# The Cost of Maintaining the Australian National Highway System

## Report

This Report discusses the objectives of the Australian national highway system, presents statistical information and describes the application of the life cycle costing technique to the pavement evaluation.

Bureau of Transport and Communications Economics

REPORT 77

# THE COST OF MAINTAINING THE AUSTRALIAN NATIONAL HIGHWAY SYSTEM

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# FOREWORD

The Federal government is outlaying over $550 million annually for construction and maintenance activities on the national highway system. Road maintenance techniques and the optimum timing of maintenance expenditure are being closely considered by road authorities and funding agencies as the road maintenance funding requirement is high and the pavement condition has large cost implications for highway users.

This report examines the expenditure level required to maintain the national highway system. In attempting to do so, the report outlines the background to the study, the methodology used and the data collection aspects.

Each of the Australian State road authorities has willingly contributed national highway data for this work and their cooperation and advice have been appreciated.

The research for this report was undertaken by Messrs J. E. Miller and C. Puttaswamy, and it used the Bureau's life cycle costing computer model which was the subject of an earlier Bureau report.

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July 1992

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## ABSTRACT

This paper discusses the objectives of the Australian national highway system, presents statistical information and describes the application of the life cycle costing technique to the pavement evaluation. The work is based upon an earlier study undertaken by the Bureau to develop a life cycle costing model, which in turn incorporated research undertaken by the World Bank. Details of that work are contained in the Bureau publication *Pavement Management: Development of a Life Cycle Costing Technique.*

The work documented in this paper used inventory information on all of the 16 000 kilometres of national highway, which was supplied by all State road authorities, and assessed the maintenance requirements by computer processing this information using the life cycle costing model. All pavements were assessed for a simulated 40-year period.

This work examined the national highway system at a strategic level rather than at a micro level and therefore site-specific planning will still be required to determine the optimum maintenance project and its scheduling at any given location.

This Bureau work has provided an estimate of the average annual maintenance requirement for each major link of the system as well as an estimate of the change in maintenance requirements over future years. The report comments on the likely rise in the pavement maintenance requirements as first the older, then the more recently constructed sections of the highway begin to deteriorate. The report has provided information for government policy makers, road maintenance managers and for road users.

## SUMMARY

There is a need to ensure that the expenditure to maintain the Australian road system, as well as the expenditure to upgrade the system, are set at appropriate levels to meet national economic and social objectives, and that within a given budget, funds are allocated in a cost-effective and efficient manner

This report focuses on the maintenance requirements of the Australian national highways, with maintenance defined as all works required to preserve the pavement asset.

The objective was to assess the total cost to maintain the Australian national highway system for each State.

This was achieved using the following steps:

- adapt the life cycle costing technique which was selected as a base for the evaluation methodology;
- produce test data and process sample outputs;
- collect all national highway physical inventory and cost data information;
- edit and update any difficulties encountered with the supplied national highway data;
- collect and determine road maintenance parameter information;
- organise sensitivity testing;
- undertake the evaluation; and
- consider the findings and their implications and prepare the report.

The assessment covered all types of maintenance including the routine maintenance such as patching potholes and edge treatments, along with the cyclic maintenance such as resealing and asphalt overlays as well as estimating the reconstruction needs. The Bureau work examined the relationship between benefits and costs of national highway pavement maintenance work. In this analysis the direct costs included the maintenance activities noted above, whereas the direct benefits were savings in vehicle operating costs. The analysis did not include an assessment of indirect costs and benefits such as environmental issues, resource usage, or safety impacts. As road user travel times are not usually changed by road maintenance, travel time savings were not included.

There is a significant correlation between traffic level and maintenance benefit–cost ratio, which means that a funding program based on economic efficiency will favour high volume sections. Predictions have been made of the impact of maintenance funding levels on national highway sections and traffic affected and the future roughness levels.

The work undertaken by the Bureau indicated that the requirement for the national highway pavements to be reconstructed will rise as the pavements age. This means that the national highway pavement maintenance will increase over the next twenty years as the average age of pavements increase.

The potential year-by-year expenditure requirements and the possible preventative treatments which could be undertaken to reduce this problem were assessed in detail. Treatments such as asphalt overlays can be cost-effective both in reducing pavement roughness and increasing pavement strength, leading to a reduction in the total expenditure. This saving is further magnified with inclusion of the vehicle operating cost savings.

# CHAPTER 1 INTRODUCTION

## BACKGROUND

In Australia increasing emphasis is being given to road maintenance relative to road construction. Increased competition for funds by all sectors of the Australian economy means that potential road construction and maintenance projects are under closer scrutiny. Also as the Australian national highway system has reached its current level of development this has meant that asset maintenance issues have become more important for road fund managers and for road authorities.

There is a need to ensure that the expenditure to maintain the national highway system, as well as the expenditure to upgrade the system, are set at appropriate levels to meet efficiently national economic, social and community objectives.

The Bureau of Transport and Communications Economics has examined the life cycle costs of pavement and the trade-off between road construction and maintenance costs. Any variation of road funding levels or variation in the balance between road construction and maintenance will have economic implications for the road authorities and road users. Some of these implications can be tested using life cycle costing analysis.

It was appropriate for this Bureau to study the maintenance requirements of the Australian national highway system: there is increased competition for funds by all sectors of the Australian economy, and the Australian national highway system has reached a level of development which has meant that asset maintenance issues have become more important for road fund managers and for road authorities as there is now increasing emphasis being given to road maintenance relative to road construction.

## EFFICIENCY, GOVERNMENT POLICY AND USER ISSUES

When a road maintenance program is planned strategically and is well designed, there can be very large society wide efficiency benefits. For this reason it is important to determine the optimum level of maintenance and construction activities, the correct balance between routine and the cyclic or reconstruction maintenance and the timings of those activities. These decisions can have a significant impact on the efficiency both of the pavement management and for the road user. Because of the importance and the size of the research task, this report concentrates on road maintenance, with construction aspects to be examined in detail in the next stage. There can be large savings using optimum maintenance treatments, particularly when considering the pavement life cycle. Because the vehicle operating costs are usually much higher than the authority costs there can be very large user benefits associated with optimum maintenance strategies. The conclusion to this report presents the findings of this work and the impact on these groups.

## STRUCTURE OF THE REPORT

This report contains six chapters. Chapter 2 describes the objectives of the national highway system, the definitions of maintenance used, and the methodology and data collection process. Chapter 3 describes the expenditure on the national highway system. The condition of the system is discussed in chapter 4 and chapter 5 discusses possible levels of funding, tested against various options. Chapter 6 refers to the implications of various funding levels, particularly the possible impact in the future of the aging of the infrastructure, and concludes with the implications of the study findings.

# CHAPTER 2 OBJECTIVES, METHODOLOGY AND DATA COLLECTION

## OBJECTIVES OF THE NATIONAL HIGHWAY SYSTEM

The Australian national highway system was established in 1974 with the following objectives (refer to Bureau of Roads 1975):

- to encourage and contribute, to a major extent, to trade and commerce, overseas and among States;
- to assist industry located in major centres of population to be complementary to industry located in neighbouring major centres;
- to reduce significantly transport costs of the products of rural and/or secondary industry, between points of production or points of export or consumption;
- to provide for long distance movement associated with recreation and tourism; and
- to improve movement between defence production centres, defence supply and storage locations, and defence establishments generally.

The goals of the national highway system have been more recently couched in terms to indicate when specific construction activities (such as length sealed or duplicated) are expected to be completed. The above original objectives remain as the most comprehensive objectives articulated for the system.

The national highway system was conceived and developed as a road network to link and unite the Australian nation. In this respect the national highway system may be different from other roads whose links may be evaluated in isolation. The impact of any potential reduction of maintenance levels must be viewed in the context of that original vision for the network.

The national highway network, pictured in figure 2.1, requires maintenance to keep it in operational condition to fulfil the objectives listed above. This study has quantified the annual expenditure level which is necessary to maintain the system and the implications of any reduction in expenditure levels for pavement roughness.

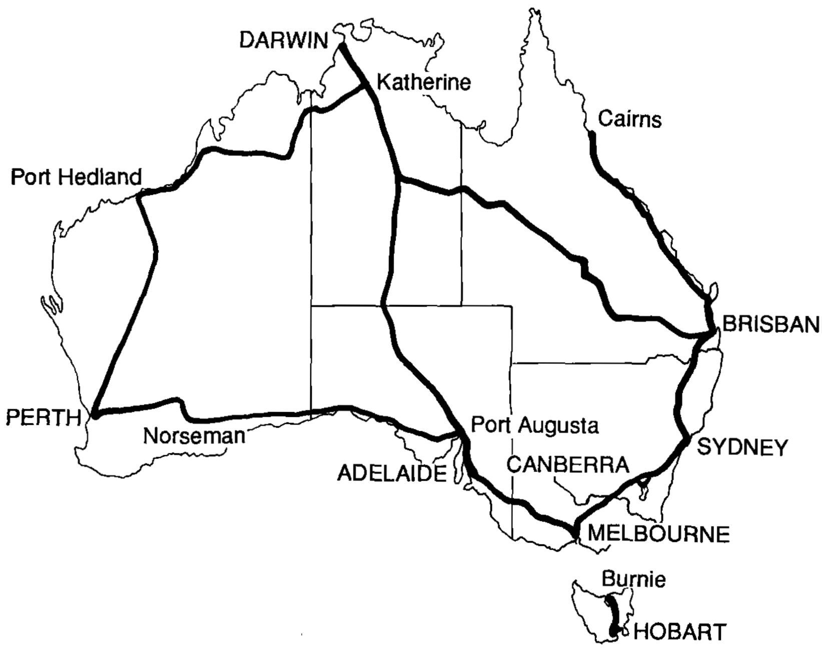



**Figure 2.1 The Australian national highway system**

The methodology adopted in this work used the pavement life cycle costing model developed within the Bureau, as reported in BTCE (1990). That work adapted pavement deterioration algorithms developed by the World Bank and other specialists in this field. Refer to Cox (1990) for further information on this subject. For the Bureau study, information on the physical details and condition of the national highways and the traffic, as well as unit costs of various maintenance activities was collected from each State road authority.

## MAINTENANCE DEFINITIONS

For the purposes of this report, maintenance of the national highway system embraces the conservation of that asset, and therefore the cost of maintaining the road has included all works to enable the road pavement to deliver its current level of service, virtually in perpetuity.

At the outset, it is desirable to outline the maintenance definitions used for roadways, bridges and traffic facilities:

- *Routine maintenance.* Typical examples of this type of work include pothole repair, minor pavement resealing or resurfacing of limited thickness and length, edge repair, shoulder regrading, minor pavement repairs, roadside maintenance, drainage clearance, grass cutting, sign cleaning, minor bridge and culvert maintenance.

- *Specific maintenance.* Typical examples of this type of work include pavement resealing and resurfacing with thin asphalt overlays. This type of maintenance can normally be predicted and planned by extent and location and is therefore more amenable to detailed management.
- *Restoration maintenance.* Typically this type of work is required after flooding or traffic accidents. Whilst these works are unpredictable they may be budgeted for, based on long term information.

Another form of maintenance covered in this work is *pavement reconstruction* (often termed pavement rehabilitation) to reinstate it to its original condition after the pavement has reached the end of its functional life. A typical example of this work is the removal and replacement of the existing road pavement.

This report is concerned with the preservation of the infrastructure and the term *intervention maintenance* is used which includes:

- specific maintenance;
- restoration maintenance; and
- pavement reconstruction.

## MAINTENANCE OF THE NATIONAL HIGHWAY SYSTEM

Because the objective of this Bureau study is to estimate the cost of conserving and maintaining the national highway system, the general term *maintenance* used in this report covers both:

- routine maintenance; and
- intervention maintenance.

As maintenance of the physical asset covers both routine and intervention maintenance, rather than the traditional definition of 'maintenance' which typically only considers routine maintenance and minor resealing works, the level of maintenance considered here is greater than many 'maintenance' estimates.

### Aspects not covered in this report

There is another category of maintenance works which is not covered in this report. This is termed *maintenance to conserve the operational performance,* which includes work undertaken to restore or upgrade the level of service due to changes in traffic volumes, projects designed to increase the width/volume ratio, to compensate for increased axle loads, to provide for unforeseen traffic growth, all widening, realigning and bypass works. This type of work is normally considered as upgrading, enhancement or improvement work rather than maintenance.

Whilst there are a very large number of maintenance treatments available, this study has focused on the most significant options, such as routine maintenance, resealing, thin asphalt overlays and reconstruction and for uniformity, applied combinations of those works to all national highway segments in all States.

This study is designed to assess the national highway maintenance requirements at a strategic level. To predict the national highway expenditure requirements at specific locations or for specific periods more localised planning techniques should be used.

Any asset will require maintenance at a defined operational condition if it is to continue to return the anticipated benefits. This study was designed to examine the costs and benefits of maintaining the national highway system at differing levels of funding and of standards.

## STUDY APPROACH

There are important issues which are significant in the future allocation of funds, whether to use economic criteria or to use some notional standards for the allocation of funds, for improvement and maintenance of the national highway system. These issues are:

- many low traffic volume sections do not necessarily have high economic returns and because of this, evaluations based primarily on minimising user plus authority expenditure are likely to lead to funds being directed away from these sections of roads, which could impact on the ability of those sections to meet the national highway objectives outlined in this chapter;
- in the past only limited historical, easily accessible, data on dates of improvements have been available to determine the adequacy of given sections of road; and
- pavement strength, which is significant in the assessment, is difficult to ascertain owing to the cost of collection and the lack of historical information.

One of the ground rules established for this study was to undertake the research without the need to collect data over and above that currently collected by the State road authorities. Because pavement strength data were limited, the methodology presupposed that all national highways were constructed in accordance with the National Association of Australian State Road Authorities pavement design guide (NAASRA 1987). Using that as a basis it is possible to estimate the design pavement strength based on the number of truck axles passing over the pavement.

## ECONOMIC EVALUATION

The approach for this study was to evaluate maintenance program strategies designed to minimise the net present value (NPV) of the vehicle operating costs (VOC) plus the road authority costs (also expressed in NPV terms) for any given annual road authority maintenance expenditure. The VOCs used in this work are expressed in resource or economic costs, which excludes all taxes and excises and other transfer payments in the evaluations.

This was achieved by calculating the maintenance benefit–cost ratio for every section of the Australian national highway system and then ranking all projects by benefit–cost ratio and funding the highest priority projects in turn, until funds were exhausted.

In all evaluations the routine national highway maintenance was calculated and then given highest priority or first call on the available funding. The approach was adopted because:

- routine maintenance is otherwise difficult to evaluate;
- this is generally the way in which road authorities give priority to their work; and
- is consistent with the approach adopted by the World Bank.

## PAVEMENT LIFE CYCLE COSTING MODEL

The life cycle costing (LCC) model was developed within the Bureau to assess the life cost of pavements. The model and algorithms developed are discussed in BTCE (1990). That report outlines a comparison of road pavement deterioration algorithms, presents a simple model for the analysis of flexible road pavements in Australia, and discusses its application.

One of the objectives of this Bureau study is to estimate the cost to maintain the national highway system. For this reason project types such as new improvement works, road deviations, bypasses and upgrading of the level of service are not included. The LCC model is ideally suited for evaluating the cost of asset maintenance works.

The LCC model uses the inventories of the national highways, traffic and traffic growth data and costing information to calculate asset maintenance requirements and benefits and costs.

The World Bank based pavement deterioration algorithm within the LCC model has a defined mathematical form and is dependent on a number of input variables. Because pavements are not homogeneous and they exist in variable environments, it is not possible to accurately model the life of any given section of pavement, but a calibrated model can provide valuable information for strategic planning purposes.

There are obviously many road maintenance possibilities and the LCC model is capable of assessing multiple maintenance options for any given section of road. Because this work considered the national highway at a strategic level and to limit the combinations of possible treatments, rules were established for each evaluation of the entire national highway system. The treatment options selected are detailed later in the report.

It is important to reiterate that it is not possible to accurately predict the actual deterioration pattern of any given section of the national highway system, nor is it possible to model every possible remedial action. The use of a life cycle costing model meant that it is possible to estimate in aggregate the likely deterioration regimes and to consider a possible range of responses and in turn assess their worth. Whilst the LCC model, using the World Bank algorithm, will produce deterioration of pavement to structural failure based on roughness value and subsequent rehabilitation of the pavement, many roads will be corrected using a mix of pavement rehabilitation, overlay and other localised treatments. Because the model assesses every section of the national highway system equally and with the ability of the model to assess many types of maintenance works, this modelling approach is appropriate for this strategic assessment of the maintenance requirements.

**Pavement strength**

One of the most significant data items to estimate the remaining life of a road pavement, namely pavement strength, was not available to the Bureau at the time of the preparation of this maintenance assessment. Therefore the LCC model used the assumption that all pavements were constructed to the requirements of National Association of Australian State Road Authorities (1987), based on the expected axle loadings. The LCC model calculated the equivalent standard axle (ESA) loading for a 20-year period based on the current truck traffic and determined the pavement strength requirement as outlined in BTCE (1990). While assessing future axle numbers and loadings, a uniform growth rate was assumed.

**Pavement roughness**

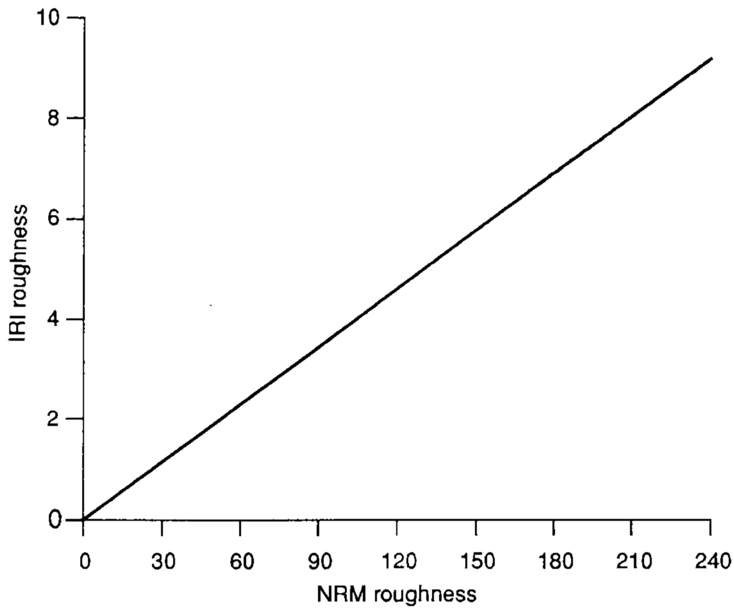
For the purpose of this study, roughness was adopted as the most appropriate criterion to measure road deterioration, since this approach is recognised by both road users and State road authorities throughout Australia. It is also the approach adopted by overseas road authorities using pavement management systems. The importance of roughness as a primary measure of road condition is discussed in detail in Paterson (1987), which states that:

> 'Road roughness therefore emerges as a key property of road condition to be considered in any economic evaluation of design and maintenance standards for pavements, and also in any functional evaluation of the standards desired by road users'. (p. 15)

There is a correlation between pavement roughness and riding comfort for users. Roughness is not the only measure which could have been used. Cracking or rutting of the pavement is also important, but roughness is a universally understood measure. This report refers to both the International Roughness Index (IRI) and the NAASRA Roughness Meter (NRM) measures of pavement roughness. The relationship between these two measures is described in BTCE (1990) and is shown in figure 2.2.

**Pavement deterioration and improvement**

The way in which the Paterson or the World Bank HDM-III algorithm replicates road pavement deterioration was outlined in BTCE (1990). That algorithm combines cracking, rutting, truck traffic and pavement strength to progressively change pavement roughness over a 40-year period.




*Source* Figure 4.3 of BTCE (1990).

**Figure 2.2 Comparison between IRI and NAASRA roughness**

A typical World Bank deterioration and reconstruction curve for a road pavement is shown in figure 2.3. Also shown is the pavement strength and its deterioration over the years.

The model is also able to assess reseal and asphalt overlay options. Various asphalt overlay thicknesses can also be tested in the model as can various timing options. Using the same pavement conditions as was shown in figure 2.3 and with a reseal at year 11, the results are plotted in figure 2.4. Figure 2.5 shows the impact on the pavement life with a 50-millimetre asphalt overlay at year 11. Obviously these treatments extend the pavement life. These graphs also plot the change in the pavement strength or pavement number.

The LCC model uses equations linking overlay thickness with roughness reduction and an increase in pavement strength. Figure 2.6 shows how an overlay reduces the pavement roughness and figure 2.7 shows the impact of an overlay on pavement strength. Obviously a reseal, which could be considered as an overlay of virtually zero thickness, has no impact on pavement strength or roughness. A reseal does have an impact on cracking, which is the reason for the increase in pavement life which is shown by comparing figure 2.4 with figure 2.3. Further information on the functioning of the LCC model is contained in BTCE (1990) and in BTCE (1991).

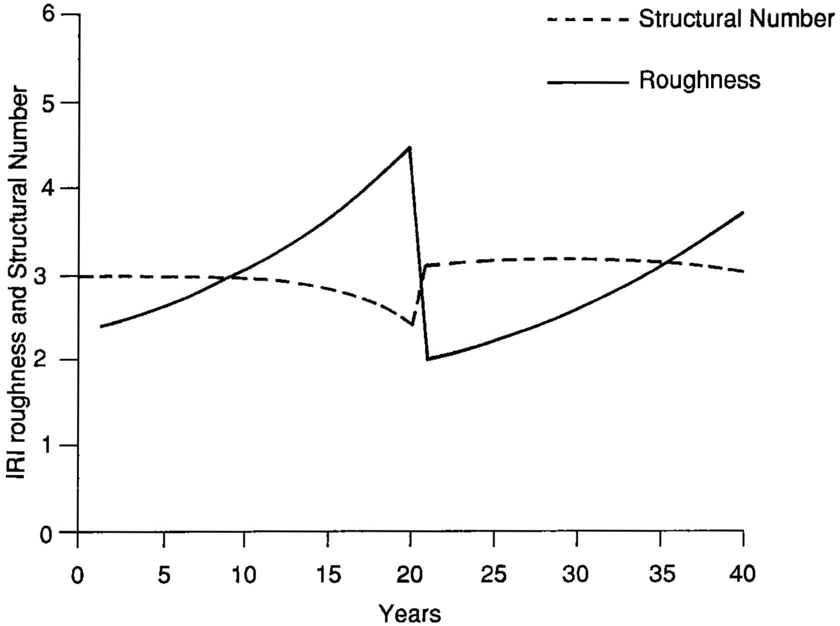



**Figure 2.3 A typical pavement deterioration curve**

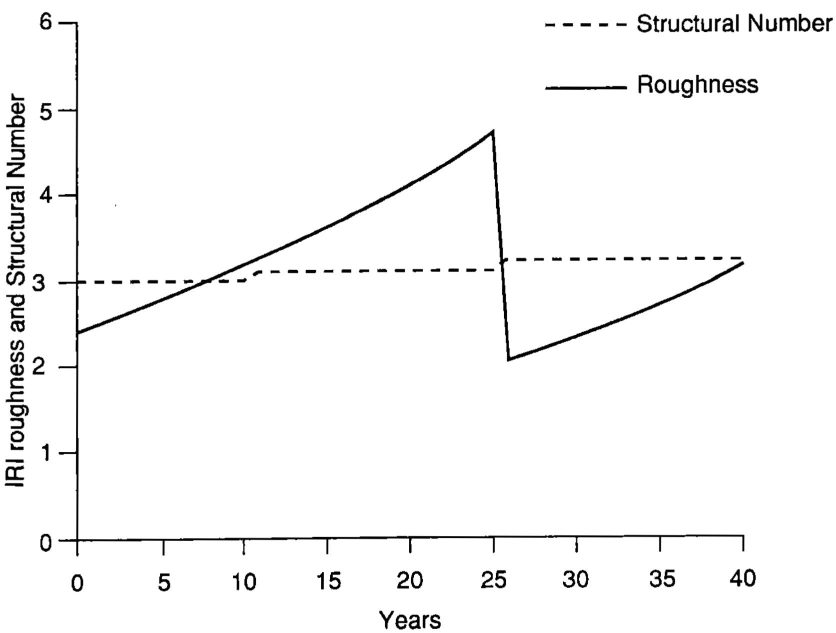



**Figure 2.4 The impact of a reseal at year 11**

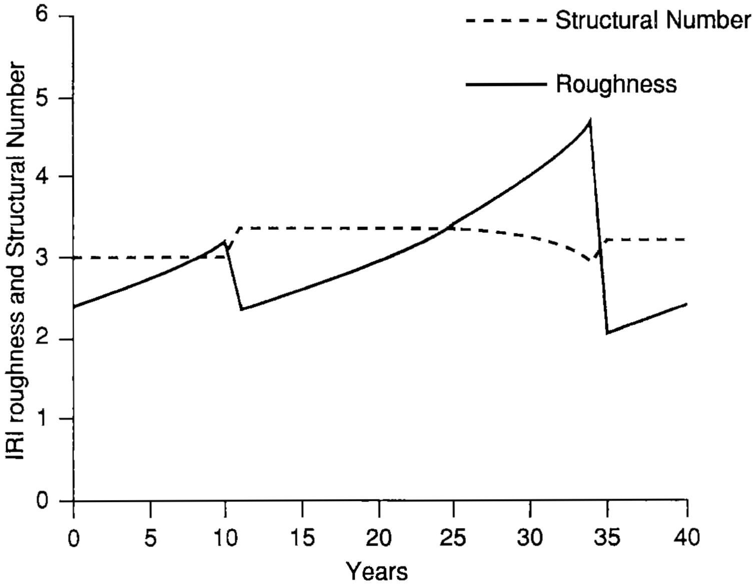
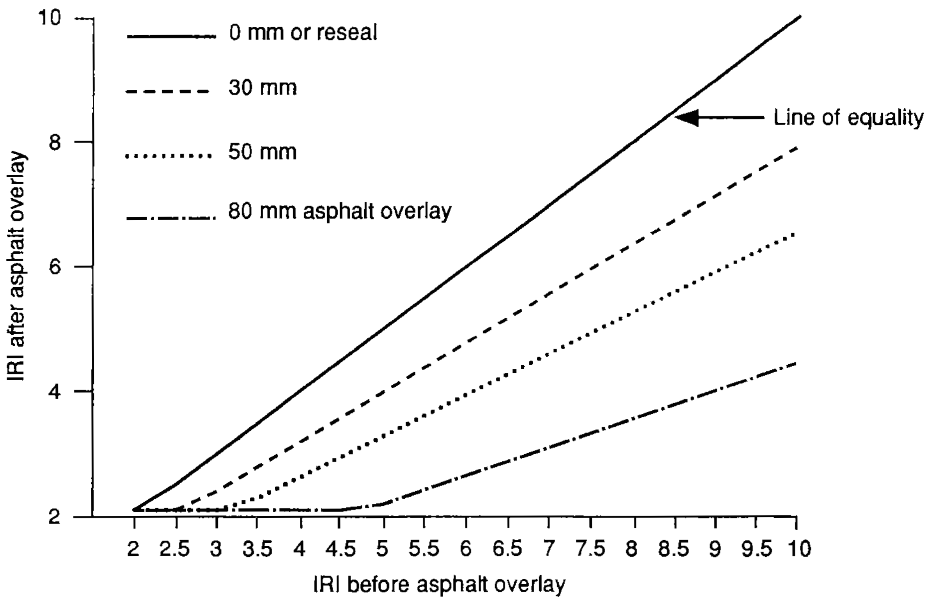
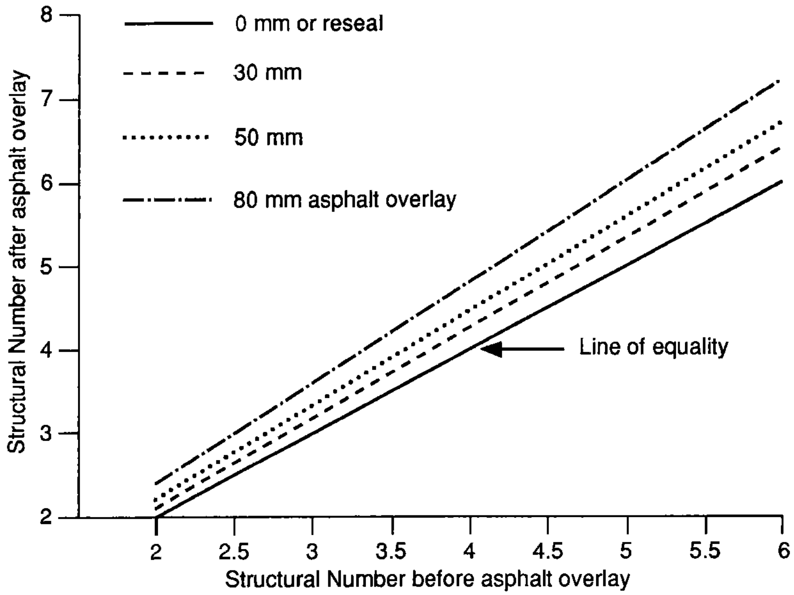



**Figure 2.5 The impact of a 50-millimetre asphalt overlay at year 11**




*Source* Adapted from HDM-III relationships and work undertaken by John Cox at the Australian Road Research Board.

**Figure 2.6 The change in pavement roughness after an overlay**




*Source* Figure 4.6 of BTCE (1990).

**Figure 2.7 The change in pavement strength after an overlay**

## Year-by-year expenditure

The LCC model can be used to determine patterns of possible future expenditure and can produce year-by-year expenditures for 40 years. By considering various reseal, overlay and reconstruction options it is possible to optimise expenditures. This optimisation could be based on the minimisation of the net present value of the authority costs or the authority plus user costs. This matter is discussed later in this report.

## Vehicle operating costs

The vehicle operating costs were derived using the World Bank parameters with Australian costs. Those results were calibrated with figures contained in NRMA (1989) for cars and with a commercially available computer-based truck costing package.

The equations used to calculate the vehicle operating costs in this work are as follows:

$$VOC_{car} = 18.3 + 0.13 * IRI^2$$
$$VOC_{rigid\ tr} = 29.9 + 5.05 * IRI$$
$$VOC_{artic\ tr} = 95.9 + 8.5 * IRI$$

where $VOC_{car}$ is the resource cost in cents per kilometre for cars, $VOC_{rigid\ tr}$ is the resource cost in cents per kilometre for rigid trucks and $VOC_{artic\ tr}$ is the resource cost in cents per kilometre for articulated trucks at the international roughness index (IRI) level.

The above equations give a 3 to 11 per cent change in VOC for each IRI unit of roughness change. The impact of pavement roughness is obviously more significant for trucks than cars. The quadratic relationship for cars indicates that cars are more sensitive to higher roughness levels. AUSTROADS are currently investigating the impact of roughness on vehicle operating costs.

The evaluation of road maintenance requirements included only savings in vehicle operating costs due to pavement improvements as benefits. Travel time and accident savings were not included, as travel time savings are difficult to quantify for the type of projects considered in this report and accident savings are not only difficult to quantify but are not likely to be very large. Excluding these benefits from project evaluation would not be likely to have any significant impact on the distribution of projects within the national highway system.

## Road authority and user costs

Figure 2.8 shows for a given traffic volume how the vehicle operating costs increase with increased terminal roughness and the authority costs reduce. For low traffic volume roads the authority costs can be a large proportion of the total costs, so the costs can be minimised by accepting a higher level of roughness than advocated for high traffic volume roads. For high traffic volume roads user

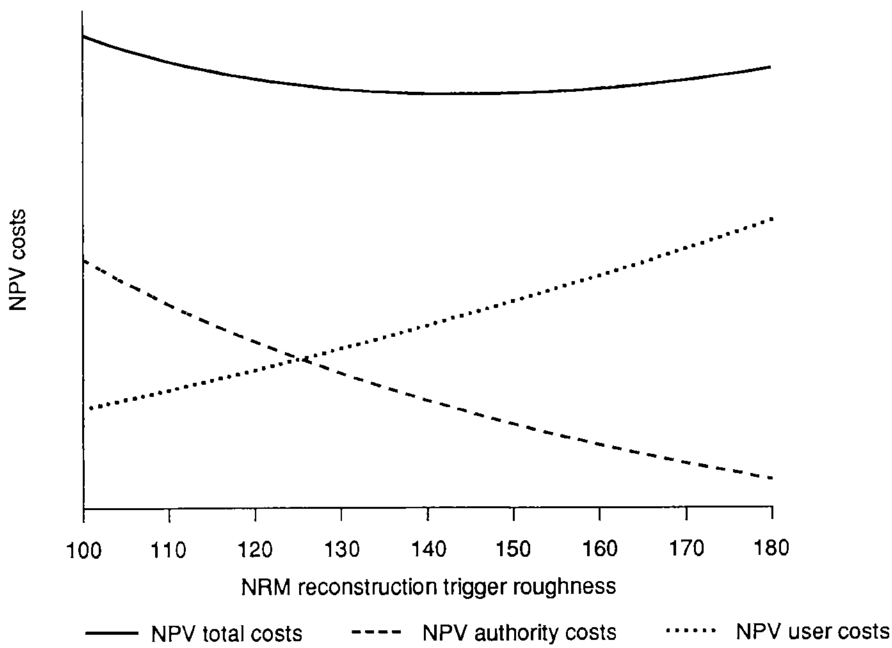



**Figure 2.8 The impact of terminal roughness levels on authority and user costs**

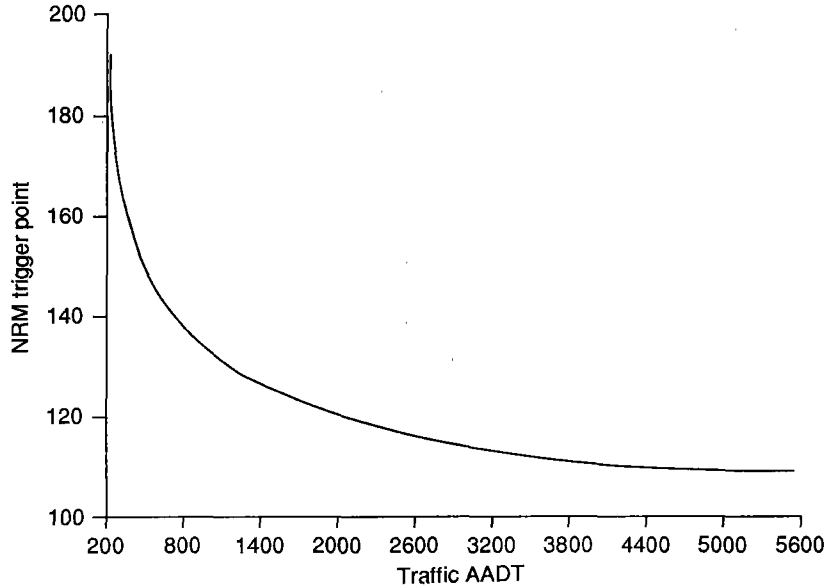



**Figure 2.9 Typical pavement reconstruction point to minimise total road authority and vehicle operating costs**

costs can be a very large proportion of the total costs, so costs can be minimised by maintaining a smooth surfaced road.

To ensure that each section of the national highway system achieved the highest possible economic returns, all analysis was undertaken using a terminal roughness which was varied with traffic volume to ensure that the sum of the NPV of the user costs plus the authority costs was minimised. This terminal roughness point was determined using the LCC model prior to the major analysis for this report. Typical NAASRA roughness trigger points for pavement reconstruction used to minimise the road authority plus user costs for any national highway system traffic level are plotted in figure 2.9. As an example, at an annual average daily traffic (AADT) of 2200, the optimum trigger point for reconstruction activity is at NAASRA roughness of 120.

## DATA CONSOLIDATION

The data required for this Bureau study were obtained from several sources. The main sources were the State road authorities and the Land Transport Division of the Department of Transport and Communications. Because the data to be obtained needed to suit the Bureau requirements, a data format was sent to the State road authorities for completion in May 1990. Details of this format are contained in appendix II. It was not until March 1991 that all States were able to finalise their data returns.

Under the Australian Centennial Roads Development (ACRD) Program requirements for national highways, States were to have in place Pavement Management Systems (PMS) and were required to supply performance information to the Federal government, commencing July 1990. All States put in place PMS arrangements and submitted limited information on the physical characteristics, traffic, as well as roughness, cracking, rutting and surface texture information. This information became available to the Bureau during the period July to November 1990.

This performance information was used to create the data base and where necessary supplement information forwarded to the Bureau by the States. In coding the data, the Bureau was careful to ensure that short uncharacteristic sections, such as those with high roughness or high traffic, were not 'averaged out' over longer sections, but were separated to minimise the likelihood of a State being disadvantaged in describing its road system and aggregate condition.

The aggregated information supplied as a requirement of ACRD presented some difficulties in ensuring that the current condition of the road was best described, particularly where information was only available to indicate the length of each characteristic between each origin and destination pair. Whilst it was often difficult to determine where combinations of, say, high traffic and roughness coincided, in creating continuous homogeneous sections the Bureau attempted to take these factors into account to ensure that no State was disadvantaged.

All the authorities were very cooperative in supplying the available information. In April 1991 all States were supplied with copies of their edited State data for verification. There were no difficulties encountered. Each road authority was also given the opportunity to provide details of any particular issues they wished to raise regarding the maintenance requirements for their national highways.

The Bureau extended the data records supplied by the States to include the longitudes and latitudes of each node, which enabled the results to be mapped using geographic information systems. The Bureau also added fields to contain costing, benefit and future roughness information.

Further details of the data collection, editing, updating and data processing are found in appendix III.

## DATA ANALYSIS

The data obtained were checked for consistency and accuracy and necessary modification was made to the data which did not conform to Bureau requirements. As noted, prior to the analysis of the data, the edited and finalised national highway files were returned to all State road authorities for verification. The processed data were then used in the preparation of the statistics and in conjunction with the LCC model to determine the maintenance expenditure requirements.

As mentioned earlier under the terms of the Australian Centennial Roads Development Program, State road authorities were required to supply information to the Federal government on certain pavement performance indicators using national highway reporting links of the national highway system. The links adopted and corresponding inventory information supplied is shown in appendix I. The findings in this report are presented for each of those ACRD national highway condition reporting links.

# CHAPTER 3 CURRENT NATIONAL HIGHWAY EXPENDITURE

This chapter presents information on current levels of national highway system expenditure and considers the requirement for routine maintenance.

## CONSTRUCTION AND MAINTENANCE EXPENDITURE

Table 3.1 presents details of the Federal government allocation under the Australian Centennial Roads Development Act to national highways for construction and maintenance for 1990–91.

For the purpose of the Act maintenance is defined as:

> maintenance in relation to a road, includes works and repairs to keep the road in a safe and trafficable condition.

There could be differences between States in the interpretation of this definition, particularly regarding cyclic maintenance activities, such as reseals. This reduces the value of these interstate comparisons.

Table 3.2 indicates the likely Federal allocations for the year 1990–91 and provides information on traffic levels and road length in each State.

TABLE 3.1 FEDERAL NATIONAL HIGHWAY ALLOCATION, 1990–91

*($ million)*

| *State or Territory* | *Major construction* | *Maintenance* | *Administration* | *Total* |
|---|---|---|---|---|
| NSW | 141.3 | 71.7 | 9.5 | 222.5 |
| Vic. | 50.2 | 13.0 | 3.0 | 66.2 |
| Qld | 63.9 | 60.0 | 5.0 | 128.9 |
| SA | 18.1 | 15.6 | 1.5 | 35.2 |
| WA | 35.5 | 15.9 | 2.0 | 53.4 |
| Tas. | 13.5 | 5.7 | 0.8 | 20.0 |
| NT | 19.5 | 9.5 | 1.0 | 30.0 |
| Australia | 342.0 | 191.4 | 22.8 | 556.2 |

*Source* Department of Transport and Communications.

TABLE 3.2 COMPARISON OF FEDERAL GOVERNMENT ALLOCATION TO NATIONAL HIGHWAYS, WITH TRAFFIC, 1990–91

| *State or Territory* | *Allocation ($ million)* | *Funding (per cent)* | *Truck VKT (per cent)* | *Total VKT (per cent)* | *Length (per cent)* |
|---|---|---|---|---|---|
| NSW | 222.5 | 40.0 | 33.1 | 33.0 | 8.4 |
| Vic. | 66.2 | 11.9 | 19.7 | 15.7 | 4.4 |
| Qld | 128.9 | 23.2 | 21.1 | 27.5 | 24.3 |
| SA | 35.2 | 6.3 | 9.6 | 8.9 | 15.3 |
| WA | 53.4 | 9.6 | 8.1 | 7.3 | 28.9 |
| Tas. | 20.0 | 3.6 | 3.1 | 4.9 | 2.0 |
| NT | 30.0 | 5.4 | 5.3 | 2.9 | 16.7 |
| Australia | 556.2 | 100.0 | 100.0 | 100.0 | 100.0 |

VKT Vehicle-kilometres of travel

*Source* Department of Transport and Communications and table I.1.

It can be seen that the allocation of total construction and maintenance funds to each State for national highways, correlates more closely with traffic than with road length. Further work could be undertaken using regression analysis to assist in assessing the factors influencing that distribution.

## CURRENT MAINTENANCE EXPENDITURE

### Routine maintenance assessed from previous expenditures

Table 3.3 shows the allocation in each State to routine maintenance expressed as a percentage of all expenditure for national highways between 1974–75 to 1986–87 and were reported in BTCE (1989).

TABLE 3.3 NATIONAL HIGHWAY ROUTINE MAINTENANCE EXPENDITURE AS A PERCENTAGE OF TOTAL EXPENDITURE, 1974–75 TO 1986–87

| *Year* | *NSW* | *Vic.* | *Qld* | *SA* | *WA* | *Tas.* | *NT* | *Australia* |
|---|---|---|---|---|---|---|---|---|
| 1974–75 | 20 | 6 | 22 | 12 | 19 | 8 | 56 | 18 |
| 1975–76 | 14 | 6 | 19 | 11 | 19 | 8 | 38 | 14 |
| 1976–77 | 14 | 6 | 20 | 11 | 14 | 7 | 45 | 14 |
| 1977–78 | 12 | 9 | 20 | 16 | 17 | 11 | 30 | 15 |
| 1978–79 | 12 | 11 | 25 | 15 | 16 | 11 | 28 | 16 |
| 1979–80 | 12 | 11 | 23 | 17 | 21 | 11 | 22 | 16 |
| 1980–81 | 13 | 10 | 25 | 15 | 16 | 12 | 36 | 17 |
| 1981–82 | 13 | 11 | 30 | 15 | 36 | 10 | 15 | 19 |
| 1982–83 | 13 | 13 | 31 | 18 | 67 | 13 | 22 | 20 |
| 1983–84 | 11 | 10 | 31 | 16 | 32 | 18 | 25 | 18 |
| 1984–85 | 13 | 9 | 32 | 25 | 20 | 14 | 20 | 19 |
| 1985–86 | 12 | 8 | 34 | 16 | 16 | 14 | 24 | 17 |
| 1986–87 | 12 | 6 | 34 | 34 | 26 | 14 | 42 | 20 |

*Source* BTCE (1989).

From table 3.2 and table 3.3 it appears that the routine maintenance is a higher proportion of total expenditure in those States which have longer national highway lengths. This indicates there is a relationship between total routine maintenance expenditure and pavement length or more specifically pavement area. The more remote areas could also have higher routine maintenance cost per square metre of pavement. The table also shows that the proportion of funds spent on routine maintenance has increased slightly over the period, although there are fluctuations between years.

## Maintenance assessed previously by the Bureau

An estimate of the future maintenance requirement for national highways was presented in BTE (1987), and table 3.4 provides these figures updated to 1990–91 prices and converted to an annual estimate rather than the 11-year figure quoted in that report.

In the work reported in BTE (1987), routine maintenance included resheeting and resealing. *Preservation of the physical asset* was defined as rehabilitating the pavement at the end of its economic life without any upgrading of the geometric standards. Upgrading of the geometric standards or improving the level of service provided by the road was considered as *preservation of the operational performance.*

Though the maintenance works assessed in this report are comparable with the routine maintenance plus the preservation of the physical asset covered in BTE (1987), the assumptions made and the methodology used are different, particularly with the use of thin asphalt overlays.

TABLE 3.4 ESTIMATED FUTURE NATIONAL HIGHWAY EXPENDITURE REQUIREMENT PER ANNUM

*($ million)*

| *State or Territory* | *Routine maintenance* | *Preservation of the physical asset* | *Subtotal* | *Preservation of the operational performance* | *Total* |
|---|---|---|---|---|---|
| NSW | 28.1 | 30.5 | 58.6 | 44.1 | 102.7 |
| Vic | 14.0 | 12.8 | 26.8 | 16.0 | 42.8 |
| Qld | 46.5 | 54.2 | 100.7 | 75.5 | 176.2 |
| SA | 10.4 | 25.3 | 35.7 | 31.1 | 66.8 |
| WA | 27.8 | 20.3 | 48.1 | 25.6 | 73.7 |
| Tas | 3.5 | 8.2 | 11.7 | 10.3 | 22.0 |
| NT | 9.9 | 24.6 | 34.5 | 36.9 | 71.4 |
| Australia | 140.1 | 175.9 | 316.0 | 239.6 | 555.6 |

*Source* BTE (1987), tables 5.4, 5.5 and 5.6, converted to single-year 1990–91 prices.

# CHAPTER 4 CURRENT CONDITION OF THE NATIONAL HIGHWAY SYSTEM

This chapter presents a number of physical indicators of the status of the national highway system including length, width, surface type, traffic and roughness.

## LENGTH AND TRAFFIC

Table 4.1 indicates the physical status of the national highway system as it existed at 30 June 1990 and the traffic usage characteristics on a State basis. As expected States with high population densities exhibit higher usage, particularly New South Wales, Victoria and Tasmania.

TABLE 4.1 NATIONAL HIGHWAY LENGTH AND USAGE BY STATE, 1990

| *State or Territory* | *Length (kilometres)* | | | | *Mean traffic flow* |
|---|---|---|---|---|---|
| | *One-lane*[a] | *Multi-lane* | *Divided* | *Total* | *(AADT)*[b] |
| NSW | 0.0 | 920.8 | 422.5 | 1 343.3 | 10 172 |
| Vic. | 0.0 | 389.8 | 318.8 | 708.7 | 9 154 |
| Qld | 0.0 | 3 698.6 | 198.8 | 3 900.2 | 2 919 |
| SA | 0.0 | 2 325.6 | 134.2 | 2 459.7 | 1 492 |
| WA | 353.5 | 4 279.4 | 7.6 | 4 640.5 | 652 |
| Tas. | 0.0 | 272.9 | 46.3 | 319.2 | 6 350 |
| NT[c] | 0.0 | 2 666.0 | 7.0 | 2 673.0 | 444 |
| Australia | 353.5 | 14 553.1 | 1 135.2 | 16 044.5 | 2 583 |

AADT Annual average daily traffic

a. Roads are classified as 'one-lane' where the seal width is 4.5 metres or less.

b. Mean traffic flow calculated from vehicle-kilometres divided by route length.

c. Accurate information on divided highway length was not available for the Northern Territory.

*Notes* 1. Owing to rounding, figures may not add to totals.

2. Status as at 30 June 1990.

*Source* BTCE survey.

All of the Australian national highway system is now sealed. The national highway status reported in table 5.1 of BTE (1987) indicated that there were 75.7 kilometres of unsealed national highway in June 1989 (all in Western Australia) and 679.8 kilometres of one-lane sealed sections, predominantly in Western Australia and Northern Territory.

TABLE 4.2 NATIONAL HIGHWAY COMMERCIAL VEHICLE TRAFFIC, 1990

| | | *Commercial vehicles* | | | |
|---|---|---|---|---|---|
| *State or Territory* | *Total vehicle VKT ($x10^6$)* | *Total vehicle commercial VKT ($x10^6$)* | *ESAs per commercial vehicle*[b] | *Total ESAs per annum*[c] *($x10^6$)* | *Mean ESAs per annum km ($x10^6$)* |
| NSW | 4 987.5 | 957.1 | 1.8 | 1 177.23 | 0.876 |
| Vic. | 2 367.8 | 568.0 | 1.9 | 1 079.20 | 1.522 |
| Qld | 4 155.0 | 611.2 | 1.5 | 916.80 | 0.235 |
| SA | 1 339.2 | 276.6 | 2.0 | 553.20 | 0.224 |
| WA | 1 103.6 | 234.3 | 1.5 | 351.45 | 0.076 |
| Tas. | 739.7 | 90.1 | 1.1 | 99.11 | 0.311 |
| NT | 433.3 | 153.4 | 1.9 | 291.46 | 0.109 |
| Australia | 15 126.1 | 2 890.8 | .. | 4 468.45 | 0.278 |

ESA Equivalent standard axle
VKT Vehicle-kilometres of travel

a. A more detailed breakdown of the above traffic information by ACRD Condition Reporting Links is provided in appendix I.

b. NAASRA (1987), table E5.

c. The total ESAs is for state travel on the national highway system.

*Source* BTCE roads data files.

TABLE 4.3 ALL ROADS ANNUAL TONNE-KILOMETRES, 1982 TO 1988

| *State or Territory* | *1982 (million tonne-km)* | *1985 (million tonne-km)* | *1988 (million tonne-km)* | *Annual growth 1982–88 (per cent)* |
|---|---|---|---|---|
| NSW | 20 384 | 23 950 | 24 927 | 3.4 |
| Vic. | 13 781 | 17 612 | 22 885 | 8.8 |
| Qld | 8 853 | 11 058 | 13 334 | 7.1 |
| SA | 6 305 | 8 017 | 8 413 | 4.9 |
| WA | 6 366 | 8 255 | 10 162 | 8.1 |
| Tas. | 1 513 | 1 878 | 2 523 | 8.9 |
| NT | 1 757 | 3 177 | 2 687 | 7.9 |
| ACT | 407 | 354 | 598 | 6.6 |
| Australia | 59 367 | 74 300 | 85 529 | 6.3 |

*Source* ABS *Survey of Motor Vehicle Use* (1984, 1987, 1990).

TABLE 4.4 INTERSTATE MOVEMENTS ANNUAL TONNE-KILOMETRES, 1982 TO 1988

| *State or Territory* | *1982 (million tonne-km)* | *1985 (million tonne-km)* | *1988 (million tonne-km)* | *Annual growth 1982–88 (per cent)* |
|---|---|---|---|---|
| NSW | 3 206 | 4 141 | 3 444 | 1.2 |
| Vic. | 4 224 | 5 413 | 6 190 | 6.6 |
| Qld | 1 149 | 1 566 | 3 154 | 18.3 |
| SA | 2 547 | 2 864 | 3 056 | 3.1 |
| WA | 479 | 825 | 536 | 1.9 |
| Tas. | 53 | 7 | 40 | –4.6 |
| NT | 247 | 711 | 697 | 18.9 |
| ACT | 283 | 169 | 372 | 4.7 |
| Australia | 12 189 | 15 696 | 17 490 | 6.2 |

*Source* ABS *Survey of Motor Vehicle Use* (1984, 1987, 1990).

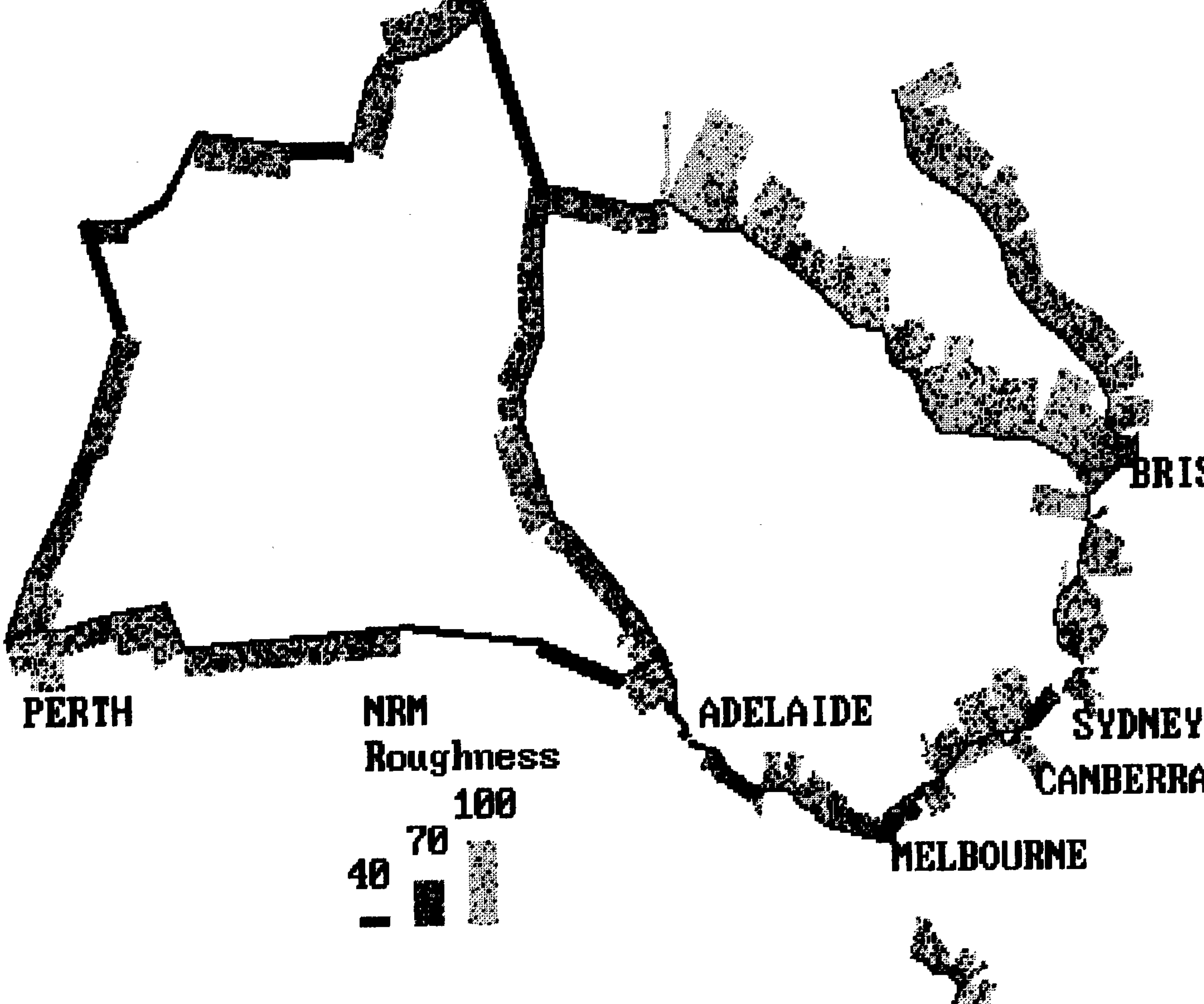
The average volumes of articulated trucks, rigid trucks and cars are presented diagrammatically for each length of national highway in figure 4.1. A more detailed breakdown of some of the above information, by the Australian Centennial Roads Development Program Condition Reporting Links, is provided in appendix I.

Further details on the commercial vehicle traffic on national highway are shown in table 4.2.

Further information on tonne-kilometres of travel for vehicles registered in each State (national highway plus other roads) for the latest available 6 years is provided in table 4.3.

Table 4.3 covers travel on all Australian roads. Information on tonne-kilometres of travel for interstate movements for vehicles registered in each State is contained in table 4.4.

Table 4.4 covers interstate movements on all Australian roads including national highways. By comparing tables 4.3 and 4.4 interstate movements were only 20 per cent of all tonne-kilometre movements in 1988. It also can be seen that the interstate movement component of travel in New South Wales, Victoria and the Australian Capital Territory comprises 57.2 per cent of the 1988 interstate travel, and from table 4.3 these States' total travel represents 56.6 per cent of the Australian total travel. These States contain 61.4 per cent of the Australian population. In table 4.4 vehicles registered in Victoria undertake more interstate tonne-kilometres of travel than do vehicles registered in New South Wales. This probably relates to the smaller size of Victoria and the impact of the large manufacturing sector.


BRISBANE
PERTH
ADELAIDE
SYDNEY
CANBERRA
MELBOURNE
NRM
Roughness
100
70
40

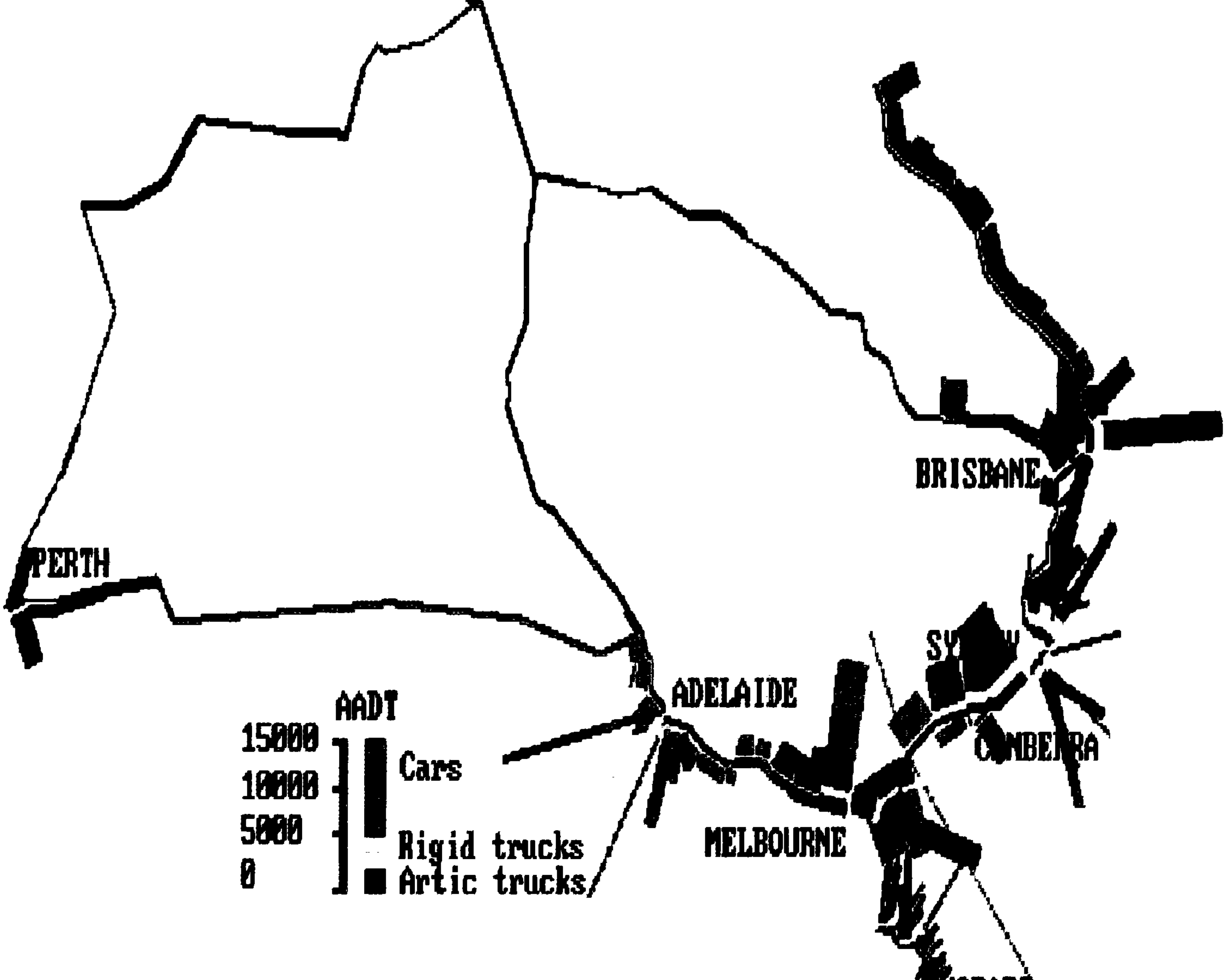

PERTH
ADELAIDE
BRISBANE
MELBOURNE
AADT
15000
10000
5000
0
Cars
Rigid trucks
Artic trucks

TABLE 4.5 NATIONAL HIGHWAY LENGTHS BY SURFACE TYPE, 1990
*(kilometres)*

| *State or Territory* | *Undivided sprayed seal* | *Undivided asphalt surface* | *Divided sprayed seal* | *Divided asphalt or concrete surface* | *Total* |
|---|---|---|---|---|---|
| NSW | 847 | 74 | 102 | 321 | 1 343 |
| Vic. | 3 | 387 | 0 | 319 | 709 |
| Qld | 3 657 | 44 | 86 | 113 | 3 900 |
| SA | 2 278 | 48 | 32 | 102 | 2 460 |
| WA | 4 467 | 166 | 0 | 8 | 4 640 |
| Tas. | 162 | 111 | 18 | 28 | 319 |
| NT | 2 564 | 101 | 0 | 8 | 2 673 |
| Australia | 13 978 | 931 | 238 | 899 | 16 045 |

*Note* As discussed in appendix III, accurate pavement type information was not available for Victoria and therefore an estimate based on earlier data has been used.

*Source* BTCE roads data files.

## PAVEMENT

National highway pavement surface type varies from State to State. The surface type by length of carriageway is shown in table 4.5.

The range of current national highway system pavement roughness as determined using the NAASRA roughness meter (NRM) for each State is shown in table 4.6.

Table 4.6 indicates that Queensland has a higher proportion of rough roads, with an average (weighted by road length) NRM roughness reading of 81, and South Australia has on average the smoothest roads with an average

TABLE 4.6 NATIONAL HIGHWAY PAVEMENT ROUGHNESS

| | *Length of highway (kilometres)* | | | | | |
|---|---|---|---|---|---|---|
| *State or Territory* | *Roughness <60* | *Roughness 60–79* | *Roughness 80–99* | *Roughness 100–120* | *Roughness >120* | *State average roughness*[b] |
| NSW | 557 | 355 | 224 | 130 | 77 | 68 |
| Vic. | 333 | 371 | 4 | – | – | 55 |
| Qld | 191 | 2 027 | 1 239 | 185 | 258 | 81 |
| SA | 1 879 | 477 | 91 | 9 | 3 | 51 |
| WA | 3 262 | 913 | 371 | 74 | 20 | 55 |
| Tas. | 107 | 186 | 25 | 2 | – | 64 |
| NT | 1 747 | 692 | 185 | 42 | 7 | 57 |
| Australia | 8 076 | 5 021 | 2 139 | 442 | 366 | 64 |

a Roughness as determined using the NAASRA roughness meter.
b. Average roughness for the State weighted by length.

*Source* BTCE data holdings.

roughness of 51. The possible reasons for the rougher national highways in Queensland may include the influence of the expansive black clays in the west of the State and the use of lighter pavements to facilitate completion of the long lengths of roads in Queensland. Also much of the Queensland national highway system may not yet have been reconstructed, whilst other States may have reconstructed much of their national highways.

In 1990 about 366 kilometres (out of 16 045 kilometres) of national highway length exceeded the suggested NAASRA NRM roughness reconstruction point of 110, quoted in NAASRA (1987). This roughness status is presented diagrammatically in figure 4.2.

## STRUCTURES

Bridges and culverts are an important component of the national highway system and information was obtained during the Bureau of Transport Economics survey in 1987, reproduced in table 4.7. In that survey a structure was classified as a bridge when it exceeded 6.1 metres in length. A major culvert was 2.7 to 6.1 metres in length. Table 4.7 indicates that New South Wales, Queensland and Victoria have 78 per cent of the 1397 bridges on the national highway system. Of the major culverts, 74 per cent are located in New South Wales and Queensland.

TABLE 4.7 NUMBER OF BRIDGES AND MAJOR CULVERTS ON AUSTRALIAN NATIONAL HIGHWAYS

| *State or Territory* | *Bridges* | *Major culverts* | *Total* |
|---|---|---|---|
| NSW | 399 | 240 | 639 |
| Vic. | 174 | 37 | 211 |
| Qld | 521 | 282 | 803 |
| SA | 70 | 22 | 92 |
| WA | 77 | 7 | 84 |
| Tas. | 61 | 27 | 88 |
| NT | 92 | 92 | 184 |
| Australia | 1 397 | 709 | 2 106 |

*Source* BTE survey June 1977.

# CHAPTER 5 ASSESSMENT OF THE MAINTENANCE REQUIREMENT

This chapter outlines the method used to determine the maintenance requirement for the national highway system. The method involved calculating the cost per kilometre for various types of works and determining the timing for the works using economic criteria.

## STANDARDISED UNIT COSTING

One of the most important tasks in this Bureau study was to determine an appropriate set of unit costs for maintenance work. The way in which this was done is set out below.

The States were asked to supply maintenance costing data on a cost per square metre of pavement, as detailed in appendix II. Whilst the quality and consistency of all State supplied data were reasonable, there were variations in the costing data submitted, as is set out below:

- some road authorities supplied detailed costing information for each major section of the national highway;
- two road authorities supplied a single set of unit costs for the entire State;
- one road authority supplied a set of routine maintenance cost which appeared to be unexplainably higher than the remaining States; and
- a number of State road authorities were unable to supply maintenance cost data.

The differences in the supply of cost data are possibly attributable to lack of relevant information, and often the divisions of the State road authorities responsible for pavement management which supplied the physical inventory data are not the divisions responsible for maintaining cost information.

The Bureau used regression analysis on the submitted costing data to examine the results, then contacted all States to discuss the costing submissions, and some updating was undertaken. Because maintenance costing data were limited those findings were also reviewed against the following considerations:

- Kinhill (1989) indicated that routine maintenance for various classes of road was related to the number of trucks using the road;

- the NSW Roads and Traffic Authority had undertaken limited field research in the southern region and found that routine maintenance unit costs increased as much as five times after pavement conditions deteriorated;
- intuitively routine maintenance will increase in wetter regions, will increase as traffic increases and will increase as the pavement ages;
- there is evidence that the unit cost for routine maintenance is higher in remote areas because of the travelling costs and non-availability of skilled labour; and
- in high traffic volume areas, maintenance work becomes more costly due to traffic management and the worker protection requirements.

Regression analysis was carried out on the national highway records supplied by the State road authorities, which gave a weak relationship linking maintenance expenditure with the logarithm of the traffic. Record keeping of unit costs of routine maintenance and the determination of appropriate levels of expenditure is obviously an area where much work is required.

Because there was close agreement amongst all States regarding the unit costs of resealing, asphalt overlays and pavement reconstruction, all national highway analysis was carried out using the following unit costs:

| | |
|---|---|
| Routine maintenance | $0.60 per square metre of pavement per year |
| Reseal | $2.50 per square metre per treatment |
| Asphalt overlay 50 mm | $12.50 per square metre per treatment |
| Pavement reconstruction | $55.00 per square metre excluding surfacing |

The unit cost for routine maintenance of $0.60 per square metre was adopted as an appropriate average. In high traffic areas there are economies of scale in maintenance work but these are offset by increased costs associated with maintenance under traffic. In the low volume sections the reduced maintenance is often offset by the remoteness and other factors. There was general agreement between States on the costs for intervention maintenance.

To reduce the combinations of possible maintenance treatments for this strategic assessment, it was assumed that when a flush seal pavement was to be reconstructed, it was replaced with a similar pavement. When an asphalt pavement required reconstruction it was replaced with an unbound granular base and 100 millimetres of asphalt. Again to reduce the combinations of treatments possible, all asphalt overlays were designed and costed using a 50-millimetre thickness. Concrete pavements were handled separately. It is expected that the most appropriate maintenance response, for any particular section of road, would be determined using maintenance project techniques.

## ROUTINE MAINTENANCE

The LCC model was applied to the national highway data which were submitted to the Bureau in the format shown in appendix II. The model calculated the routine maintenance costs using the unit costs noted above, combined with road lengths and pavement widths. The same routine maintenance costs were used for all assessments, and routine maintenance was given the highest priority for funding.

## TOTAL MAINTENANCE

The LCC model was used to calculate the annual routine maintenance, the intervention maintenance, the vehicle operating costs for a 40-year period and the maintenance benefit–cost ratio (BCR) of each section of the national highway system submitted by the State road authorities. The model also calculated roughness changes for each option and each year. BTCE (1990) details how the LCC model deteriorates the pavement, modifies pavement parameters including roughness, cracking, rutting and strength with upgrading treatments such as reseals and overlays, costs the work and calculates BCRs. The model was run using the following options to estimate the total routine and intervention maintenance requirement:

- *Option A*

  All routine maintenance included.

  No reseals or overlays utilised.

  The pavement reconstruction roughness trigger point based on minimising the sum of the NPV of the road authority plus the user costs as per figure 2.9.

- *Option B*

  All routine maintenance included.

  All pavements resealed every 7 years.

  The pavement reconstructed as per figure 2.9.

- *Option C*

  All routine maintenance included.

  All pavements overlayed with 50 millimetres of asphalt with the period between overlays varying with traffic, such that higher volume roads were overlayed more frequently. The period between overlaying was set at 42/log(AADT), with a maximum period for low volume roads of 18 years and a minimum for high volume roads of 10 years. This was done to ensure that the model produced the highest benefits with realistic overlay timings. Where the roughness exceeded IRI 3.5 or NRM 78 the pavement was allowed to deteriorate to where it was reconstructed as per figure 2.9.

- *Option D*

  All routine maintenance included.

  All pavements were overlayed irrespective of the roughness, with 50 millimetres of asphalt with the period as specified in option C.

A number of other options were also tested to assess whether the total of authority and user costs could be reduced. These other options included: to reduce the number of reseals, to mix reseals and overlays, to reduce reseals and overlays on very rough pavements. Some of these other options are discussed below, but the above four options were considered to be the most appropriate set of responses for examination in this strategic study.

One of those other options tested involved reconstructing pavements using a reconstruction trigger point of 110 NRM. (refer to table 7.4 of NAASRA 1987). This option not only produced the highest authority costs ($437 million annually), but also required high expenditures on low volume sections of the national highway thereby potentially reducing funds available for the higher benefit–cost ratio sections and States. This option also leads to a high maintenance level for low volume sections of the highway and has the lowest benefit–cost ratios. Whilst there is a case for uniformity of standards for national highways, roughness standards could be reduced for the low volume sections of the national highway system, to maximise the total benefits.

Another option tested involved examining possible reduced costs for pavement reconstruction in remote areas, using a reconstruction cost of $40 per square metre for AADT levels less than 600, with all other parameters as per option A. This assessment changed the results slightly (compared with option A) for Queensland, South Australia, Western Australia and Northern Territory. The total maintenance needs were reduced in those States and the reduced costs produced higher benefit–cost ratios. This meant that those States would receive slightly less funding than for option A at the unconstrained budget and slightly higher proportion as the funds decreased. Because of this and the desirability of using an equitable costing approach, this option was not explored further.

All analysis of pavement reconstruction was undertaken using a terminal roughness which was varied with traffic to ensure that the sum of the NPV of the user costs plus the authority costs was minimised. This terminal roughness point was determined using the LCC model prior to the major analysis being undertaken for this report.

The impact of all options was monitored closely for remote areas. Options B, C and D indicate there are potential reductions in life cycle costs for road authorities and road users with the use of reseals and particularly using thin asphalt overlays.

All preliminary maintenance assessments were prepared using a discount rate of 7 per cent. The implications of differing discount rates are discussed later in this chapter. The results for all four major options for all maintenance projects irrespective of their benefit–costs ratios are shown in table 5.1. The figures shown in the table represent the average annual expenditure for a 40-year period for both routine and intervention maintenance.

TABLE 5.1 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE REQUIREMENT

*( $'000 1990–91 prices)*

| *State or Territory* | *Option A* | *Option B* | *Option C* | *Option D* |
|---|---|---|---|---|
| NSW | 70 412 | 62 484 | 44 645 | 40 000 |
| Vic. | 31 985 | 22 414 | 14 974 | 14 062 |
| Qld | 121 786 | 93 450 | 73 492 | 47 525 |
| SA | 42 483 | 28 528 | 27 247 | 26 605 |
| WA | 68 182 | 44 978 | 49 386 | 44 010 |
| Tas. | 9 435 | 7 993 | 5 813 | 5 354 |
| NT | 39 699 | 25 510 | 27 081 | 2 5568 |
| Australia | 383 982 | 285 357 | 242 638 | 203 124 |

The results of each of the four options with cumulative expenditures against benefit–cost ratios, using a 7 per cent discount rate, for the total of all States are plotted in figure 5.1.

These findings were considered and some of the issues are listed below:

- Option A, which was based on a pavement reconstruction approach, resulted in high average roughness combined with a high average annual expenditure requirement ($384 million). Because of this, option A was considered as a benchmark figure only.

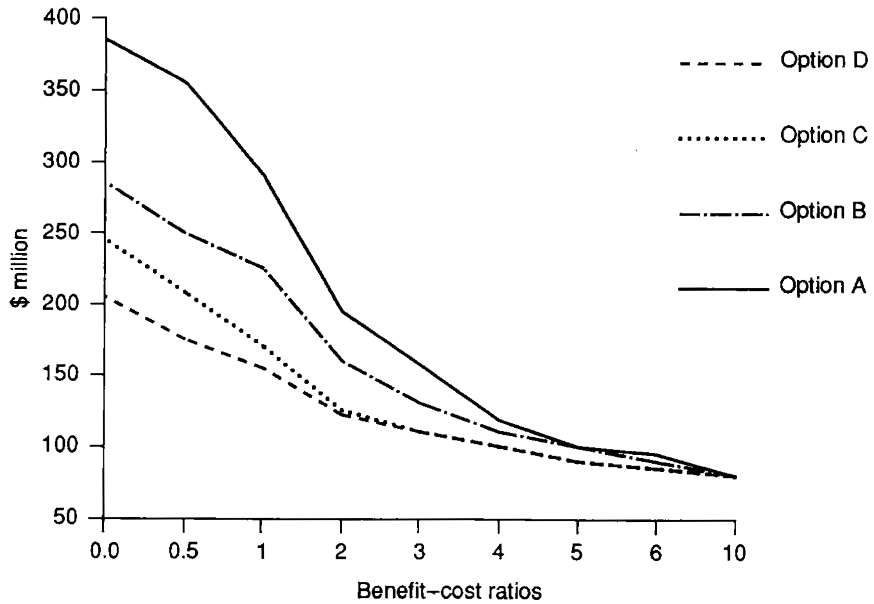



**Figure 5.1 Benefit–cost ratios plotted against cumulative expenditure on the national highway system**

TABLE 5.2 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE REQUIREMENT FOR OPTION C

*($'000 in 1990–91 prices)*

| *State or Territory* | *Routine maintenance* | *Intervention* | *Total* |
|---|---|---|---|
| NSW | 13 516 | 31130 | 44 645 |
| Vic. | 4 934 | 10 040 | 14 974 |
| Qld | 17 055 | 56 437 | 73 492 |
| SA | 11 640 | 15 607 | 27 247 |
| WA | 19 301 | 30 085 | 49 386 |
| Tas. | 1 927 | 3 886 | 5 813 |
| NT | 11 654 | 15 427 | 27 081 |
| Australia | 80 027 | 162 611 | 242 638 |

- Option B with the use of reseals is an improvement over option A as it mirrors current practice, and was able to maintain the national highway pavements at a lower cost than option A and was therefore preferable.
- Option C, which used a 50-millimetre overlay providing the pavement was in reasonable condition, otherwise reconstruction was used, provided lower costs and reduced vehicle operating costs than either of the above options. Option C also gave a lower level of reconstruction projects, and costs, than option B.
- Option D which involved 50-millimetre overlays as the only response, at the timings related to the traffic, irrespective of the condition of the pavement, provided the lowest cost option, but was considered to be an unrealistic possibility as many pavements require a more significant treatment than just an asphalt overlay.

For those reasons option C was selected as the base case for further assessment.

The results for each State for both routine and intervention maintenance for option C, irrespective of the benefit costs ratios of the projects, are presented in table 5.2.

## ECONOMIC EVALUATION

The remainder of this chapter examines the results of the economic evaluation of the benefits and costs associated with maintenance of the national highway system. As noted earlier the evaluation was undertaken using the life cycle costing computer model. Because of the importance of the choice of a discount rate for economic evaluation some aspects of this issue are discussed below.

TABLE 5.3 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE LEVELS AT 7 PER CENT DISCOUNT RATE FOR OPTION C
*($ million)*

| *State or Territory* | *All* | *BCR >1* | *BCR > 3* | *BCR > 5* | *BCR >10* |
|---|---|---|---|---|---|
| NSW | 44.6 | 41.6 | 25.1 | 19.1 | 13.9 |
| Vic. | 15.0 | 15.0 | 10.2 | 6.6 | 5.0 |
| Qld | 73.5 | 47.5 | 24.8 | 18.6 | 18.3 |
| SA | 27.2 | 19.5 | 12.0 | 11.7 | 11.6 |
| WA | 49.4 | 26.9 | 20.2 | 20.2 | 19.5 |
| Tas. | 5.8 | 5.3 | 3.1 | 2.2 | 2.0 |
| NT | 27.1 | 13.8 | 12.1 | 12.1 | 12.1 |
| ACT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Australia | 242.6 | 169.7 | 107.5 | 90.4 | 82.4 |

BCR Benefit–cost ratio.
*Note* Owing to rounding, figures may not add to totals.

## Choice of the discount rate

The discount rate is used as a means for comparing the alternative uses for funds, and some of the issues involved are discussed in BTCE (1990). Projects having differing time-stream profiles of costs and benefits can be compared through the use of discounting to determine their present worth. The selection of an appropriate discount rate for public sector projects in the absence of suitable private sector comparisons is discussed in Department of Finance (1990). In that paper the Department of Finance recommends the use of a benchmark discount rate of 10 per cent in real terms and that sensitivity testing be carried out. When this work was undertaken, the Department of Finance advocated the use of 7 per cent (real) as the benchmark. For these reasons all analysis in this report has been undertaken at 4, 7 and 10 per cent discount rates. The recent revision by the Department of Finance of the appropriate real discount rate to 8 per cent was not incorporated into the analysis.

Firstly using a 7 per cent discount rate, table 5.3 shows the total of the routine maintenance and the intervention maintenance for Australian national highways at various benefit–cost ratio cut-off levels using option C.

Figures 5.2 and 5.3 present the distribution of benefit–cost ratios for option C for all States at a 7 per cent real discount rate.

Sensitivity testing using 4 per cent and 10 per cent were also undertaken and the results are shown in tables 5.4 and 5.5, which have the same format as table 5.3 which used a 7 per cent discount rate.

## Impact of a change in the discount rate

A comparison of tables 5.3, 5.4 and 5.5 indicates that as the discount rate increases the number and the total annual cost of projects with a benefit–cost

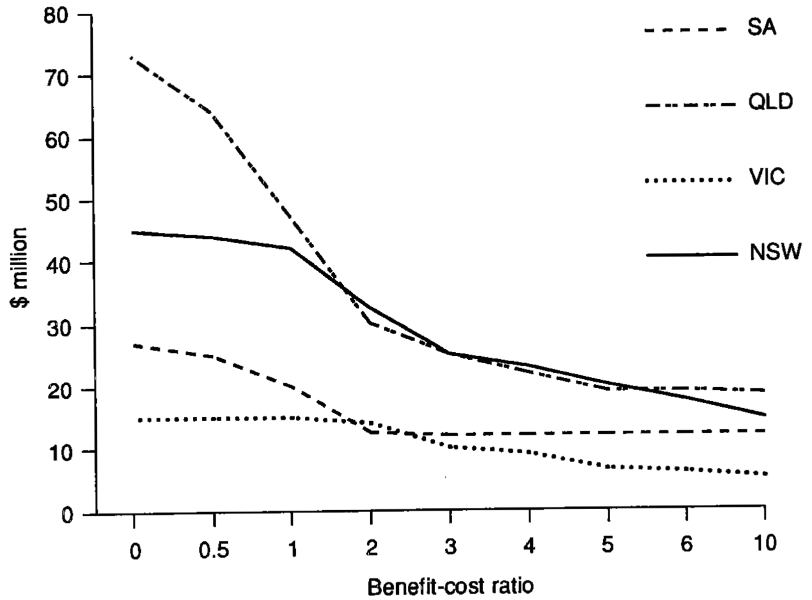



**Figure 5.2 Benefit–cost rations plotted against cumulative expenditure for New South Wales, Victoria, Queensland, and South Australia for option C**

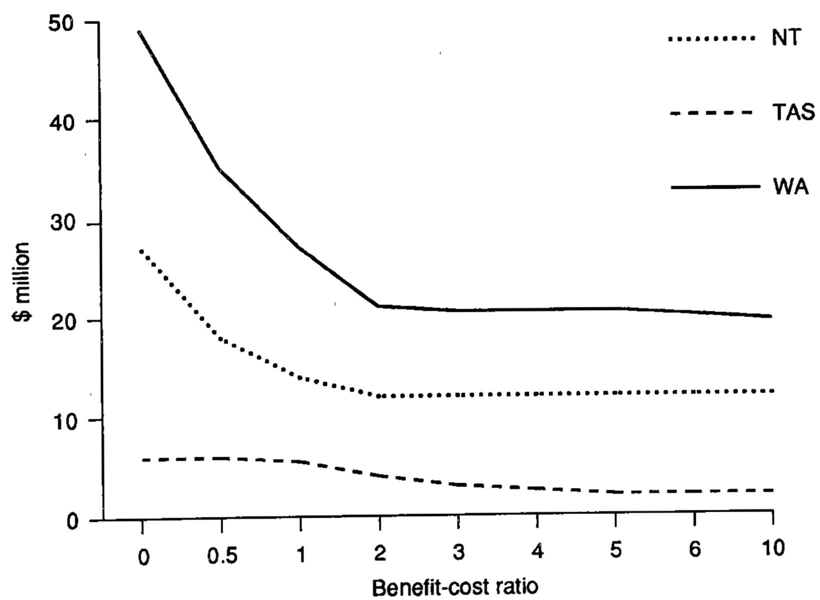



**Figure 5.3 Benefit–cost ratios plotted against cumulative expenditure for Western Australia, Tasmania and Northern Territory**

TABLE 5.4 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE LEVELS AT 4 PER CENT DISCOUNT RATE FOR OPTION C
*($ million )*

| *State or Territory* | *All* | *BCR > 1* | *BCR > 3* | *BCR > 5* | *BCR > 10* |
|---|---|---|---|---|---|
| NSW | 44.6 | 42.0 | 26.7 | 20.2 | 14.5 |
| Vic. | 15.0 | 15.0 | 12.4 | 9.2 | 5.4 |
| Qld | 73.5 | 52.7 | 26.9 | 20.6 | 17.1 |
| SA | 27.2 | 21.0 | 12.8 | 12.3 | 12.2 |
| WA | 49.4 | 28.8 | 20.4 | 20.0 | 19.3 |
| Tas. | 5.8 | 5.5 | 3.4 | 2.4 | 1.9 |
| NT | 27.1 | 14.7 | 12.1 | 12.1 | 12.1 |
| Australia | 242.6 | 179.7 | 114.7 | 96.8 | 82.5 |

BCR Benefit–cost ratio.
*Note* Owing to rounding, figures may not add to totals.

TABLE 5.5 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE LEVELS AT 10 PER CENT DISCOUNT RATE FOR OPTION C
*($ million)*

| *State or Territory* | *All* | *BCR >1* | *BCR > 3* | *BCR > 5* | *BCR > 10* |
|---|---|---|---|---|---|
| NSW | 44.6 | 40.2 | 23.2 | 16.5 | 13.8 |
| Vic. | 15.0 | 15.0 | 9.3 | 5.7 | 5.1 |
| Qld | 73.5 | 43.2 | 21.2 | 17.3 | 17.1 |
| SA | 27.2 | 17.9 | 12.2 | 11.9 | 11.9 |
| WA | 49.4 | 25.3 | 20.0 | 19.7 | 19.3 |
| Tas. | 5.3 | 4.9 | 2.7 | 2.0 | 2.0 |
| NT | 27.1 | 13.3 | 12.0 | 12.0 | 11.9 |
| Australia | 242.6 | 159.9 | 100.2 | 85.1 | 81.0 |

*Note* Owing to rounding, figures may not add to totals.

ratio greater than 1, decreases. The reason for this is that as the discount rate increases the discounted project benefits, particularly in later years, are reduced. It is significant that as the discount rate reduces, a greater proportion of expenditure occurs in the States with the low traffic volumes. With high discount rates more funds need to be directed to high traffic roads which tend to have higher benefits to costs. This change in distribution between the States, after a change in discount rates for projects with benefit–cost ratio greater than 0.5, is shown in figure 5.4. The figure shows the percentage of the total available expenditure that would be allocated to each State for all projects with a benefit–cost ratio greater than 0.5 using discount rates of 4, 7 and 10 per cent.

All the remaining assessments presented in this report use the 7 per cent real discount rate, with option C as the base case.

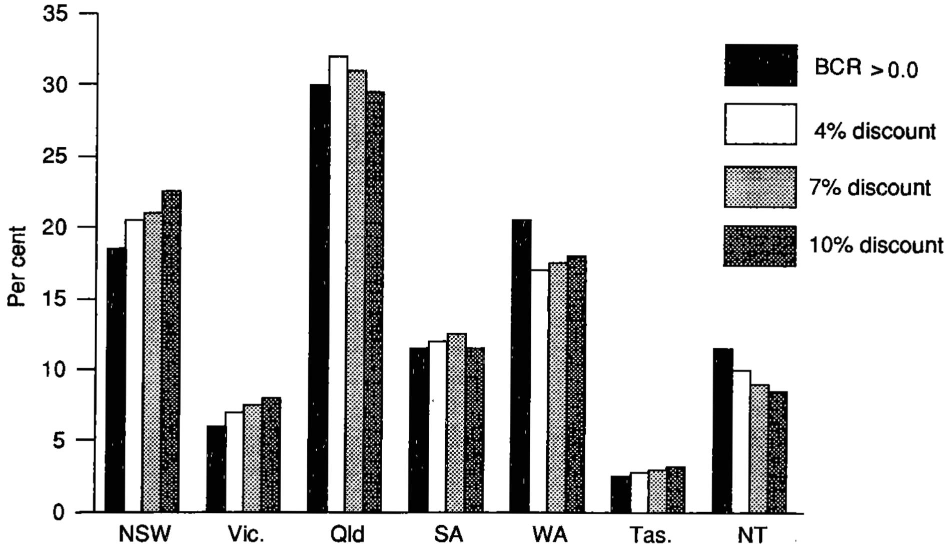



**Figure 5.4 Distribution of expenditure between States with different discount rates with project benefit–costs ratios greater than 0.5 for option C**

Further information on the location of the national highway system maintenance works and the expected funding, for option C for all projects, irrespective of their benefit–cost ratio, is shown for each ACRD Condition Federal Reporting Link in table 5.6. It must be stressed that this report presents a strategic overview of the national highway maintenance requirements and there may be modifications required for projects, as determined by local conditions.

## Structures

The cost of maintaining bridges, including grade-separated overpasses, on the Australian national highway system was included on the following basis. Concrete bridges are normally expected to have a life expectancy of at least 60 to 100 years and are generally widened, or replaced due to road realignments, rather than needing to be rebuilt. Bridges tend to require small amounts of routine maintenance typically limited to work on the expansion joints. Bridges which incorporate steel trusses or girders will require repainting. Table 4.7 of this report provided an estimate of the number of bridges and major culverts in each State. Using a 60-year replacement cycle and an average width of 8.5 metres, length of 35 metres and a construction cost of $1 400 per square metre, an approximate average annual cost of maintenance is presented in table 5.7.

The above analysis has shown that the total annual maintenance requirement for bridges on the national highway system is approximately $10 million per annum, with nearly 80 per cent required in the three mainland eastern States. Maintenance to restore a closed bridge must be given highest priority because of the strategic

TABLE 5.6 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE REQUIREMENT FOR EACH ACRD LINK
*($'000 in 1990–91 prices)*

| | *ACRD Link no.* | *Routine maintenance* | *Intervention maintenance* | *Total* |
|---|---|---|---|---|
| *New South Wales* | | | | |
| Liverpool–Marulan | 1 | 2 676 | 5 477 | 8 154 |
| Marulan– Snowy Mts Hwy | 2 | 1 993 | 5 712 | 7 705 |
| Snowy Mts Hwy–Vic. border | 3 | 1 973 | 3 852 | 5 825 |
| Hornsby–Minmi | 4 | 1 508 | 2 981 | 4 489 |
| Wallarah Ck–Swansea | 5 | 384 | 1 024 | 1 408 |
| Newcastle–Aberdeen | 6 | 990 | 2 326 | 3 316 |
| Aberdeen–Armidale | 7 | 1 945 | 4 760 | 6 705 |
| Armidale–Qld border | 8 | 1 084 | 2 443 | 3 527 |
| Federal Hwy | 9 | 703 | 1 778 | 2 481 |
| Barton Hwy | 10 | 257 | 778 | 1 036 |
| Total | | 13 516 | 31 130 | 44 645 |
| *Victoria* | | | | |
| Melbourne–Seymour | 1 | 885 | 1 704 | 2 589 |
| Seymour–NSW border | 2 | 1 634 | 3 026 | 4 660 |
| Melbourne–Ballarat | 3 | 872 | 1 774 | 2 646 |
| Ballarat–SA border | 4 | 1 543 | 3 537 | 5 079 |
| Total | | 4 934 | 10 040 | 14 974 |
| *Queensland* | | | | |
| Brisbane–Gympie | 1 | 1 212 | 2 476 | 3 688 |
| Gympie–Rockhampton | 2 | 2 084 | 4 641 | 6 725 |
| Rockhampton–Townsville | 3 | 3 148 | 7 480 | 10 628 |
| Townsville–Cairns | 4 | 1 502 | 6 184 | 7 686 |
| Ipswich–NSW border | 5 | 1 112 | 3 344 | 4 457 |
| Ipswich–Toowoomba | 6 | 686 | 1 329 | 2 016 |
| Toowoomba–Roma | 7 | 1 390 | 7 532 | 8 922 |
| Roma–Morven | 8 | 649 | 3 552 | 4 200 |
| Morven–Barcaldine | 9 | 1 657 | 5 036 | 6 693 |
| Barcaldine–Cloncurry | 10 | 2 511 | 9 110 | 11 621 |
| Cloncurry–NT Border | 11 | 1 103 | 5 752 | 6 856 |
| Total | | 17 055 | 56 437 | 73 492 |
| *South Australia* | | | | |
| Adelaide–Tailem Bend | 1 | 880 | 1 658 | 2 538 |
| Tailem Bend–Vic. border | 2 | 996 | 1 733 | 2 729 |
| Adelaide–Port Augusta | 3 | 1 687 | 2 722 | 4 409 |
| Port Augusta–Ceduna | 4 | 1 804 | 2 376 | 4 180 |
| Ceduna–WA border | 5 | 1 938 | 1 999 | 3 938 |
| Port Augusta–NT border | 6 | 4 335 | 5 119 | 9 453 |
| Total | | 11 640 | 15 607 | 27 247 |
| *Western Australia* | | | | |
| Perth–Northam | 1 | 340 | 748 | 1 088 |
| Northam–Southern Cross | 2 | 1 140 | 2 346 | 3 486 |
| Southern Cross–Norseman | 3 | 1 546 | 3 130 | 4 676 |
| Norseman–SA border | 4 | 3 090 | 4 576 | 7 666 |
| Perth–Wubin | 5 | 982 | 2 229 | 3 211 |

TABLE 5.6 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE REQUIREMENT FOR EACH ACRD LINK (Cont.)
*($'000 in 1990–91 prices)*

| | *ACRD Link no.* | *Routine maintenance* | *Intervention maintenance* | *Total* |
|---|---|---|---|---|
| Wubin–Meekatharra | 6 | 1 771 | 2 284 | 4 054 |
| Meekatharra–Port Hedland | 7 | 3 647 | 4 073 | 7 720 |
| Port Hedland–Broome turn-off | 8 | 2 646 | 4 076 | 6 722 |
| Broome turn-off–Fitzroy Cr | 9 | 1 281 | 2 092 | 3 373 |
| Fitzroy Cr–Halls Ck | 10 | 1 541 | 2 429 | 3 970 |
| Halls Ck–NT border | 11 | 1 318 | 2 103 | 3 421 |
| Total | | 19 301 | 30 085 | 49 386 |
| *Tasmania* | | | | |
| Hobart–Launceston | 1 | 1 023 | 2 112 | 3 135 |
| Launceston–Devonport | 2 | 512 | 1 033 | 1 545 |
| Devonport–Burnie | 3 | 392 | 741 | 1 133 |
| Total | | 1 927 | 3 886 | 5 813 |
| *Northern Territory* | | | | |
| Darwin–Katherine | 1 | 1 377 | 2 249 | 3 626 |
| Katherine–Alice Springs | 2 | 5 367 | 5 326 | 11 899 |
| Alice Springs–SA border | 3 | 1 205 | 1 632 | 2 838 |
| Katherine–WA border | 4 | 1 687 | 2 445 | 4 132 |
| Tennant Creek–Qld border | 5 | 2 017 | 2 569 | 4 586 |
| Total | | 11 654 | 15 427 | 27 081 |

*Source* BTCE computation.

TABLE 5.7 ANNUAL COST OF MAINTAINING BRIDGES ON THE AUSTRALIAN NATIONAL HIGHWAY SYSTEM

| *State or Territory* | *Bridges (no.)* | *Replacement cost ($ million)* | *Total annual cost ($'000)* |
|---|---|---|---|
| NSW | 399 | 166 | 2 769 |
| Vic. | 174 | 72 | 1 208 |
| Qld | 521 | 217 | 3 617 |
| SA | 70 | 29 | 486 |
| WA | 77 | 32 | 535 |
| Tas. | 61 | 25 | 423 |
| NT | 92 | 38 | 639 |
| Australia | 1 397 | 582 | 9 698 |

*Note* Refer to table 4.7.

nature of bridges in the system. Bridge maintenance therefore represents approximately 4 per cent of the asset maintenance figures presented in this report.

# CHAPTER 6 THE IMPACT OF VARIOUS FUNDING LEVELS

The level of funds available for road authorities is often predetermined and outside their immediate control. In turn the proportion of those funds which they can make available for road maintenance activities will depend on relativities between maintenance, construction, administration, road safety, road operation and bridge activities.

When facing constrained budgets, road authorities are able to further adjust maintenance expenditure patterns by:

- modifying technical, engineering or performance standards for both road construction and maintenance;
- improving the efficiency of their operations;
- redirecting funds to differing geographic areas; and/or
- changing construction and maintenance activity commencement or duration.

Each of these options will have long-term implications and road authorities are able to evaluate possible outcomes. In this study the Bureau has examined the implications of various funding levels and presented the results using three major measures. These measures are:

- economic efficiency;
- the pavement roughness; and
- the achievement of the national highway objectives.

Economic evaluation is a key input into the process of allocation of resources to provide value for money for the community and therefore it is the basis used in this study for the apportionment of funding. It is also useful to show the possible change in pavement quality or roughness, which is an indicator comprehended by road users, who know that with deteriorating pavement roughness there will be an increase in their vehicle operating costs and a decrease in their driving comfort. Road authorities also use roughness as a measure of how the pavement is deteriorating and an indicator of the need for work required on the pavement.

This report presents information on the ability to achieve national highway objectives at various funding levels. The Bureau's economic evaluation was undertaken using the life cycle costing methodology, with benefits based on vehicle operating cost savings. This has been detailed previously. There are other benefits obtainable from road maintenance and upgrading, which include travel time savings and safety improvements as well as non-quantifiable benefits relating to access, the environment and social improvements. Because there has been limited research into the impact of road maintenance on these factors, vehicle operating cost savings were the only benefits quantified. The inclusion of other benefits would raise the benefit–cost ratio obtained for each section. Any comparison with other benefit–cost ratios obtained using other methodologies will need to take account of the benefits used in those studies.

This study has accepted that routine maintenance would be funded for all 16 045 kilometres of the national highway system. Without routine maintenance the pavement could deteriorate quickly and become a safety hazard. Whilst it is difficult to evaluate routine maintenance activities, it is accepted that there are worthwhile benefits in preserving the integrity of the national highway pavement structure. This report focuses on the remaining maintenance activities (reseals, overlays and reconstructions, which were defined previously as intervention maintenance), which are the major maintenance expenditure categories and have considerable implications for the pavement roughness and its condition and also for road users and their vehicles.

## ANALYSIS OF MAINTENANCE FUNDING

The analysis reported in this chapter examines the impact on average road roughness in each State, the percentage of length involved and the percentage of vehicle-kilometres of travel (VKT) affected if project funding is based entirely on benefit–cost ratio order. Table 6.1 details the consequence on average roughness of selecting particular funding levels. This table is based on the funding levels set out in table 5.3, which shows the impact of funding projects with the highest economic returns. Table 6.1 also shows how the pavement roughness would deteriorate at each reduced funding level and also shows the percentage length of highway affected and percentage of the State's VKT involved. This means that if funds are distributed in accordance with economic merit, as the funding availability reduces it will generally be the low volume sections of the highway which will have funding cuts. These sections make up the highest proportion of the length, but carry a smaller percentage of the traffic volume.

Using economic merit as the basis for funding, the results presented in table 6.1 show how States with lower traffic volumes and lower economic benefits are affected by reduced funding levels. If the level of funding was reduced from $243 million to $207 million annually, only those projects with a benefit–cost ratio greater than 0.5 would be undertaken, and hence most of the reduction would be in Queensland, South Australia, Western Australia and the Northern Territory. The length for which only routine maintenance would occur would be 5 700 kilometres with the vehicle-kilometres of travel equal to 5 per cent of the total national highway travel. This means that funding would be directed to 64 per cent of the length which carries 95 per cent of the traffic.

If the level of funding was further reduced to $170 million, only those projects with a benefit–cost ratio greater than 1.0 would be included and hence the length

TABLE 6.1 IMPLICATIONS OF VARIOUS FUNDING LEVELS

| *State or Territory* | *Total expenditure:* *Benefit–cost ratio cut-off:* | *$242.63 million* *All* | *$207.00 million* *0.5+* | *$169.70 million* *1+* |
|---|---|---|---|---|
| *NSW* | | | | |
| Roughness[a] | | 64.20 | 64.67 | 68.09 |
| Length per cent[b] | | 0.00 | 2.00 | 15.60 |
| VKT per cent[c] | | 0.00 | 1.28 | 7.60 |
| *Vic.* | | | | |
| Roughness | | 62.15 | 62.15 | 62.15 |
| Length per cent | | 0.00 | 0.00 | 0.00 |
| VKT per cent | | 0.00 | 0.00 | 0.00 |
| *Qld* | | | | |
| Roughness | | 66.80 | 68.07 | 71.80 |
| Length per cent | | 0.00 | 19.10 | 44.04 |
| VKT per cent | | 0.00 | 2.19 | 8.66 |
| *SA* | | | | |
| Roughness | | 62.26 | 64.29 | 72.77 |
| Length per cent | | 0.00 | 21.50 | 59.53 |
| VKT per cent | | 0.00 | 4.63 | 22.67 |
| *WA* | | | | |
| *Roughness* | | *66.82* | *83.02* | *97.72* |
| *Length per cent* | | *0.00* | *57.20* | *84.04* |
| *VKT per cent* | | *0.00* | *34.18* | *59.52* |
| *Tas.* | | | | |
| *Roughness* | | *63.11* | *63.54* | *68.34* |
| *Length per cent* | | *0.00* | *0.07* | *9.95* |
| *VKT per cent* | | *0.00* | *0.36* | *8.72* |
| *NT* | | | | |
| Roughness | | 64.79 | 84.79 | 101.89 |
| Length per cent | | 0.00 | 66.70 | 92.43 |
| VKT per cent | | 0.00 | 31.49 | 73.00 |
| *Australia* | | | | |
| Roughness | | 64.59 | 67.04 | 71.74 |
| Length per cent | | 0.00 | 35.80 | 61.04 |
| VKT per cent | | 0.00 | 5.07 | 13.75 |
| Total expenditure | | 242.63 | 207.00 | 169.70 |
| At benefit–cost ratio | | All | 0.5+ | 1+ |

a. Steady-state roughness weighted by vehicle-kilometres of travel.

b. Percentage of the length of the national highway system in that State which would receive only routine maintenance.

c. Percentage of the vehicle-kilometres of travel in that State using sections which would receive only routine mainenance.

unfunded would be 9 800 kilometres, which would involve about 14 per cent of the vehicle-kilometres of travel on the national highway system. This means that funding would be directed to 39 per cent of the length which carries 86 per cent of the traffic.

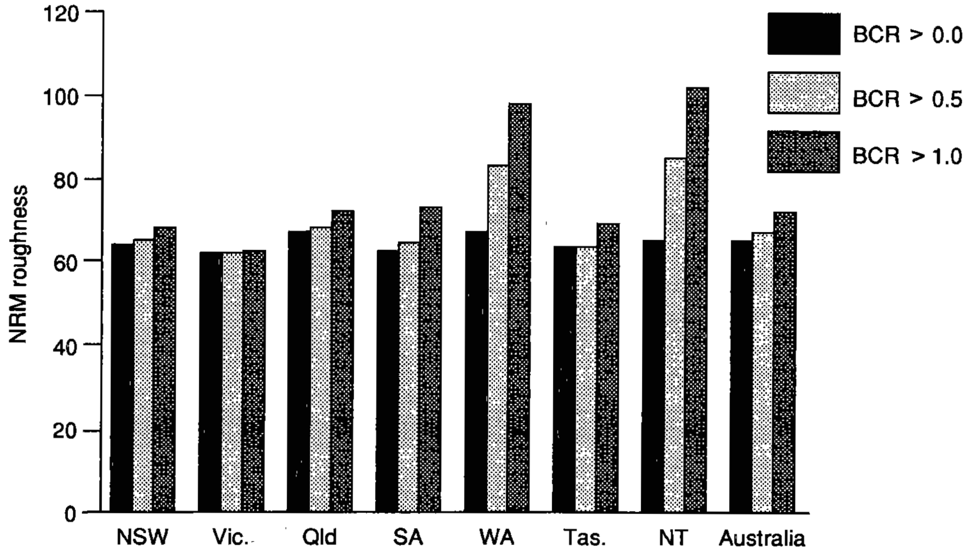



**Figure 6.1 Change in average pavement roughness with reduced funding levels — based on a vehicle-kilometres of travel weighted average for option C**

## The implications of varying maintenance standards

The analysis showed that using the same standards for maintenance on all sections of the national highway system was not a desirable option. The national highway traffic varies from over 50 000 vehicles per day near Sydney, to less than 100 in western Queensland and in the north of Western Australia. When the same standard of roughness was used as the indicator for the need to reconstruct, the very low traffic sections gave low benefits to costs, relative to the high traffic sections. For these reasons, the maintenance standard, based on pavement roughness, was progressively varied for all sections relative to the traffic and costs to maximise the benefits. This was discussed in chapter 2. If overlays were not able to correct roughness problems, there was a maximum level of roughness where reconstruction work had to be carried out. The absolute maximum permitted roughness was set at NAASRA 180 for all sections irrespective of the traffic. Whilst this was an engineering judgment, based on providing a reasonable level of comfort, it may be possible, for the very low traffic sections, to further increase this limit. Subsequent studies of vehicle operating cost savings resulting from maintenance work on these low volume sections would be warranted.

The Australian national highway system was developed and constructed to fulfil objectives that were not necessarily of an economic nature. Many kilometres of low traffic volume lengths have recently been sealed and this has now completed the sealing of all of the national highway system. Many of these sections have low benefits measured in savings in travel time, vehicle operating costs and safety, relative to the costs. Therefore careful consideration must be given to any move to reduce the pavement maintenance which will lead to higher pavement roughness.

Using varying standards to maximise benefits relative to costs, the change in average roughness for each State is plotted in figure 6.1. In interpreting this it can be seen that there is no change in average roughness in Victoria. The reason for this is that Victoria has higher economic warrants, with all projects having a benefit–cost ratio greater than 1.0, which means no change in the allocation of funds in Victoria would be carried out, and therefore no reduction in roughness would occur.

## COMPARISON WITH CURRENT FUNDING

Table 6.2 consolidates the details presented in table 5.2 for all maintenance projects irrespective of the benefit–cost ratio, and highlights the results of this study as compared with the current total national highway funding allocation presented in table 3.2 for all projects.

Table 6.2 indicates that the total national highway maintenance expenditure required ($243 million) is 44 per cent of the total 1990–91 national highway allocation ($556 million). The table also indicates how a higher proportion of the total allocation is required for maintenance works in those States with the lower traffic volumes and long lengths of national highway. The analysis presented in table 5.3 provides information as to the way in which maintenance funds would be distributed to the States with funding allocated to projects with higher benefit–cost ratios. The results of this work show that, with the current allocation of funds, all States are able to maintain their national highway pavements to current standards.

TABLE 6.2 TOTAL ANNUAL NATIONAL HIGHWAY SYSTEM MAINTENANCE REQUIREMENT

*(1990–91 prices)*

| *State or Territory* | *Routine maintenance ($'000)* | *Intervention ($'000)* | *Total of ($'000)* | *Total construction and maintenance allocation (per cent)* |
|---|---|---|---|---|
| NSW | 13 516 | 31 130 | 44 645 | 20 |
| Vic. | 4 934 | 10 040 | 14 974 | 23 |
| Qld | 17 055 | 56 437 | 73 492 | 57 |
| SA | 11 640 | 15 607 | 27 247 | 77 |
| WA | 19 301 | 30 085 | 49 386 | 92 |
| Tas. | 1 927 | 3 886 | 5 813 | 29 |
| NT | 11 654 | 15 427 | 27 081 | 90 |
| Australia | 80 027 | 162 611 | 242 638 | 44 |

*Note* Excluding annual bridge maintenance costs of $10 million; refer to table 5.7.

*Source* Tables 3.2 and 5.2.

The maintenance expenditure requirement determined in this study can be compared with actual routine maintenance expenditures, shown in table 3.3 and the previous Bureau study (BTE 1987), with those results summarised in table 3.4. Table 3.3 shows that routine maintenance has been historically 14 to 20 per cent of the total national highway expenditure. This study has shown that routine maintenance (table 6.2) is 15 per cent of the allocation shown in table 3.1. Because the historical expenditures by State road authorities on national highway reseals, overlays and reconstructions are difficult to obtain, the figures obtained in this study can be compared with Bureau figures in table 3.4. Table 3.4 indicates that the estimated cost of the preservation of the physical asset would be $176 million in 1990–91 prices, and table 6.2 indicates that the requirement from this study would be $163 million. If the annual bridge maintenance cost of $10 million is added to the figures from table 6.2 the totals are very similar.

As discussed earlier, a distribution of funds based on economic criteria for the maintenance levels for Australia's national highway system may result in increasing average pavement roughness levels and pavement deterioration in some States, particularly those with longer lengths and lower traffic volumes. In a wider context, this may result in a better use of road funds. It is important that national highway funding is continually monitored as the traffic and road conditions change, to maximise the total economic benefits.

It is also important to reiterate that the national highway system was conceived and developed as a road network to link and unite the Australian nation. In this respect the national highway system is different from other roads whose links may be evaluated in isolation. The sealing of the pavement around the nation has only recently been completed. Whilst there can be some variation in the standards for the alignment, construction and maintenance, the impact of any potential reduction of maintenance activity must be reviewed in the context of that original vision for the network.

## EXPENDITURE PROFILE

The study also investigated whether there is likely to be any period in the future when there may be higher than normal maintenance expenditure requirements. Figure 6.2 shows the yearly expenditure (based on a five-year average) required for routine and intervention maintenance. The maintenance requirement is $243 million per year, but between the years 2006 and 2010 the annual requirement is forecast to peak at $324 million. Many of these pavements would have been constructed in the 1970s and with a 30- to 40-year life will require higher maintenance.

As detailed in chapter 2, the maintenance level defined in this report covers the preservation of the existing asset under current and projected future traffic. Construction or upgrading expenditures may be required to maintain or raise the operational characteristics or the level of service of the road due to traffic growth or other factors. This will be the subject of a further study.

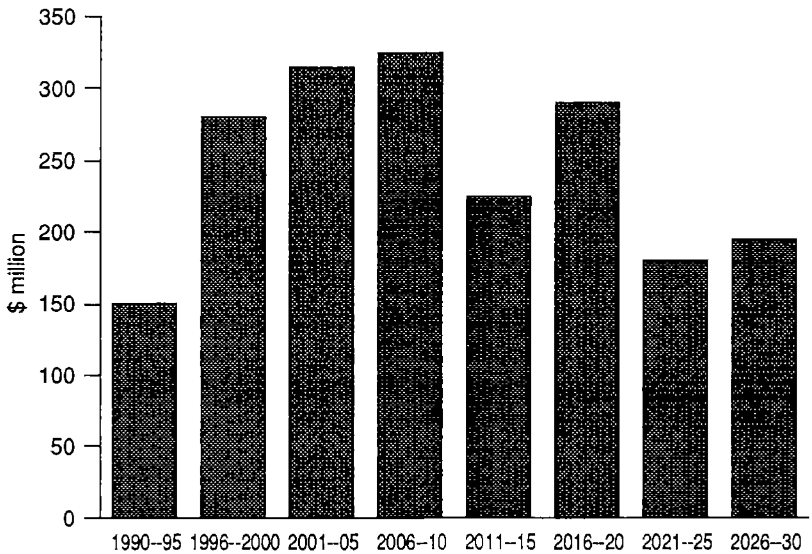



**Figure 6.2 Annual expenditure profile for the period 1990–2030 for option C**

## OBJECTIVES AND FUNDING LEVELS

As discussed in chapter 2, the national highway system was established to assist:

- interstate and overseas trade;
- regional industry;
- in the movement of primary products;
- recreation and tourism; and
- defence.

It is difficult to precisely quantify the long-term impact of maintenance works on the attainment of the stated objectives of the national highway system. This report has concluded that the cost of all routine maintenance, reseals, overlays and reconstructions on the national highway is $243 million per year. If the maintenance allocation is less than $243 million this will have an impact on the achievement of the objectives. If funding for national highway maintenance is determined by economic merit, the implications for the achievement of objectives are assessed below.

The following analysis is based on the numbers of cars and trucks using each section of the highway and an estimation of the trip purposes. Because it is important to understand the requirements of the user, the Bureau will investigate further the impact of maintenance changes on commodity flows and road user and community groups.

**With maintenance funded at $207 million annually**

This is the funding level ($207 million) required to provide routine maintenance, reseals, overlays and pavement reconstructions to all national highway sections with benefit–cost ratios greater than 0.5.

At this funding level any reduction in the quality of the national highway system pavement roughness would be expected to have limited impact on Australia's *interstate and overseas trade* as there are relatively small numbers of commercial vehicles servicing interstate and overseas trade traversing sections of the road likely to face a decline in funding.

At this funding level, in the short term, *regional industries* located near those sections of the national highway system affected would be slightly influenced as vehicle operating costs would start to increase with the older pavements deteriorating, particularly beyond the year 2000.

The *movement of primary products* would be unlikely to be affected as many of these freight movements are either by rail or use non-national highways.

Recreation and tourism in the north and north-west would start to be slightly affected as coach travel would be less comfortable on some sections of rougher roads.

Defence implications would be negligible at this funding level.

**With maintenance funded at $170 million annually**

At this funding level (funding only projects with a benefit–cost ratio greater than 1) transport associated with *interstate and overseas trade* and *regional industries* would be influenced only slightly as most of the heavy industrial movements are in the south-east of Australia, where benefit–cost ratios are higher, with funding little changed. There could be longer term problems for Australia if the national highways were permitted to deteriorate in the more heavily trafficked areas.

The *movement of primary products* would be only slightly affected in the short or medium term at this funding level.

Recreation and tourism would be affected particularly in Western Australia and Queensland; coach travel over these roads would become uncomfortable and the maintenance levels on long distance coaches travelling on these roads would start to increase significantly.

Defence movements would be unlikely to be influenced at this funding level, but there would be some increase in transport costs between defence supply and storage locations owing to increased vehicle operating costs.

Even though this study has used a time horizon of 40 years the maintenance requirements and priorities for the national highway system will change as sections of the road deteriorate and losses to society increase through added vehicle operating costs, travel time and other costs. For this reason it is important to continuously reassess national highway maintenance.

## CONCLUSION

The above results have shown that there are potential transport efficiency gains obtainable from the appropriate level and timing of national highway maintenance expenditure. These gains measured in vehicle operating cost savings alone can easily exceed the expenditure outlays. As well as these savings, road maintenance will usually result in reductions in road user travel times and improvements in road safety.

The Bureau estimates that $243 million (in 1990–91 prices) per annum will be needed to maintain the national highway pavement at current roughness. There will be an extra annual costs for bridges ($10 million) and operational costs including lighting. There is likely to be an increased maintenance need in the early part of the next century as many of the pavements which were constructed in the 1970s and 1980s will require major rehabilitation work. The analysis shows that the maintenance requirements are forecast to peak at $324 million in the years 2006 to 2010.

The current study considered only maintenance of the existing pavement. A further Bureau study will be undertaken to complement the work presented in this report and examine both maintenance and construction activities on the Australian national highway system. It will examine the impact for road users, commodity flows and the wider impacts for society due to the multiplier effects of national highway expenditure.

In terms of road expenditure, the analysis has shown that adequate and well planned maintenance of our national highway system represents a worthwhile expenditure with high economic and social returns.

# APPENDIX I STATISTICS FOR THE AUSTRALIAN NATIONAL HIGHWAY SYSTEM

The following table which is an expansion of table 4.1, presents the lengths of the national highway, the average traffic volume and truck traffic by ACRD Condition Reporting Links.

TABLE I.1 NATIONAL HIGHWAY ROAD LENGTHS AND TRAFFIC VOLUMES BY ACRD CONDITION REPORTING LINKS

| *State or Territory* | *ACRD Link no.* | *One-lane[a] (km)* | *Multi-lane (km)* | *Divided (km)* | *Total (km)* | *Mean total vehicle AADT[b]* | *Mean commercial vehicle AADT* |
|---|---|---|---|---|---|---|---|
| *New South Wales* | | | | | | | |
| Liverpool–Marulan | 1 | – | 15 | 144 | 159 | 19 562 | 5 086 |
| Marulan–Snowy Mts Hwy | 2 | – | 127 | 73 | 200 | 9 536 | 2 479 |
| Snowy Mts Hwy–Vic. border | 3 | – | 114 | 67 | 181 | 6 430 | 1 672 |
| Hornsby–Minmi | 4 | – | – | 85 | 85 | 28 836 | 3 573 |
| Wallarah Creek–Swansea | 5 | – | 42 | – | 42 | 16 327 | 2 122 |
| Newcastle–Aberdeen | 6 | – | 100 | 8 | 108 | 15 317 | 2 533 |
| Aberdeen–Armidale | 7 | – | 248 | 9 | 257 | 4 903 | 818 |
| Armidale–Qld border | 8 | – | 209 | – | 209 | 3 754 | 488 |
| Federal Hwy | 9 | – | 30 | 37 | 67 | 8 592 | 773 |
| Barton Hwy | 10 | – | 37 | – | 37 | 5 528 | 718 |
| Total | | – | 921 | 423 | 1 343 | 10 172[c] | 1 952[c] |
| *Victoria* | | | | | | | |
| Melbourne–Seymour | 1 | – | 3 | 89 | 91 | 20 810 | 3 730 |
| Seymour–NSW border | 2 | – | 68 | 135 | 203 | 9 163 | 3 018 |
| Melbourne–Ballarat | 3 | – | 2 | 91 | 94 | 15 257 | 2 392 |
| Ballarat–SA border | 4 | – | 317 | 4 | 321 | 4 060 | 1 185 |
| Total | | – | 390 | 319 | 709 | 9 154[c] | 2 196[c] |
| *Queensland* | | | | | | | |
| Brisbane–Gympie | 1 | – | 65 | 99 | 163 | 18 080 | 2 055 |
| Gympie–Rockhampton | 2 | – | 464 | 5 | 468 | 3 133 | 483 |
| Rockhampton–Townsville | 3 | – | 703 | 13 | 715 | 3 075 | 425 |
| Townsville–Cairns | 4 | – | 335 | 11 | 346 | 3 703 | 411 |
| Ipswich–NSW border | 5 | – | 210 | 16 | 226 | 3 767 | 935 |
| Ipswich–Toowoomba | 6 | – | 38 | 57 | 95 | 10 476 | 1 826 |
| Toowoomba–Roma | 7 | – | 337 | – | 337 | 2 740 | 343 |
| Roma–Morven | 8 | – | 177 | – | 177 | 333 | 244 |

TABLE I.1 NATIONAL HIGHWAY ROAD LENGTHS AND TRAFFIC VOLUMES BY ACRD CONDITION REPORTING LINKS (Cont.)

| State or Territory | ACRD Link no. | One-lane[a] (km) | Multi-lane (km) | Divided (km) | Total (km) | Mean total vehicle AADT[b] | Mean commercial vehicle AADT |
|---|---|---|---|---|---|---|---|
| Morven–Barcaldine | 9 | – | 416 | – | 416 | 432 | 97 |
| Barcaldine–Cloncurry | 10 | – | 634 | – | 634 | 383 | 68 |
| Cloncurry–NT border | 11 | – | 320 | – | 320 | 520 | 91 |
| Total | | – | 3 699 | 199 | 3 900 | 2 918[c] | 429[c] |
| *South Australia* | | | | | | | |
| Adelaide–Tailem Bend | 1 | – | 1 | 94 | 95 | 10 417 | 1 356 |
| Tailem Bend–Vic. border | 2 | – | 191 | – | 192 | 2 758 | 828 |
| Adelaide–Port Augusta | 3 | – | 259 | 39 | 298 | 4 354 | 716 |
| Port Augusta–Ceduna | 4 | – | 467 | 1 | 468 | 684 | 251 |
| Ceduna–WA border | 5 | – | 483 | – | 483 | 420 | 84 |
| Port Augusta–NT border | 6 | – | 927 | – | 927 | 363 | 115 |
| Total | | – | 2 326 | 134 | 2 460 | 1 492[c] | 309[c] |
| *Western Australia* | | | | | | | |
| Perth–Northam | 1 | – | 62 | 8 | 70 | 6 457 | 799 |
| Northam–Southern Cross | 2 | – | 271 | – | 271 | 1 530 | 283 |
| Southern Cross–Norseman | 3 | – | 355 | – | 355 | 742 | 229 |
| Norseman–SA border | 4 | – | 721 | – | 721 | 430 | 198 |
| Perth–Wubin | 5 | – | 250 | – | 250 | 1 666 | 286 |
| Wubin–Meekatharra | 6 | 188 | 305 | – | 493 | 314 | 66 |
| Meekatharra–Port Hedland | 7 | 42 | 820 | – | 862 | 146 | 25 |
| Port Hedland–Broome turn-off | 8 | – | 567 | – | 567 | 674 | 147 |
| Broome turn-off–Fitzroy | 9 | – | 366 | – | 366 | 481 | 80 |
| Fitzroy Creek–Halls Creek | 10 | – | 283 | | 283 | 727 | 125 |
| Halls Creek–NT border | 11 | 124 | 278 | – | 402 | 310 | 41 |
| Total | | 354 | 4 279 | 8 | 4 640 | 652[c] | 139[c] |
| *Tasmania* | | | | | | | |
| Hobart–Launceston | 1 | – | 156 | 20 | 176 | 4 634 | 1 256 |
| Launceston–Devonport | 2 | – | 93 | 1 | 94 | 6 912 | 748 |
| Devonport–Burnie | 3 | – | 24 | 25 | 49 | 11 395 | 1 132 |
| Total | | – | 273 | 46 | 319 | 6 350[c] | 765[c] |
| *Northern Territory* | | | | | | | |
| Darwin–Katherine | 1 | – | 282 | 7[d] | 289 | 1 162 | 457 |
| Katherine–Alice Springs | 2 | – | 1 177 | – | 1 177 | 314 | 150 |
| Alice Springs–SA border | 3 | – | 295 | – | 295 | 273 | 84 |
| Katherine–WA border | 4 | – | 468 | – | 468 | 126 | 55 |
| Tennant Creek–Qld border | 5 | – | 444 | – | 444 | 283 | 137 |
| Total | | – | 2 666 | 7 | 2 673 | 444[c] | 157[c] |
| *Australia total* | | 354 | 14 553 | 1 135 | 16 045 | 2 583[c] | na |

na Not available
a. Roads are classified as 'one-lane' where the seal width is 4.5 metres or less.
b. Mean traffic flow calculated from vehicle-kilometres divided by route length.
c. Totals are weighted means.
d. Accurate information on divided highway length was not available for Northern Territory.

*Notes* 1. Owing to rounding, figures may not add to totals.
2. Status as at 30 June 1990.

*Source* BTCE data holdings.

# APPENDIX II INVENTORY FORMAT USED TO COLLECT DATA FOR THE AUSTRALIAN NATIONAL HIGHWAY SYSTEM

## INVENTORY ITEMS

TABLE II.1 INVENTORY ITEMS FOR EACH NATIONAL HIGHWAY SECTION

| *No.* | *Item* | *Type* | *Mnemonic* | *Width* | *Explanation* |
|---|---|---|---|---|---|
| *Location information* | | | | | |
| 1 | State | char | STATE | 3 | NSW, Vic., Qld., SA, WA, Tas., NT, ACT |
| 2 | Highway name | char | HIGHW | 15 | As required |
| 3 | Major centre from | char | FROMMC | 15 | As required |
| 4 | Major centre to | char | TOMC | 15 | As required |
| 5 | Division | num | DIV | 3 | As required |
| 6 | Route | char | ROUT | 8 | As required |
| 7 | Link | num | LINK | 3 | As required |
| 8 | Section | num | SECT | 6 | As required |
| 9 | Start km | num | STARTKM | 11.2 | Distance from last major centre |
| 10 | Length | num | LENGTH | 1.2 | Kilometres, e.g. 4.32 |
| 11 | Functional class | num | FC | 3 | Any item 1 to 9 |
| 12 | Legal class | num | LC | 3 | As required |
| 13 | Commonwealth class | char | CC | 2 | NH |
| *Usage information* | | | | | |
| 14 | AADT | num | AADT | 8 | AADT in year 1990 |
| 15 | Rigid commercial vehicle | num | RIGIDV | 6.1 | Heavy rigid and buses per cent of AADT, e.g. 5.5 |
| 16 | Articulated vehicle | num | ARTICV | 6.1 | Articulated vehicle per cent of AADT, e.g. 13.5 |
| *Pavement information* | | | | | |
| 17 | Carriageway type | char | CW | 2 | S single CW; D divided CW; F freeway |
| 18 | Surface/pavement type | char | ST | 2 | US unsealed; FS flush seal; AC asphalt; CC concrete |

TABLE II.1 INVENTORY ITEMS FOR EACH NATIONAL HIGHWAY SECTION (Cont.)

| *No.* | *Item* | *Type* | *Mnemonic* | *Width* | *Explanation* |
|---|---|---|---|---|---|
| 19 | Surface width | num | SW | 6.1 | Metres, e.g. 7.4 for divided roads code sum of both CWs |
| 20 | Surfacing year | num | SY | 6 | Year, e.g. 1985 |
| *Pavement condition information* | | | | | |
| 21 | Benkelman beam | num | BBEAM | 5.1 | Millimetres, e.g. 2.3 |
| 22 | Roughness | num | ROUGH | 5 | NAASRA count per km in year 1990 |
| 23 | Rutting | num | RUT | 6.1 | Per cent length with ruts greater than 20 mm depth in both wheel paths, e.g. 9.1 |
| 24 | Cracking | num | CRACK | 6.1 | Per cent of pavement area with intermittent cracks greater than 2 mm e.g. 8.2 |
| *Pavement costing information* | | | | | |
| 25 | Routine maintenance | num | RM | 7.2 | Annual cost in dollars per sq. metre, e.g. x.xx |
| 26 | Reseal | num | RS | 7.2 | Cost in dollars per sq. metre, e.g. x.xx |
| 27 | Asphalt overlay | num | AO | 7.2 | Cost in dollars per sq. metre, e.g. x.xx |
| 28 | Pavement reconstruction | num | PR | 7.2 | Cost in dollars per sq. metre, e.g. xx.xx |
| *Items added by BTCE* | | | | | |
| 29 | Annual routine maintenance | num | ARTMN | 9 | Annual cost in $'000 for record |
| 30 | Annual intervention maintenance (reseal, overlay or reconstruction) | num | ANINMN | 9 | Annual cost in $'000 for record |
| 31 | Benefit–cost ratio | num | BCR | 9.1 | BCR for record |
| 32 | X-coordinate (longitude) | num | XCOORD | 11 | Longitude of major centre, FROMMC |
| 33 | Y-coordinate (latitude) | num | YCOORD | 11 | Latitude of major centre, FROMMC |
| 34+ | Further items used for average roughness and expenditure patterns over future years | | | | |

## CODING DETAILS FOR EACH SECTION OF NATIONAL HIGHWAY

### *Location information*

| | |
|---|---|
| Items 3 and 4 | Major centres possibly 50 km apart; this road section will be between these two centres |
| Items 6 to 8 | Location details can take any alpha-numeric form comprising 17 characters in total |
| Item 9 | Distance from last major centre to start of this section |
| Item 10 | Typical section lengths could be 5 km for high traffic volume sections and 40 km for low traffic sections |

### *Usage information*

| | |
|---|---|
| Item 14 | For a divided road there is one record for both CWs combined, so if divided carriageways, sum AADT for each CW |
| Items 15 and 16 | Comm. veh. defined as 'A vehicle having at least one axle with dual wheels and/or having more than two axles' - refer appendix A, NAASRA (1987) |

### *Pavement information*

| | |
|---|---|
| Item 17 | For dual CW only one record is required |
| Item 18 | For AC over concrete pavement code AC for differing pavement types on each CW code oldest pavement |
| Item 19 | For dual CW total both left and right surface widths and code total |
| Item 20 | Latest surfacing year |

### *Pavement condition information*

| | |
|---|---|
| Items 21, 22, 23 and 24 | Where data are available |
| Items 23 and 24 | Refer to AUSTROADS PMS Project Group definitions for intermittent occurrence |
| Item 23 | 20 mm rutting for left hand lanes, total wheel path length divided by twice pavement length as a per cent |

### *Pavement costing information*

| | |
|---|---|
| Items 25, 26, 27 and 28 | Definitions as per NAASRA (1987) |
| Item 25 | Include shoulder and provision for traffic allowance |
| Item 25 | Include administration and overhead costs, exclude bridge costs |
| Items 26, 27 and 28 | Include administration and overhead costs, exclude non-pavement and bridge costs |
| Items 26 and 27 | As appropriate for the surface type |
| Item 27 | For 50 mm thickness |
| Item 28 | For complete pavement reconstruction, excluding earthworks or drainage and asphalt or seal surfacing. Reconstruction initiated after roughness limit exceeded. |

### *Items added by BTCE*

| | |
|---|---|
| Item 29 | Annual cost in $'000 |
| Item 30 | Annual cost in $'000 |
| Item 31 | Benefit–cost ratio for record |
| Item 32 | Xcoord. (longitude) of major centre: 148° 30′ coded as 1485000000 |
| Item 33 | Ycoord (latitude) of major centre: 32° 30′ coded as 325000000 |
| Items 34+ | Other items coded by BTCE |

# APPENDIX III STUDY DETAILS

## HANDLING OF SPECIFIC DATA ISSUES

As noted in chapter 2 of this report the maintenance requirements of the Australian national highway system were calculated using the life cycle costing model and data supplied by each State road authority. The following section of this report discusses variations made to the model to ensure that the results obtained from the simulation were as accurate and realistic as possible. As noted in chapter 2 of this report all data used for the assessments were forwarded to the States for verification in April 1991. All State road authorities accepted the information without any difficulties.

### Climbing lanes and passing lanes

The inventory data from all States did not necessarily include pavement area associated with climbing, passing or parking lanes and for interchanges. After analysis of the results of information obtained from the NSW Roads and Traffic Authority and considering that the impact was limited, no allowance was made for any local widening of national highways.

### Reseal year

Because the years to the last reseal have an impact on the life expectancy of the pavement, where this information was not available assessments were made using information held by the Bureau and from likely resealing scenarios.

### Rigid and articulated trucks

Data supplied by the State road authorities included information on both rigid and articulated trucks. The calculation of the equivalent standard axle loadings used in the pavement deterioration algorithm were taken from table VI.2 of Inter-State Commission (1990). With a 35-tonne, 6-axle articulated truck and a 17-tonne, 3-axle rigid truck the ESAs are 1.513 and 1.467 respectively. These figures closely matched the ESAs shown in table E5 of NAASRA (1987).

The LCC model was developed using two vehicle types to calculate the vehicle operating costs; cars and articulated trucks. The model was expanded to incorporate rigid trucks using the World Bank vehicle operating cost model calibrated using Australian information.

### Environmental and climatic issues

The World Bank in developing the algorithm which drives the LCC model incorporated a factor to take into account the impact of climatic conditions on pavement life. In running the model for Australian conditions the values for the environmental coefficient were considered by comparing the parameters set out in table 8.7 of Paterson (1987) and the Australian climatic conditions as documented in figure 5 of Bureau of Meteorology (1989). After testing the sensitivity of the results against changes in this parameter it was decided to adopt an environmental coefficient of 0.016 for all States as given in table 4.4 of BTCE (1990).

### Concrete pavements

The particular deterioration characteristics of rigid cement concrete pavements were catered for in the model by recalibrating the deterioration coefficient to ensure that the life expectancy of these pavements was at least forty years. The model automatically calculated the annual routine maintenance and the higher ultimate reconstruction cost for this type of pavement.

### Traffic growth rates

An examination of *Survey of Motor Vehicle Use* (ABS 1990 and various) and the growth rates for total kilometres travelled by type of vehicle for interstate movements and an examination of truck and other vehicle traffic on selected Australian national highways resulted in a growth rate of 3.5 per cent being used for all simulation runs. The LCC model used a linear growth rate for all traffic projections.

## DETAILS OF THE STATE SUPPLIED DATA

National highway information supplied to the Bureau by each State road authority required different techniques to ensure that it conformed to the Bureau requirements to enable all States to be processed uniformly. All data were checked using the ACRD submissions as a control total for length. Because of the aggregated nature of many States' ACRD submissions, it was not possible to check all data items, but all those able to be checked were checked and amendments were made where necessary.

The data items which appeared to present the greatest difficulty for road authorities were traffic counts and costing information. The quality of some of this data was not as high as in other areas. The reason for this was largely related to the pavement management sections of the road authorities generally not being responsible for costing or traffic information.

### New South Wales

The New South Wales data arrived in the NSW based Condition Management Information System format. The data were reformatted electronically by converting and reorganising each of the data items. After the supply by the Roads and Traffic Authority of a number of missing sections, a small number of sections of the national highway were added by the Bureau to match the ACRD control lengths. Cost data were not supplied.

### Victoria

The Victorian data were supplied in the format detailed in appendix II and matched the ACRD control lengths and required only minor editing. No cost data or surface type data were supplied.

### Queensland

The Queensland data were initially coded by the Bureau using the ACRD submission as a base. The SRA subsequently updated this Bureau inventory and supplied some cost data which were subsequently converted by the Bureau to costs per square metre of pavement.

### South Australia

For South Australia the ACRD submission was coded by the Bureau with year of surfacing assumed on the basis of the roughness of the section. South Australia supplied detailed maintenance costing information for categories of work for sections of road.

### Western Australia

For Western Australia the first set of data was coded by the Bureau from the ACRD submission and sent to the State road authority for verification. The State road authority submitted a hard copy of data which was used by the Bureau to recode the data. Certain assumptions were needed regarding date of pavement resurfacing or reconstruction where this was not provided.

### Tasmania

Tasmanian data were in the NSW based Condition Management Information System (CMIS) format, which is used in Tasmania for pavement management. The CMIS format provided could not be converted to the BTCE format because of lack of information on the structure of the CMIS file. At a later stage when a copy of the actual highway inventory was obtained from Tasmania this was coded into the format by BTCE. Rutting, cracking and texture information was assumed on the basis of roughness information provided in the highway inventory. A single set of cost data was provided for all of Tasmania.

### Northern Territory

Data were coded by Bureau from the ACRD submission and where necessary assumptions were made regarding the date of surfacing and the reconstruction year. One set of unit cost data was provided.

## DETAILS OF THE COMPUTING USED FOR THIS PROJECT

The results presented in this report were obtained using the data collected from the States as detailed above, which were processed using a computer spread sheet version of the BTCE life cycle costing model. The output was then tabulated using a database system and a statistical analysis program. Three 386 desktop computers were used for all data processing.

The data and output were also incorporated into a geographic information system and plotted to produce the colored maps utilised in this report. Not only can any collected or geographically linked parameter be mapped, but, using modifications of the same system, it was also possible to produce strip maps of the road, as well as animated driver's eye views of the road.

## REFERENCES

| | |
|---|---|
| ABS | Australian Bureau of Statistics |
| AGPS | Australian Government Printing Service |
| BTCE | Bureau of Transport and Communications Economics |
| BTE | Bureau of Transport Economics |
| NAASRA | National Association of Australia State Road Authorities |
| NRMA | National Road and Motorists' Association |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## ABBREVIATIONS

| | |
|---|---|
| AADT | Annual average daily traffic |
| ABS | Australian Bureau of Statistics |
| AC | Asphaltic Concrete |
| ACRD | Australian Centennial Roads Development program |
| BCR | Benefit–cost ratio |
| BTCE | Bureau of Transport and Communications Economics |
| BTE | Bureau of Transport Economics |
| CMIS | Condition Management Information System |
| DoTC | Department of Transport and Communications |
| ESA | Equivalent Standard Axle |
| IRI | International roughness index |
| km | kilometre |
| LCC | Life cycle costing |
| NAASRA | National Association of Australian State Road Authorities |
| NHS | National highway system |
| NPV | Net present value |
| NRM | NAASRA Roughness Meter |
| PMS | Pavement management system |
| SRA | State Road Authority |
| VKT | Vehicle kilometres of travel |
| VOC | Vehicle operating costs |
| * | Signifies multiplication |