relative to other modes.

Recent history of the rail industry in Australia by jurisdiction

Commonwealth

The Commonwealth Government owned Australian National Railways Commission, which traded as Australian National (AN), was formed in 1977. It comprised the former Commonwealth Railways, Tasmanian Railways, and the non-metropolitan elements of the South Australian Railways.

The National Rail Corporation, which traded as National Rail (NR), was established in 1992 following an agreement made at the 1991 Special Premiers' Conference to provide a single management regime for the operation of interstate freight services. It was jointly owned by the Commonwealth, New South Wales and Victorian governments, and began commercial operations in April 1993.

Specialised Container Transport (SCT) commenced interstate rail freight operations in June 1995 in competition with the National Rail Corporation. TNT (acquired by Toll Holdings and now part of Pacific National Limited) followed a year later (Productivity Commission 1999).

Australian National established the Track Access Unit in February 1995 to manage the Commonwealth's mainline interstate rail network. It began charging access fees in July 1995. The Australian Rail Track Corporation was created in February 1997 to manage access and infrastructure development on the interstate network, and commenced operations in July 1998.

The Commonwealth Government announced its intention to sell Australian National and its interest in National Rail in November 1996. Australian National's intrastate freight and interstate passenger services were sold to private operators in November 1997 (Webb, 2000), when the Great Southern Railway, owned by Serco Asia Pacific, took over the operation of the Indian Pacific, the Ghan and the Overland from Australian National Passenger Rail (Great Southern Railway, 2000). The remaining South Australian freight operations were sold to Australia Southern Railroad, and Tasrail was sold to Australian Transport Network.

In July 1998 Australian National's mainline interstate track was vertically separated and transferred to the Australian Rail Track Corporation (ARTC) (Productivity Commission 1999). The ARTC currently owns the interstate track in South Australia, including the track to Kalgoorlie in Western Australia, and manages Victoria's interstate standard gauge track under a lease agreement. However, wholesale rights over train path sales in New South Wales, Western Australia and Queensland have yet to be reached.

In January 2002, the Commonwealth, New South Wales and Victorian Governments announced the sale of FreightCorp and National Rail Corporation to the National Rail Consortium, comprising Toll Holdings Ltd (now Pacific National) and Lang Corporation Ltd (DOTARS 2002).

New South Wales

The New South Wales Government introduced formal funding arrangements for community service obligations in 1991–92. The impact of this on the rail industry was to replace the previous system of funding the deficits of unprofitable State Rail Authority operations with a defined payment for services provided system.

In July 1996, the former State Rail Authority (SRA) of New South Wales, which provided all passenger and freight services for that State, was separated into four entities. These entities included Rail Access Corporation (RAC), the track owner; Rail Services Authority (RSA), the maintenance contractor (which was later renamed Rail Services Australia); FreightCorp, which was primarily an intrastate freight train operator; and a new State Rail Authority, the urban and country passenger train operator.

Following the recommendations contained in the initial interim report (November 2000) from the Inquiry into the Glenbrook rail accident, the NSW Parliament passed the *Transport Administration Amendment (Rail Management) Act 2000*. The Act merged the Rail Access Corporation (RAC) and Rail Services Australia (RSA) into one corporation in January 2001 (Lloyds List Daily Commercial News Rail Express, 2001). The new corporation, Rail Infrastructure Corporation (RIC), is responsible for all rail access, network management and maintenance. Rail Infrastructure Corporation is a state-owned corporation and the New South Wales Minister for Transport has been granted the powers of directing it.

Victoria

The Victorian Government reformed Victoria's rail services in stages during the 1990s.

Country rail passenger services were offered to private operators in 1993. Two services were taken over by private operators: West Coast Railway, operating between Melbourne and Warrnambool; and Hoys Roadlines Pty Ltd, operating between Melbourne and Shepparton.

Freight and passenger transport services were horizontally separated within the Public Transport Corporation's corporate structure, and then urban and non-urban rail passenger services were split into separate units. These units were established as new rail organisations in July 1998. V/Line Freight and V/Line Passenger (the non-urban rail passenger service) retained their old names. Met Train 1 became Bayside Trains and Met Train 2 became Hillside Trains. Victorian Rail Track Access (VicTrack) was created in July 1997, and assumed responsibility for train control and signalling operations on non-electrified intrastate track, the maintenance and management of related land and infrastructure, and the marketing and negotiation of access to the intrastate network.

In February 1999, Victoria's rail freight operator, V/Line Freight, was sold to the United States regional rail operator, Rail America. Trading as Freight Australia, the company is Victoria's major freight company and also operates interstate, including providing locomotives and crews for interstate freight services.

In mid-1999, Victoria's rail passenger services were franchised to private operators. The United Kingdom-based National Express Group contracted to operate V/Line Passenger for 10 years, M>Train for 15 years, and M>Tram for 12 years. The French-based Connex commenced a 15 year franchise for the part of Melbourne's train network not operated by the National Express Group. The Australian-based MetroLink Group, including the major construction company Transfield, contracted to operate Yarra Trams for 12 years.

Queensland

The vast majority of the railways in Queensland are operated by Queensland Rail (QR), a vertically integrated entity owned by the Queensland Government, which was incorporated in July 1995. Queensland Rail is Australia's largest rail freight tonnage carrier. Currently Queensland Rail's three primary business groups are Coal and Freight Services, Passenger Services (both suburban and long distance), and Network Access. The Network Access Group was established in July 1998 to negotiate track access with operators and to manage what is presently Australia's largest rail network, with a combined total of almost 10 000 kilometres of narrow and standard gauge track. Queensland Rail's main business is transporting coal from the hinterlands to seaports and transporting urban passengers in Brisbane.

The Queensland Government introduced funding arrangements for community service obligations in 1993–94, including funding for particular rail services. Queensland Rail now provides services for the Queensland Government via a series of commercial and performance-based transport contracts. However, the purchaser-provider relationship between Queensland Rail and Queensland Transport was refined over time rather than fully established at a single point.

Queensland Rail's commercial activities were distinguished from its community service obligations and access functions in stages following the June 1999 Rail Services Agreement. There were three key milestones. The first was the set of transport services contracts that separated the commercial activities and the community service obligations of the Brisbane Suburban and Intersuburban Network, and dealt with access to rail infrastructure, which were effective from July 1999. The second was the contract that dealt with the Queensland Long-distance Passenger Network effective from July 2000. The third was the contract that dealt with regional general freight trains effective from July 2001.

In May 2002, Queensland Rail purchased the freight and business assets of Northern Rivers Railroad (NRR), based in Casino, New South Wales, and established a separate entity called Interail Australia. Interail Australia was established to form the basis of Queensland Rail's interstate rail freight operations.

Western Australia

The Western Australian Government railway operator, Westrail, was commercialised under the 'Right Track' program in July 1995, and sold in October 2000 to the Australian Railroad Group (ARG), a company equally-owned by the USA railway company Genesee & Wyoming and Wesfarmers. The Australian Railroad Group also leases the Western Australian Government's rail infrastructure, which is managed by the Australian Railroad Group's subsidiary company, WestNet Rail.

Metropolitan passenger services in Perth, Transperth, are owned and operated by Western Australian Government Railways Commission (WAGR).

The iron ore railways that have been built in Western Australia, principally in the Pilbara region, are privately owned.

The Office of Rail Safety was established in February 1999 to regulate the Rail Safety Act 1998 and the Intergovernment Agreement on National Rail Safety. It recovers its costs from the railways it accredits. Its activities include approving changes to safety management systems, undertaking compliance audits, undertaking compliance inspections and independent rail accident investigations, monitoring and assessing safety performance, giving safety directions to improve safety, contributing to the development of a consistent national approach to safety regulation, maintaining accident databases, as well as producing safety statistics and reports (Western Australian Department of Transport 2001).

South Australia

South Australia is the only State that still uses all three rail gauges (narrow, standard, and broad). In 1991, the South Australian Government provided urban passenger services through the State Transport Authority (STA), whilst Australian National provided intrastate and interstate freight and passenger operations. In 1994, the State Transport Authority was broken up into two new organisations, TransAdelaide and the Passenger Transport Board. TransAdelaide was corporatised in January 1999, and owns, controls, and operates the Metropolitan passenger rail network and the Adelaide to Glenelg tram system through TransAdelaide Infrastructure and TransAdelaide Operations. The Passenger Transport Board undertakes planning, regulatory and purchasing functions for public transport in Adelaide.

In November 1997, the former Australian National was sold. The outcomes of this sale for South Australia were:

- the interstate standard gauge main lines in South Australia connecting Adelaide to Melbourne, Perth and Sydney were transferred to the Australian Rail Track Corporation (ARTC);
- the South Australian country regional rail network (with narrow, standard, and broad gauges) was purchased by Australia Southern Railroad (ASR), a subsidiary of the USA railway operator, Genesee & Wyoming Inc;
- the Overland, Indian Pacific and Ghan passenger trains were bought and operated by Great Southern Railway; and
- the interstate railway line between the coal fields at Leigh Creek and the power station at Port Augusta were vested in the South Australian Government. The track infrastructure and land were transferred to Transport South Australia with the privatisation of the South Australian electricity industry in 2000. This infrastructure was leased by the South Australian Government to the private operators of the coal mine and power station, NRG, a USA energy company.

Genesee and Wyoming in conjunction with Westfarmers has since created a new company, called the Australian Railroad Group (ARG), which owns the former ASR and WestRail systems.

The Tarcoola to Alice Springs section of the Darwin Line is owned by Asia Pacific Transport.

Various heritage rail groups operate on some of the other non-commercial rail lines.

Tasmania

No regular rail passenger services have been provided in Tasmania in recent years, except for a very small number aimed at tourists. In November 1997, Australian National's intrastate freight operation in Tasmania was purchased by Australian Transport Network (ATN), a consortium that includes the USA railway, Wisconsin Central. Wisconsin Central was bought by the Canadian National railway company after it acquired Tasrail. The Australian Transport Network bought both the freight operation and the track infrastructure, and leased the land for fifty years from the Tasmanian Government. The Australian

Transport Network also acquired the business and assets of the Emu Bay Railway Company Ltd. The major commodities carried are cement, coal, logs, paper and mineral concentrates.

Northern Territory

The Great Southern Railway operates interstate passenger services including the Ghan from Melbourne and Sydney via Adelaide to Alice Springs and return.

The Alice Springs to Darwin railway, which has been under construction since May 2001, when completed will provide passenger and freight services between Darwin and Alice Springs, and from there to Adelaide and the rest of the country. It is being built by Asia Pacific Transport (APT), a consortium that includes the Australian Railroad Group (ARG), which will also lease and operate a new container terminal at the East Arm Port at Darwin (AARC 2002).

ABBREVIATIONS

AARC	AustralAsia Railway Corporation
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
AIHW	Australian Institute of Health and Welfare
AIRS	Australian Incident Reporting System
AN	Australian National Railways Commission
APT	Asia Pacific Transport
ARG	Australian Railroad Group
ARRB	Australian Road Research Board (now ARRB Transport Research)
ARTC	Australian Rail Track Corporation
ARA	Australasian Railway Association
ARG	Australian Railroad Group
AROU	Australian Rail Operations Unit
ASCIR	Australian Spinal Cord Injury Register
ASR	Australia Southern Railroad
ATC	Australian Transport Council
ATFR	Australasian Transport Research Forum
ATN	Australian Transport Network
ATSB	Australian Transport Safety Bureau
BTCE	Bureau of Transport and Communications Economics (now BTRE)
BTE	Bureau of Transport Economics (now BTRE)
BTRE	Bureau of Transport and Regional Economics
CJC	Criminal Justice Commission
CTM	Connex Trains Melbourne
DALY	Disability Adjusted Life Years

DRG	Diagnosis Related Group
FRA	Federal Railroad Administration (US)
IAC	Industries Assistance Commission (now IAC)
IC	Industry Commission (now PC)
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th Revision
ICD-10-AM	Australian Modification of ICD-10
IGA	Intergovernmental Agreement
LLDCN	Lloyds List Daily Commercial News
MTE	Melbourne Transport Enterprises
NRC	National Rail Corporation
NRR	former Northern Rivers Railroad (now Interail Australia)
NRTC	National Road Transport Commission
NTC	National Transport Commission
PC	Productivity Commission
QALY	Quality Adjusted Life Years
QR	Queensland Rail
RAC	Rail Access Corporation
RIA	Rail Infrastructure Authority (now RIC)
RIC	Rail Infrastructure Corporation
RSA	Rail Services Australia
RSA	Rail Services Authority (now Rail Services Australia)
SCT	Specialized Container Transport
SPAD	Signal Passed at Danger
SRA	State Rail Authority
STA	State Transport Authority
TAC	Victorian Transport Accidents Commission
TC	Transport Canada
TEU	twenty-foot container equivalent
TNT	Thomas Nationwide Transport, which became TNT then Toll, and is now part of Pacific National
WAGR	Western Australian Government Railways

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