HEAVY VEHICLE LOADING OF LOW TRAFFICKED ROADS

Part 1 — Strategic Framework for Reviewing Expenditure

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Project Manager
Mr Paul Smith, DMR Qld

Prepared by
Mr Peter Rufford, ALGA and Mr Tim Martin, ARRB TR

Published by Austroads Incorporated
Level 9, Robell House
287 Elizabeth Street
Sydney NSW 2000 Australia
Phone: +61 2 9264 7088
Fax: +61 2 9264 1657
Email: austroads@austroads.com.au
www.austroads.com.au

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Part 1 — Strategic Framework for Reviewing Expenditure

AUSTROADS
Sydney 2002

AUSTROADS PROFILE

Austroads is the association of Australian and New Zealand road transport and traffic authorities whose purpose is to contribute to the achievement of improved Australian and New Zealand transport related outcomes by:

- developing and promoting best practice for the safe and effective management and use of the road system
- providing professional support and advice to member organisations and national and international bodies
- acting as a common vehicle for national and international action
- fulfilling the role of the Australian Transport Council's Road Modal Group
- undertaking performance assessment and development of Australian and New Zealand standards
- developing and managing the National Strategic Research Program for roads and their use.

Within this ambit, Austroads aims to provide strategic direction for the integrated development, management and operation of the Australian and New Zealand road system — through the promotion of national uniformity and harmony, elimination of unnecessary duplication, and the identification and application of world best practice.

AUSTROADS MEMBERSHIP

Austroads membership comprises the six State and two Territory road transport and traffic authorities and the Commonwealth Department of Transport and Regional Services in Australia, the Australian Local Government Association and Transit New Zealand. It is governed by a council consisting of the chief executive officer (or an alternative senior executive officer) of each of its eleven member organisations:

- Roads and Traffic Authority New South Wales
- Roads Corporation Victoria
- Department of Main Roads Queensland
- Main Roads Western Australia
- Transport South Australia
- Department of Infrastructure, Energy and Resources Tasmania
- Department of Transport and Works Northern Territory
- Department of Urban Services Australian Capital Territory
- Commonwealth Department of Transport and Regional Services
- Australian Local Government Association
- Transit New Zealand

The success of Austroads is derived from the synergies of interest and participation of member organisations and others in the road industry.

FOREWORD

This Austroads project aims to develop analytical tools for developing maintenance strategies on low trafficked routes, primarily in rural areas. While the report analyses data from specific routes, it should not be seen as a critique of the participating Councils. Rather the focus should be on what we can learn from the analysis.

Twenty eight routes were selected, all with heavy vehicle usage. Their maintenance strategies are reflected in their actual expenditure patterns. However, this is mostly over one year and at best only represents a snapshot in time rather than a life cycle pattern.

Generally speaking, managers of these low trafficked roads do not think in terms of long term strategies; rather they focus on current needs across their network. There needs to be a culture change towards maintenance strategies that span a ten year period, or longer.

Councils and State Road Authorities need to establish an affordable strategy on a route by route basis and then stick to it over a number of years. They need to track their costs and measure the performance of each route over time as the basis for the ongoing review of their maintenance strategy.

However, managers of these low trafficked roads do not always have the analytical tools to interpret their current expenditures, nor in many cases, the financial reporting systems to accurately tell them how much they are spending on each route.

This Austroads project is an attempt to establish a framework that may be of assistance to them. The first part of the project and reported in this Internal Report, establishes intuitive relationships between expenditure, traffic and road condition, which although based on imperfect data, shows a way forward.

One of the greatest concerns of the project was the quality of expenditure data at a route level and more work is needed by individual Councils and State Road Authorities to build financial systems for the task.

Councils also need to start measuring the condition of their roads in a systematic and ongoing way either by measuring roughness where appropriate or by the simple road condition measures used in this project. But whatever the measures, they need to be in a nationally consistent format.

This report provides a strategic framework based on the analysis of the 28 routes. It is the first step towards developing tools for Councils and State Road Authorities to underpin the asset management of their low trafficked routes. The next stage will involve Councils and State Road Authorities in testing the framework and will be reported as Part 2 of the project.

The results of the practical application of the principles will then be consolidated into an Austroads Asset Management Report, which will be of interest to all managers of low trafficked roads.

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CHAPTER 1 — INTRODUCTION

1.1 BACKGROUND

The Mass Limits Review highlighted the lack of information on the performance of low trafficked roads. A report by ARRB Transport Research[1] suggested that the impact of increasing the mass limits for vehicles with air suspension was likely to be marginal except in areas where there were high water tables and in areas with poor geometric design and drainage.

There is a need to have a better understanding of the likely impacts on the management of low trafficked roads where the materials are likely to have marginal performance characteristics. This understanding needs to be extended to unsealed roads as well because of the high percentage of unsealed roads in Australia.

The main issue for local government is that most of the technology and systems have been developed for the management of state rather than local roads. The measurement of road condition is therefore not uniform across Australia. Further, the road condition measures used by State Road Authorities are not always appropriate for the lower trafficked roads and the cost of using their asset management systems is prohibitively expensive for a large number of Councils.

A lot of Councils are not aware of their future liability for recurring maintenance and renewal as their infrastructure ages. This will increasingly present a budgetary problem for those Councils who have old road networks.

A road system that is depreciating in value is a community issue and strategies defining levels of service need to be addressed as a community priority well before it becomes critical. This underscores the need for predictive tools for forecasting future funding requirements and a better understanding of acceptable community levels of service.

The 1997-98 Austroads research program included two projects on road condition and levels of service on low trafficked roads. These projects provided concepts that are relevant to the assessment of heavy loading on low trafficked roads.

The Victorian Department of Local Government undertook an assessment[2] of future infrastructure liabilities for all Councils in Victoria. A number of leading Councils in South Australia is finalising a similar study of Councils in that State. The principles underpinning these two studies are relevant to all managers of low trafficked roads.

Local road congresses in Moree (March 2000) and more recently in Mildura (March 2001) highlighted the need for more information on asset management. The report[3] to the Mildura Congress included an approach for estimating the shortfall in road maintenance expenditure.

Funding was sought from Austroads for an asset management project on low trafficked roads with a particular emphasis on community expectations. A project titled 'BS.A.N.503 - Heavy Vehicle Loading of Low Trafficked Roads' was approved in the 1999-2000 Austroads National Strategic Research Program. The research was contracted to the Australian Local Government Association who used the resources of The LGInfo Group to undertake the work. The regional co-ordinators used in the project are listed in Appendix A.

[1] Internal report to the National Road Transport Commission
[2] Facing the Renewal Challenge. Victorian Department of Infrastructure (1998)
[3] The Butcher Report can be found at www.algin.net/transinfo

The scope of the project was to establish appropriate asset management measures, levels of service and maintenance expenditure, for low trafficked roads subjected to heavy mass loading. The outcomes were defined as:

- A national assessment of whether Councils in rural areas are adopting the appropriate maintenance strategy to meet future asset management liabilities and community expectations.
- A national assessment of the implications of heavy loading on future road condition.
- Asset and pavement management analytical techniques applied at a national level for rural roads.

It was envisaged that the project would be undertaken in three stages. Part 1 and the subject of this report would identify the framework for reviewing expenditure on low trafficked roads. Part 2 would test the framework in the field and would be undertaken in 2001/02. If warranted, consideration would then be given to testing some of the underlying principles using the accelerated loading facility (ALF).

This report documents the approach taken in establishing the strategic framework from data collected from 28 routes across all States and the Northern Territory.

During consultation with Council personnel in the data capture phase of Part 1 of this project, it became clear that managers of low trafficked roads tend to focus mostly on current needs on their networks, rather than developing long term strategies and tailoring works to fit with those strategies.

1.2 APPROACH TAKEN

The project was undertaken in four steps. The first involved collecting data to establish key relationships for the strategic framework. The second built the framework while the third applied it to the study routes. A data template was then established as the fourth step for managers of low trafficked routes to apply the framework more generally.

Data Collection

There were essentially two levels of data collection and involvement of Councils. The first involved 32 Councils in the provision of expenditure and road condition data on 28 heavy vehicle routes. A complete list of the routes is given in Appendix B.

Generally, the roads were constructed to typical rural standard, namely two lanes with a flexible pavement and a bituminous seal. The traffic levels varied considerably, with some routes being as low as 100 vehicles per day while others exceeded 1,000 vehicles per day. The routes were generally on flat to undulating terrain.

The Councils involved in the project are shown in Table 1.

Table 1 — First level of data collection

Type of Data	State	No of Councils	No of routes	Councils
Expenditure and Road Condition	NSW	10	7	Guyra Kempsey Wakool Young/Harden Temora/Weddin Oberon Dubbo/Cabonne
	Vic	5	5	Greater Bendigo Horsham Rural Mitchell Greater Shepparton Wellington
	SA	3	2	Grant Mt Barker/Alexandrina
	WA	5	55	Lake Grace Tambellup Plantagenet Manjimup Albany
	Qld	5	5	Mareeba Murgon Mackay Whitsunday Broadwater
	Tas	2	2	Circular Head Central Coast
	NT	2	2	Katherine Litchfield
	Totals	**32**	**28**	

The second level of data collection involved the measurement of roughness and a community expectation survey of the level of service provided by the route. A total of 5 routes in five States were involved in the survey. In addition, there were two routes where roughness measurements were made but not the community assessment.

The Councils involved in the second level of data collection are shown in Table 2.

Table 2 — Second level of data collection

Type of Data	State	No of Councils	Councils
Roughness and Community Survey	NSW	1	Wakool
	Vic	1	Horsham Rural
	SA	2	Mt Barker/Alexandrina
	WA	1	Manjimup
	Tas	1	Circular Head
Roughness only	Qld	1	Murgon
	Tas	1	Central Coast
	Total	**8**	

Details of the selection process and data collected are given in Appendix C.

Strategic Framework

The strategic framework needs to be considered in the context of the continuous improvement in the management of road assets, described in Chapter 2. It must provide Councils with the tools to move from one stage in this path to another.

Essentially the framework developed in this project was established to evaluate the level of expenditure and maintenance strategy on each route. Two approaches were taken. One involved a benchmark approach comparing expenditure with values used by the Moree Steering Committee[4]. This is called the Benchmark Approach.

The other approach assessed the expenditure and levels of service in the context of the life cycle analysis developed by ARRB Transport Research[5]. This approach is called the Life Cycle Costing Approach.

The ARRB-TR analysis required measures of roughness for each route as a proxy for community acceptance. While the approach has a theoretical rigor, many Councils, due to the cost of roughness testing, cannot readily apply it.

The strategic framework therefore used the same theoretical concepts but applied it in a way more accessible to Councils. This was achieved by developing a road condition index and correlating it to roughness. The road condition assessment was based on previous Austroads work[6].

Contributing research to both approaches is described in Chapters 3 and 4.

The relationships established from data collected from the 28 routes are described in Chapters 5 and 6, while the strategic framework is described in Chapter 7.

Application to the Selected Routes

The framework is then applied to each route and general conclusions drawn on the level of expenditure and the current maintenance strategy adopted by each Council. This is described in Chapter 8.

Data Template for More General Application

Chapter 9 describes the proposed data template for the next stage in the project. This involves the application of the analysis framework by managers of low trafficked routes in all States, Territories and New Zealand. State Road Authorities as well as Councils will be involved in this next stage.

The findings will be consolidated into a Part 2 report before being finalised as an Austroads report for general application.

The general conclusions from progress to date are drawn in Chapter 10.

[4] Established by the Moree Rural Roads Congress (March 2000).
[5] Community Expectations of Levels of Service on Local Roads. Austroads Internal Report IR-12.
[6] Condition of Local Roads. Austroads Internal Report IP-15/01.

CHAPTER 2 — CONTINUOUS IMPROVEMENT IN ASSET MANAGEMENT

2.1 INTRODUCTION

A pattern is emerging on the continuous improvement process for effective asset management by local government.

The challenges that Councils face at this time arise from insufficient funding to maintain their aging and deteriorating road networks. There is also no denying that the issues are complex, requiring an increasingly sophisticated approach to asset management and road funding.

The purpose of this Chapter is to identify the path that Councils need to follow to increase the sophistication of their approach to defining their infrastructure needs. The Austroads project should provide the technology to assist Councils move along the continuous improvement path.

Recent research in a number of States suggests that many Councils may not be able to fund the renewal of infrastructure built during the period of rapid growth in the 1950's, 60's and early 70's. Much of this infrastructure may require renewal (particularly rehabilitation) in the next 10 to 15 years.

Effective planning is crucial to addressing this problem and ensuring that scarce resources are allocated to the best advantage not only at the local but at the regional level as well. This requires Councils to plan within a regional context.

Important asset management issues are central to a continuous improvement process. They include:

- What is the renewal cost of local road networks and when is it required?
- How does a rural or industry rationalisation impact on the flow of traffic and demand for infrastructure?
- What is the capacity of local communities to fund necessary maintenance and renewal in a cost-effective way?
- Are there opportunities for more cost effective ways of funding infrastructure?

Councils are at different stages of sophistication in addressing these questions and yet the answers are crucial to the effective management of their roads.

2.2 FIVE STAGES OF CONTINUOUS IMPROVEMENT

There is considerable variation in the level of understanding of asset management throughout local government in Australia and in the capacity of Councils to measure, plan and find solutions to issues such as sustainable infrastructure.

Continuous improvement seeks to move an increasing number of Councils from where they don't know whether they can sustain their road infrastructure to where they have confidence in their capacity to find solutions to achieve local and regional transport outcomes.

The mechanisms to achieve this continuous improvement include:

- Skills and technology transfer in asset management
- Coordination of pilot schemes of Councils progressively moving to higher levels of sophistication in their asset management
- Exchange of information between Councils

There are five stages of continuous improvement as described below.

First Stage

The first stage is one where Councils are not aware that their current levels of expenditure may be inadequate for maintaining their roads in the future. Once a Council acknowledges that it has a future liability problem, it is ready to move onto the second stage.

Second Stage

The second stage involves Councils quantifying their future liability with respect to their transport infrastructure. The Victorian (and subsequent South Australian) local government studies used a modelling technique for projecting future funding to maintain their road infrastructure.

All Councils should undertake this analysis. The general results from recent studies suggest that Councils have a future liability exceeding their current expenditure.

The analysis essentially involves 4 steps:

1. establish the economic life of the road pavement based on community acceptance;
2. identify the age profile of the network;
3. review Council's maintenance and upgrading cost structures; and
4. estimate the future expenditure profile to match community expectations.

An adaptation of this type of analysis was undertaken in establishing the framework for this project.

Third Stage

The third stage is where Councils recognise that they have a significant future liability and need to take a regional perspective on the management of the issue.

The process needs to:

1. seek the involvement of all the Councils within the region;
2. undertake the strategic analysis of future funding liability by all Councils;
3. define the freight and community flows within the region;
4. identify the regionally significant routes and infrastructure needed to minimise transport costs and accidents;
5. agree on infrastructure development priorities;
6. compare cost structures between Councils and adopt a regional maintenance strategy (This may result in some resource sharing); and
7. develop a strategic plan for the region which outlines the commitment of each Council to work toward the broader interests of the region as well as their own local needs.

State Governments are active in most States in facilitating a regional approach to transport infrastructure and Councils are encouraged to participate in these initiatives. However, it is also clear that in some cases in the absence of a State initiative, Councils need to initiate their own study to ensure that their specific concerns are adequately addressed.

Fourth Stage

The fourth stage is a process that engenders a regional cooperative approach to identifying the future infrastructure needs based on regional development as the prime outcome.

This stage attempts to identify the infrastructure and institutional constraints to achieving regional development. An Austroads project[7] explored the potential for understanding the systems dynamics between stakeholders to the transport sector. This report showed that while the transport system was in fact complex there was scope for addressing issues at the regional level through a facilitated stakeholder process.

Fifth Stage

The fifth stage is where there is some acceptance by the community of the strategies being adopted by Councils to manage their transport infrastructure.

This stage is where solutions are found for sustaining local and regional infrastructure by strategies such as:

1. engaging local communities in defining sustainable levels of service and user pays strategies where appropriate;
2. demand management strategies;
3. satisfying regional transport needs through liaison with State and Commonwealth Transport, Trade, Commerce and Tourism agencies; and
4. value management of transport infrastructure, capital provision and maintenance, to ensure effective utilisation of existing infrastructure. This strategy includes rationalisation of assets by matching existing and future need and disposal of under utilised infrastructure.

This final stage is ongoing with further refinement as strategies are implemented.

[7] A Systems Approach to Regional Transport Issues. Austroads Report AP-R170/00

CHAPTER 3 — PREVIOUS AUSTROADS WORK

3.1 INTRODUCTION

Austroads has recently undertaken two research projects relevant to the current project.

The first researched relationships between community expectation and levels of service on local roads[8]. This project established the techniques for assessing community expectations and the analytical framework for the life cycle asset management analysis.

The second project addressed the measurement of the condition of local roads in Australia[9]. It highlighted the lack of a consistent approach to road condition measurement across the country and established a framework and hierarchy of road condition measures.

The results and findings of both reports are discussed in this Chapter.

3.2 COMMUNITY EXPECTATIONS OF LEVELS OF SERVICE ON LOCAL ROADS

This Austroads project aimed to gain a better understanding of community expectations, particularly how to evaluate the level of expenditure on low trafficked roads within the context of community expectations and levels of service. It explored the relationships between community expectations and measures of road condition to assist Councils in managing their low trafficked road networks.

The approach used road roughness as a primary measure of road condition against which a quantified assessment of community expectation was compared. However, few Councils in Australia had roughness measures of their low trafficked roads, providing a limitation on the number of Councils who could objectively select test sites and thereby participate in the research.

Control on the integrity of the data was crucial to the research and controlled testing was undertaken on all test sites. In view of the pilot nature of the study and considering the limited amount of roughness testing on local roads in other States, the research was limited to roads in four Councils areas from Victoria (Knox, Campaspe, Ballarat and Horsham). Thirty sites were selected from these four Councils to provide a range of urban and rural local road conditions.

It was acknowledged at the outset that while the research would provide an insight into fundamental relationships and concepts, it would need to be tested in other States and Territories before being universally applied to all Austroads members.

The analytical framework was developed to address two issues:

1. whether the existing road condition was meeting the community's expectations;
2. whether the current annual maintenance and renewal expenditure was either reducing or increasing the level of service.

The approach involved firstly establishing a relationship between community expectation and measures of road condition. In particular, an assessment was made as to whether road roughness could justifiably be used as a measure of road condition in an analysis of community expectation.

[8] Community Expectations of Levels of Service on Local Roads. Austroads Internal Report IR-12

[9] Condition of Local Roads in Australia. Austroads Internal Report IR-15

The analysis hinged on establishing a theoretical relationship between maximum roughness and the annualised maintenance and renewal expenditure over the life of the pavement (EAM). The resulting plot was called the EAM Variation relationship and was derived using ARRB Transport Research's pavement life cycle costing model.

Whether the current existing road condition was meeting the community's expectations was addressed simply by comparing the actual roughness measurement with a roughness level corresponding to a median value of community expectation.

The question of whether the existing expenditure would increase or decrease the level of service at each site was made from the position of the actual expenditure and roughness relative to the theoretical EAM Variation relationship.

The results of a community survey of factors influencing service levels confirmed other previous surveys that road characteristics, and in particular road roughness, are paramount in making an accurate assessment of the community's expectations of levels of service. This result validated the use of road roughness to assess the community's expectations of levels of service.

The results also confirmed that apart from road roughness, the factors that influence perceptions of road characteristics are not universal. That is, rural and urban communities are influenced by distinctly different factors when it comes to perception of levels of service.

Measurements of roughness provide a useful assessment of whether individual sites are within reasonable community expectations, notwithstanding the simplistic approach taken to measure community expectations.

The approach taken for interpreting the adequacy of current expenditure levels at a number of sites was also simplistic but nevertheless instructive. The interpretation at any one site was limited by only having one year's expenditure and without knowing where the pavement was in its life cycle, it was difficult to draw definitive conclusions.

3.3 CONDITION OF LOCAL ROADS

This Austroads research project established a national set of guidelines for monitoring the road pavement condition of local roads. A survey of Councils was undertaken to establish the types of measure used throughout Australia. This survey was followed by an international and local literature search to establish best practice guidelines.

53% of all Councils across Australia responded to the survey and their responses are summarised as follows:

- 71% indicated that they collected some form of road condition data. The percentage was higher for urban Councils (92%) than rural Councils (55%).
- 97% of those that collected condition data employed visual methods. In contrast, 43% collected roughness (although only half used automated means) and 33% collected rut depth data.
- Very few Councils collected structural capacity, skid resistance and surface texture information.
- 65% of Councils have a Pavement Management System (PMS) which by and large defined the road condition measures adopted by those Councils. The variety of PMSs used with different data requirements makes the comparison of road condition data across Australia very difficult.

The report suggested that the road condition measures for local roads should be categorised by safety, serviceability and structural capacity. The proposed measures and their priority for heavily trafficked local roads are summarised in Tables 3 and 4 for both sealed and unsealed roads.

Table 3 — Condition parameters for sealed local roads
(source: Austroads, 2001)

Issue	Condition parameter	Measurement or reporting unit	Priority
Safety	Edge Defect	Sum of the length of edge break and edge drop off per km	1
Safety	Rutting	% length with rutting > 20mm	1
Serviceability	Roughness	NRM Roughness weighted by area	1
Safety	Skid Resistance	% length F60 < 0.12, or SFC50 < 0.35	2
Safety	Surface Texture	% length Vp < 34, or texture depth < 0.40mm	2
Structural Capacity	Structural Capacity	% area > 5 years remaining life	2
Structural Capacity	Crocodile Cracking	% area of road surface	2
Serviceability	Ravelling/stripping	% area of road surface	3
Serviceability	Potholes and Pothole Patches	Number per km	3
Serviceability	Environmental Cracking	% area of road surface	4

Table 4 — Condition parameters for unsealed local roads
(source: Austroads, 2001)

Issue	Condition parameter	Measurement or reporting unit	Priority
Structural Capacity	Gravel Loss	Gravel loss in mm	1
Serviceability	Roughness	Roughness weighted by area	2

CHAPTER 4 — ASSET MANAGEMENT ANALYSIS

4.1 INTRODUCTION

Two types of asset management analyses were undertaken on the routes selected for the project.

The first was based on the approach used by the Moree Steering Committee to estimate the theoretical funding needed to maintain the existing condition of the asset. This approach involved developing a model based on average existing expenditure levels with an asset management strategy superimposed. This type of analysis is called the Benchmark Approach because it compares existing expenditure with a theoretical average.

The second analysis followed that developed by ARRB Transport Research in their earlier work on community expectations and levels of service. In this approach, a theoretical relationship was established between the minimum level of roughness and the average maintenance and renewal expenditure required over the cycle of the road. This analysis is called the Life Cycle Costing Approach.

Both approaches are complementary and lead to a better understanding of techniques for assessing the implications of funding levels on levels of service. They are described in this Chapter.

4.2 BENCHMARK APPROACH

The Moree Committee analysis[10] estimated the shortfall in current expenditure to maintain existing road conditions. It did not attempt to identify the funding needed by Councils to meet community expectations or to minimise their costs over the full pavement life cycle.

The maintenance levels suggested were based on a 10% annual resealing and a 1% annual pavement renewal.

Specifically, the derived maintenance level was based on:

1. a routine maintenance level based on 50% of the average current maintenance expenditure on the existing road assets;
2. a pavement renewal expenditure based on an annual pavement renewal of 1% per annum; and
3. generalised unit costs for unpaved and unformed roads.

The actual maintenance and renewal expenditure on each route was compared to the average theoretical value for the particular Council class. A similar approach was taken with the percentage expenditure on capital renewal. These ratios interpreted in the context of the traffic volume and road condition of the route provide the main framework for the Benchmark Approach.

[10] See Appendix D.

4.3 LIFE CYCLE COSTING APPROACH

Basic Principles

The life cycle costing approach took a different approach. It is based on assessment of current annual expenditure relative to that required to maintain a minimum level of roughness over the life cycle of the road. The minimum level of roughness is determined from a survey of community expectations.

The annualised maintenance and renewal expenditure (EAM) reflects the average expenditure on the existing asset to ensure that the pavement roughness is maintained above the minimum standard. It is established from a theoretical life cycle analysis based on an adaption of the World Bank HDM-III model by ARRB Transport Research for local road conditions in Australia.

Figure 1 shows a typical EAM relationship, with a maximum acceptable roughness of 175 NRM (6.65 IRI) superimposed on the graph.

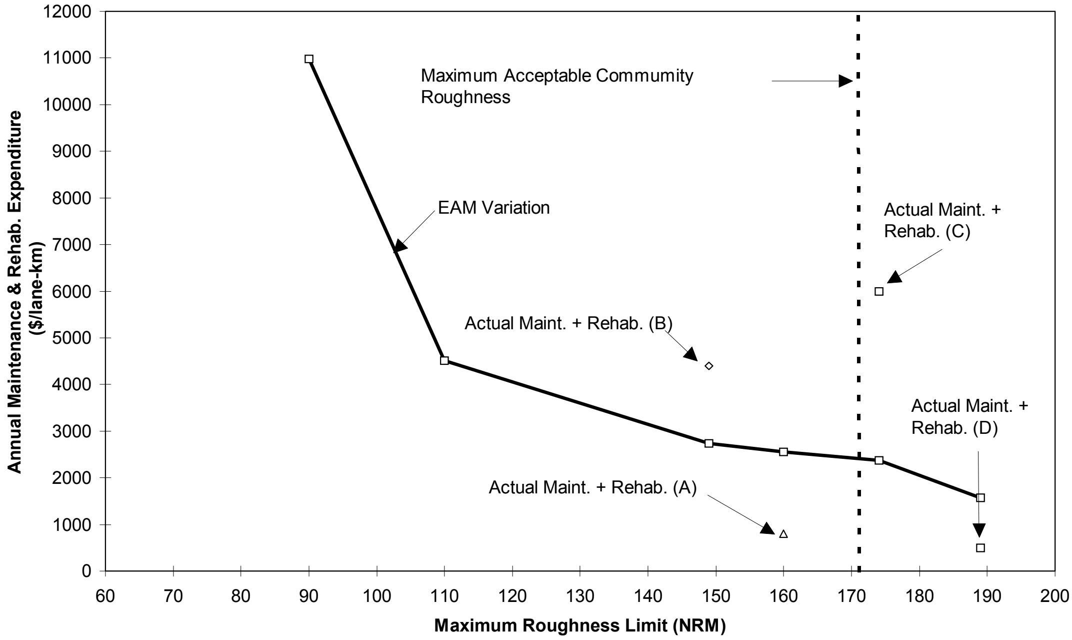


Figure 1 — Typical EAM roughness relationship

An assessment of whether a route is meeting the community's expectations can be made from the following analysis:

1. Derive a theoretical EAM Variation graph from an analysis for the traffic, climatic and local conditions
2. establish the historical maintenance and renewal expenditure
3. measure the current roughness or estimate it from other measures of road condition
4. assign a value for the community's maximum acceptable roughness on the road sample using the community survey results
5. plot the maintenance and renewal expenditure against the measured roughness on the EAM Variation graph.

Interpretation

The annualised life cycle expenditure should be used in the analysis rather than an average annual expenditure. However the derivation of an annualised figure is easier said than done.

Therefore the proposed approach for interpreting the adequacy of current expenditure levels is at best simplistic. The interpretation at any one site is limited by the historical expenditure usually covering only a small number of years and nowhere near the full life cycle of the pavement.

An understanding of where the pavement is in its life cycle, its current rate of deterioration and its expected remaining life to a notional terminal roughness value, will offset a lack of historical data and help estimate an annualised figure. Further work is required to establish reliable techniques for this purpose.

The interpretation allows for a number of scenarios. If the EAM exceeds the actual annual maintenance and renewal expenditure at the current road condition, then the pavement can be expected to deteriorate below the minimum level of service over the life of the road. However, the pavement is probably well maintained if the current road condition is less than the maximum acceptable roughness level.

However, if the EAM is less than the actual annual maintenance and renewal expenditure at the current road condition, then the road is receiving more than sufficient expenditure for the level of service required. However, if the current road roughness is greater than the maximum roughness limit, there is cause for concern at the quality of the maintenance.

In addition, the analysis provides a comparison between the measured roughness and the roughness level matching the community's assessment of an acceptable level of service.

CHAPTER 5 — COMMUNITY ASSESSMENT

5.1 INTRODUCTION

The project attempted to better understand the relationship between community expectations about roads and measures of road conditions. There is a concern that scientifically measured data and professional views of road condition may vary substantially with how the wider community judges road condition. The aim of the community survey was to ask a representative cross section of the community to answer some simple questions about road conditions so that their perceptions can be compared to the actual data on road condition.

Five routes were surveyed in total in New South Wales, Victoria, Western Australia, South Australia and Tasmania, involving the Councils listed in Table 5.

Table 5 — Councils involved in community assessment

Council	State
Wakool	NSW
Horsham	Vic
Manjimup	WA
Mt Barker/Alexandrina	SA
Circular Head	Tas

In each case the Councils involved in the road condition assessment were asked to assist in identifying suitable community representatives to participate in the surveys.

5.2 APPROACH TAKEN

The community expectation survey was undertaken in accordance with the guidelines developed by ARRB Transport Research[11].

The following procedure was used:

- Select one of the routes measured for roughness and road condition and mark seven or more sections representing a range in road conditions.
- Invite 12 –14 members of the community to participate. Participants should represent a cross section of the community including age and gender.
- Use 3 or 4 similar type late model cars (with no more than 4 people in each).
- Invite responses from a two-part survey. The first was answered in the office before leaving on the road trip. The second involved two questions to be answered on the road.
- On completion of the road survey the community members returned to the office for a final chance to discuss or add extra comments.

[11] Appendix E

5.3 SUMMARY OF RESULTS

The first part of the survey related to obtaining some general information on the locality, weather conditions and details of the participants.

Details about participants

The surveys were undertaken in fine and sunny weather using late model cars. In nearly all sections the vehicles travelled at 80 km/h. The gender and age balance for four of the surveys are shown in Table 6.

In terms of age, the majority of participants were in the 45 to 60 years age group with very small percentages below 24 and over 60 years.

Table 6 — Gender and ages of participants in community assessments

Route	Gender		Age Groups				
	Female	Male	18-24	25-44	45-60	60+	Totals
Mt Barker, SA	16%	84%	1	1	8	2	12
Wakool, NSW	27%	73%	0	1	9	1	11
Horsham, Vic	24%	76%	3	3	4	1	11
Circular Head, Tas	45%	55%	0	6	5	0	11
Overall:	**28%**	**72%**	**9%**	**24%**	**58%**	**9%**	**100%**

Factors influencing perceptions of road conditions

The ranking of the factors that are most influential on road users was analysed. The survey data was collated and examined for both the combined sample and for each individual Council.

Table 7 shows the results of the importance of the 11 factors by combining the Council survey data from all five routes. The results reflect the paramount importance of ride quality and safety. This is closely followed by the presence of potholes and inadequate road width.

Table 7 — Overall ranking of road factors, based on five routes (one each in NSW, Vic, SA, WA, and Tas)

Road factor	Overall ranking
Quality of ride/roughness	1
Safety	1
Potholes	3
Road Width	4
Edge wear	5
Road Signs	5
Road Geometry	7
Surface Type	8
Rutting	8
Surface Drainage	8
Road Side Vegetation	11

The results of individual Council data sets are shown in Table 8. There is a variation in the ranking of the factors for individual Councils, reflecting differences in opinion between individuals.

Table 8 — Ranking of road factors, by route

Ranking	Wakool (NSW)	Horsham (Vic)	Manjimup (WA)	Alexandrina (SA)	Circular Head (Tas)
1	Potholes	Roughness	Potholes	Roughness	Safety
2	Safety	Potholes	Edge wear	Geometry	Potholes
3	Roughness	Road Width	Safety	Safety	Geometry
4	Edge wear	Safety	Roughness	Surface Type	Roughness
5	Surface Type	Rutting	Road Width	Road Width	Road Signs
5	Road Signs	Drainage	Road Signs	Potholes	Road Width
7	Rutting	Surface Type	Vegetation	Rutting	Rutting
7	Geometry	Edge wear	Drainage	Drainage	Edge wear
9	Road Width	Road Signs	Geometry	Edge wear	Drainage
10	Drainage	Geometry	Surface Type	Road Signs	Vegetation
11	Vegetation	Vegetation	Rutting	Vegetation	Surface Type

Community Assessments

The results of the community assessment of each test section are summarised in the Table 9. Question 2 sought a response on the ride comfort/qualities of each section while Question 3 asked for an overall assessment of the road condition. Both assessments were on a 0 (very poor) to 10 (very good) scale.

Table 9 — Results of community assessment, by road sections within routes
(Assessment on a scale from 0 (very poor) to 10 (very good)

Sealed / unsealed	Route	Section No	Ride quality (Question 2)	Overall assessment (Question 3)
Sealed	Mt Barker, SA	S-2/2S	2.8	3.2
		S-2/3S	1.3	1.3
		S-2/4S	1.8	2.3
	Alexandrina, SA	S-3/1S	2.8	2.7
		S-3/6S	4.8	4.8
	Wakool, NSW	N-3/1S	2.0	2.0
		N-3/3S	2.7	3.5
		N-3/7S	3.6	5.6
		N-3/8S	3.7	5.0
	Horsham, Vic	V-2/1S	5.8	6.5
		V-2/2S	6.2	6.3
		V-2/3S	6.8	7.3
		V-2/4S	5.3	6.3
		V-2/5S	6.6	7.2
		V-2/6S	5.5	6.0
		V-2/7S	6.2	6.6
	Circular Head, Tas	T-1/1S	1.8	1.9
		T-1/2S	3.9	4.7
		T-1/3S	6.6	6.2
		T-1/4S	7.0	7.4
	Manjimup, WA	W-2/2S	3.5	5.0
Unsealed	Wakool, NSW	N-3/2U	5.1	5.6
		N-3/4U	5.2	6.2
		N-3/5U	5.2	5.9
		N-3/6U	5.4	5.7
	Circular Head, Tas	T-1/5U	5.2	6.0

Comments

The results of the community survey are remarkably similar with a strong correlation between the responses for Questions 2 and 3.

An interesting but important observation was that although the road conditions varied greatly, this variation was not reflected in the results of the community survey. It may be that people get used to the roads in their area and think of them as “adequate”, even though by comparison with roads in other areas they may be significantly better or worse.

The gender and age imbalances reflected in these surveys may not greatly affect the results, but it would be useful in further surveys to achieve a greater gender balance and a wider range of age groups, particularly in the above 60 and under 24 age groups.

CHAPTER 6 — RESEARCH RELATIONSHIPS

6.1 INTRODUCTION

One of the project aims was to establish a framework for Councils to review their expenditure levels. Notwithstanding previous ARRB-TR work that suggested roughness was an appropriate proxy for a community assessment of level of service, a significant number of Councils cannot afford extensive roughness testing of their local roads. Nor do many Council engineers agree that roughness is the determining factor for measuring the road condition of local roads, mainly because they are primarily concerned with when to intervene for routine maintenance reasons.

Therefore a road condition index was developed from visual assessments and limited qualitative measurements as a proxy for roughness. The measures used in this index are described in this Chapter.

By measuring the road condition index and road roughness on a number of routes, a relationship between them was established. The relationship between roughness and community levels of service had been established in previous ARRB-TR research and was enhanced with data collected from the project.

A number of relationships emerged from the expenditure analysis which are included in this Chapter. One in particular emerged from the assessment of future liability and its link to the measured road condition index.

This Chapter describes the relationships between:

1. roughness and community expectations;
2. road condition index and roughness; and
3. future liability (expressed as a percentage of economic life) and the road condition index.

The Chapter presents the summary relationships. The more detailed analysis underlying each of the main relationships is presented in Appendix F.

6.2 ROUGHNESS VERSUS COMMUNITY EXPECTATIONS

Sealed Rural Roads

The full analysis of the data is reported in Appendix F using the community expectations data collected from Question 2 of the survey (Appendix E).

The results showed similar trends to the previous Austroads project[12] (involving four Victorian Councils) although there was more scatter in the data and the relationship were displaced lower on the roughness scale. This comparison is shown in Figure 2.

Although the overall recently collected State data yields a roughness and community index relationship with a better fit (greater $r^2 = 0.49$) as compared to that found for the earlier Victorian data ($r^2 = 0.24$), the position of the graph (y intercept) is significantly lower that that found for the Victorian data. The relationship from the current study predicts an intolerable road is one that has a roughness of 114 NRM (4.35 IRI) and a maximum acceptable roughness (using a community index equal to 4) of 86 NRM (3.29 IRI).

[12] Community Expectations of Levels of Service on Local Roads. Austroads Internal Report IR-12

The relationship from the earlier Victorian data predicts that a roughness of 134 NRM (5.11 IRI) is intolerable for a rural sealed road and that the maximum acceptable roughness (using a community index equal to 4) is 110 NRM (4.20 IRI).

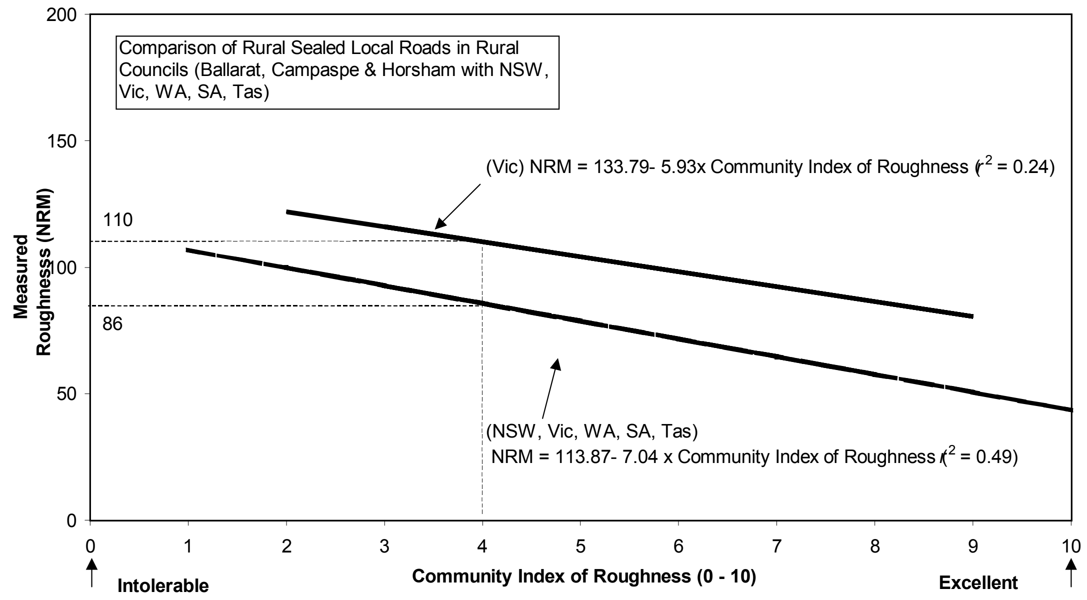


Figure 2 — Comparison of the State data with that of the Victorian data

Although the two relationships have a similar slope, they yield quite different results for the estimates of maximum acceptable roughness and intolerable roughness. The difference between the two relationships may be due to local community factors or the less than desirable variation in roughness on the recently collected data where the community was unable to make a clear assessment about its perceptions of roughness because of its low variation.

A relationship between the roughness and the community index was then based on all of the available data. That is, the earlier Victorian data was combined with the recently obtained State data to give the relationship in Figure 3.

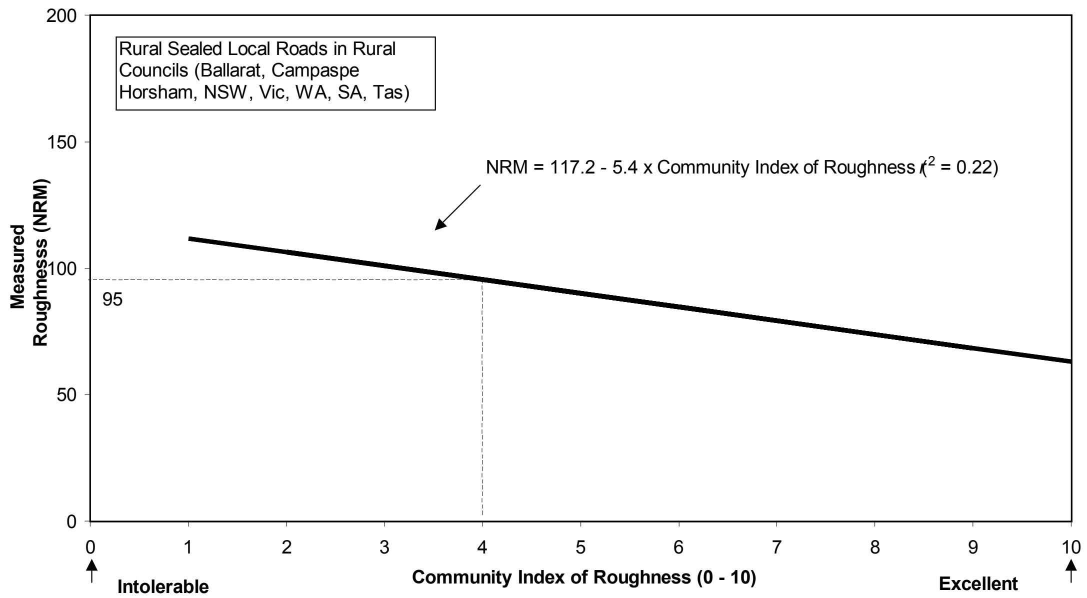


Figure 3 — Overall community assessment as a function of roughness

Comparison of these figures clearly displays the expected trend, that, a decrease in the roughness yields an increase in the acceptance of the road condition by the community. In a similar fashion to that stated above, the relationship derived from the combined data predicts that a road with a roughness in excess of 117 NRM (4.46 IRI) is intolerable to the community. This relationship also predicts that the maximum acceptable roughness (using a community index equal to 4) is 96 NRM (3.67 IRI).

Unsealed Rural Roads

In a similar fashion, the unsealed rural roads were examined and compared with the earlier data from the Victorian sites.

In the case of the unsealed roads, however, less data was available, which made the analysis subject to greater variation and lower statistical acceptability. The results are presented in Appendix F but the Figure 4 shows the trend of the unsealed road community expectation with roughness results for the States of NSW and Tasmania, compared to the previous work in Victoria.

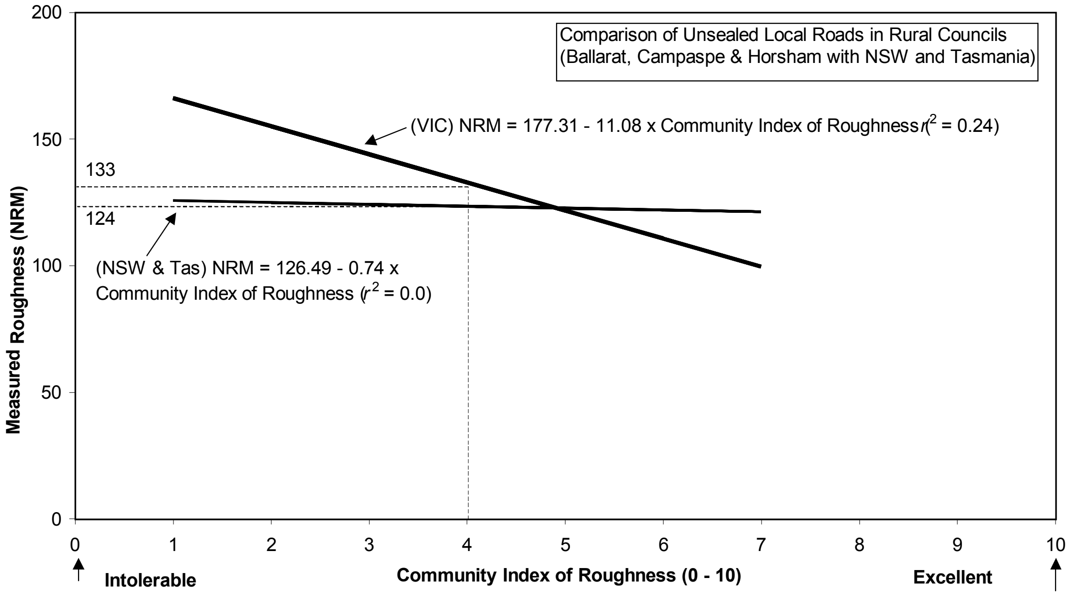


Figure 4 — Comparison of the two sets of data for roughness as a function of the Community Assessment Index

The roughness and community index relationship shows that lowering roughness on the Victorian unsealed road samples quickly increases the acceptability of the road to the community. As noted earlier, this response is not shown by the relationship derived from the recently collected data on unsealed roads.

Figure 5 shows the resulting relationship obtained from the earlier Victorian data pooled together with the recently obtained NSW and Tasmanian data on unsealed roads.

The effect of combining the two data sets is that the intolerable roughness limit is observed to decrease from 177 NRM (6.73 IRI) for Victoria samples alone to 159 NRM (6.05 IRI) for the combined data samples. When the relationships are used to predict the maximum acceptable community roughness limit, similar results are found for the combined data samples with an acceptable limit of 135 NRM (5.14 IRI), compared to an acceptable limit of 133 NRM (5.07 IRI) for the Victorian data samples.

This result suggests that the additional recently collected data has had little influence on the original relationship used to predict the maximum acceptable community roughness limit.

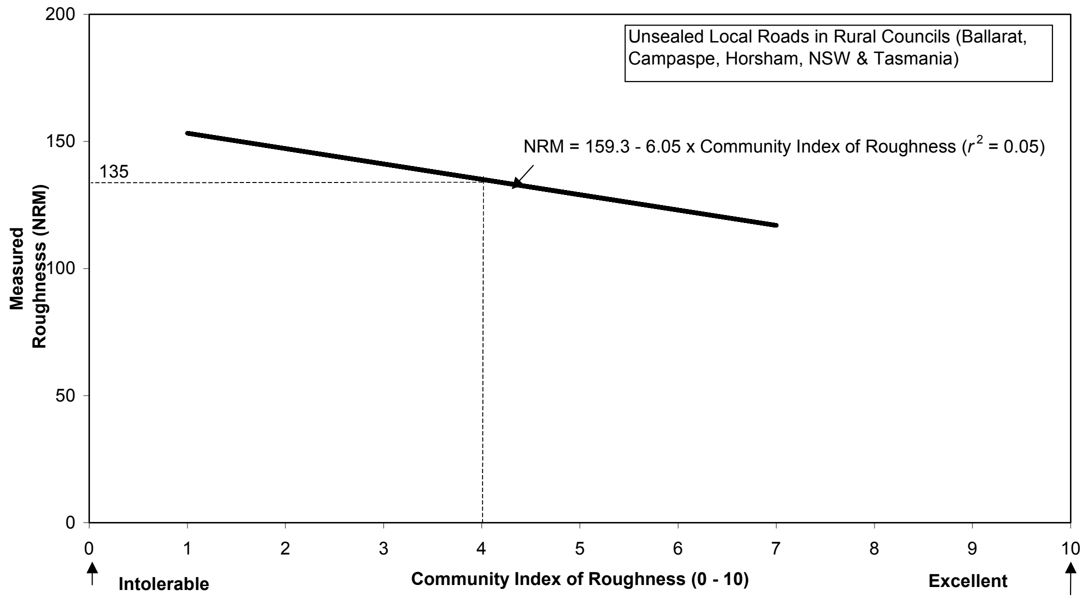


Figure 5 — Overall assessment of roughness with community expectation for unsealed roads

6.3 ROAD CONDITION INDEX VERSUS ROUGHNESS

Road Condition Index

The road condition measures used in the estimation of the road condition index are summarised in Table 10.

Table 10 — Parameters and measures in the Road Condition Index

Sealed / unsealed	Index	Parameter	Measure
Sealed Roads	Edge Index	Edge break	% of segment length
		Edge drop off	% of segment length
	Structural Index	Rutting > 20 mm	% of segment length
		Crocodile cracking	% of segment area
		Structural capacity	% of segment area remaining life > 5 yrs
	Roughness Index	Roughness perception	1 good, 5 bad
		Potholes	No of potholes per km
	Surfacing Index	Surface cracking	% of segment area
		Ravelling or stripping	% of segment area
	Skid Index	Skid resistance	1 good, 5 bad
		Surface texture	% of segment area
Unsealed Roads	Structural Index	Rutting > 20 mm	% of segment length
		Gravel road	% of segment with remaining life >5 yrs
	Roughness Index	Roughness perception	1 good, 5 bad
		Potholes	No of potholes per km

Each measure on a segment was converted to a 1 - 10 scale[13]. The value of each index was then calculated as the average of the individual measures in the index and the overall composite Road Condition Index was the average of the component indices.

Sealed Rural Roads

In a similar fashion to the approach taken with the community assessment analysis, the relationships between the roughness and the road condition index, as well as road condition index and community assessment were also investigated for both the sealed and unsealed sites. In both cases, only the responses to Question 2 are presented.

Figure 6 depicts the relationship between the measured roughness and the road condition index[14] for all the data.

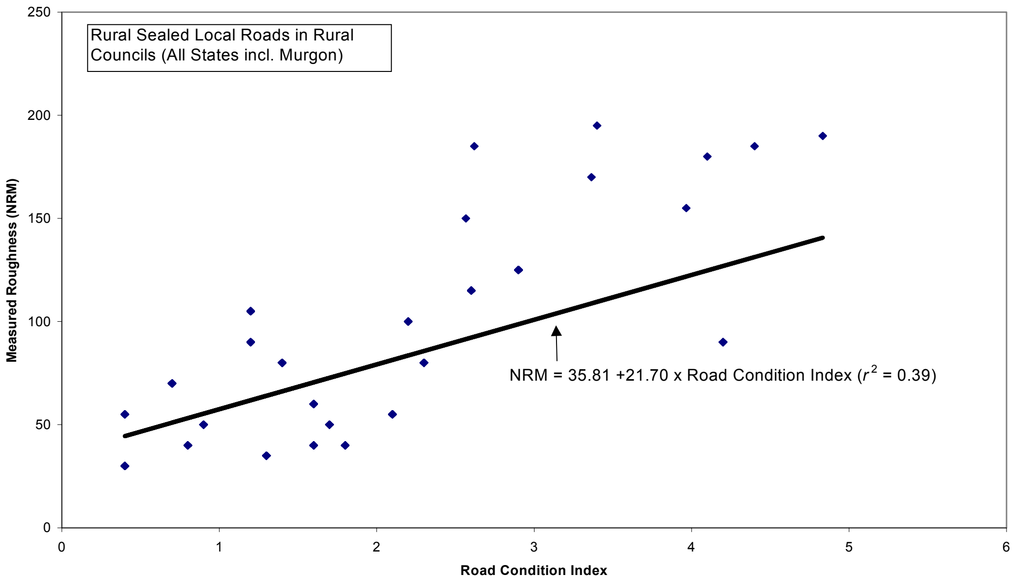


Figure 6 — Road Condition Index and roughness for sealed roads in all States

[13] Those measures expressed as a percentage of the segment length were divided by 10, while those rated on a 1 good to 5 bad scale were divided by 0.5.
[14] The regression lines on these two graphs appear out of line with the dot points. This is due to there being a number of sites under several dots in the low roughness range. This has resulted in disproportionate weighting to those points.

Unsealed Rural Roads

The same methodology was carried out on the unsealed pavements as that used for the sealed pavements. Figure 7 shows the relationship between measured roughness and road condition found from the data for unsealed pavements. In this case, the statistical fit is not quite as good (r^2 = 0.26) as that found for sealed roads (r^2 = 0.39).

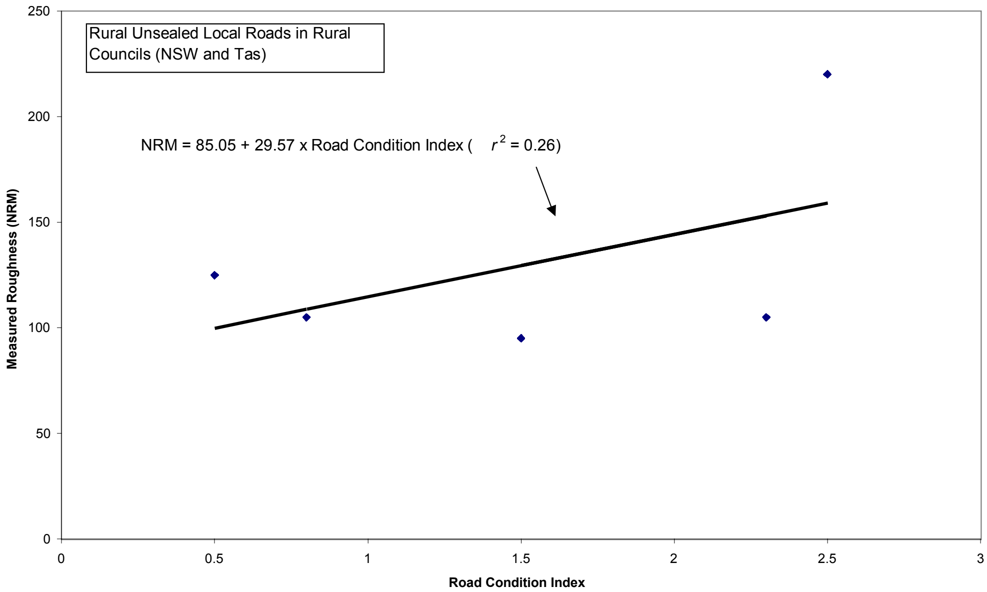


Figure 7 — Road Condition Index as a function of the measured roughness for unsealed roads

6.4 FUTURE LIABILITY VERSUS ROAD CONDITION INDEX

As part of the expenditure data collected, Councils estimated the replacement value of the route for each five year remaining life period. This data provided an estimate of the average remaining life of each route. Councils also nominated an economic life[15] enabling the remaining life to be expressed as a percentage of the economic life.

These estimates provide an insight into the future funding liability of the road. An interesting relationship emerged from the regression between the ratio of remaining and economic life to the measure of road condition, as shown in Figure 8. This relationship, if validated across a larger sample of roads, provides an important more objective approach to estimating remaining life. The regression relationship only applies to Road Condition Indices greater than 1.0, as the percentage remaining life will obviously increase to 100% for roads in an as new condition (ie a road condition index close to 0).

*Percentage Remaining life = 75% - 16 * (Road condition index)*

[15] Economic life is defined as the life of the pavement before renewal is required. While it can be defined in terms of an unacceptable (or unsustainable) level of roughness (eg NRM > 170 counts per km (IRI > 6.47)), it is also influenced by the level of community tolerance and their ability to fund the renewal.

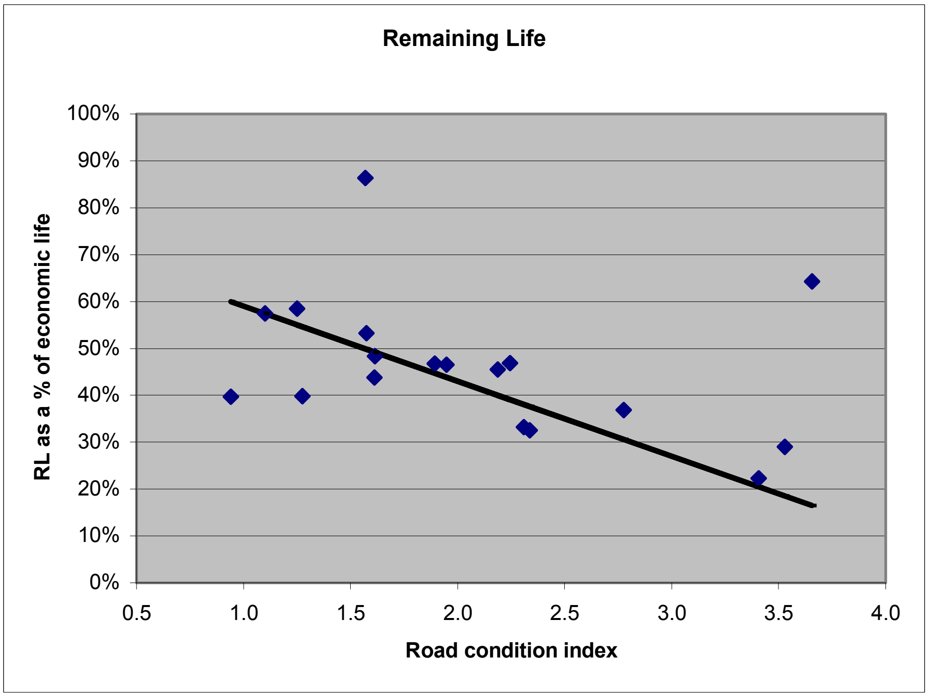


Figure 8 — Road Condition Index as a function of the Remaining Life and Economic Life

CHAPTER 7 — ASSET MANAGEMENT FRAMEWORK

7.1 INTRODUCTION

As mentioned in Chapter 4, two approaches were taken in establishing an analytic framework for Councils. The first was based on comparing the current expenditure against average values for routes with similar characteristics. This is called the Benchmark Approach.

The second approach involved comparing expenditure against the ARRB-TR life cycle cost envelopes and is called the Life Cycle Costing Approach. Both approaches are described in this Chapter.

7.2 BENCHMARK APPROACH

Level of Expenditure

The assessment involved grouping routes that had similar cost structures. The Expenditure Ratio was calculated by dividing the actual expenditure on maintenance and renewal with the modelled value for the particular Council category[16].

The expenditure was obtained from the data set collected by the State Grants Commissions for the Australian Local Government Association, in accordance with a national template. The expenditure included all road related expenditure within the road reserve, including attributed overheads.

Three cost structures were then established based on the Expenditure Ratio[17] and the Traffic Function[18,] as shown in Table 11. The three cost structures are represented graphically in Figure 9.

Table 11 — Derivation of Cost Structure

Cost Structure	Expenditure Ratio / Traffic Function
A	< 1.5
B	> = 1.5 but < = 3
C	> 3

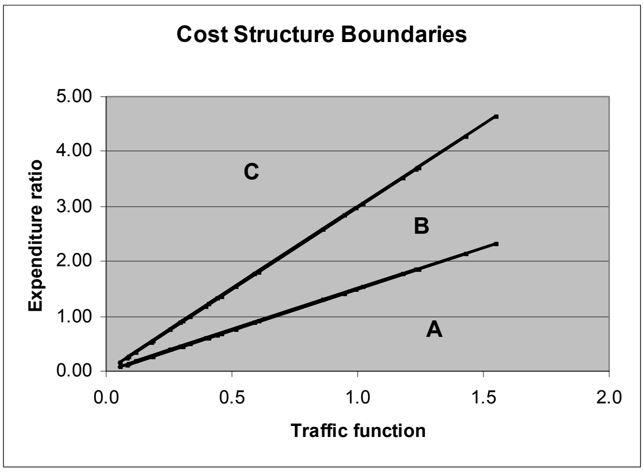


Figure 9 — Cost Structure boundaries

[16] See Appendix D
[17] Expenditure Ratio = Actual / Modelled maintenance and renewal expenditure
[18] Traffic Function = log (AADT/100)

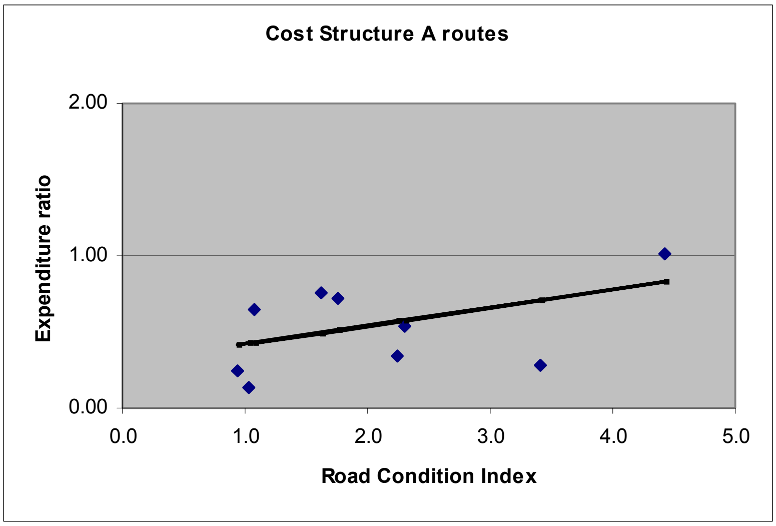
Road condition is an important consideration in assessing an appropriate level of expenditure. The test segments on each route had been selected to represent the range in road condition of the route. Therefore the average of the segments was taken as characteristic road condition of each route.

The first step involved separating the lower trafficked routes ie those with average daily traffic volumes of less than 200 vehicles per day. Relationships were then established between the Expenditure Ratio and the average road condition index for each of the three Cost Structure categories.

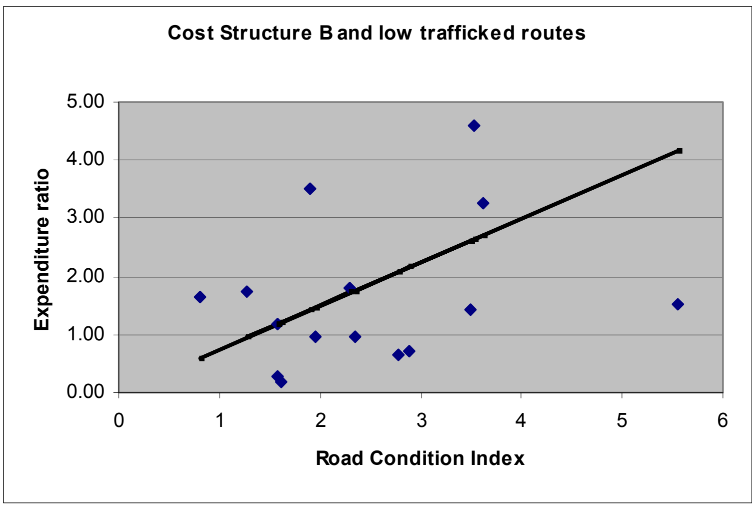
There was a reasonable correlation for all cost structures reflecting that increased expenditure was required as the road deteriorated. The relationship for the lower trafficked routes (less than 200 vpd) was similar to the Cost Structure B routes and the two datasets were therefore combined.

The following three graphs (Figure 10) show the relationships derived from the three route categories. Interestingly the slope was quite flat for the lower cost structure but increased for each increase in cost structure.

(a) Cost Structure A routes: Expenditure ratio = 0.3 + 0.12 (Road Condition Index)*



(b) Cost Structure B and low trafficked routes: Expenditure ratio = 0 + 0.75 (Road Condition Index)*



(c) Cost Structure C routes: Expenditure ratio = 0.1 + 1.10 (Road Condition Index)*

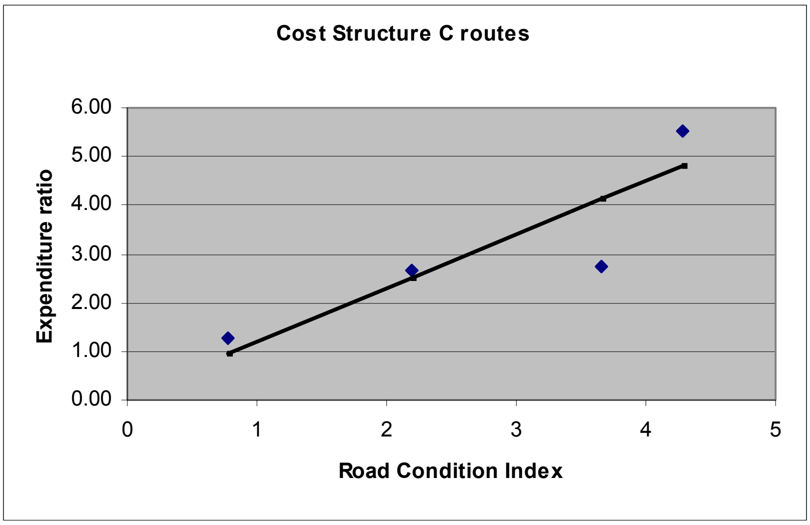


Figure 10 — Relationships between Road Condition Index and Expenditure Ratios, by Cost Structures (A, B and C)

Future Liability

An assessment of the likely future liability can be made from an assessment of the renewal expenditure against a theoretical benchmark value. The renewal expenditure was expressed as a percentage of the total maintenance plus renewal expenditure and compared against the theoretical value from the Moree[19] analysis.

The theoretical benchmark levels are shown in Table 12.

Table 12 — Theoretical Benchmark Levels

Rural Councils	
Category[20]	**Theoretical % Renewal**
RAL	47%
RAM	41%
RAS	48%
RAV	42%
RSG	34%
RTL	24%
RTM	24%
RTS	34%
RTX	16%

Urban Councils	
Category	**Theoretical % Renewal**
UDL	57%
UDM	54%
UDS	50%
UDV	58%
UFL	44%
UFM	62%
UFS	57%
UFV	55%
URL	53%
URM	46%
URS	50%
URV	26%

[19] Appendix D
[20] Appendix G

The ratio of the actual percent renewal[21] to the theoretical value (see Table 12) is called the Renewal Ratio and provides a further means of categorising the expenditure on a particular route. The thresholds used in categorising the Renewal Ratios are summarised in Table 13.

Table 13 — Derivation of Renewal Categories

Renewal Category	Renewal Ratio
X	0 - 0.5
Y	0.51 - 1.0
Z	> 1.0

Remaining Life

A third assessment involves estimating the remaining life as a percentage of the estimated economic life of the road. The threshold values for the various priority categories are shown in Table 14.

Table 14 — Derivation of Priority Categories

Priority	Remaining Life as a % age of Economic Life
Short term	< 35%
Medium Term	35 - 50%
Long term	> 50%

7.3 LIFE CYCLE COSTING APPROACH

The ARRB Transport Research Pavement Life Cycle Costing (PLCC) model was used to establish the upper and lower envelopes of generic relationships between road roughness and the equivalent annual expenditure for maintenance and renewal.

Table 15 outlines the assumptions used in the PLCC model. All these variables will influence the rate of pavement deterioration, the annual expenditure for maintenance and renewal and the total life cycle costs.

One of the critical variables, the pavement deterioration calibration factor, Kr, was based on the average roughness deterioration rate of 2.5 NRM (0.085 IRI) per year.

The PLCC analysis was then conducted over the various ranges of each variable, so that their impact could be judged on the estimated annual average maintenance and renewal expenditure. A series of PLCC analyses were performed for a number of roughness values and the results plotted graphically (refer to Figure 11).

The deterioration rate is a critical factor in estimating the annual average maintenance and renewal expenditure. Where the actual rates of deterioration are lower than those used in the PLCC analysis, the estimated annual average maintenance and renewal expenditure will be higher than necessary. The converse is true when the actual rates of deterioration are higher than those used in the PLCC analysis, the estimated annual average maintenance and renewal expenditure will be lower than necessary.

[21] Renewal as a percentage of total maintenance plus renewal expenditure

Table 15 — Input data ranges used in the PLCC analysis

Input parameter	Unit	Value
Deterioration calibration factor, Kr		0.42
Road length	Km	1.0
Lane km	Km	1.0
Lane area	'000 sq m	3.5
Average age of pavement	Years	14
Average SNCo		2.1 to 2.9
Average initial roughness	NRM (IRI)	80 (3.07)
Min roughness post reconstruction	NRM (IRI)	60 (2.31)
Average Thornthwaite Index	I	-35 to 100
Rise and fall	m/km	14
Curvature	deg/km	13
Average AADT	veh/day	50 to 500
Percentage heavy vehicles	%	5 to 25
Average ESA's per heavy vehicle	ESA/veh	2.0
Rehab fixed cost per unit area	$/sq m	$15.00
Rehab cost per 10mm of thickness	$/sq m	$1.50

Relationships for the upper and lower band limits for the annual agency expenditure for maintenance and renewal were derived from the results of the above PLCC analysis. These relationships are unique for the assumed pavement deterioration rate and are shown in Figure 11.

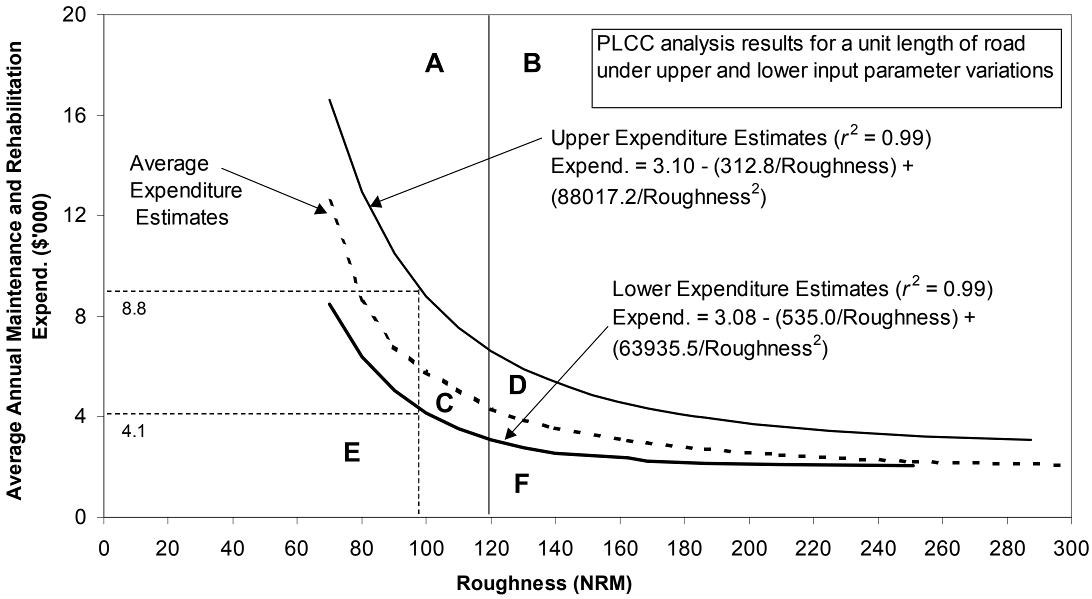


Figure 11 — Expenditure envelopes for PLCC analysis

Figure 11 shows the range in annual average maintenance and renewal expenditure, required to maintain a road at a prescribed roughness over its life cycle. As expected, a greater expenditure is required to maintain the road at lower levels of roughness.

As the prescribed roughness limit increases there is a limit to the reduction in maintenance and renewal expenditure that can be gained because the pavement must be rehabilitated at some stage even if the maintenance expenditures are minimised.

Figure 11 provides the framework for comparing the expenditure on a length of road against the measured roughness. The interpretation is limited by the fact that it is only several year's expenditure and the pavement could be anywhere in its life cycle.

Nevertheless, a PLCC classification can be made in terms of where a particular road section plots on Figure 11. Six zones are identified (A to F) around a threshold average roughness of 120 NRM (4.58 IRI) counts and whether it is above, below and within the PLCC envelopes.

It is clear that further work is required to refine this technique. In particular, guidelines need to be provided for Councils to estimate the life cycle costs equivalent to their current expenditure, reflecting the age of the road and the likely future costs estimated on a pro-rata basis from the existing expenditure.

CHAPTER 8 — APPLICATION TO THE STUDY ROUTES

8.1 INTRODUCTION

The framework described in Chapter 7 was applied to the routes selected for the study and the results are summarised in this Chapter.

Although the data has been consolidated into a few indices, care must be taken in drawing too many specific conclusions on individual routes. Rather, the emphasis should be on making broad brush observations that warrant further investigation in future studies.

8.2 BENCHMARK APPROACH

Cost Structures

The cost structure of each of the routes is summarised in Table 16.

Future Liability

The Renewal Categories for the various Councils are shown in Table 17. Routes in Table 17 are sorted by increasing traffic volume for each Renewal Category. Those routes with a traffic volume less than 200 vpd are identified with an asterisk.

Remaining Life Priority

The assessment of remaining life (RL) expressed as a percentage of economic life (EL) is shown in Table 18. As with the renewal analysis, the routes are sorted by increasing traffic volume and those routes with a traffic volume less than 200 vpd are identified with an asterisk.

It should be noted that not all Councils provided data on their remaining and economic lives and of those that did, only four fell into the short term priority group. Of the three criteria in the Benchmark Approach, the remaining life priority is the most subjective.

Combined Assessment

The overall benchmark assessment of all routes is shown in Table 19.

Table 16 — Cost Structures of routes in the study

Route Category / Cost Structure	Council	State	Traffic, v/day
Low Trafficked Routes	Albany	WA	70
	Wakool (sealed)	NSW	110
	Horsham Rural	Vic	115
	Mackay	Qld	120
	Temora	NSW	150
	Guyra	NSW	150
	Wakool (unsealed)	NSW	150
	Whitsunday	Qld	180
	Mitchell	Vic	195
Cost Structure A Routes	Alexandrina	SA	200
	Wellington	Vic	210
	Weddin	NSW	280
	Manjimup	WA	390
	Dubbo	NSW	880
	Greater Bendigo	Vic	970
	Greater Shepparton	Vic	1050
	Kempsey	NSW	1500
	Central Coast	Tas	1680
Cost Structure B Routes	Mt Barker	SA	200
	Cabonne	NSW	250
	Plantagenet	WA	320
	Katherine	NT	1700
	Circular Head	Tas	1720
	Broadsound	Qld	2670
	Litchfield	NT	3500
Cost Structure C Routes	Grant	SA	250
	Oberon	NSW	270
	Murgon	Qld	400
	Mareeba	Qld	720

Table 17 — Renewal Categories for routes in the study

Renewal Category	Council	State	Renewal Ratio
Renewal Category X Routes	Albany (*)	WA	0.0
	Horsham Rural (*)	Vic	0.0
	Whitsunday (*)	Qld	0.0
	Mitchell (*)	Vic	0.4
	Alexandrina	SA	0.0
	Weddin	NSW	0.2
	Plantagenet	WA	0.0
	Manjimup	WA	0.0
	Mareeba	Qld	0.0
	Greater Bendigo	Vic	0.0
	Greater Shepparton	Vic	0.3
	Circular Head	Tas	0.0
	Broadsound	Qld	0.0
Renewal Category Y Routes	Wakool (sealed) (*)	NSW	0.8
	Mt Barker	SA	0.8
	Wellington	Vic	0.6
	Grant	SA	0.9
	Cabonne	NSW	0.8
	Oberon	NSW	0.5
	Dubbo	NSW	0.9
	Kempsey	NSW	0.8
	Litchfield	NT	1.5
Renewal Category Z Routes	Mackay (*)	Qld	1.5
	Temora (*)	NSW	1.6
	Guyra (*)	NSW	1.6
	Wakool (unsealed) (*)	NSW	1.1
	Murgon	Qld	1.5
	Central Coast	Tas	1.2
	Katherine	NT	2.8

Table 18 — Priorities based on Remaining Life for routes in the study

Priority category	Council	State	Remaining Life as a percentage of Economic Life
Short Term Priority Routes	Mackay (*)	Qld	29%
	Plantagenet	WA	33%
	Manjimup	WA	22%
	Dubbo	NSW	33%
Medium Term Priority Routes	Wakool (sealed) (*)	NSW	40%
	Horsham Rural (*)	Vic	44%
	Temora (*)	NSW	47%
	Wellington	Vic	40%
	Cabonne	NSW	37%
	Oberon	NSW	46%
	Weddin	NSW	47%
	Greater Shepparton	Vic	48%
	Circular Head	Tas	47%
Long Term Priority Routes	Albany (*)	WA	86%
	Guyra (*)	NSW	69%
	Wakool (unsealed) (*)	NSW	58%
	Mitchell (*)	Vic	53%
	Murgon	Qld	64%
	Greater Bendigo	Vic	57%
	Kempsey	NSW	65%

Table 19 —Overall assessment of all routes in the study using the Benchmark Approach

Council, State	AADT	RCI[22]	Category			Comments
			Cost Structure	Renewal Category	RL Priority	
Albany, WA	70	1.6		X	Long	These low trafficked routes cover a range in road condition. Generally those routes in good condition do not have renewal expenditure. Significantly, the route with the worst road condition (Whitsunday) also does not have renewal expenditure. The short remaining life priority at Mackay is reflected in the below average road condition and an emphasis on renewal expenditure. The Guyra route has a strong emphasis on renewal in an attempt to contain the deterioration in road condition. The prognosis on remaining life is promising.
Wakool, NSW	110	1.3		Y	Medium	
Horsham Rural, Vic	115	1.6		X	Medium	
Mackay, Qld	120	3.5		Z	Short	
Temora, NSW	150	1.9		Z	Medium	
Guyra, NSW	150	3.5		Z	Long	
Wakool, NSW	150	1.3		Z	Medium	
Whitsunday, Qld	180	5.5		X		
Mitchell, Vic	195	1.6		X	Long	
Alexandrina, SA	200	1.0	A	X		All these low cost routes with the exception of Manjimup had better than average road condition. This accounts for the lack of a renewal strategy in their current expenditure. Manjimup on the other hand was the only route with a short term remaining life problem.
Weddin, NSW	280	2.2	A	X	Medium	
Manjimup, WA	380	3.4	A	X	Short	
Greater Bendigo, Vic	970	1.1	A	X	Long	
Greater Shepparton, Vic	1050	1.6	A	X	Medium	
Wellington, Vic	210	0.9	A	Y	Medium	Some provision has been made for renewal on these low cost routes, which is reflected in the good road condition. The Kempsey route is the exception where the road condition has deteriorated under the heavy traffic. The long remaining life for the Kempsey route is not consistent with its road condition.
Dubbo, NSW	880	2.3	A	Y	Short	
Kempsey, NSW	1500	4.4	A	Y	Long	
Central Coast, Tas	1680	1.8	A	Z		Adequate provision for renewal is maintaining the condition at a high level despite the high traffic volume.
Plantagenet, WA	320	2.3	B	X	Medium	These medium cost structure routes have little emphasis on renewal, which is reflecting in the road condition of the Broadsound route. The three Councils need to start increasing their expenditure on renewal.
Circular Head, Tas	1720	1.9	B	X	Medium	
Broadsound, Qld	2670	3.6	B	X		
Mt Barker, SA	200	2.9	B	Y		The Mt Barker and Cabonne routes are starting to deteriorate with age and hence the need for an emphasis on renewal. The Litchfield route is younger and the renewal expenditure has kept it in very good condition.
Cabonne, NSW	250	2.8	B	Y	Medium	
Litchfield, NT	3500	0.8	B	Y		
Katherine, NT	1700	2.3	B	Z		The Katherine route is quite heavily trafficked and subject to flooding. It is in average condition due to reconstruction in recent years.
Mareeba, Qld	720	4.3	C	X		The Mareeba route is in poor condition notwithstanding the level of expenditure. However there should be greater emphasis on renewal in the future to ameliorate the deterioration in road condition.
Grant, SA	250	0.8	C	Y		The greater emphasis on renewal on these high cost routes have contained the deterioration in road condition although the prognosis on remaining life is not very promising for the Oberon route.
Oberon, NSW	270	2.2	C	Y	Short	
Murgon, Qld	400	3.7	C	Z	Long	A strong emphasis on renewal on this high cost route provides a promising prognosis on remaining life, notwithstanding a below average road condition.

[22] Road Condition Index

8.3 LIFE CYCLE COSTING APPROACH

The PLCC classification of each of the routes is reported in Table 20 together with the Cost Structure classification for comparison. They are listed in increasing traffic. Those routes with a traffic volume of less than 200 vpd are also indicated with an asterisk.

Table 20 — Overall assessment of all routes in the study using the Life Cycle Costing Approach

PLCC Classification	Council	State	Cost Structure	Comment
PLCC Class B Routes	Mackay (*)	Qld		Both routes are in north Qld with high cost structures (reflecting tropical conditions) and below average road condition.
	Mareeba	Qld	C	
PLCC Class C Routes	Katherine	NT	B	Both routes have similar and high traffic volumes (1,700 vpd) being located near a town. They also have above average road condition.
	Circular Head	Tas	B	
PLCC Class D Routes	Whitsunday (*)	Qld		Three of the five routes are in Qld. The Broadsound route has the highest traffic but although the level of expenditure appears adequate, there is not enough emphasis on renewal. The Whitsunday route has the poorest road condition notwithstanding its low traffic volume. While the cost structure is high, not enough is being allocated to renewal.
	Mt Barker	SA	B	
	Murgon	Qld	C	
	Kempsey	NSW	A	
	Broadsound	Qld	B	
PLCC Class E Routes	Albany (*)	WA		The majority of the routes fell into the PLCC Class E category. They included most of the low trafficked and low cost structure routes. The higher cost structure routes are in generally good condition notwithstanding some routes with heavy traffic. As these routes deteriorate, there will be a need to increase expenditure with an increased emphasis on renewal.
	Wakool (sealed) (*)	NSW		
	Horsham Rural (*)	Vic		
	Temora (*)	NSW		
	Wakool (unsealed) (*)	NSW		
	Mitchell (*)	Vic		
	Alexandrina	SA	A	
	Wellington	Vic	A	
	Grant	SA	C	
	Oberon	NSW	C	
	Weddin	NSW	A	
	Plantagenet	WA	B	
	Dubbo	NSW	A	
	Greater Bendigo	Vic	A	
	Greater Shepparton	Vic	A	
	Central Coast	Tas	A	
	Litchfield	NT	B	
PLCC Class F Routes	Guyra (*)	NSW		These three routes have below average road condition even though their traffic volumes are not high. Clearly their expenditure needs to be increased.
	Cabonne	NSW	B	
	Manjimup	WA	A	

CHAPTER 9 – DATA TEMPLATE FOR THE NEXT STAGE

9.1 INTRODUCTION

The project has developed an approach that can be used to review their expenditure on low trafficked roads. Two approaches are advocated; one is based on comparison with the expenditure patterns of other Councils (Benchmark Approach) while the other is based on a comparison with a theoretical life cycle cost analysis (Life Cycle Costing Approach).

Both approaches have valid application but provide different perspectives of the adequacy or otherwise of existing expenditure levels. This Chapter establishes a data template and the procedures for both approaches that will be used in Part 2 of the Austroads project.

9.2 BENCHMARK APPROACH

The data for the Benchmark Approach is summarised in Table 21, and the procedure is summarised below.

Table 21 — Data for the Benchmark Approach

	Data Item	Measure	Relationship
For the Route	Council Class		Establishes Benchmarks for Expenditure and Renewal Ratios
	Traffic	AADT	Traffic function = log (AADT/100)
	Expenditure	Current Expenditure (over last 5 yrs) Maintenance Capital Renewal	Expenditure Ratio = Maintenance and Renewal Expenditure divided by Benchmark Average
			Renewal Ratio = Renewal expressed as a Percentage of Maintenance and Renewal Expenditure divided by the Benchmark Average
For Segments on the Route	Road Condition	Visual Assessment Edge, Structural, Roughness, Surfacing and Skid Indices for good, average and poor segments	Road Condition Index = Average of Indices Road Condition Index for the route is the average of the segments
	Remaining life	Expressed as a percentage of economic life	Alternatively can be estimated from Road Condition Index

Procedure for the Benchmark Approach

1. Establish whether the route is a low trafficked route ie AADT < 200 vpd.
2. Establish Cost Structure (if AADT>200vpd) from Expenditure Ratio and Traffic Function.
3. Establish Renewal Category from Renewal Ratio.
4. Establish Remaining Life Priority from assessment of remaining and economic life or from average road condition index.
5. Form an Opinion on the appropriateness of current expenditure including renewal from the Cost Structure, Traffic Volume, Road Condition Index, Renewal Category and Remaining Life Priority.

9.3 LIFE CYCLE COSTING APPROACH

The data for the Life Cycle Costing Approach is summarised in Table 22, and the procedure is summarised below.

Table 22 – Data for the Life Cycle Costing Approach

	Data Item	Measure	Relationship
For the Route	Traffic		A range is assumed in the model
	Expenditure	Current Expenditure (over last 5 yrs) Maintenance Capital Renewal	The current approach is based on the average annual current maintenance and renewal expenditure. However, future work needs to establish how to estimate an equivalent life cycle cost from the current expenditure and road condition
	Road condition	Roughness (NRM)	Can be estimated from the Road Condition Index in the absence of roughness testing. However although a practical approach, it has little precision
	Community Expectations	Roughness Intervention Level	Values from previous research can be used

Procedure for the Life Cycle Costing Approach

1. Establish the Average Life Cycle Cost equivalent to the current maintenance and renewal expenditure. This has not been attempted in the work so far and the analysis has been based on the current expenditure.
2. Establish the PLCC Class from the Roughness Intervention Level and the Average Life Cycle Cost.
3. Form an Opinion on the Appropriateness of Expenditure Level.

9.4 ADDITIONAL DATA ITEMS

Additional data items that should be collected to assist in the interpretation of the expenditure include items that relate to life cycle costs such as:

- current resealing frequency;
- age profile of the route;
- age of pavement sections that have been renewed and the basis for that renewal (ie road condition, levels of service, safety etc); and
- maximum age of sound pavement sections.

Councils should be in a position to develop a maintenance strategy for the route based on the assessments of expenditure and their likely future liabilities.

9.5 THE NEXT STAGE

The work outlined in this report establishes the framework for reviewing the expenditure on low trafficked roads. The next step is to test it in the field. Part 2 of the project for which $100,000 has been allocated by Austroads in 2001/02 and 2002/03, will invite a significant number of Councils to apply the guidelines to a route or number of routes in their local government area. The first Councils to be invited will be the 32 who participated in the current first stage and others from all States, Territories and New Zealand will also be invited to participate as well.

State Road Authorities and Transit New Zealand will also be invited to test the framework on low trafficked routes for which they are responsible.

The findings and conclusions by the various road managers involved in Part 2 will provide the information for addressing the three outcomes of the project, namely:

- A national assessment of whether Councils in rural areas are adopting the appropriate maintenance strategy to meet future asset management liabilities and community expectations.
- A national assessment of the implications of heavy loading on future road condition.
- Asset and pavement management analytical techniques applied at a national level for rural roads.

The final framework and conclusions will be reported as an Austroads research report.

CHAPTER 10 — CONCLUSIONS

The two approaches are complementary.

The data used to establish the strategic framework provides an insight into whether the participating Councils are allocating the right amount of funding (maintenance and renewal) to the selected routes. The two approaches provide complementary analyses of existing expenditure, one from a framework based on expenditure trends across local government and the other from a theoretical treatment of life cycle costs.

Three quarters of the routes had expenditure levels below the lower envelope derived by the PLCC analysis. And yet, 48% of the routes had expenditure levels greater than the benchmark levels established from the Moree analysis.

One conclusion can be drawn immediately, namely that the average expenditure over a couple of years will tend to under-estimate the average life cycle cost of those roads that are less than twenty years old. It may even under-estimate it for older pavements if the renewal process has only just started. A systematic approach needs to be developed as part of the Life Cycle Costing Approach for estimating typical average life cycle costs from current expenditure patterns.

The Benchmark Approach provides several relationships that will help in this regard, particularly the increase in expenditure and reduction in remaining life with deterioration in road condition.

Further work is needed on relationships between remaining life, road condition, expenditure and traffic.

The framework proposed attempts to take into account road condition not only as a proxy for roughness but as a determinant in estimating the remaining life of a pavement. This type of relationship is particularly important because any assessment of remaining life (and economic life) is so subjective. There is clearly scope for further research on such a relationship.

The project attempts to establish a relationship between expenditure and traffic. While this may be less significant for low trafficked local roads, it is important when assessing the appropriateness of expenditure levels on the more heavily trafficked roads. The benchmark levels established from the Moree Committee analysis reflect average values for all local road conditions and will not necessarily be applicable to a particular route.

The approach taken in this project attempts to take these values one step further by suggesting that the level of expenditure on the more heavily trafficked local roads needs to increase with traffic. The results show that this does in fact happen in practice. Councils would value any validation of the relationship between traffic and the appropriate level of expenditure.

A nationally consistent approach to measuring road condition is imperative.

The framework provides some insight into the extent to which Councils are funding renewal. Only a quarter of the Councils are spending more than the modelled average for a 1% renewal rate. Once again the theoretical value may be misleading as the need for renewal is strongly influenced by the age of the road and where it is in its life cycle. This underscores the need for a consistent approach to road condition for Councils to use some of the relationships that are emerging from this type of analysis.

There is scope for deriving benchmark levels, whether it is in terms of maintenance strategies (such as rates of renewal), expenditure levels for different categories of road (traffic, environment, existing road condition, remaining life etc) or levels of service (roughness or a road condition index). Although every road is different in some way, Councils need to understand why they are different and the implications for their maintenance strategies.

Measuring levels of service is also important.

Measuring levels of service is important and this needs to be done in a nationally consistent way. Many Council engineers have reservations about the value of roughness as a measure of road condition. These engineers need to adopt an approach similar to that used in this project. Discussion and agreement on the relevant factors and their weightings should now be a high priority for Austroads.

ARRB Transport Research has undertaken valuable research in recent years bringing together the concepts of life cycle costs and community levels of service. Previous research had established relationships between community standards and roughness but they were based on sites selected to give the community representatives a range in standards and roughness.

However, sites for this project were constrained by the need for them to be on a single route. While the sites covered a range in conditions, for a number of the routes the measured roughness did not span the range of the previous work. Therefore some accommodation was required when the data was combined for the assessment framework. While this did not invalidate the relationships or concepts, it did highlight that community standards can be very subjective.

The next stage will field test the framework.

The next stage in the project will test the practicality of the framework to managers of low trafficked routes. The 28 Councils participating in the first stage will be asked to apply the approach to another route in their local government area. A further 52 Councils and State Road Authority offices will be asked to do the same.

The data collected and the conclusions drawn by the 80 low cost road managers will provide material to deliver the three main outcomes for the project.

APPENDIX A

REGIONAL CO-ORDINATORS

State	Name	E-mail	Phone
New South Wales	Phil Hawley	hawley@shoal.net.au	0419 460 310
	Steve O'Rourke	cspl@mpx.com.au	0427 011 143
Victoria	Chris Starr	chris@rns.com.au	(03) 5382 4435
	John Bennett	jba@netconnect.com.au	0418 351 343
Western Australia	Michael Wood	mgwood@iinet.net.au	0417 187 464
Queensland	Peter Jones	pajengco@mackay.net.au	(07) 4955 6633
	Richard Wilson	wilsonrm@iprimus.com.au	0409 391 941
Tasmania	Geoff Webb	webbs6@southcom.com.au	0419 875 456
South Australia	Jeff Roorda	jeffro1@msn.com.au	0404 478 421
National Co-ordinator	Peter Rufford	wzerbst@bigpond.com	0411 095 511

APPENDIX B

ROUTES INVOLVED IN THE STUDY

State	*Council*	Route No	Description
NSW	Guyra	N-1	Black Mountain Road. 16km sealed road. Originally sealed for use by school buses but now used by quarry trucks. Failure due to rutting rather than roughness.
	Kempsey	N-2	Maria River Road. 16km sealed road. Designed for light traffic but now used by trucks.
	Wakool	N-3	Former MR94 between Swan Hill and Wakool. 60km long with both sealed and unsealed sections.
	Young/Harden	N-4	Demondrille to Young Road. 30km in length. 8t load limit has been imposed to discourage heavy through traffic.
	Temora/Weddin	N-5	Back road between Temora and Carragabul via Morangarell. All sealed and with a number of bridges.
	Oberon	N-6	Shooters Hill Road. Mostly sealed and carries logging vehicles.
	Dubbo/Cabonne	N-7	Obley Road between Dubbo and Yeoval. Length fully sealed.
SA	Grant	S-1	Mingbool / Attamurra Roads. 32km long with 25km sealed and the remainder gravel. High volume of logging vehicles. Varying conditions along route.
	Mt Barker/Alexandrina	S-2	Wistow to Woodchester 15 km of sealed a further 15km of sealed road between Woodchester to Langhorne Creek
NT	Katherine	NT-1	Florina Road. 16km sealed road west from Katherine and serving a mix of agricultural and pastoral properties. Strong traffic growth in recent years and subject to flooding from the Katherine River.
	Litchfield	NT-2	Girraween Rd. Main sub-arterial for the Shire serving a developing outer urban community. It runs east for 6.2 km from the Stuart Highway and is fully sealed (7m wide).
Vic	Greater Bendigo	V-1	The route is actually a combination of Allies Rd/Averys Rd/Eaglehawk-Epsom Rd/Howard St and the back route from the Calder Hwy @ Marong to the Saleyards @ Epsom. Varying conditions with very heavy truck traffic (especially on sale days).
	Horsham Rural	V-2	Dimboola-Minyip 5 Chain Rd. 22kms long. Route between townships of Dimboola and Minyip and runs through 3 Councils. Short cut for heavy vehicles which cause ongoing damage.
	Mitchell	V-3	Dry Creek Rd (includes Sth O'Gradys Rd) 13kms long. Sections of varying conditions - sealed and gravel. Significant number of CV's emanating from 2 quarries.
	Greater Shepparton	V-4	Lemnos North Rd. - 27km long and sealed. Varying road conditions.
	Wellington	V-5	Gormandale-Stradbroke Rd - 33.6 km long with 23.4km sealed and the remainder gravel. Main route between Hyland Hwy and Sth Gippsland Hwy. Varying conditions with log trucks and milk tankers.
Tas	Circular Head	T-1	43.9km route linking Woolnorth Rd, West Montagu Rd, Montagu Rd, Davis St and Nelson St.
	Central Coast	T-2	Approx 50km route on Preston Road/Castra Road, with about 5km unsealed. Affected by logging and agricultural traffic.

State	*Council*	Route No	Description
Qld	Mareeba	Q-1	Chettle Road and Springmount Road combine to make a 20 km sealed route.
	Murgon	Q-2	Silverleaf Road. 20km of sealed local road of variable condition. Serves the beef, grain and cotton industries.
	Mackay	Q-3	Wintons/Paskins Roads. These two sealed roads form a loop access from the Bruce Highway approx 65km north of Mackay. Serves a mix of cane, grazing and rural industries
	Whitsunday	Q-4	Up-River Road services farming country north of the Proserpine River. It was originally built for cattle grazing areas, but over time (30 years) cane farming has become established from the Bruce Highway end. Changes in machinery types and cropping techniques have led to much heavier traffic loadings than before
	Broadsound	Q-5	Golden Mile Rd. A relatively new road first commenced along the current alignment in the mid 80's as an alternative route to a previously flood prone track connecting the Dysart area to the Fitzroy Development (Beef) Road.
WA	Lake Grace	W-1	Magenta Road. 41.2 km long with the first 2.4km sealed (7.2m width) and the remainder graveled (6.5m width). Newdegate Road. 38.0 km long with the last 30.6km sealed (7.2m width) and the remainder graveled (8m width). Wheat truck haulage in harvesting season but also gypsum mines. There is some evidence of dry land salinity.
	Tambellup	W-2	Toolbrunup Road. 38.6km with the first 24.0km sealed and the remainder graveled. An east-west route is subject to the extremes in traffic volumes generated by agricultural activities. Some evidence of dry land salinity.
	Plantagenet	W-3	Woogenellup Road. 36.9km long and all sealed (5.6m width). Most agricultural traffic and not affected by dry land salinity.
	Manjimup	W-4	Perup Road. 46.2km long with 35.9km sealed (4m width) and the remainder graveled. Affected by harvesting times for agriculture and timber (plantation and natural).
	Albany	W-5	Chillinup Road. 69km long with both sealed and unsealed sections. Affected mainly by summer grain carting.

APPENDIX C

DATA COLLECTION

Selection of Routes

Routes were selected in all States to apply the asset management analysis. The routes were selected on the basis that they are under the control of a Council and that they carry a significant amount of heavily loaded traffic, even if the number of trucks is not large. They are on average between 20-50 km in length.

They include a range of road condition standards from good to poor, including sealed and unsealed sections. They were all selected on the basis that they were significant to the regional economy.

Selection of Sites

Up to 8 test sections (1-2 km in length) were selected to cover the full range of road conditions on the route.

Data Collected at Each Site

The following information was collected at each site:

1. type and age of the pavement;
2. site conditions (terrain, subgrade, etc);
3. measure of existing pavement condition;
4. current and historical (if available) annual expenditure;
5. estimated profile of future life cycle expenditure (allowing for resealing and variations in heavy patching); and
6. estimated economic life (period before reconstruction is required) and utility life (period before the standard is no longer appropriate).

Community Survey

Guidelines for the community survey were prepared by ARRB Transport Research and are included as Appendix D. Essentially they established the level of roughness (a proxy for level of service) that was acceptable to the road users.

APPENDIX D

ANALYSIS BY THE MOREE COMMITTEE

Introduction

Strategic asset management is crucial to the effective allocation of funding resources to roads. This strategic analysis has been undertaken by ALGA with the assistance of Jeff Roorda and Associates to identify the shortfall in current maintenance expenditure on local roads across Australia.

The analysis was based on:

- Expenditure data collected for ALGA through the various State Grants Commissions for the 1997-98 financial year.
- Detailed asset management analyses of Councils in Victoria, South Australia and to a lesser extent New South Wales.

The approach involved the following steps:

1. Average the expenditure (for existing and new assets) for each Council class.
2. Estimate typical average economic life based on detailed assessments of individual Councils.
3. Estimate the percentage of the total expenditure on the existing asset spent on recurrent maintenance.
4. Average the current replacement value of existing assets and calculate the average expenditure needed to replace the asset over its economic life.
5. Add the average recurrent maintenance with the average annual replacement expenditure to give the theoretical expenditure needed.
6. Calculate the difference between the theoretical expenditure and current expenditure on the existing asset.
7. Scale up the results to give an estimate of the annual shortfall in expenditure across all Councils.
8. Conduct some sensitivity testing on key input variables.

The detailed analysis of Council data showed that the need for road funding was not uniform over time. Rather the need was cyclical in line with the life cycles of the of all the road elements in the network.

The task for the asset manager in each Council is to understand the likely future demand for road funding across the road network and to target available funding to minimise the expenditure needed to maintain a desired level of service.

Strategic Options

There are a number of strategies that could be pursued by local government nationally. They essentially relate to the frequency of resealing and reconstructing the road asset. A previous survey in 1997 indicated that Councils were resealing their roads on average every fifteen years. On the other hand they had a goal of reconstructing their roads every 50-80 years.

There is general agreement amongst Council engineers that a fifteen year reseal frequency is not frequent enough. A second strategy is to reduce the resealing period to ten years but increase the reconstruction period to 100 years. There was evidence that VicRoads has applied this strategy over the last five years for their rural arterial roads and has in fact measured an improvement in the level of service over that period. Whether this strategy is sustainable in the longer term is yet to be tested but clearly the same approach is worth considering by local government.

The analysis involved modelling the two strategies and determining the financial implications for the various Council classes in Australia.

The assumptions made for the two strategies are summarised in Table D.1.

Table D.1 — Asset management strategy assumptions

Pavement Treatment	Strategy 1	Strategy 2
Reseal frequency, % pa	7%	11%
Pavement renewal, % pa	1.5%	1%

The number of Councils included in the analysis from which the relationships were derived is shown in Table D.2 together with the total number of Councils across Australia.

Table D.2 — Numbers of Local Councils

Council Category	No of Councils	
	In Analysis	Total
Rural Agricultural	208	313
Rural Remote	29	110
Rural Significant Growth	5	23
Urban Regional	75	109
Urban Fringe	34	45
Urban Developed	64	88
Totals:	415	688

The Model

The model involved estimating the theoretical maintenance and renewal expenditure (to maintain current standards), based on:

- length of sealed, gravelled and other unsealed road;
- current annual expenditure on the existing asset;
- maintenance strategy on resurfacing and pavement renewal frequency;
- generic unit costs for pavement renewal;
- assumptions regarding the percentage of existing expenditure allocated to routine maintenance and other fixed expenditure; and
- average statistics on the extent of unformed roads.

The model was applied to expenditure and road length statistics provided by Councils for the 1997-98 financial year. It included data from Councils in all States except Tasmania and the Northern Territory.

The results were calculated by Council and averaged by Council category.

Results

The theoretical expenditure needed for the various categories of Councils is summarised in Table D.3.

Table D.3 — Theoretical funding needs, by Council Category

Council Category	Theoretical needs, $ per km per annum	
	Strategy 1	Strategy 2
Rural Agricultural	$1,372	$1,232
Rural Remote	$839	$911
Rural Significant Growth	$2,008	$1,787
Urban Regional	$3,745	$3,202
Urban Fringe	$6,147	$5,041
Urban Developed	$11,255	$9,128

The shortfall is calculated as the difference between the theoretical maintenance and the total expenditure on the existing road asset. The average shortfall per Council and by Council category is shown in Table D.4, along with the corresponding national totals for Australia for the two strategies.

Table D.4 — Estimated annual funding shortfalls for Local Roads

Council Category	Average Annual Shortfall ($ per Council)		Total Annual Shortfall (A$m)	
	Strategy 1	Strategy 2	Strategy 1	Strategy 2
Rural Agricultural	$291,416	$121,875	$91	$38
Rural Remote	$392,019	$499,193	$43	$55
Rural Significant Growth	- $132,194	- $268,986	- $3	- $6
Urban Regional	$778,176	$137,431	$85	$15
Urban Fringe	$1,583,743	$609,298	$71	$27
Urban Developed	$854,989	$118,205	$75	$10
		Totals:	$363	$140

Conclusions

1. Strategy 2 requires substantially less funding that Strategy 1 although their equivalence in terms of road performance has yet to be evaluated.
2. There is a case for increased maintenance funding for all Council categories. The exception was the RSG category (Rural Significant Growth Councils) which undoubtedly reflects the small sample size.
3. The total shortfall in rural areas (including Urban Regional Councils) is twice that in urban areas.
4. There is a case for at least an additional average $140 million to be allocated each year to the existing local road system based on the second strategy.
5. A national effort should be made to monitor the performance of the strategy over the next five years before continuing beyond that time.
6. The actual need for an individual Council in any one year will depend on the age of its asset relative to its life cycle.
7. The analysis provides the framework for developing an asset management template for regional strategic asset management.

APPENDIX E

GUIDELINES FOR THE COMMUNITY EXPECTATION SURVEY

E.1 INTRODUCTION

This appendix includes the guidelines developed by ARRB Transport Research to assess the community's expectations of levels of service on their local roads. It is understood that the levels of service relate to those confined to the road pavement and its condition, rather than the following broader issues:

- whether social and other non-commercial demands are being met by local roads;
- the minimisation of delays to road users; and,
- community consultation and communication.

The above social, road capacity and community communication issues require a different approach to the methodology needed for a relatively narrow assessment of pavement condition levels of service.

Users of the guidelines will be able to adopt the methodology outlined and carry out their own assessment of their local community's expectations of levels of service. The guidelines will facilitate a consistent approach to the assessment of community expectations across a wide range of Councils throughout Australia.

The work in this Report is a component of a broader study aimed at gaining a better understanding of the asset management of low trafficked roads subjected to heavy mass loadings. As a logical part of this study, a rational assessment needs to be undertaken of the community's expectations of its levels of service from these roads. This assessment is a form of performance criterion because it can be used to set the limits of the community's tolerance of road conditions.

E.2 BACKGROUND

The development of guidelines for a methodology to assess the community's expectations of levels of service on local roads was initially reported under Austroads Project N.BS.9703 during 1998 (Martin et al. 1999). An assessment of the community's expectations was made using these guidelines on a sample of some 30 local roads across Victoria. This assessment was found to be a particularly difficult task because it showed that:

- levels of service vary with the function and geographical location of the local roads and the socio-economic status and cultural values of the users; and
- levels of service vary with the importance of the level of service issue relative to its perceived impact on the user.

Consequently, it is important to have clear guidelines for the methodology so that an accurate as possible assessment is made to detect the differences in levels of service between the different users and different types of local roads.

E.3 METHODOLOGY FOR COMMUNITY EXPECTATIONS ASSESSMENT

The five basic steps for undertaking an assessment of community expectations of levels of service for local roads are as follows:

1. community survey panel selection;
2. local roads sample selection;
3. designing the community survey questionnaire;
4. conducting the assessment survey for 'rating' the condition of the local roads samples with the individual panel members; and
5. undertaking an analysis of the survey and a summary of its results.

The sections below expand the detail of each of the above steps. Figure E.1 below shows all these steps in the procedure.

Community Survey Panel Selection

The survey panel used to assess the community's expectations should be selected on the basis of being representative of the broad range of users of the community's local roads. It is important that the expectations of those who regularly use the local roads are being assessed rather than infrequent users of the roads (Potter et al. 1991).

The elimination or minimisation of potential misrepresentation of community expectations is the aim of the selection guidelines for the survey panel. This aim must be balanced against the costs and time involved in achieving it. The following guidelines are recommended for selection of the survey panel:

- establish a clear understanding of the aim of the community survey regarding which local road types are to be included in the survey. Where only one particular local road type is being surveyed the selected panel members must be regular users of this road type. Similarly, where a wide range of roads are being surveyed, all panel members must be regular users of these roads;
- select panel members from the local road user community that broadly represent the socio-economic status and cultural values of the community. The minimum number of panel members selected on this basis is eight, however, sixteen panel members is a preferable sample size for each community;
- the above selection should at least cover an equal number of male and female road users with a similar age distribution over the following four age ranges - 18 to 24 years, 24 to 44 years, 45 to 60 years and over 60 years; and,
- alternatively, select a much larger panel of equal numbers of male and female members of the community, say in excess of thirty members, with a similar age distribution to the above including all the possible variations in the socio-economic status and cultural values of the community. However, this option is more demanding of resources, including the overall time taken to complete the assessment survey, but it is likely to lead to a more reliable assessment.

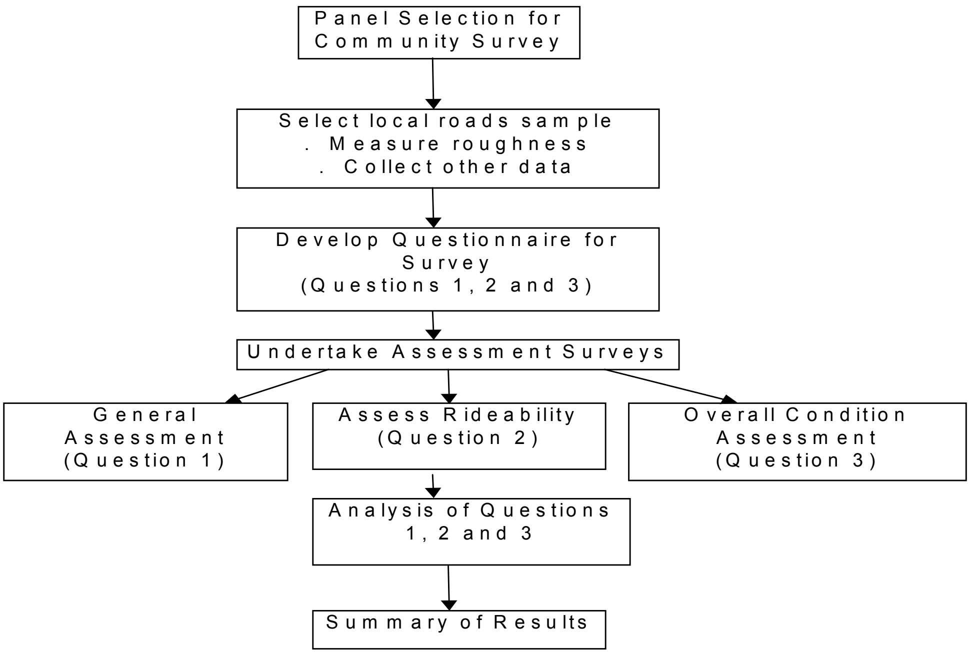
The earlier pilot study of the community's expectations of levels of service (Martin et al. 1999) used mainly employees of the Council in the panel, but avoided using road engineering staff. This selection reduced the costs and resources involved in seeking members of the wider community, however, it may have resulted in a less representative panel and therefore an assessment of lower reliability. This example demonstrates the need to balance the reliability of the assessment outcome against the costs and resources involved in achieving it.

Local Roads Sample Selection

For the strategically important rural based local roads that are to be assessed, the following road types are relevant:

- sealed granular pavements in rural areas whose users prefer relatively high speed travel; and
- unsealed gravel pavements in rural areas whose users also prefer relatively high speed travel, although the prevailing conditions do not always permit this.

Figure E.1 — Process for assessing community expectations of levels of service for local roads



Implicit in the above is the view that user speed is a major factor in the assessment of local road surface conditions.

The local roads sampled should cover a relatively wide range of existing surface conditions, for each local road type, where this is the level of service being assessed by the community. The range should ideally extend from surface conditions that will be perceived favourably by the users and those that obviously will not. This means that some portion of the samples over their test length should have an average roughness greater than 160 NRM (6.09 IRI) and some portion of the samples should have an average roughness less than 90 NRM (3.45 IRI) over their test length.

This range in sample road surface condition must be achieved where only one Council is being sampled for a particular road type. Where a number of Councils are being sampled for one or several road types, a wide range of existing conditions must be achieved across the aggregate of the road samples for each road type.

Sampling Size

It is recommended that a minimum of eight road samples be used for each road type, provided a reasonably wide range in surface conditions are sampled. In reality this range in condition is usually not present in such a small sample size. Ideally, the sample number should be around 30 so that a wide range in surface conditions is more likely to be sampled.

Again where sampling of particular road types occurs across a number of Councils, the above limit may not be so onerous.

Sample Length and Other Features

Local road type sample length should vary with the expected travel speed of the user. More information on the expected travel speed for the test sample is provided below.

The main aim of the expected travel speed is to ensure that all tests are conducted at the same speed for the same road types.

The sample lengths and test speeds in Table E.1 are recommended for particular road types.

Table E.1 – Recommended sample lengths and test speeds

Local road type	Constant Test Speed Range	Minimum Sample Length
Sealed in rural area	80 to 100 km/h	1.0 km
Unsealed in rural area	60 to 80 km/h	1.0 km

Ideally pavement surface conditions, edges and shoulders, including their widths, should be uniform as much as possible over the sample length. In addition, the sample length should be on a relatively straight and flat road length rather than on a graded curve unless this alignment is representative of this road type such as prevails in hilly terrain.

Sample Information

The following information is needed to form part of the assessment of community expectations of levels of service as well as a follow up for detailed pavement life-cycle costing (PLCC) analysis on each local road sample:

- the location of the sample length, at least in terms of road name and chainage or reference distance from a well defined intersection, overall road length and number of lanes;
- a current estimate of average annual daily traffic, AADT (vehicles per day), using the sample length;
- a current estimate of the portion of AADT that are heavy vehicles (that is, vehicles in excess of 4 tonnes gross mass), including an estimate of the distribution of these vehicles into heavy vehicle classes such as rigid trucks and buses, articulated vehicles and combination vehicles such as B-doubles and road trains;
- an estimate of the gross vehicle mass and axle configurations of the typical vehicles in each of the above heavy vehicle classes. This information will aid estimation of the annual traffic loading per lane on the local road sample in terms of cumulative equivalent standard axles;
- an estimate of the pavement age, that is the number of years since initial construction or the last renewal (asphalt overlay or granular resheet);

- an estimate of average annual maintenance and renewal expenditure, in $'s per lane–km;
- an accurate objective measurement of the sample road roughness, in terms of the International Roughness Index (IRI, m/km) for lane roughness, over the full sample lane length using laser based equipment, or equivalent (AUSTROADS 2001); and
- an accurate visual assessment of other surface defects in the sample lane such as cracking, rutting, surface loss and edge break, in terms of its severity and extent.

As noted earlier, most of the above information will be used for a more detailed PLCC analysis to estimate levels of maintenance funding for the sample. The assessment of the community's expectations of levels of service is an important input to this analysis. Any visual assessment of surface defects should be conducted and reported in accordance with guidelines set out in the RCOND 90 Manual (RTA/NSW 1990).

Community Survey Questionnaire

General Assessment of Factors
A general assessment of all the factors that could influence the community's perceptions of general pavement conditions and other associated features with levels of service should be made as the first assessment step. The questions associated with this assessment are not to be directed to any specific road in the sample. This is because the questions are aimed at gaining a general understanding and ranking of importance of the factors that influence the community's perception of road conditions.

Each member of the panel should make their assessment of these factors only in terms of high, medium or low influence on their perceptions of general road conditions. The factors to be included in the questionnaire are the following:

1. Quality of ride/roughness;
2. Type of road surface (sealed, unsealed);
3. Road width (width of sealed surface, overall width);
4. Potholes;
5. Edge wear;
6. Rutting;
7. Road geometry (features such as sharp curves, steep roads and sight distance);
8. Safety;
9. Road side vegetation;
10. Drainage of the surface;
11. Road signs; and,
12. Other factors.

The above factors may not be an exhaustive list of all the pertinent factors that could influence all communities. Therefore other factors specific to a particular community should be included in the questionnaire if they are regarded to be significant in relation to the perception of road condition.

Quality of ride usually ranks high for communities in both urban and rural areas. Different rankings of the factors that influence the community's perceptions of road conditions ostensibly reflects the different priorities community's have in regard to their local roads. Previous community surveys (Cairney et al. 1989; AGB McNair 1995; Martin et al. 1999) tend to show that road characteristics, and in particular road smoothness or rideability, are paramount in making an accurate assessment of the community's expectations of levels of service.

Rideability
As noted above, this is usually a major factor in assessing the community's expectations of levels of service. Consequently, this should be a major focus for the survey. Appendix A (Part (B) Question 2 in Austroads IP-12) provides an example of a typical questionnaire used for this assessment.

Each member of the community panel should make an assessment of the rideability of each sample road, in terms of a number, or community index of roughness, from 0 (bad) to 10 (excellent). Table E.2 shows the full range of community assessment values to be assigned to the rideability of each sample road:

Table E.2 — Community assessment of rideability

Community Value	Community Index of Rideability
Excellent	10
Very Good	9 to 8
Good	7 to 6
Adequate	5 to 4
Poor	3 to 2
Bad	1 to 0

Table E.2 shows that a Community Index of between 4 and 5 is assessed as being acceptable. In assessing the quantitative limit of community acceptable roughness, the lower limit of 4 has been used.

Overall Road Condition Assessment
An opportunity for the community should be provided to rate the condition of each of the road samples on an overall condition basis rather than just by the rideability criterion. This is because factors other than roughness may also influence the community's perceptions of levels of service for road condition.

The Assessment Survey for 'Rating' Local Road Condition

General Assessment Survey (Question 1)
The first step of the survey involves a general assessment of all the factors that could influence the community's perceptions of general pavement conditions and other associated features, as noted earlier. This survey should be conducted, as shown in Section 3.3.1, prior to any field survey because the nature of the road sample may bias this outcome if it is undertaken after the field survey.

Rideability Survey (Question 2)
The second step of the survey involves undertaking the rideability survey. This involves undertaking the rideability survey on the sample of local roads. The test conditions for the rideability assessment should be the same for all panel members. This includes the test car, the test car speed, the road conditions, the direction of travel and the weather. Ideally the survey should be conducted on the same day or over days where the weather and other conditions are similar.

The above approach is based on a number of previously reported pilot rideability surveys on arterial roads (Kaesehagen et al. 1972; Potter et al. 1991), assuming the same limitations apply to local roads as for arterial roads.

The aim of selecting a test vehicle for the rideability survey is to use a commonly available passenger car in reasonable condition. The vehicle should be a relatively common passenger car. A three to five year old Commodore or Falcon sedan in sound mechanical condition is recommended. Newer passenger cars are not broadly representative of most communities, while cars greater than ten years old are likely have suspension systems operating at less than optimum performance. In all cases the same test car should be used for all members of the survey panel.

Each member of the panel may choose to drive or be driven over the sample roads. Where panel members choose to drive they must all drive at approximately the same constant speed for each particular local road sample. The driving speed is to be within the legal speed limit applicable for each road sample. Where panel members choose to be driven, the same requirements must be observed.

The sequence in which the sample roads are assessed for their rideability needs to be considered. There are several possibilities for the test sequences if the aim of the testing is to develop a good correlation with community perceptions of rideability and measured roughness. The most practical approach is to run the test vehicle with each panel member over an sample road which has an average value of measured roughness of all the sample roads before the survey actually commences. This sample should be described as one that has an average rideability and is therefore a reference for the survey that follows. The sequence of sample roads in the survey should not necessarily follow either an ascending or descending order if this average rideability reference is used.

Each member of the panel should drive or be driven over each local road sample and make their rideability assessment immediately upon completion of their travel over each sample road. It is expected that if assessments are made after varying delays upon completion of each sample local road, the perceived rideability is not likely to be as acute with increases in the delay of the assessment. The rideability assessment should be made in accordance with the values assigned to the community values in Section 3.3.2.

Overall Road Condition Assessment (Question 3)
The third step of the survey involves undertaking an overall road condition assessment.

As noted earlier, factors other than roughness may also influence the community's perceptions of levels of service for road condition. These factors include; lane width, edge condition, potholes and so forth. It may be possible to make an assessment of rideability by including these factors, provided they are measured on each local road sample. These factors should be reduced to a quantitative variable for each of them. This is further detailed below.

The overall assessment value, as required by Question 3 requires a value form zero to ten (0 – 10), the same scale as for the Community Index.

Survey Analysis and Results Summary

Analysis of the General Assessment Survey
A simple ranking analysis can be performed on the general assessment survey results from each community panel. In addition, it may be possible to combine the analysis results for community panels based in similar broad areas such as rural areas and urban areas. It might also be possible to combine the results from separate surveys on other criteria. For example, the general assessment survey results from communities expected to have similar socio-economic values could be combined. Combining survey results will provide a larger sample with higher statistical significance than the results from two or three separate surveys.

Separate ranking analyses should be performed for each community panel results because it is assumed initially from each survey that the factors influencing community perceptions of road conditions are discrete to each community.

Each of the factors influencing community perceptions of road conditions are weighted as follows in the ranking process:

- the high rate of influence factor is weighted by three;
- the medium rate of influence factor is weighted by two; and
- the low rate of influence factor is weighted by one.

Each of the influence factors can be therefore be ranked by summing up all the weighted ratings. On this basis the influence factor with highest ranking is the most important and the one with the lowest ranking is the least important. The weights applied to the above factors were based on judgement. Further refinement of the weights applied is possible.

Analysis of Rideability Survey
At the completion of the rideability survey there will be results of the community index values of rideability against the measured roughness values for each sample local road.

A simple relationship between the dependent variable of rideability, as measured by road roughness, and at least one other significant independent variable that influences the communities perception of service level, such as the community index of rideability, can be used in estimating the community's maximum acceptable roughness limit. The general roughness relationship can be postulated to be of the following form:

$$R(t)_M = R(t)_P \times k_1 + (\text{lane width}) \times k_2 + (\text{edge condition}) \times k_3 + \text{etc.} \quad (1a)$$

where;

$R(t)_M$ = measured road roughness at time t

lane width = measured in metres (m)

edge condition = use different values for condition, say 1 = good; 0.5 = average; 0 = poor

$R(t)_P$ = community perception of road roughness at time t, the community index of rideability

k_1, k_2, k_3 = road condition level of service calibration coefficients for roughness, lane width and edge condition, respectively.

It may be possible to fully calibrate equation (1a) provided the road sample lane width, edge conditions and other factors that may be relevant are also measured as noted above. Equation (1a) means that the road condition level of service factors, k_1, k_2 and k_3, could have different values for different local road communities.

When the road condition level of service factors, such as k_2 and k_3 for lane width and edge condition are not relevant, equation (1a) reduces to the following relationship:

$$R(t)_M = R(t)_P \times k_1 + K \qquad (1b)$$

Equation (1b) is the more usual form of the relationship between measured rideability and perceived rideability when all the road condition level of service factors, except roughness, are either not measured or not relevant to the local road community.

The calibration of equations (1a) and (1b) is achieved by a linear regression analysis of the measured rideability, the dependent variable of road roughness, against the perceived rideability, the independent variable of community index of rideability, and other independent variables such as lane width and edge condition. The resulting relationship will generate the calibration coefficients, k_1, k_2 and k_3 for the independent variables.

Usually a linear regression analysis to calibrate equations (1a) and (1b) is undertaken for a group of local roads of similar type based on location and pavement surface (see Section 3.2.2) because the samples are from a similar population and the resulting relationship should be a good statistical fit (r^2) to the data. Consequently it is found that different calibration factors are found for different local road groups.

Estimation of the community's maximum acceptable roughness limit using a calibrated version equation (1b) for a particular road type can be made by simply substituting a lower bound value for community acceptable rideability, $R(t)_P$ (the Community Index of rideability), of 4.

Analysis of Overall Road Condition Assessment Survey
For each of the sample roads a comparison between the ratings from the rideability survey and overall road condition assessment should be made to detect any significant difference between these ratings. Any significant difference in ratings suggests that factors other than the perceived rideability are an important issue in the community's assessment of road condition. This is particularly the case with rural local roads where higher travel speeds are expected by the community and some other factors, apart from roughness, may influence their perceptions of levels of service.

If the above is the case, a relationship between the dependent variable of rideability, as measured by road roughness, and the independent variables for perceived rideability (the Community Index of rideability) and the overall road condition assessment (representing other factors such as lane width, edge conditions, alignment, etc) can be developed.

This relationship can be used in estimating the community's maximum acceptable roughness limit. The general roughness relationship can be postulated to be of the following form:

$$R(t)_M = R(t)_P \times k_1 + (\text{overall assessment}) \times k_2 + K \qquad (2)$$

where;

$R(t)_M$ = measured road roughness at time t

overall assessment = the overall assessment value representing lane width, edge conditions, alignment, etc. for rural roads

$R(t)_P$ = community perception of road roughness at time t, the Community Index of rideability

k_1 and k_2 = road condition level of service calibration coefficients for roughness and other factors, respectively.

The calibration of equation (2) is achieved by a linear regression analysis of the measured rideability, the dependent variable of road roughness, against the perceived rideability, the independent variable of Community Index of rideability, and the overall road condition assessment value. The resulting relationship will generate the calibration coefficients, k_1, and k_2 for the independent variables.

E.4 SUMMARY

Appendix E provides the detailed guidelines for a methodology to assess the community's expectations of levels of service on strategically important rural based local roads. The methodology covers the following:

- achieving community representation through a survey panel;
- selection of local roads to be sampled;
- the community questionnaire design seeking assessment of general perception factors,
- rideability and overall road condition; and
- conducting the assessment survey and its analysis.

Further refinement of these guidelines may occur after they have been used in a number of community assessment trials.

E.5 REFERENCES

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APPENDIX F

DATA ANALYSIS

F.1 INTRODUCTION

This appendix includes the underlying relationships established from the data collected in the project. The derived relationships and conclusions are reported in Chapter 6.

F.2 ROUGHNESS VERSUS COMMUNITY EXPECTATIONS

Sealed Rural Roads

The community expectation data was initially analysed on a State by State basis, with sealed and unsealed rural pavements treated separately. This analysis was carried out on the raw data supplied for Question 2 of the community survey (Appendix E).

Figure F.1 displays the variability in the Measured Roughness with the Community Index of Roughness. Although there is a rather large spread in the data (Community Index of Roughness), the range of roughness observations between the individual road segments was quite limited. This yielded a less than robust linear roughness versus community index relationship.

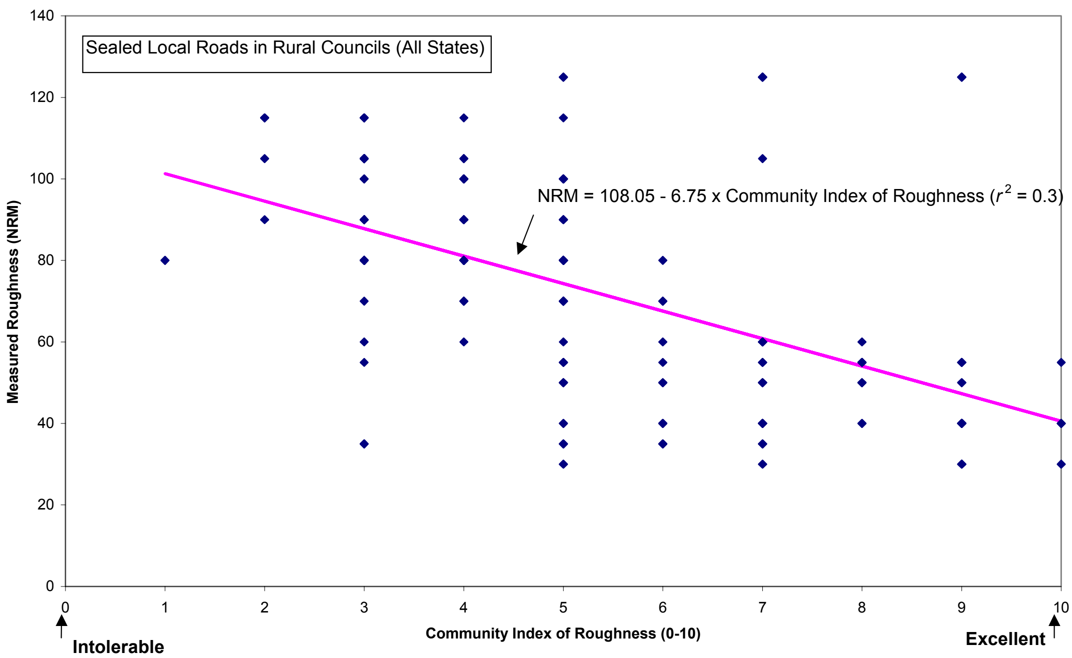

Figure F.1 — Community assessment of roughness for a range of measured roughness values

In light of the rather low spread in roughness observations for the above case, a similar analysis was conducted on the Tasmanian data only, as it possessed a greater variation in the roughness values observed. The resulting graph is in Figure F.2.

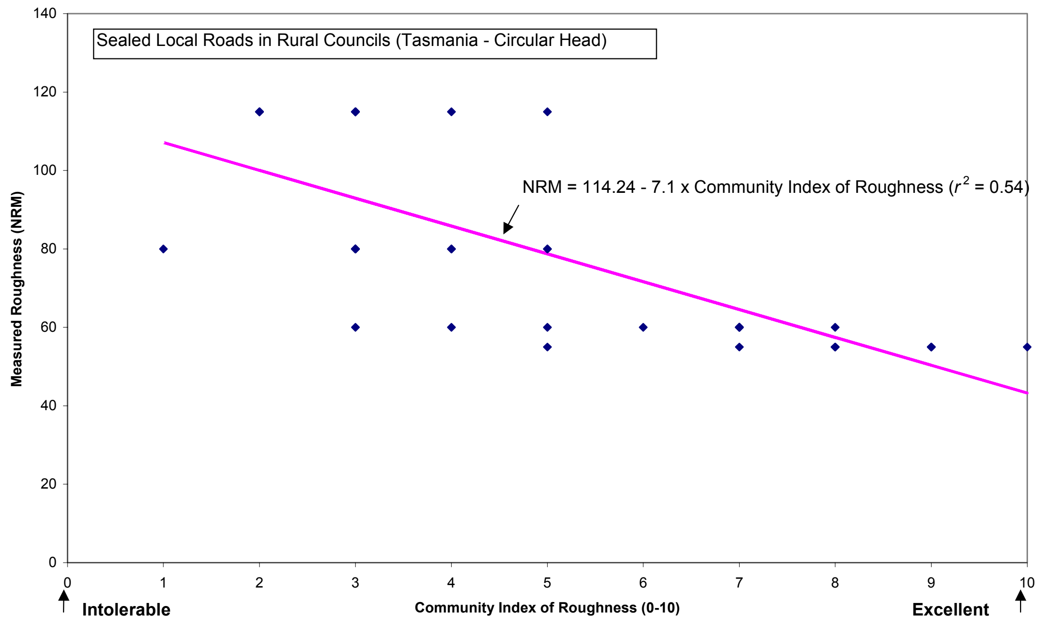

Figure F.2 — Community assessment of roughness and roughness as measured on Tasmanian sealed roads

Figure F.2 shows a lower variability in the observed community assessments with respect to the measured roughness observations. The sloping trend in the increased acceptance with decreasing roughness is better defined for the Tasmanian site compared with that for all sites. This is because some States did not possess a wide enough range in their measured roughness values between the individual segments, thereby making it difficult for the community to accurately assess the roughness where there was such a small range in its variation.

In order to exploit as much value as possible from all the available data, an average value for each of the States was incorporated in the Tasmanian data. This gave more observational data with less variation because of the averaging of the States' data with the small range in roughness. The latter data, with its less than desirable roughness range, when added to the Tasmanian data, provided a better overall representation of the community's perception of roughness, as shown in the Figure F.3.

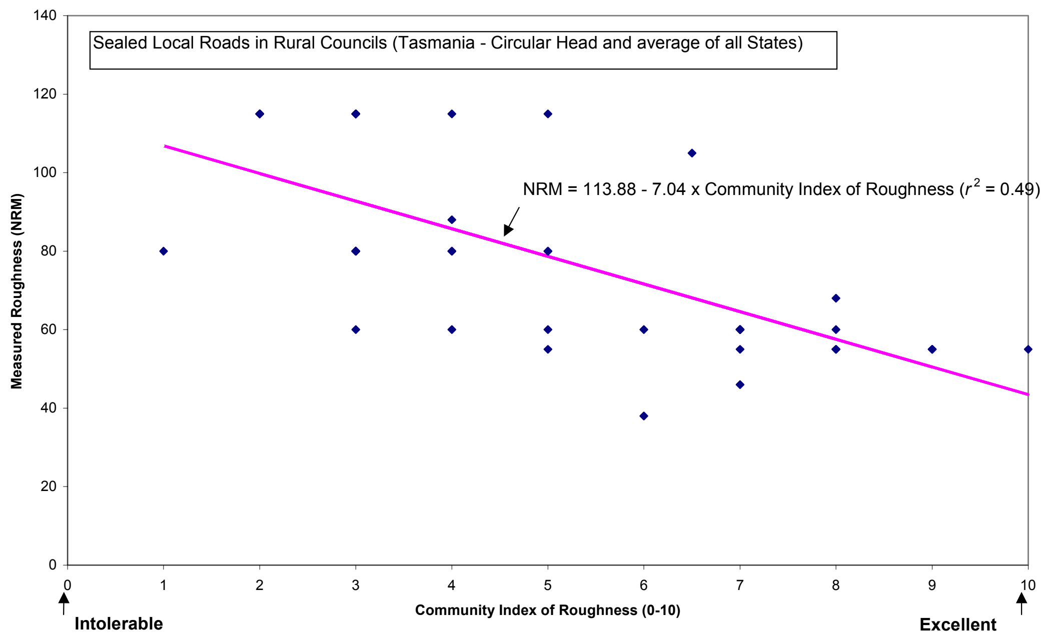

Figure F.3 — Community roughness assessment of sealed roads
(Tasmanian Samples Combined with an Average Value for each of Vic, NSW, SA and WA

Unsealed Rural Roads

In a similar fashion, the unsealed rural roads were examined and compared with the earlier data from the Victorian sites.

In the case of the unsealed roads, however, less data was available, which made the analysis subject to greater variation and lower statistical acceptability. Figure F4 shows the trend of the unsealed road community assessment with roughness results for the States of NSW and Tasmania.

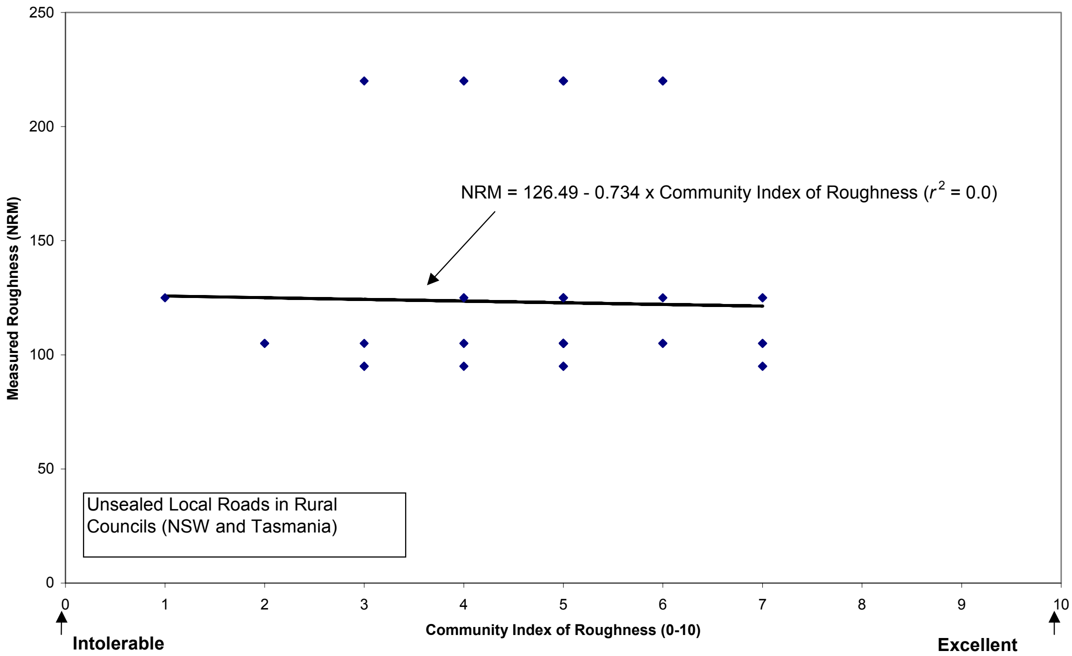

Figure F.4 — Community assessment and roughness for NSW and Tasmanian unsealed roads

Figure F.4 shows virtually no statistical fit of the linear relationship to the raw data. This is mainly attributed to the lack of a wide range of roughness observations. Once again similar parallels may be drawn to that of the sealed roads samples. In this instance, the resulting relationship predicts any roughness greater than 126 RM (4.80 IRI) is considered intolerable for an unsealed road, while it also predicts that the maximum acceptable community roughness is 124 NRM (4.73 IRI).

This outcome is unsatisfactory because it shows virtually no change in community acceptability with decreasing roughness. However, the predicted maximum acceptable community roughness (124 NRM, or 4.73 IRI) for unsealed roads based on these samples is higher than that predicted for the sealed roads (86 NRM, or 3.29 IRI) with the recently collected samples. This outcome is logical if it is assumed that higher roughness values can be tolerated at the lower speeds travelled on unsealed roads.

F.3 ROAD CONDITION INDEX VERSUS ROUGHNESS

Sealed Rural Roads

In a similar fashion to the approach taken with the community assessment analysis, the relationships between the roughness and the road condition index, as well as road condition index and community assessment were also investigated for both the sealed and unsealed sites. In both cases, only the responses to Question 2 are presented.

Figures F.5 and F.6 depict the relationship between the measured roughness and the road condition index for all States' data with and without that of the Murgon sites in Queensland. The Murgon data was excluded in Figure F.5 because it was not part of the community index analysis.

Comparison of Figures F.5 and F.6 shows an increase in the goodness of fit of the data with the inclusion of the Murgon data, at the expense of a decrease in the slope and constant of the relationship between measured roughness and condition index.[23]

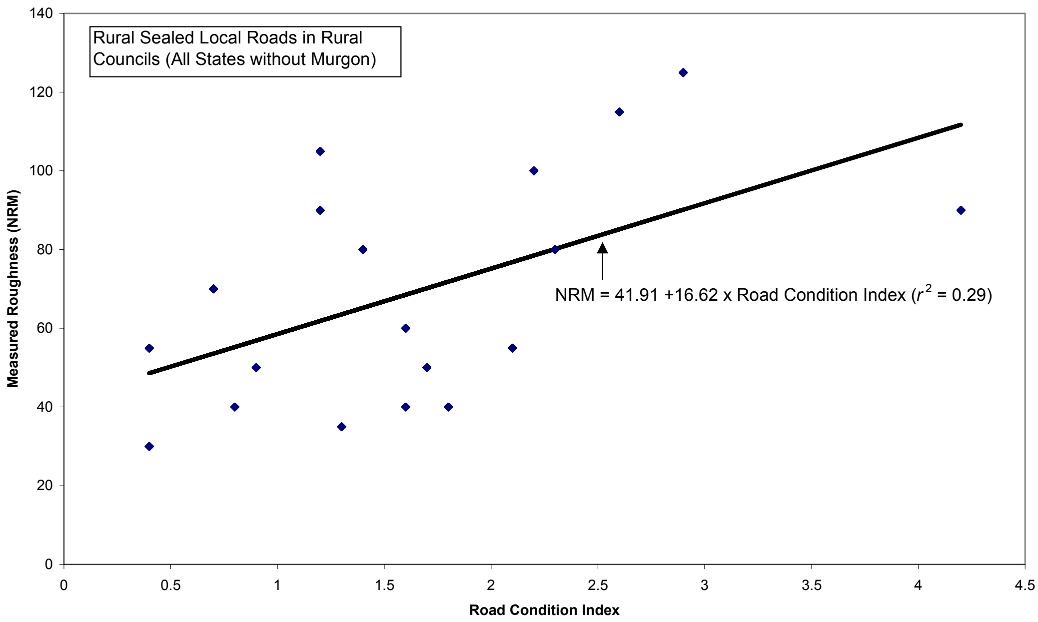

Figure F.5 — Road Index and Roughness for Sealed Roads in all States Excluding Murgon

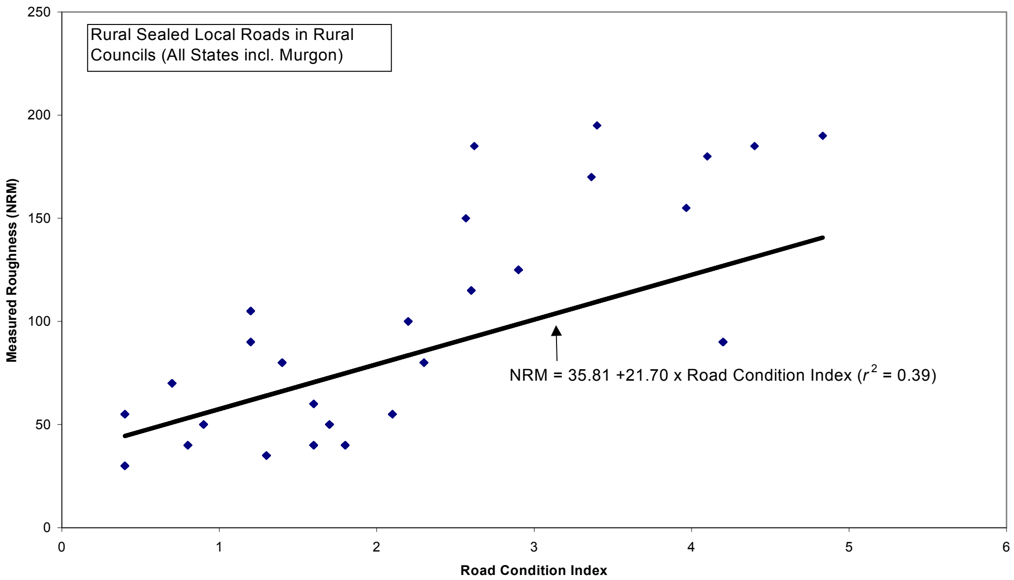

Figure F.6 — Road Index and Roughness for Sealed Roads in all States Including Murgon

[23] The regression lines on these two graphs appear out of line with the dot points. This is due to there being a number of sites under several dots in the low roughness range. This has resulted in disproportionate weighting to those points.

F.4 ROAD CONDITION INDEX VERSUS COMMUNITY ASSESSMENT

As expected, the goodness of fit of the relationship for road condition index against the community index (see Figures F.7 and F.8 for sealed and unsealed roads) is less than that found for roughness against road condition because of the decreasing precision in the factors being assessed.

Figure F.7 shows that, for sealed roads, an improvement in road condition (a reduction in its index) brings about a greater appreciation by the community. However, because of the very poor fit of this relationship to the observed data ($r^2 = 0.1$) it should not be used without qualification.

However, the goodness of fit of the unsealed road relationship is virtually non-existent ($r^2 = 0$), which is significantly less than that found for this relationship for sealed roads. This suggests that the recently acquired data has not made any contribution to the precision of these relationships.

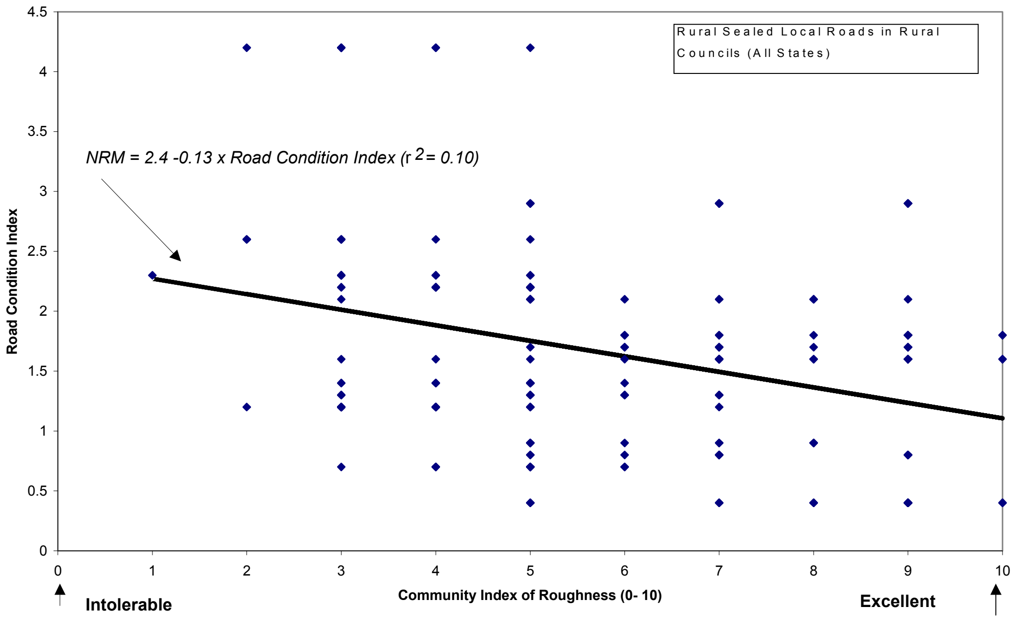

Figure F.7 — Community Assessment and Road Condition Index for Sealed Roads in all States.

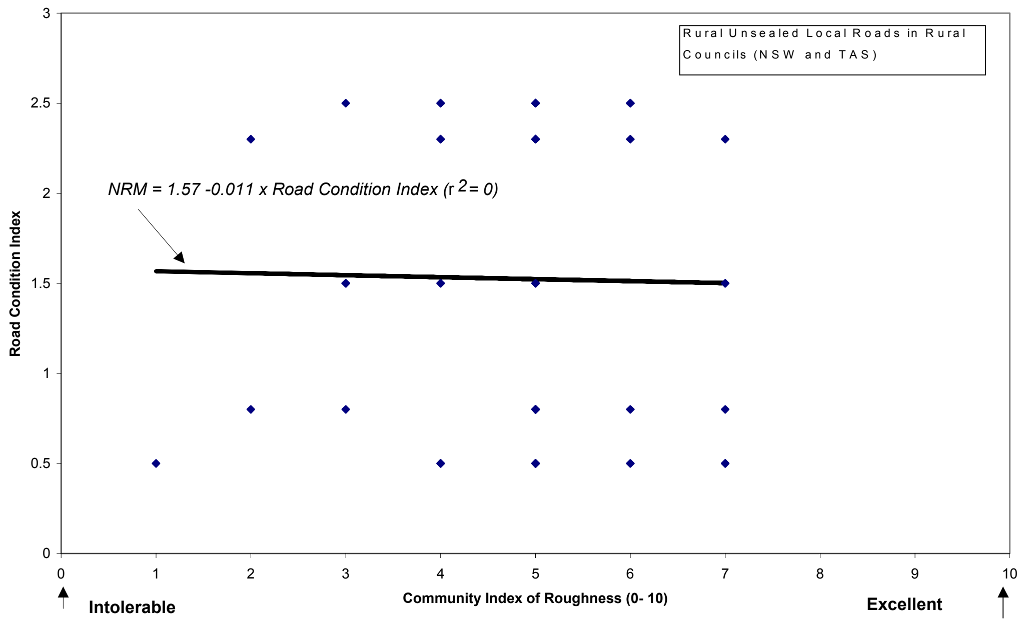

Figure F.8 — Community Index and Road Condition Index for Unsealed Roads

APPENDIX G

CLASSIFICATION OF LOCAL GOVERNMENTS

Description	Category	Description	Population
URBAN: LGA with a population of > 20,000 or pop density > 30 persons per sq km			
Urban Capital City	UCC	Capital City	
Urban Metropolitan Developed Small	UDS	Part of an urban centre of >1,000,000 people or population density > 600 per square km	Up to 30,000
Urban Metropolitan Developed Medium	UDM		30,001 - 70,000
Urban Metropolitan Developed Large	UDL		70,001 - 120,000
Urban Metropolitan Developed Very Large	UDV		> 120,000
Urban Fringe Small	UFS	A developing LGA on the margin of a developed or regional urban centre	Up to 30,000
Urban Fringe Medium	UFM		30,001 - 70,000
Urban Fringe Large	UFL		70,001 - 120,000
Urban Fringe Very Large	UFV		> 120,000
Urban Regional Town/City Small	URS	Part of an urban centre of < 1,000,000 people and predominantly urban in nature	Up to 30,000
Urban Regional Town/City Medium	URM		30,001 - 70,000
Urban Regional Town/City Large	URL		70,001 - 120,000
Urban Regional Town/City Very Large	URV		> 120,000
RURAL: LGA with a population of < 20,000, pop density < 30 persons per sq km and < 90% of LGA is urban			
Rural Significant Growth	RSG	Population growth >3% pa and pop > 5,000	> 5,000
Rural Agricultural Small	RAS		Up to 2,000
Rural Agricultural Medium	RAM		2,001 - 5,000
Rural Agricultural Large	RAL		5,001 - 10,000
Rural Agricultural Very Large	RAV		10,0001 - 20,000
Rural Remote Extra Small	RTX	Situated in a remote locality	Up to 400
Rural Remote Small	RTS		401 - 1,000
Rural Remote Medium	RTM		1,001 - 3,000
Rural Remote Large	RTL		3,001 - 20,000

INFORMATION RETRIEVAL

Austroads (2002), **Heavy Vehicle Loading of Low Trafficked Roads: Part 1 — Strategic Framework for Reviewing Expenditure**, Sydney, A4 77pp, IR-28/02

KEYWORDS:

Community, evaluation, heavy vehicle, investment, ride quality, road management, road network, roughness

ABSTRACT:

This document records the initial phase of a study that aims to develop a framework to assist road agencies in reviewing expenditure levels and compiling asset management strategies for roads with low traffic volumes and carrying heavy vehicles.

The initial phase of the study involved 28 sealed and unsealed routes in 32 Council areas covering all six Australian States and the Northern Territory. Community assessments and expectations of road conditions were related to technical assessments of road condition which were measured and reported using established techniques. This work builds on an earlier similar pilot study in four Council areas in Victoria.

This document also outlines other recent Austroads work on asset management for local roads, and proposes a five stage incremental process of continuous improvement in road asset management that smaller road agencies might follow.

The document examines methods for determining whether existing road conditions satisfy community expectations, and whether existing funding levels would hold or improve levels of service. Two approaches are described in detail, viz a Benchmark Approach based on comparing existing expenditure to a theoretical benchmark, and a Life Cycle Costing Approach, based on the ARRB TR PLCC model.

Using data obtained in the study, this document also explores potential relationships between road roughness and community expectations, road roughness and a road condition index (derived from visual assessment), and between future liability (remaining life as a proportion of economic life) and the road condition index. The study identified a need for further work to establish these types of relationships.

Using both the Benchmark Approach and the Life Cycle Costing Approach, broad conclusions are drawn about each route in the study, as an indication of the potential benefits to road agencies of these approaches. The study concludes that a nationally consistent approach to measuring road condition is imperative, and that levels of service should also be measured.

This document outlines the next phase planned for this study which will test the practicality of the framework by applying it to a larger number of routes.

AUSTROADS PUBLICATIONS

Austroads publishes a large number of guides and reports. Some of its publications are:

AP-1/89	Rural Road Design
AP-8/87	Visual Assessment of Pavement Condition

Guide to Traffic Engineering Practice

AP-11.1/88	Traffic Flow	AP-11.9/88	Arterial Road Traffic Management
AP-11.2/88	Roadway Capacity	AP-11.10/88	Local Area Traffic Management
AP-11.3/88	Traffic Studies	AP-11.11/88	Parking
AP-11.4/88	Road Crashes	AP-11.12/88	Roadway Lighting
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AP-11.7/88	Traffic Signals	AP-11.15/99	Motorcycle Safety
AP-11.8/88	Traffic Control Devices		

AP-12/91	Road Maintenance Practice
AP-13/91	Bridge Management Practice
AP-14/91	Guide to Bridge Construction Practice
AP-15/96	Australian Bridge Design Code
AP-17/92	Pavement Design
AP-18/00	RoadFacts 2000
AP-22/95	Strategy for Pavement Research and Development
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AP-26/94	Strategy for Structures Research and Development
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AP-43/00	National Performance Indicators
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AP-T05/00	Polymer Modified Binder Sprayed Seal Trials
AP-T07/00	Service life prediction of reinforced concrete structures
AP-G65.1/01	Guidelines for Road Condition Monitoring: Part 1 – Pavement Roughness
AP-T10/01	2001 Pavement Design Guide (Final Draft for public comment)

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ARRB Transport Research Ltd
500 Burwood Highway
VERMONT SOUTH Vic 3131
Australia

Telephone: +61 3 9881 1547
Fax: +61 3 9887 8144
Email: donm@arrb.com.au
Website: www.arrb.com.au

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