Southwest Region University Transportation Center

Implementation of the Urban Roadway Management System

SWUTC/96/465550-1

Center for Transportation Research
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Austin, Texas 78705-2650

1. Report No.	2. Government Accession No.	3.
SWUTC/96/465550-1		

4. Title and Subtitle	5. Report Date
IMPLEMENTATION OF THE URBAN ROADWAY MANAGEMENT SYSTEM	April 1996
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Farrukh Sohail, Terrence Dossey, W. Ronald Hudson	Research Report 465550-1
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Center for Transportation Research University of Texas at Austin 3208 Red River, Suite 200 Austin, Texas 78705-2650	11. Contract or Grant No. 0079
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Southwest Region University Transportation Center Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	14. Sponsoring Agency Code

15. Supplementary Notes

Supported by a grant from the Office of the Governor of the State of Texas, Energy Office

16. Abstract

Preservation of existing roads and streets has become a major activity for all levels of government. Deteriorating urban roads and reduced funding are a major problem for the local governments. Funds designated for pavements must therefore be used as effectively as possible. For the effective and efficient management of urban roadway network, regulations calling for the involvement of Metropolitan Planning Organizations in the development and implementation of Pavement Management Systems were established by the Intermodal Surface Transportation Efficiency Act of 1991. Considerable effort is now under way at state and local government levels for developing and implementing PMS. The Urban Roadway Management System (URMS) was developed at the University of Texas at Austin. URMS provides small to medium sized cities with a simple, flexible, and user-friendly PMS. Implementation of such a system can save money for both the agency and the user, and improve not only the efficiency but also the effectiveness of decision making involved in managing pavements.

This project aims at the demonstration of the use of URMS through its implementation in small to medium sized cities. The implementation was decided to be carried out at two levels. At the first level, the City of Lampasas was directly assisted in the implementation. At the second level, the City of Terrell was assisted via telephone in the implementation. The report documents the strategy and process of implementation of URMS. The process involved nation wide surveys to identify candidate cities for the implementation, final selection of cities using results of the surveys, and implementation of URMS in the cities selected.

17. Key Words	18. Distribution Statement
Pavement Management System (PMS), Urban Roadway Management System (URMS), Surveys, Micro Paver, Candidate City, Network, Maintenance and Rehabilitation, Subsystems, Networks	No Restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	139	

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IMPLEMENTATION OF THE URBAN ROADWAY MANAGEMENT SYSTEM

by

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Research Report SWUTC/96/465550-1

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April 1996

EXECUTIVE SUMMARY

For the effective and efficient management of urban roadway network, regulations calling for the involvement of Metropolitan Planning Organizations (MPOs) in the development and implementation of Pavement Management Systems (PMS) were established by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Considerable effort is now under way at state and local government levels for developing and implementing PMS. The Urban Roadway Management System (URMS) was developed at The University of Texas at Austin. URMS provides small and medium cities with a simple, flexible, and user-friendly PMS. Implementation of such a system can save money for both the agency and the user and improve not only the efficiency but also the effectiveness of decision making involved in managing pavements.

The objectives of this project were to implement URMS in small to medium sized cities and to gain knowledge of pavement management practice at the regional level all over the country. To achieve these objectives, three surveys were conducted. The Texas survey was performed in the summer of 1994 to gain knowledge of regional level pavement management practice in Texas. Information obtained was utilized to identify candidate cities for URMS implementation. The US survey was conducted in November, 1994, to identify pavement management practice at the regional level across the country. The Micro PAVER Survey was carried out in September, 1994, to assess the active use of PAVER by its users, as listed by APWA, and to find their interest in examining the URMS.

Results of the surveys revealed that there is a shortage of simple, flexible, and user-friendly PMS for urban streets. Micro PAVER is the most commonly used PMS at the local government level. Many active users pointed out problems associated with the general complexity and non user-friendliness of Micro PAVER. Deficient report generating capabilities, extensive data requirements, and practical problems in collection of required data were criticized by the users. URMS seems to have most of the capabilities identified to be lacking in Micro PAVER by its users. It is simple, flexible and user-friendly. It generates variety of reliable reports and charts, as needed by the DPW for planning and reporting purposes. Most of the cities already collect the minimum data required to implement URMS, and hence the system can be implemented in small to medium sized cities without any extensive data collection efforts. The survey results also revealed immense interest of a large number of cities in the implementation of URMS. However, the limitation of funds restricted complete implementation to only two cities of Texas. If the second phase of this study is funded, the results can be used to implement URMS in many other cities.

The Texas survey results were analyzed to select cities for the two level URMS implementation. Interest of cities, their population, availability of funds, collection of street condition data, and active use of any network level PMS were considered as main selection parameters. Based on these parameters, a factorial approach was utilized to come up with the 5 top priority implementation cities. The URMS package, along with a detailed questionnaire, was distributed to the 5 top priority cities and all other cities which showed interest and had implementation funds budgeted. Analysis of replies of detailed questionnaire and immense interest in implementation led to the selection of the City of Terrell for telephone implementation of URMS. A meeting with the 5 top priority cities was held in January, 1995, to come up with the city for assisted implementation. Based on the discussion in the meeting and the replies of detailed questionnaire, the City of Lampasas was selected.

The implementation process in the cities of Lampasas and Terrell included; training city personnel, helping the cities to collect and organize required data, helping the cities to determine the Model Parameters of URMS, converting the data obtained by cities to the URMS format, and running the software and getting the reports identifying and selecting M&R projects.

URMS was implemented in the two cities without any extensive added data collection effort by city personnel. Once the data was collected, it took only a data base manager and a city engineer to completely implement the system in each city. Reports generated for M&R needs and recommended M&R projects were used by DPWs for network planning purposes. The successful implementation in Terrell shows that URMS can be implemented in a city using the URMS user's guide and with some support, which can be provided via telephone. A similar process can be adapted in the future for implementation in other cities.

ACKNOWLEDGMENT

This publication was developed as part of the University of Transportation Centers Program which is funded 50% in oil overcharge funds from the Stripper Well settlement as provided by the Texas State Energy Conservation Office and approved by the U.S. Department of Energy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

Preservation of existing roads and streets has become a major activity for all levels of government. Deteriorating urban roads and reduced funding are a major problem for the local governments. Funds designated for pavements must therefore be used as effectively as possible. For the effective and efficient management of urban roadway network, regulations calling for the involvement of Metropolitan Planning Organizations in the development and implementation of Pavement Management Systems were established by the Intermodal Surface Transportation Efficiency Act of 1991. Considerable effort is now under way at state and local government levels for developing and implementing PMS. The Urban Roadway Management System (URMS) was developed at The University of Texas at Austin. URMS provides small to medium sized cities with a simple, flexible, and user-friendly PMS. Implementation of such a system can save money for both the agency and the user, and improve not only the efficiency but also the effectiveness of decision making involved in managing pavements.

This project aims at the demonstration of the use of URMS through its implementation in small to medium sized cities. The implementation was decided to be carried out at two levels. At the first level, the City of Lampasas was directly assisted in the implementation. At the second level, the City of Terrell was assisted via telephone in the implementation. The report documents the strategy and process of implementation of URMS. The process involved nation wide surveys to identify candidate cities for the implementation, final selection of cities using results of the surveys, and implementation of URMS in the cities selected.

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CHAPTER 1. INTRODUCTION

Billions of dollars have been invested on roadways in urban areas. Sound decisions on preventive maintenance, rehabilitation, and reconstruction of urban streets are crucial to protecting that large investment. For the effective and efficient management of urban roadway network, regulations calling for the involvement of Metropolitan Planning Organizations (MPOs) in the development and implementation of Pavement Management Systems (PMS) were established by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ISTEA requires all states to certify that the MPOs have a working PMS by October 1, 1995 on the National Highway System (NHS), and by October 1, 1997 on the non NHS Federal-aid highways [11].

Preservation of existing roads and street system has become a major activity for all levels of government. There is a shortage of funds to maintain the street system at the state level. Deteriorating urban roads and reduced funding are also a major problem for the local governments. Funds that have been designated for pavements must therefore be used as effectively as possible. One proven method to obtain maximum value of available funds is through the use of a PMS. Considerable effort is now under way at state and local government levels for developing and implementing PMS [5, 8, 12, 14, 16]. In response to the need, development of low cost, microcomputer based, and easily maintained and operated PMS at the municipal level was required [21]. The Urban Roadway Management System (URMS) was developed at The University of Texas at Austin. URMS provides small and medium cities with a simple, flexible, and user-friendly PMS. Implementation of such a system can save money for both the agency and the user and improve not only the efficiency but also the effectiveness of decision making involved in managing pavements.

OBJECTIVES OF THE PROJECT

The primary objective of this project was to demonstrate the use of URMS through implementation in small to medium sized cities. The process involved the following stages:

1) nationwide surveys to gain knowledge of pavement management practices at the regional level, and to identify candidate cities for implementation,
2) distribution of the URMS package to candidate cities,
3) final selection of cities using results of the surveys,
4) helping the cities selected for implementation to collect and organize the data required by URMS,

5) converting the data obtained by cities to URMS format, and
6) running the software and generating reports identifying and selecting Maintenance and Rehabilitation (M&R) projects for the cities.

It was decided that the implementation should be carried out at two levels. At the first level, the City of Lampasas was directly assisted and the project staff worked closely with the city on the implementation. At the second level, the city of Terrell was assisted, via telephone, in the implementation.

PAVEMENT MANAGEMENT SYSTEMS

Pavement management involves the identification of optimum strategies at various management levels as well as the implementation of these strategies. It is the process of planning, budgeting, funding, designing, constructing, monitoring, evaluating, maintaining, and rehabilitating the pavement network to provide maximum benefits for available funds. A PMS is a set of tools or methods that assists decision makers in finding optimum strategies for providing and maintaining pavements in a serviceable condition over a given time period. Without an adequate routine pavement maintenance program, roads require more frequent reconstruction, thereby costing the state and local governments millions of extra dollars. The function of a PMS is to improve the efficiency of decision making, provide feedback on the consequences of decisions, facilitate the coordination of activities within the agency, and ensure consistency of decisions made at different management levels within the same organization [10, 18]. The total decision making process is based on information from PMS coupled with engineering experience, budget constraints, scheduling parameters, management prerogatives, public input, political considerations, and planning and programming factors [7, 13].

PMS can provide several benefits at both the network and the project levels. Agencywide programs of new construction, maintenance or rehabilitation, having the least total cost, or greatest benefits, over the selected analysis period, are developed at the network level. At the project level, detailed consideration is given to alternative design, construction, maintenance or rehabilitation activities for a particular section or project within the overall program which will provide the desired benefits or service levels at the least total cost over the analysis period [10].

PAVEMENT MANAGEMENT AT THE LOCAL GOVERNMENT LEVEL

Municipal highway agencies throughout the country are adopting PMS for a variety of reasons: to develop a physical inventory, to justify maintenance budget increases, to preferentially rate maintenance needs, and , most importantly, to attain the best possible road network for the least money.

PMS for the Local Governments

The completeness of a PMS can range from a simple work sheet based system to a system that includes optimization features. Between these two levels, there is a range in possible systems. The level required will, to a large extent, be influenced by the objectives set for the system. Wells, et al. [19], as a result of a development program in the PMS area by the Metropolitan Transportation Commission (MTC), have listed three features as being of primary importance in a PMS for local governments. These are:

1. A procedure to objectively quantify pavement condition,
2. A listing of the most cost effective maintenance treatments, and
3. A means of matching treatments to problems.

Since the development of PMS software is time consuming and expensive, it is desirable that the resulting software be flexible in such a way that it can be easily tailored to local policies of the agency that will finally use it. Flexible PMS computer programs may significantly reduce the cost of developing and implementing PMS by extending the applicability of the product to many agencies [5, 7]. User friendly PMS software is also important in the implementation phase. Good PMS software should be easy to use and easy to learn. The application of graphical user interface technology greatly improves the user-friendliness of PMS software. Geographical information system (GIS) technology has also been applied to pavement management; however, because of the high cost and the time and effort to implement it for pavement management, its application is restricted to medium and large cities [9].

Pavement management can be established in local communities by several methods including consultant contract, existing off-the-shelf packages, and public domain programs. Because of the shortage of personnel with training or background in development of PMS, many cities and counties contract with consultants to assist in developing a PMS specifically tailored for the agency in question. This is an expensive option (out of question for many small to medium sized cities) but has the additional advantage of strong initial support during the implementation phase. Unfortunately, many PMS projects are abandoned after the consultant support has terminated, due to a lack of trained personnel to maintain the system. Existing packages use available software that may not meet each agencies' specific needs. The final option is to choose a public domain program. Several are available, but most of them are characteristically single purpose and non-flexible. The need was to develop a simple, flexible, and user-friendly PMS for the use of cities and counties. The Urban Roadway Management System (URMS), developed at The University of Texas at Austin, fulfilled this need for small to medium sized cities [9].

SCOPE OF THIS REPORT

This project aims to implement the URMS in small to medium sized cities. Surveys were done in United States, with an emphasis on Texas, for this purpose. Funds and time constraints limited the assisted implementation to one city in Texas. All the other interested cities were offered assistance via telephone for the implementation. However, complete telephone implementation could take place only in the city of Terrell.

This report documents the strategy and process of implementation of URMS. Chapter 1 presents the objectives and scope of the project and provides the background of pavement management at the local government level. Chapter 2 compares some prominent PMS used at the local government level including the URMS. The subsystems, structure, and data specifications of the URMS along with the implementation in Georgetown and the potential benefits of implementing URMS are also discussed here. Chapter 3 describes the design, goals, and implementation, of different surveys conducted during the study. Chapter 4 presents the results of surveys conducted. Chapter 5 evaluates the results of surveys to come up with the candidate implementation cities. The selection of final cities for the two stage implementation is also discussed here. Chapter 6 details the implementation of URMS in the selected cities. Finally, Chapter 7 presents the summary and recommendations.

CHAPTER 2. URMS AND OTHER PMS FOR LOCAL GOVERNMENTS

Several PMS are available for use at local government level. This chapter provides a comparision of some of the prominent PMS used at urban level. A background on URMS, developed at The University of Texas at Austin, is also presented in this chapter.

A COMPARISION OF PMS FOR LOCAL GOVERNMENTS

A comparision of some of the promising local government PMS is given in Tables 2.1 to 2.7. No attempt is made here to rank the software on a best to worst basis since each management system has instances where it will best meet agency needs. Comparision is based on two studies. The first study was performed by the Rhode Island Department of Transportation and The University of Rhode Island on implementation of PMS for municipally maintained roads in Rhode Island [2]. The second study is an evaluation of public domain and private pavement management software and data collection procedures, performed by the Federal Highway Administration (FHWA) [17]. Characteristics of PMS used for evaluation included: inventory data and project history, condition data, storing and managing capabilities, capability for identifying sections needing repairs, prioritization capability, impact analysis, management of unpaved roads, and training and support.

Most systems appeared to be fairly easy to learn and use with adequate documentation, accessibility and quality of support . The quality of data management components, for most of the systems, depended on limitations of the data base manager used in their development. Deficiency in terms of file flexibility was common, especially those that used coding methods other than the American Standard Code for Information Interchange (ASCII) or did not allow files to be printed to disk. Considering output flexibility, in most of the systems, specific information can be generated by selecting appropriate options, and then reports can be sent to a disk file, screen, or printer. For data analysis, in most systems a pavement condition index (PCI) or rating is derived from quantity and severity of pavement distress. The distress data and the PCI are then used in other analysis routines. Most programs allowed network and project level analysis, although some of the systems included capabilities for only one level of analysis. All packages were suitable for municipal use, however, URMS was observed to be the most flexible, simple, and user-friendly PMS available for municipally maintained roads at present time.

TABLE 2.1 URBAN PMS CONSIDERED FOR EVALUATION

PMS	ABBREVIATION	DEVELOPED BY
Needs Inventory Software	NIS	McTRANS
Flexible Pavement Management System	FPMS	McTRANS
Pavement Management System	PMS-ITRE	ITRE
Road Surface Management System	RSMS	University of New Hampshire
Micro PAVER	Micro PAVER	American Public Work Assoc.
Bay Area Pavement Management System	BAPMS	Metro. Trans. Commission
Urban Roadway Management System	URMS	University of Texas at Austin
CTL-Pavement Management System	CTL-PMS	CTL Engineering, Inc.
Road Manager	RM-AC	Vanasse Hangen Bruslin, Inc.
Road Scan-Pavement Management System	Road Scan	Huntington Engg & Env., Inc.

TABLE 2.2 EVALUATION OF URBAN PMS BASED ON INVENTORY AND PROJECT HISTORY DATA

PMS	NIS	FPMS	PMS ITRE	RSMS	MICRO PAVER	BAPMS	URMS	CTL PMS	RM-AC	ROAD SCAN
Street ID	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Length, Width, and Area	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Functional Class.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
# Traffic Lanes	Y	Y	N	Y	N	N	Y	Y	Y	Y
Traffic History	Y	Y	N	N	Y	N	Y	Y	Y	Y
Projected Traffic	Y	N	N	N	N	N	Y	Y	N	Y
Constrn. History	Y	Y	Y	N	Y	N	Y	Y	Y	Y
M & R History	N	Y	Y	N	Y	N	N	Y	Y	Y
Layer Types	N	Y	Y	N	Y	N	N	Y	Y	Y
Programmed Work	N	N	N	N	Y	N	N	Y	Y	Y
Work in Progress	N	N	N	N	N	N	N	N	N	Y
GIS Interface	N	N	N	N	N	N	N	N	Y	Y

TABLE 2.3 EVALUATION OF URBAN PMS BASED ON THE CONDITION DATA

PMS	NIS	FPMS	PMS ITRE	RSMS	MICRO PAVER	BAPMS	URMS	CTL PMS	RM-AC	ROAD SCAN
Type	N	N	N	Y	N	N	Y	N	Y	N
Num. AC	N	Y	Y	Y	Y	Y	N	Y	Y	Y
Num. PCC	N	N	N	N	Y	Y	N	Y	N	Y
Structural Capacity	Y	N	N	N	Y	N	N	N	N	Y
Roughness	N	Y	N	Y	Y	N	N	Y	Y	Y
Skid	N	N	N	N	Y	N	N	N	N	Y
Subjective Evaln.	Y	N	N	N	Y	N	Y	N	Y	Y

TABLE 2.4 EVALUATION OF URBAN PMS BASED ON IDENTIFICATION OF SECTIONS NEEDING REPAIRS

PMS	NIS	FPMS	PMS ITRE	RSMS	MICRO PAVER	BAPMS	URMS	CTL PMS	RM-AC	ROAD SCAN
Project Condn.	N	N	N	N	Y	Y	N	Y	Y	Y
Trigger Single Value	N	N	N	N	Y	N	N	Y	N	N
Trigger Multiple Value	N	Y	Y	Y	N	Y	Y	N	Y	Y
Identify PM by Interval	N	N	N	N	Y	Y	N	Y	N	N
Identify PM by Type of Distress	N	Y	N	Y	Y	Y	Y	N	Y	N
Identify PM by Quan. of Distress	N	Y	N	Y	N	Y	Y	N	Y	Y
ID Treatment Type	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
List Section Need M & R	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Proj. Condn. w/t & w/t out repair	N	N	N	N	Y	Y	N	Y	Y	Y
Total Cost/yr	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Needs for Pav. Class & Treat.Type	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Budget Reports	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

TABLE 2.5 EVALUATION OF URBAN PMS BASED ON STORING AND MANAGEMENT OF DATA

PMS	NIS	FPMS	PMS ITRE	RSMS	MICRO PAVER	BAPMS	URMS	CTL PMS	RM-AC	ROAD SCAN
Computerized	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Powerfull PC	N	N	N	N	N	N	N	N	Y	Y
Password Protection	N	N	Y	N	Y	N	N	N	N	Y
Data Dictionary	N	N	N	N	N	N	N	N	N	Y
User Manual	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
DB Manager	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Inventory Feedback	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Distress Reporting	N	Y	Y	Y	Y	Y	Y	N	Y	Y
Condition Summary	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Condition Prediction	N	N	N	N	Y	Y	N	N	Y	Y

TABLE 2.6 EVALUATION OF URBAN PMS BASED ON PRIORITIZATION CAPABILITIES

PMS	NIS	FPMS	PMS ITRE	RSMS	MICRO PAVER	BAPMS	URMS	CTL PMS	RM-AC	ROAD SCAN
Distress	N	Y	N	N	N	N	N	N	N	N
Functnl. Classn.	N	Y	N	Y	Y	Y	Y	Y	Y	Y
Perform./Condn.	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Composite	N	N	N	Y	N	Y	Y	Y	Y	Y
First Cost	N	N	N	Y	N	N	N	N	N	Y
EUAC	N	N	N	N	N	Y	N	N	N	N
B/C Ratio	N	N	N	N	N	N	N	N	Y	Y
Cost Effect. Analysis	N	N	N	N	N	Y	N	N	N	Y
Select Candidate Sections	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Multi-Year Prioritizn.	N	N	N	N	Y	Y	N	Y	Y	Y
Specific Year Repair of Secns.	N	N	N	N	N	N	Y	Y	Y	Y

TABLE 2.7 EVALUATION OF URBAN PMS BASED ON IMPACT ANALYSIS, UNPAVED ROAD MANAGEMENT AND TRAINING AND SUPPORT PROVIDED

PMS	NIS	FPMS	PMS ITRE	RSMS	MICRO PAVER	BAPMS	URMS	CTL PMS	RM-AC	ROAD SCAN
IMPACT ANALYSIS										
Overall Condn.	N	N	N	N	Y	Y	N	N	Y	Y
Condn. Category	N	N	N	N	Y	Y	N	N	Y	Y
Backlog of Need	N	N	N	N	Y	Y	Y	Y	N	Y
Deferred Funding	N	N	N	N	Y	Y	Y	N	N	Y
Stop-Gap Maint.	N	N	N	N	Y	Y	N	N	N	Y
Remaining Life	N	N	N	N	N	N	N	N	N	Y
UNPAVED STREETS										
Condition	Y	N	N	Y	Y	N	N	Y	Y	Y
Prediction	N	N	N	N	Y	N	N	Y	N	Y
Cost	N	N	N	Y	Y	N	N	Y	Y	Y
TRAINING & SUPPORT										
Training Classes	N	N	Y	N	Y	Y	Y	N	N	N
Support	Y	N	Y	Y	Y	Y	Y	Y	Y	Y

MICRO PAVER

Micro PAVER has found to be the most commonly used PMS at the local government level in the United States. According to its developers, the Micro PAVER system provides the user with a practical design approach for identifying cost effective road and street maintenance strategies. Micro PAVER's interface programs provide critical information report generation capabilities that allows input to the decision making process. Other capabilities include data storage and retrieval, pavement network definition, PCI rating, project rating, inspection scheduling, determination of present and future network condition, determination of needs for maintenance and repair, economic analysis, and budget planning [15].

A Micro PAVER user survey was performed during this study to find which users are still actively using the PAVER and whether they are interested in examining a simpler, more flexible, and user friendly PMS. The survey results are presented in the next chapter.

THE URBAN ROADWAY MANAGEMENT SYSTEM (URMS)

The Urban Roadway Management System (URMS) is the result of extensive research done at The University of Texas at Austin by Dr. Xin Chen, Dr. W. Ronald Hudson and Terrence E. Dossey. URMS is a comprehensive pavement management system developed primarily for application in small to medium size cities. The system provides managers and engineers of public works departments with a computer based tool to assist in managing their roads and streets efficiently and effectively at both the network and the project levels. The simple, flexible, and user friendly software is designed to work on any IBM personal computer (or compatible) with a VGA monitor, and therefore seems to be within the means of even small cities. A primary feature of the program is that, unlike other available software, it can provide useful output with a minimum of data input, and can be easily custom tailored to particular pavement distress problems and the rehabilitation decision process of each individual city. It has a user friendly graphic interface that is designed to be easily accessible to persons only slightly familiar with personal computers [3].

Subsystems of URMS

The complete system consists of four sub systems: planning at the network level, and design, construction, and maintenance at the project level [3].

The act of planning is the determination of short to long range plans-specific strategies programs, and policies to meet organizational objectives. The major objective of planning subsystem is to assist in identifying and selecting the most cost effective Maintenance and Rehabilitation (M&R) projects at the network level. That is, to determine where, when, what, and how the M&R will be performed. In addition, the system also estimates multi-year M&R programs for up to five years. The planning subsystem has capabilities to evaluate pavement and traffic conditions in terms of evaluation indices, present traffic and pavement condition distribution, and to report both evaluation and M&R programs in various forms such as graphical charts, listings, and summary reports.

The design subsystem can be used to select materials and determine layer thicknesses for those projects scheduled for overlay and reconstruction. The AASHTO pavement design procedure is being used for flexible pavement design. The design subsystem can import data from the planning subsystem and can also serve as a stand alone program.

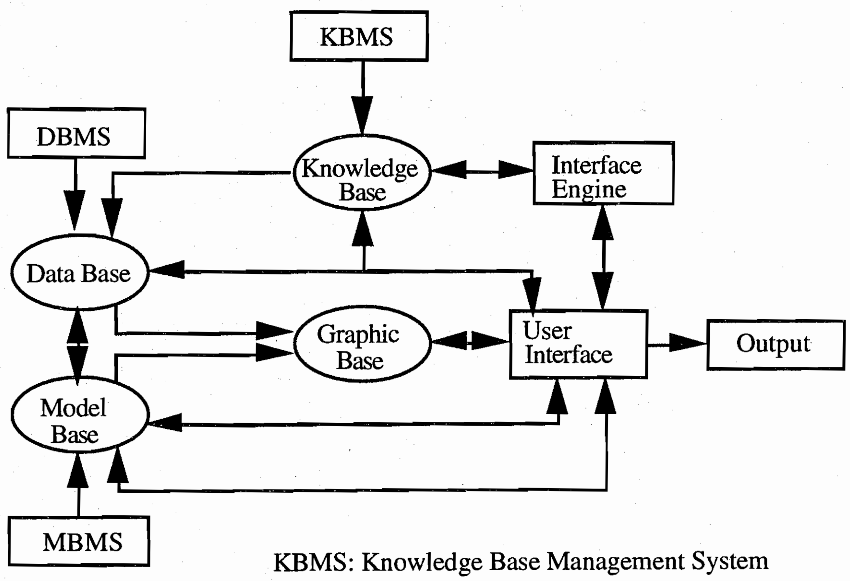
The construction subsystem is intended to help schedule pavement overlay and reconstruction activities. It can import data from both the planning and the design subsystems, or can serve as a stand alone program.

The maintenance subsystem is a simplified expert system development tool. It is intended to help pavement maintenance engineers build their own expert system applications for selecting effective distress repair methods.

System Structure of URMS

URMS consists of three data bases, a model base, a knowledge base, and a graphics base [3]. As shown in Figure 2.1, all the bases are integrated through a graphical user interface. Each subsystem can be used as a stand alone program or integrated with other subsystems. Figure 2.2 shows the overall URMS structure.

System Utility Module. A system utility module is included, in addition to the four subsystems. As shown in Figure 2.3, the system utility module presents a brief introduction to URMS, gives the overall data flow diagram, and all the program files. It is also used to provide identification of the user and to set up colors and printer.



KBMS: Knowledge Base Management System
DBMS: Data Base Management System
MBMS: Model Base Management System

Figure 2.1 Components of URMS

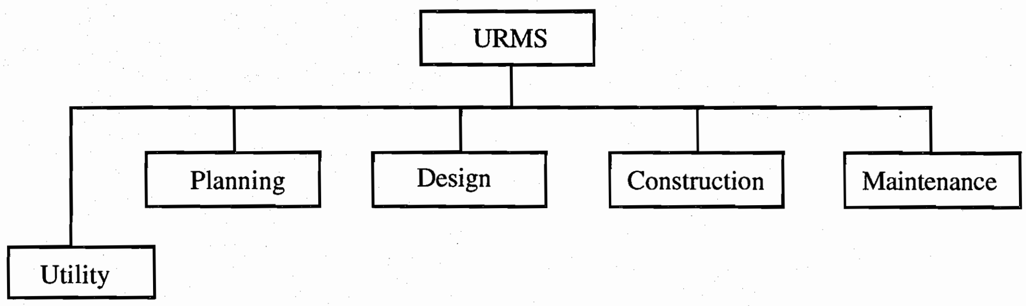


Figure 2.2 Overall structure of URMS

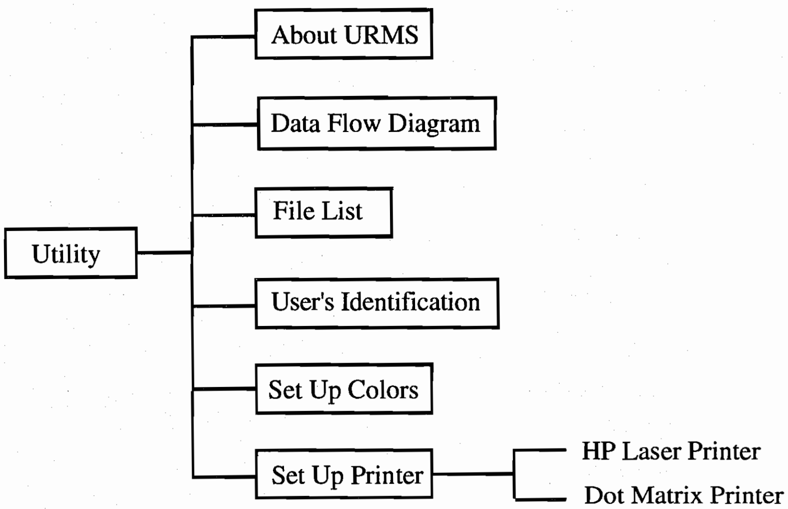


Figure 2.3 Structure of the system utility module

Planning Structure. The structure of the Planning subsystem is shown in Figure 2.4. This complicated subsystem includes ten modules. The Select Model module allows the user to select either pavement age or soil type for pavement evaluation, and either manual input or calculation from distresses for Pavement Condition Index (PCI). A total of seven screens are designed in the Edit Model module. Important features include a decision tree that takes PCI, AGE and Truck Average Daily Traffic (TADT) into account and uses them for assigning an M&R strategy for each section. Two priority ranking matrices and a priority rating equation are combined

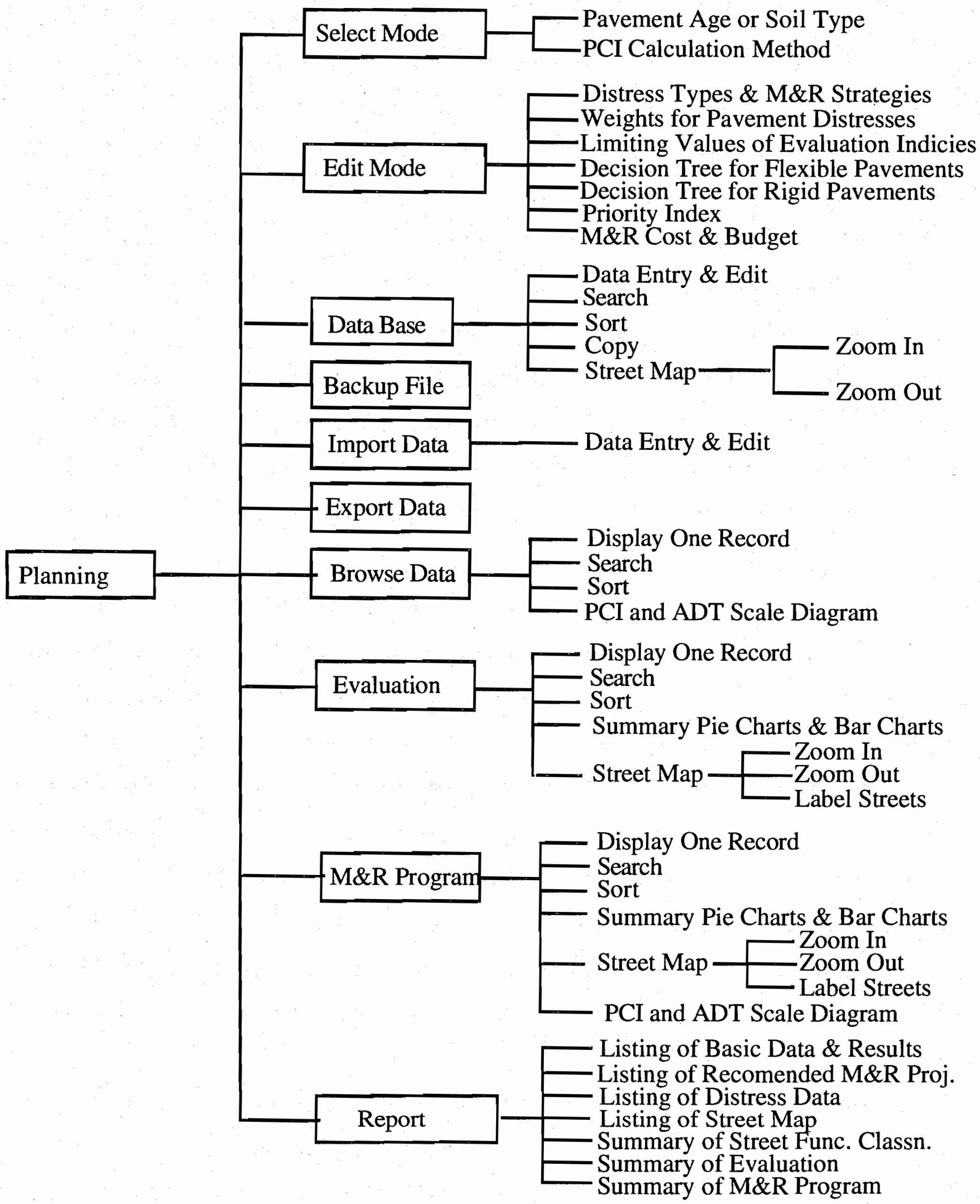


Figure 2.4 Structure of the planning subsystem

for M&R project prioritization. The module helps one change model parameters and define distress types and M&R strategies in terms of local conditions. The Data Base module, together with the Backup File, Import Data, Export Data, and Browse Data modules, performs the function of a Data Base Management System (DBMS) which includes data storing, retrieving, updating, editing, sorting, importing, and exporting. The Evaluation Module aims to evaluate pavements in terms of PCI, pavement age (or subgrade type), and Average Daily Traffic (ADT). The module can display evaluation results section by section, summarize the network condition in tabular forms and bar charts, as well as draw a color coded street map. The M&R Program Module helps to select cost effective M&R projects in a street network. Each section is assigned an M&R strategy by the decision tree model based on evaluation results. If total required M&R cost is greater than available budget, prioritization is performed. The Report Module can produce seven types of reports: four are listings, and three are summaries. Listing reports include basic input and output information, recommended M&R projects, pavement distress data, and street map x-y coordinates. Summary reports include street functional classes and pavement types, pavement condition and traffic evaluation, and M&R needs and recommended M&R projects.

Design Structure. The structure of the Design subsystem, shown in Figure 2.5, consists of five modules. The Database module is designed for data entry and modification for both new pavements and overlay designs. The Design Model Module (DMM) and the Report Module (RM) can be called in the Database module. The Import Data Module can import related data from the planning subsystem. Sections selected for overlay or reconstruction in the planning subsystem can be retrieved from the planning database and stored in the design database. The DMM and the RM can also be called here. The DMM can select the least cost material for different layers, if more than one material is available for a layer, and determine the layer thicknesses. Two methods are available for new pavement design in this module: (1) conventional design, and (2) optimal design. The RM produces both the input data, and conventional design and optimal design results.

Construction Structure. Figure 2.6 shows four Construction subsystem modules. The Database Module (DBM) can be used to enter, modify, sort, copy, and search data. The Schedule Project Module (SPM) has a built-in CPM/PERT (Critical Path Method/Program Evaluation and Review Technique) model to help schedule construction activities for overlay and reconstruction. Using the Report Module a report can be generated and printed.

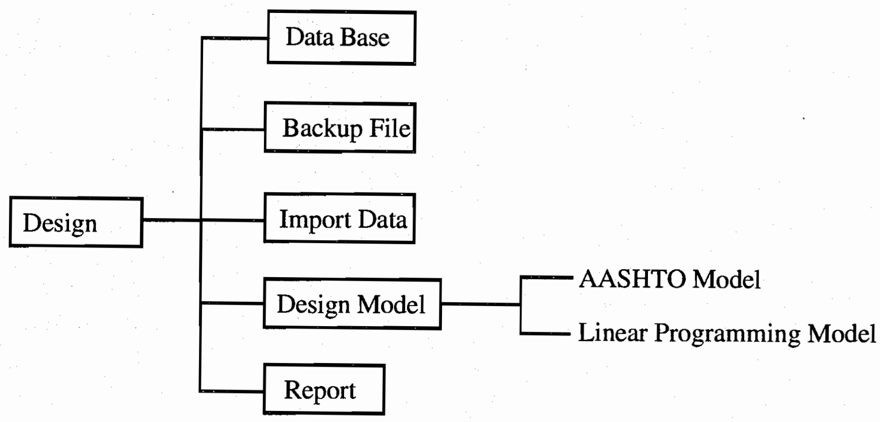


Figure 2.5 Structure of the design subsystem

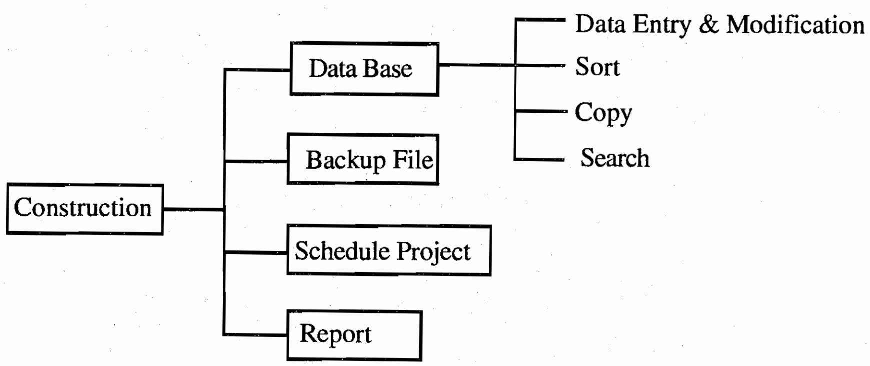


Figure 2.6 Structure of the construction subsystem

Maintenance Structure. The Maintenance Subsystem consists of a Knowledge Base Module (KBM), a Consultation Module (CM), and a Rule Conversion Module (RCM), shown in Figure 2.7. The KBM is created on two screens. On the first screen, distress types and variables related to that distress type are specified and levels and description for each level is defined. The second screen is used for specifying distress repair methods in the form of a decision tree. The CM is also composed of two screens: first is the dialogue menu on which all variables and levels of each variable for a distress type are listed, and second is a decision tree for tracing the decision process. The RCM converts the Knowledge Base to rules and prints the rules.

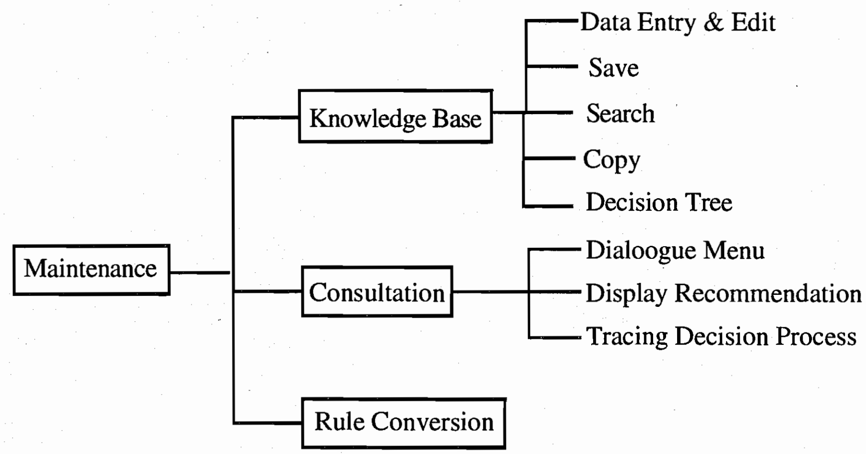


Figure 2.7 Structure of maintenance subsystem

Data Specifications

In order to effectively use the program, one must understand data specifications. The input and output for each subsystem are given below.

Planning. A total of 44 data items are defined in the planning subsystem. Forty items are input data and 4 items are output data.

Input data. Input data required in the planning subsystem are shown in Table 2.8:

TABLE 2.8 INPUT DATA FOR THE PLANNING SUBSYSTEM

INPUT DATA	DESCRIPTION
Section Identification	Section code, street name, location from, location to, and pavement type
Pavement Geometry	Section length, Pavement width, and the number of traffic lanes
Pavement History	Construction Year
Traffic	Capacity (v/h), ADT, traffic growth rate, and truck percentage
Condition Index	Ranges from 1 to 100, with 100 representing the perfect condition of pavement
Subgrade Type	Strong or Weak
Street Map	x and y coordinates of the starting and ending points of the streets
Distress Data for Each Distress Type	Up to 7 types of distresses can be defined. The severity of each distress type is divided into 3 levels: low, medium, and high, so the total distress items are 21.

Minimum data required. Minimum data required to run the planning subsystem includes section code, street name, location from, location to, pavement type, section length, pavement width, number of traffic lanes, construction year or subgrade type, average daily traffic, and the Condition Index (CI) for pavements.

Output data. The output information contains:

1) M&R Strategy,
2) Priority Index,
3) Recommended Action Year, and
4) Cost.

Design. The design subsystem covers Asphalt Concrete (AC) pavement design and AC overlay design. The data items needed vary from problem to problem. All the data items are listed below. Reference to the AASHTO Pavement Structural Design Guide [1] can help to understand the data.

Input data. The input data required is shown in Table 2.9

TABLE 2.9 INPUT DATA FOR THE DESIGN SUBSYSTEM

INPUT DATA	DESCRIPTION
Section Identification	Project number, street name, starting location, and ending location
Pavement Geometry	Section length, number of traffic lanes, and pavement width
Traffic	Performance period, traffic growth rate, and initial annual two way 18k ESALs
Design Reliability	Design reliability (R) and standard deviation (So)
Sericeability	Initial and terminal Pavement Serviceability Index
Roadbed Swelling	Potential vertical rise, swelling probability, and swell rate constant
Roadbed Frost Heave	Max. potential serv. loss, frost heave prob., and frost heave penetration
Soil Resilient Modulus	Roadbed soil resilient modulus (MR)
Layer Material Characteristics	Type of material, minimum thickness, elastic modulus, layer coefficient, drainage coefficient, and unit cost for different layers
Overlay Design	Remaining life factor and effective structural capacity

Section identification and pavement geometry data need to be entered into the program only if the design subsystem is used as a stand alone program.

Output data. For new flexible pavements, output of the design subsystem consists of material types, thicknesses of each of the layers, and the cost of the pavement structure. For overlay design, the surface course material and thickness, and the cost for the overlay are the outputs.

Construction. The construction subsystem uses the Program Evaluation and Review Technique (PERT).

Input data. The input data for the construction subsytem is given in Table 2.10.

TABLE 2.10 INPUT DATA FOR THE CONSTRUCTION SUBSYSTEM

INPUT DATA	DESCRIPTION
Section Identification	Project nurnber, street name, location from, and location to
Pavement Geometry	Section length, number of traffic lanes, and pavement width
Construction Schedule	Activity description, begin & end node, optirnistic, realistic, & pessimistic duration of the activity, and direct and indirect cost

Output data. Output data of the construction subsystem includes average duration of each activity, standard deviation, type of activity, early start time of each activity, early finish time of non-key activity, late start time of non-key activity, late finish time of each activity, slack time of non-key activity, total direct cost, total indirect cost, total expediting cost, and total project cost.

Maintenance. The maintenance subsystem is a simplified expert system development tool. In this subsystem, the possible repair methods for each distress type is related to a maximum of three variables, and each variable can be divided into a maximum of three levels, so at most 27 possible repair methods can be defined for each distress type.

Input Data for the Knowledge Base. The knowledge base is built into decision trees. Number of branches of the tree depends on number of variables and number of levels of each variable. Take alligator cracking as an example: using three variables, severity, density, and traffic related to alligator cracking, divide the severity of alligator cracking into low, medium, and high; density into low and high; and traffic into light, average, and heavy. This needs a total 3x2x3 = 18 combinations. To build a decision tree, levels with their description has to be entered for each variable specified. For example, the traffic variable for alligator cracking can be described as:

LEVELS	DESCRIPTION
Light	ADT < 2000
Average	ADT = 2000-5000
Heavy	ADT > 5000

Next, the result for each combination has to be specified. For example,

If	Distress = Alligator Cracking	(Distress Type)
	and Severity = Low	(Variable # 1)
	and Density = Low	(Variable # 2)
	and Traffic = Light	(Variable # 3)
Then	Recommended Repair Method	
	= Do Nothing	(Result)

The user does not need to write any rules as shown above. He only needs to fill out the results in the decision tree.

Output of Consultation. Once the knowledge base is ready, the expert system can be used for consultation. The consultation module is made up of a dialogue box and a module to trace the decision. The output of consultation is the recommended distress repair method(s).

Implementation of URMS in Georgetown

To demonstrate its use, URMS was implemented in the city of Georgetown [3]. Georgetown is a small town in central Texas with a population of approximately 15,000, covering an area of about 10 square miles. The city has approximately 160 center-line street miles, which are all flexible pavements. The Public Utilities Department of Georgetown is responsible for maintaining their streets. URMS was implemented on a pilot basis in the city of Georgetown, Texas, at the network level.

For implementation, the city collected and stored data for section identification and pavement geometry of 180 sections of arterial and collector streets. The condition index data for pavements was collected on a subjective visual rating scale, divided into three levels: Good, Fair, and Poor. The data was transferred form Lotus 1-2-3 spread sheets to URMS. Georgetown uses GIS location for the city streets. However, street names were not available in the GIS file.

Hence,the street map data for URMS were manually entered instead to be imported from the GIS file. The city decided to use soil type, instead of age of pavements, for the network planning model. The soil type was divided into two categories, strong and weak. Average Daily Traffic (ADT) was divided into three levels: Light, Medium, and Heavy. The soil type and ADT data, for sections considered, was added into URMS file by city personnel using URMS editor.

Table 2.11 gives the evaluation indices for Georgetown. The average unit cost of different M&R treatments utilized in Georgetown are given in Table 2.12.

TABLE 2.11 EVALUATION INDICES FOR GEORGETOWN

PCI	Soil Type	Mixed ADT	Truck ADT
Poor	Weak	Light	Light
Fair	Strong	Medium	Medium
Good		Heavy	Heavy

TABLE 2.12 M&R STRATEGIES DEFINED FOR THE CITY OF GEORGETOWN

No	M & R Strategy	Description	Unit Cost ($/SY)
1	Do Nothing		
2	Seal Coat		0.45
3	Overlay	1 - 2 inches	1.3
4	Reconstruction		9

In constructing the decision tree for assigning an M&R strategy to each section, pavement condition was considered to be the main factor. For those sections in which PCI was good, no action was taken regardless of traffic volume or subgrade. The M&R strategy assignment model built for Georgetown is shown in Figure 2.8. Since only three levels for both PCI and ADT are defined, the code "1" and "5" are not actually used in the model.

Figure 2.9 shows the priority index model for the city. PCI and traffic are considered more important than subgrade condition and street functional class respectively. For example, a section with type 2 soil (strong) and level 1 PCI (bad) has a higher priority (smaller PIX) than that with level 2 PCI (poor) and type 1 soil (weak)

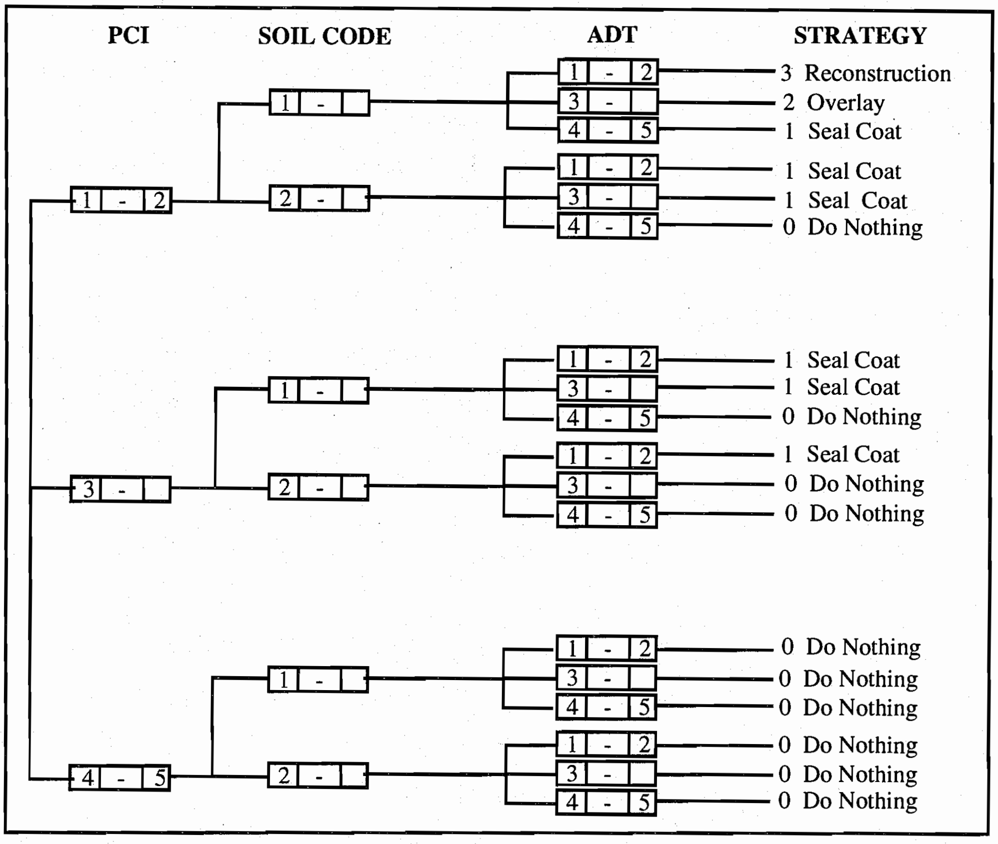


Figure 2.8 M&R assignment model screen for Georgetown

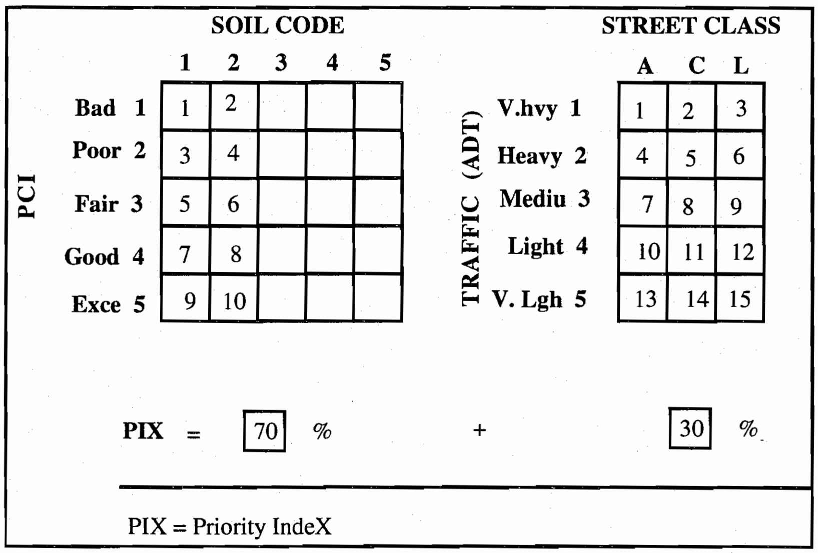


Figure 2.9 Priority index model screen for Georgetown

The outputs of the pavement evaluation and the M&R program, both for M&R needed and M&R recommended projects, for the sections considered during the implementation are shown in Figure 2.10 and 2.11. It was observed that in all 13 sections (5.86 miles) need seal coats and 2 sections (1.16 miles) need an overlay. This required a total of $78,400 in 1993. For a budget of $60,000, URMS recommended 4 sections for seal coat and 2 sections for overlay.

Potential Benifits of Implementation

The implementation of URMS can save both agency and user costs, and improve the efficiency and effectiveness of management decision making. A study was done to estimate the effects of URMS on Fuel Consumption and Emissions [4]. The effects of URMS on Fuel Consumption and Emissions were estimated by taking into consideration the improved management of Work Zone areas where more fuel and emissions values result due to traffic congestion.

Almost all cities employ some form of management technique to schedule roadway maintenance. URMS can significantly reduce the duration and number of these maintenance operations. As shown in figure 2.12, these decreases in the duration and number of operations result in a reduction in Fuel Consumption and Emissions.

Austin, Texas, was used as the pilot city for the study. The study indicates that significant reductions can result in fuel and emissions from the implementation of a roadway management system.

Fuel Savings - 62,800 gallons per year.

Reduction in CO Emissions - 15,205,000 grams per year.

Reduction in HC Emissions - 304,000 grams per year.

Reduction in NOx Emissions - 198,000 grams per year.

Based on estimates for the city of Austin, the fuel savings were projected through 1999 as given in Table 2.13.

URBAN ROADWAY MANAGEMENT SYSTEM (URMS V.1.1) Planning Subsystem

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SUMMARY OF PAVEMENT CONDITION AND TRAFFIC EVALUATION (1993)

Input File: GURMS.PLA Report Date: 9-01-1993

CONDITION CODE	DESCRIPTION	LIMITING VALUE	SECTION NUMBER	%	LENGTH MILES	%	AREA 1000 SY	%
* PCI								
1	Bad	<= 30	0	0	0	0	0	0
2	Poor	30 - 55	5	3.4	3.8	8	78.1	9.5
3	Fair	55 - 75	24	16.4	8.1	17	115.6	14
4	Good	75 - 90	117	80.1	35.9	75	631	76.5
5	Exce	> 90	0	0	0	0	0	0
* SOIL								
1	Weak		27	18.5	9.7	20.2	158.7	19.2
2	Strong		119	81.5	38.2	79.8	666	80.8
* MADT								
1	V. Heavy	> 4000	0	0	0	0	0	0
2	Heavy	3000 - 4000	61	41.8	21.2	44.3	370.5	44.9
3	Medium	2000 - 3000	59	40.4	19.5	40.8	355.5	43.1
4	Light	1000 - 2000	26	17.8	7.1	14.9	98.7	12
5	V. Light	<= 1000	0	0	0	0	0	0
* TADT								
1	V. Heavy	> 4000	0	0	0	0	0	0
2	Heavy	3000 - 4000	61	41.8	21.2	44.3	370.5	44.9
3	Medium	2000 - 3000	59	40.4	19.5	40.8	355.5	43.1
4	Light	1000 - 2000	26	17.8	7.1	14.9	98.7	12
5	V. Light	<= 1000	0	0	0	0	0	0
	TOTAL		146	100	47.9	100	824.7	100

City: Georgetown User: Public Utilities

Figure 2.10 Printout of the summary for pavement evaluation for Georgetown

URBAN ROADWAY MANAGEMENT SYSTEM (URMS V.1.1) Planning Subsystem
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SUMMARY OF MAINTENANCE & REHABILITATION PROGRAM
FLEXIBLE PAVEMENT

1. Maintenance & Rehabilitation Needs

Input File: GURMS.PLA Report Date: 9-01-1993

M&R STRATEGY Code	Description	UNIT COST ($/SY)	SECTION Number	%	LENGTH (mile)	%	BUDGET $ 1000	%
0	Do Nothing	0	131	89.7	40.85	85.3	0	0
1	Seal Coat	0.45	13	8.9	5.86	12.2	49	62.5
2	Overlay	1.30	2	1.4	1.16	2.4	29.38	37.5
3	Reconstruction	9.0	0	0	0	0	0	0
	TOTAL		146	100	47.87	100	78.4	100

2. Recommended M & R Projects for 1993

M&R STRATEGY Code	Description	UNIT COST ($/SY)	SECTION Number	%	LENGTH (mile)	%	BUDGET $ 1000	%
0	Do Nothing	0	140	95.9	43.46	90.8	0	0
1	Seal Coat	0.45	4	2.7	3.25	6.8	28.8	49.5
2	Overlay	1.30	2	1.4	1.16	2.4	29.38	50.5
3	Reconstruction	9.0	0	0	0	0	0	0
	TOTAL		146	100	47.87	100	58.2	100

City: Georgetown User: Public Utilities

Figure 2.11 Printout of M&R program for Georgetown

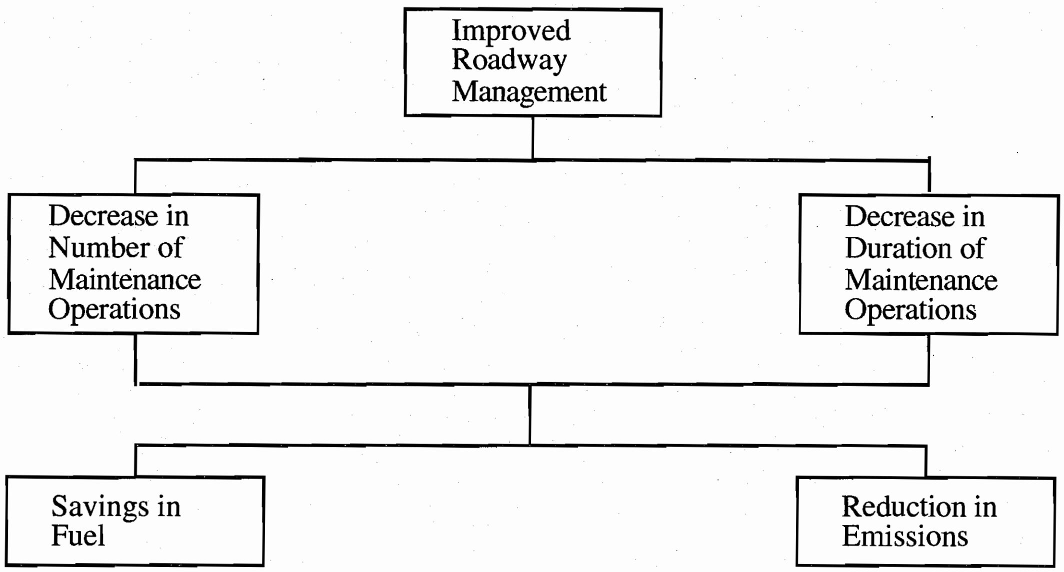


Figure 2.12 Flow of the information and the potential improvements in fuel consumption and emissions through URMS

TABLE 2.13 PROJECTED FUEL SAVINGS

YEAR	1994	1995	1996	1997	1998	1999
NO. OF CITIES	5	10	20	40	80	160
FUEL SAVINGS (mi Gallons)	0.314	0.628	1.256	2.512	5.024	10.05

CONCLUSIONS

This chapter presented a comparision of promising PMS used at the local government level in the United States. URMS, developed at the university of Texas at Austin, was identified as the most simple, flexible, and user-friendly PMS available at present time to manage urban road network. Implementation of such a system can save money for both agency and users.

Under this study, URMS was implemented in two cities of Texas. The next four chapters of this report will discuss the process of URMS implementation. Chapter 3 will describe design and goals of nationwide surveys conducted to gain knowledge of pavement management practices at the regional level, and to identify candidate cities for implementation. Chapters 4, 5, and 6 will give a comprehensive presentation of results of surveys conducted; evaluation of results for surveys conducted in Texas, to come up with candidate cities; and discussion on URMS implementation in cities selected.

CHAPTER 3. SURVEY DESIGN AND GOALS

The primary objective of this project is to implement the URMS in small to medium sized cities. The second objective is to gain a knowledge of pavement management practice at the regional level around the USA. To achieve these objectives, three surveys were conducted. The first survey, administered in the Summer of 1994, included 238 cities in Texas. In second survey around 650 regional councils in the United States were contacted in November, 1994. A third survey was conducted in September, 1994, in which Micro PAVER users were contacted to find out if they were still actively using Micro PAVER and whether they were interested in knowledge of URMS.

SURVEY RESPONSE VALIDITY

One of the most important concerns in designing any survey questionnaire is that it generates valid and reliable data. Wentland and Smith recently published the results of an extensive study that examined the validity of survey responses [20]. The researchers report that there are three broad causes of response error in surveys. The first of these, inaccessibility of the information to the respondent, refers to the inability of respondents to recall and/or report accurately. As Wentland states, "a respondent simply may not have the requested information or be unable to remember it, particularly if the recall period is long and if the behavior or event in question was not significant to the respondent". Problems of communication, the second cause of errors, refers to the inability of questions to convey to respondents meaningful information. This cause is particularly insidious because, "it is likely that respondents do not wish to appear uninformed, uncooperative, or unable to supply information. Therefore, responses will probably be provided without requests for clarification". The final error source, motivational factors, deals with the respondents' perceived value of the information requested. If the value of the information is not perceived by respondents, survey responses will tend to be inaccurate, if provided at all.

Several methods can be used to minimize the response error effects described above. Provision of contextual cues, ability of the questionnaire to establish a "rapport" with respondents, obtaining respondents commitment to the survey, and reducing the amount of questions specificity are cited as factors that can reduce response error. A final conclusion reported by Wentland is that binary response questions provide more accurate information than questions that have more than one response category. With these observations in mind, several measures were undertaken to ensure that valid data was obtained from our survey. First, the questionnaires were kept as short as possible without missing useful information. Second, most of the questions were posed in a binary format to heighten the validity of responses. Finally, a conscious effort was under taken to establish a rapport with the respondents through survey and cover letter verbiage. The specific ways in which these tasks were performed is reported in the questionnaire design section below.

SURVEY IMPLEMENTATION STRATEGY

There are three ways to implement this kind of survey: face to face interviews, phone interviews, and mail questionnaires. Resources available to the project coupled with the country-wide focus of the survey goals eliminated the face to face approach. Phone administration of the questionnaire offered the significant benefit of interviewer/respondent interaction and high potential response rate, but had the disadvantage of requiring large amounts of implementation time, effort, and money [21]. The telephone survey done later in this study, to collect condition survey information for some cities in Texas, supports this fact.

The mail questionnaire provided several advantages. First , since less time and effort was required to implement the survey, once the survey instrument was designed, more time could be spent on data analysis. Second, the mail format allowed questions with complex response categories to be posed and batteries of similar questions to be asked [6]. Third, the survey could be done with less amount of money. Finally, validity problems associated with the recall time, the amount of time required for respondents to remember the information, were eliminated because the survey is self administered without a perceived response time limit [20]. Because of these advantages and despite anticipated low mail survey response rates, the mail survey format was selected for the study due to funds available.

SURVEYS IN TEXAS AND UNITED STATES

The surveys in Texas and the United States were performed to identify potential cities for URMS implementation and to get an overall picture of pavement management practices in Texas and the US. It was proposed that these surveys would be administered in two steps. In the first step, a post card survey was to be conducted for Texas and the United States to determine current pavement management practices, to solicit interest in URMS, and to place cities of various sizes on the candidate list for URMS implementation. The second step proposed a detailed survey of cities selected after analysis of the post card survey. The detailed survey questionnaire was designed to get an in depth knowledge of current pavement management practice of selected cities, and to get detailed information about data collection for street maintenance in these cities. Under this project, URMS was to be implemented in one to two cities, in Texas. Information obtained from the detailed survey can be very useful to select the final cities for current URMS implementation and for implementation of URMS in other cities in future. For the Texas survey, both steps were taken. However, for the nation-wide survey, time and fund constraints allowed the execution of only the first step.

The Texas survey was conducted in three stages. In the first stage, a post card questionnaire was prepared and sent to 238 cities along with a cover letter. The second stage, or follow-up mailing, was sent only to first stage non-respondents and consisted of a similar questionnaire with an additional question about the condition survey information under a new cover letter. After analysis of the two stages replies (described in the next chapter), 25 cities were selected for a detailed survey. A detailed questionnaire was designed and sent to these cities along with a copy of URMS and a cover letter.

The US survey was performed in one stage only in which the postcard and a cover letter were sent to 650 regional councils in the United States. The replies to the US survey provided an over all picture of pavement management, as practiced by regional councils at the national level. The Texas survey replies provide a detailed knowledge of pavement management, as practiced by Texas cities. Replies from the Texas survey were used to identify candidate cities for implementation of URMS. The US survey replies provided information that can be used in the future to implement URMS nationwide.

Sample Cities for Surveys

The University of Texas library (PCL) lists 276 cities in the state of Texas. The addresses to public works or street department of these cities were obtained from the Texas Municipal League, which had 238 Texas cities in their data base. The 86% sample thus obtained was considered statistically adequate for this study. For the US survey, a list of cities in the United States was prepared. To get public works or streets division addresses of these cities , American Public Works Association (APWA) and Federal Highway Administration (FHWA) were contacted. APWA was unable to provide any help for the US survey, however, FHWA furnished addresses for the members of the National Association of Regional Councils (650 members) and the National Association of County Engineers (1210 members). For the US survey, a postcard along with a cover letter were sent to all the members of the National Association of Regional Councils.

Survey Scope

The Texas post card surveys was conducted to: 1) make the cities aware of the ISTEA requirements about the Pavement Management Systems implementation, 2) get a knowledge of current pavement management practice in different cities, 3) develop criteria for selection of potential cities for implementation, and 4) get a knowledge of cities interested in implementing URMS.

The US survey, in which about 650 Regional Councils around the country were contacted, was conducted with a general perspective as compared to the Texas survey where 238 cities in Texas were sent the post cards. The scope of the US survey was: 1) to make the regional councils aware of the ISTEA requirements, 2) to get a knowledge of current pavement management practice at the regional level around the country, and 3) to get a knowledge of regional councils interested in implementing URMS.

Limitations of funds and time restricted implementation to one to two Texas cities. Hence, the detailed questionnaire was sent to the 25 Texas cities, selected after the analysis of the Texas post card survey. Goals of the detailed survey were 1) to get in depth knowledge of current pavement management practice, and 2) to gather information about the data collected for street maintenance in the selected cities.

Post Card Design

To fulfill the objectives, the post card designed for the Texas and US survey should obtain (1) information of cities' current pavement management practice , (2) information of street maintenance data cities collect, (3) information of any funds cities have to implement a PMS, and (4) cities' interest in the URMS.

Keeping the scope in mind, the format shown in Figure 3.1 was designed for the Texas and US post card surveys. The first set of post cards sent to the Texas cities did not have a question regarding street maintenance data collection. Hence, during the analysis phase, some cities had to be contacted via telephone to get this information. For the Texas follow-up survey and the US survey, a question was added to get street condition information. Question 1 makes the cities aware of the ISTEA requirement, question 2 and 3 address current pavement management practice, question 3 b, 4 and 5 provides some criteria for the selection of candidate cities for the implementation of URMS, and question 6 addresses interest of cities in URMS implementation. Hence, the post card fulfills all the goals considered for the two surveys.

Detailed Questionnaire Design

The detailed questionnaire, designed to fulfill the objectives discussed above, is shown in Appendix A. To achieve its goals, the questionnaire was divided into two parts: Section A deals with evaluation of current city pavement management practices, and Section B focuses on data collected by cities for maintenance of their road network.

Your Name: **Telephone # :**

Address: **Fax # :**

1. Before this mailing were you aware that the Intermodal Surface Transportation Efficiency Act 1991 [11] requires that all states should certify that metropolitan planning organizations have a working pavement management system (PMS) by October 1,1995 on the National Highway System (NHS), and by October 1, 1997 on the non NHS Federal aid highways ? ☐ Yes ☐ No

2. Do you have an organized pavement management department in your organization ? ☐ Yes ☐ No

3. Are you currently using any network level PMS for your roads and streets ? ☐ Yes ☐ No
   - a) What is the name of the system you are using ?
   - b) Are you actively using it now ? ☐ Yes ☐ No

(Please feel free to attach a letter if you have any specific comments or details about the system to share with us.)

4. Do you perform condition survey for your pavement network? ☐ Yes ☐ No
If yes, what data do you collect?

5. Do you have funds budgeted to implement or operate a PMS software ? ☐ Yes ☐ No
If yes, approximately how much ? (Please check one.)
☐ $1000-$5000 ☐ $6000-$10,000 ☐ $11,000-$20,000 ☐ More than $20,000

6. The Urban Roadway Management System (URMS), developed by the University of Texas at Austin, can be provided to you at the cost of duplication. Would you be interested in implementing the system in your city ? ☐ Yes ☐ No

7. **YOUR COMMENTS:**

Figure 3.1 Postcard designed for the US and Texas Surveys

A cover letter signed by Dr. W. R. Hudson, Dewitt C. Greer Centennial Professor in Civil Engineering at the University of Texas at Austin, and the project director, encouraged recipients to respond to the surveys. The post card had return postage-paid stamps on them (business reply mail) where as, the detailed questionnaire included a postage-paid envelope so as to prevent a responder from incurring any out of pocket cost.

MICRO PAVER SURVEY

Micro PAVER is a PMS developed by Army Corps of Engineers. Micro PAVER was adopted by American Public Works Association (APWA), and it is currently the most widely used PMS at the local government level. A post card survey was conducted among the Micro PAVER users in October 1994 to asses if they were still actively using PAVER and whether they were interested in examining URMS.

Survey Sample

A list was obtained through APWA containing names and addresses of the agencies in the active Micro PAVER users category. Micro PAVER users included Department of Public Works of cities (DPWs), consulting companies, universities, and international organizations. A questionnaire was sent to all 198 users on the list provided by APWA.

Survey Scope and Design

The objectives of Micro PAVER survey were: 1) to determine current pavement management practices of PAVER users listed in APWA's list, 2) to asses if the listed PAVER users were still actively using it, 2) to identify the most useful and most problematic aspects of Micro PAVER and, 3) to know if the users were interested in examining URMS.

Keeping the above scope in perspective, a survey postcard, shown in Figure 3.2, was designed. Questions 1 and 2 provides information on the current pavement management of the cities. Question 3 tells if the respondent is an active user of Micro PAVER. Question 4 and 5 provides information about the most useful and most problematic aspects of the Micro PAVER. Question 6 tells respondent's willingness to examine URMS.

Your Name: **Telephone # :**

Address: **Fax # :**

1. Do you have an organized pavement management department in your organization ? ☐ Yes ☐ No

2. Do you perform condition survey on your pavement network? ☐ Yes ☐ No

If yes, what data do you collect?

3. Are you now actively using Micro PAVER for your roads and streets ? ☐ Yes ☐ No

4. What do you find most useful in Micro PAVER for your pavement network management?

5. What is the most crucial problem you encounter while using Micro PAVER (if any)?

(Please feel free to attach a letter if you have any specific comments or details about Micro PAVER to share with us.)

6. The Urban Roadway Management System (URMS), developed by the University of Texas at Austin, can be provided to you at the cost of duplication. Would you be interested in examining the system? ☐ Yes ☐ No

7. **YOUR COMMENTS:**

Figure 3.2 Postcard designed for Micro PAVER Users' Survey

CHAPTER 4. RESULTS OF SURVEYS

This chapter discusses the results of the three surveys described in Chapter 3.

TEXAS SURVEY RESULTS

The Texas survey was mailed out in three stages. The first stage postcard was mailed on the August 1, 1994. By September 29 (60 days), the target date for initial mailing return, 58 responses had been received. Six additional responses were later received. The resulting 64 first stage replies amounted to a 27% first stage response rate. The follow up mailing was sent on September 29, 1994. Out of 174 cities which were sent the post card, 67 responded to the second stage survey. This amounts to a second stage response rate of 38.5%. Considering the two stages together, 131 out of 238 cities responded to the survey, and hence an excellent over all response rate of 55% was obtained. However, all the responses could not be used for the analysis. This was because 32 postcards came back with no name, address, or telephone number on them, and had to be discarded for the analysis. Therefore, 99 cities were considered for analysis to select potential cities for URMS implementation. These amount to 41.6% of the total cities considered during the survey.

Postcards designed for the first stage survey did not have any question regarding street condition. Hence, there were 64 cities in all, and 54 cities considered for analysis, which did not have data regarding the condition of their road network. For the analysis (see chapter 5), cities were divided into two major categories. The first category was based on the interest of the cities in URMS and the budget they had for PMS implementation. The second category was based on city population. It was decided that data should be complete for all interested cities which had some budget for PMS implementation. Hence, the 17 cities in this category, which had no condition survey data, were contacted via telephone and the data was collected regarding any condition survey performed by them to collect the distress data on their pavements.

The analysis of cities with population between 50,000 and 250,000 revealed that Longview, a city with no budget to implement a PMS, can be a potential city for URMS implementation because of its existing street data base. To save the analysis from any bias, it was necessary to have street condition information for the other 5 cities which fell in the same category as Longview. These cities were contacted on the telephone and the information was collected.

Overall Results

Table 4.1 gives the over all response to different questions asked in the survey. Figure 4.1 gives graphical representation of these results. It can be seen in Table 4.1 that "no response" categories has significance only for condition survey results, and hence is included only for condition survey results in Figure 4.1. The "not sure" category is insignificant for all results, and hence is neglected.

It was observed that almost 62% of the cities which replied to the Texas Survey were not aware that ISTEA requires all states to certify that Metropolitan Planning Organizations (MPOs)have a working PMS by October 1, 1995 on the NHS, and by October 1, 1997 on the non NHS Federal aid highways. This shows that the survey effectively fulfilled its first objective, to make the cities aware of the ISTEA PMS implementation requirements.

The second objective, i.e., to get the knowledge of current pavement management practice in different cities, was also achieved successfully. It was observed that out of the cities replied, 66.4% do not have an organized pavement management department, 12.2% have a network level PMS for their roads and streets, and only 9.2 % are actively using the PMS they have. Hence, 25% of the cities which have a PMS are not actively using it.

It can be seen that 24.4% of the cities indicated they have some funds in their budget to implement a PMS, whereas, in all 34.4% perform condition surveys. However, we do not have condition survey information for 41 cities (31%). The budget and the condition survey information fulfilled the third survey objective. This information was very useful in the selection of candidate cities for the URMS implementation. Finally, the last and the most important objective was achieved, and the results show that around 85.5% of the cities replied are interested in implementing URMS.

Results Based on Interest, Population and Funds

One of the main survey objective was to come up with some criteria for the selection of potential cities for URMS implementation. The interest of cities in implementation, their population, and funds available for PMS implementation were selected as main criteria. To have a better understanding, and to ensure effective use while selection of candidate cities, results are divided into three major categories: interest, population, and funds.

Interest in Implementation. Survey results by the interest of cities in the implementation of URMS are shown in Figure 4.2. It can be seen that 85% of the cities replied are

TABLE 4.1 OVERALL RESPONSE TO THE TEXAS SURVEY

QUESTIONS	RESPONSE			
	Yes	No	Not Sure	No Response
ISTEA Requirement	49 (37.4%)	81 (61.8%)	0 (0%)	1 (0.76%)
Organized Pavement Management Department	43 (32.83%)	87 (66.41%)	0 (0%)	1 (0.76%)
Network Level PMS	16 (12.22%)	113 (86.3%)	0 (0%)	2 (1.53%)
Actively Using PMS	12 (9.16%)	116 (88.5%)	1 (0.76%)	2 (1.53%)
Condition Survey	32 (24.43%)	99 (75.6%)	0 (0%)	0 (0%)
PMS Implementation Budget	112 (85.5%)	19 (14.5%)	0 (0%)	0 (0%)
Interested in URMS Implementation	42 (32.1%)	39 (29.8%)	46 (35.1%)	4 (3.1%)

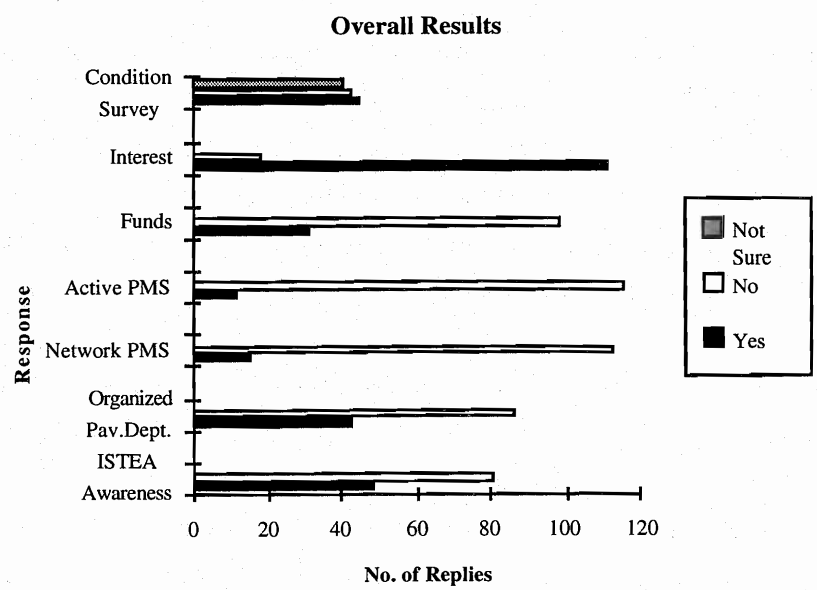


Figure 4.1 Overall response to the Texas survey

Survey Results by Interest

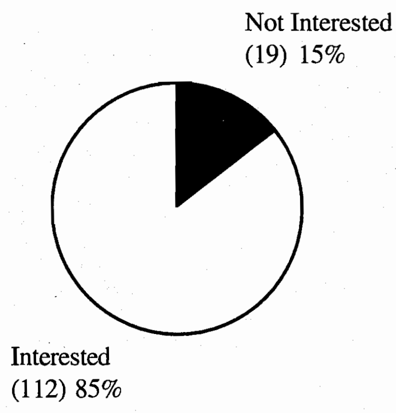


Figure 4.2 Survey results by the interest of cities in implementing URMS

interested in implementing the URMS. The remaining 15% "not interested" cities are not considered further in the results and analysis.

Population Division of Cities Interested. This project aimed at the implementation of URMS in small to medium sized cities. The cities were divided into three sizes based on population: Population 1; large cities with population greater than 250,000, Population 2, medium cities with population between 50,000 to 250,000, and Population 3, small cities with population less than or equal to 50,000. Out of 131 cities which replied to the survey, 32 had no name and address on the post cards. Hence, no information about population can be obtained for these replies. This resulted in the consideration of 99 cities in the population subdivision.

Dividing the 99 cities into population categories mentioned above, Table 4.2 gives numbers of cities which replied to the survey, and numbers of cities which are interested in implementation in each population category.

Out of the 99 cities considered, 11 are not interested. Figure 4.3 shows the population division of remaining 88 cities which are interested in URMS implementation. Implementation is aimed at small to medium sized cities, however, results are also prepared for large cities since they provided valuable information. Table 4.3 gives a further division of interested cities based on the

TABLE 4.2 REPLIES BASED ON POPULATION DIVISION

POPULATION CATEGORY	TOTAL CITIES	CITIES REPLIED	CITIES INTERESTED
1	8	6	6
2	31	19	16
3	199	74	66

TABLE 4.3 POPULATION AND FUNDS DIVISION OF CITIES INTERESTED IN IMPLEMENTATION

POPULATION	FUNDS	NO FUNDS
1 (>250K)	4 (67%)	2 (33%)
2(50K-250K)	3 (18.8%)	13 (81.2%)
3(<50K)	16 (25.8%)	50 (74.2%)

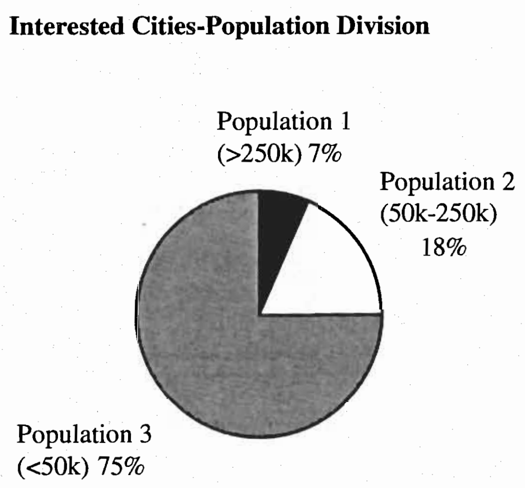


Figure 4.3 Population division of cities interested in implementation

availability of funds for different population subdivisions. It can be seen that most of the population category 1 cities, 67%, have funds budgeted for implementation, as compared to cities of the other two categories where this percentage is very low.

Responses to the survey for interested cities in the three population categories are shown in the Table 4.4, . Figure 4.4 to 4.6 give similar information for each population division. "No response" and "not sure" categories are neglected for all questions except the question about condition survey. The percentages of replies calculated in Table 4.4 are based on the population categories.

TABLE 4.4 RESPONSE OF THE INTERESTED CITIES BASED ON THE POPULATION DIVISION

QUESTIONS		POPULATION		
		> 250 k	50k-250k	< 50k
ISTEA Awareness	Y	6 (100%)	10 (63%)	20 (30%)
	N	0 (0%)	6 (37%)	46 (70%)
Organized Pavement Management Department	Y	2 (33%)	3 (19%)	26 (39%)
	N	4 (67%)	13 (81%)	39 (59%)
Network Level PMS	Y	1 (17%)	4 (25%)	5 (8%)
	N	5 (83%)	12 (75%)	60 (91%)
Active PMS	Y	1(17%)	3 (19%)	2 (3%)
	N	5 (83%)	13 (81%)	65 (97%)
Budget for PMS Implementation	Y	4 (67%)	3 (19%)	17 (26%)
	N	2 (33%)	13 (81%)	49 (74%)
Condition Survey	Y	4 (67%)	10 (63%)	19 (29%)
	N	0 (0%)	5 (31%)	17 (26%)
	NS	2 (33%)	1 (6%)	30 (45%)

Awareness of the ISTEA requirement decreases from population category 1 to population category 3. The use of an active PMS is very low for population category 3 cities, as compared to the other two. The availability of funds to implement a PMS is much greater for the population category 1 cities. Finally, the condition survey results show that most of the population category 1 and 2 cities perform condition surveys. Condition survey information is not available for 30 (45%) population 3 category cities, however, all these cities fall in the no budget group, and hence, as discussed in the next chapter, have the lowest priority for possible selection for implementation.

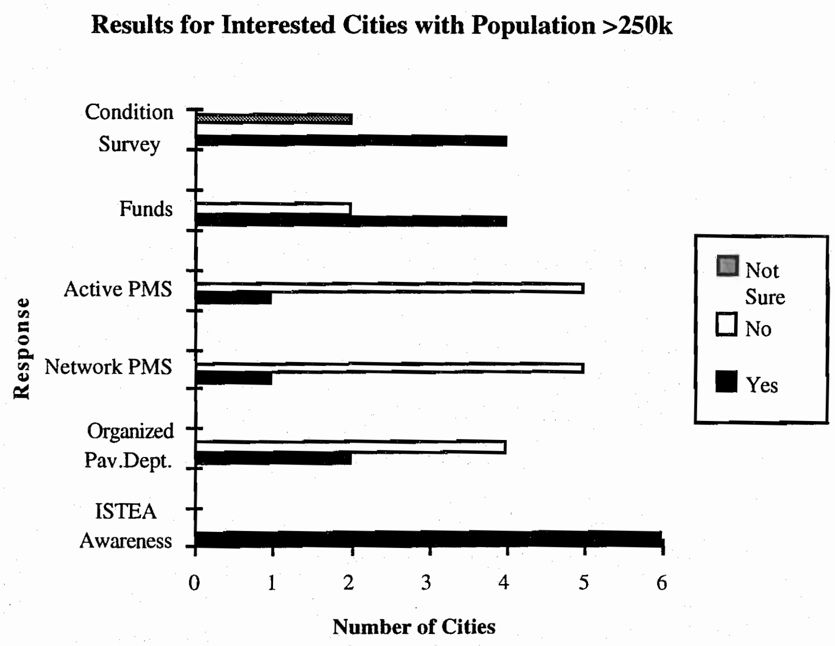


Figure 4.4 Response of the cities interested in population category 1

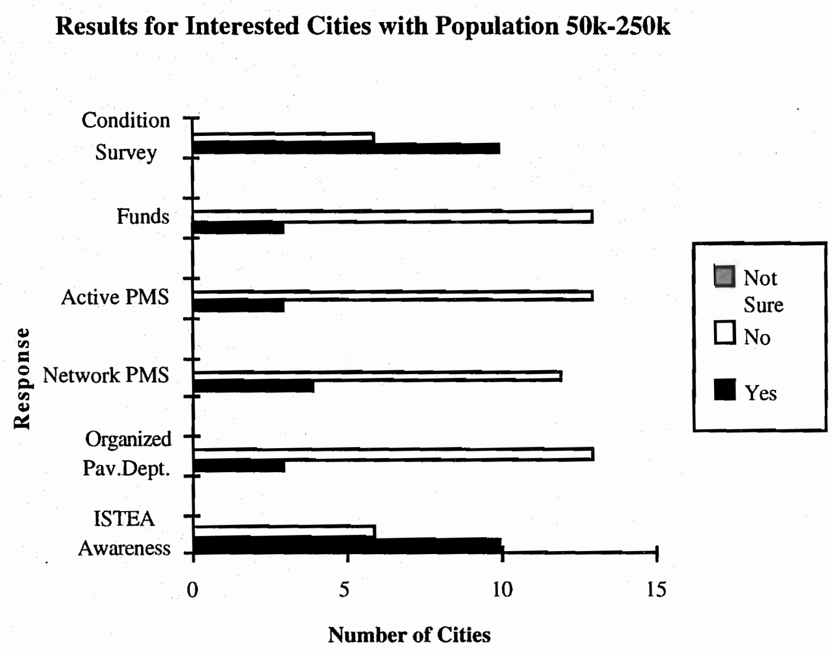


Figure 4.5 Response of the cities interested in population category 2

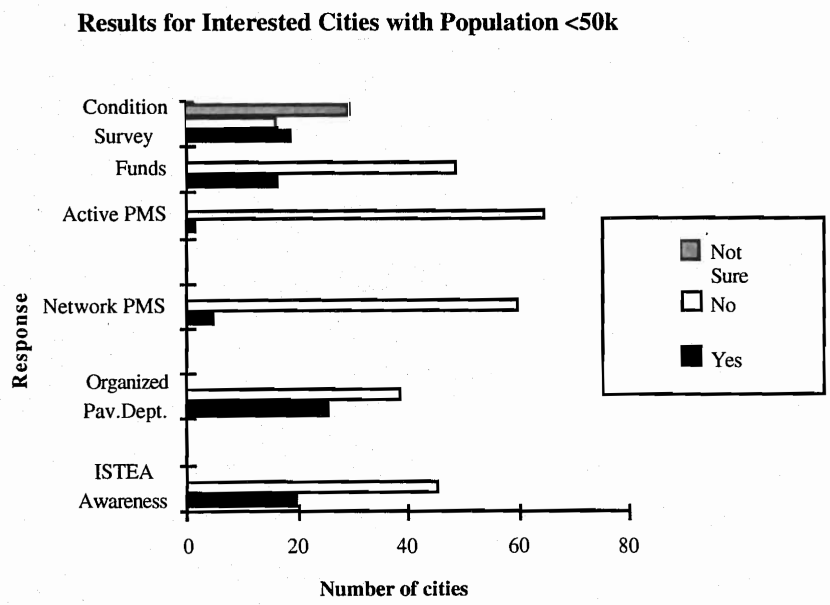


Figure 4.6 Response of the cities interested in population category 3

Funds Division. Availability of funds to implement a PMS was considered as one of the main criteria to select candidate implementation cities. Cities interested in implementation of URMS are divided into two categories; those which have funds budgeted for implementation, and those which do not have any budget for implementation. Figure 4.7 shows that 28 cities (25%) fall in the former category, and 84 cities (75%) fall in the later.

Table 4.5 further shows response of interested cities based on budget division and Figure 4.8 and 4.9 give the similar results graphically. The "not sure" response category is added only for condition survey information. All percentages in Table 4.5 are based on availability of funds.

It is observed that ISTEA awareness is greater for cities which have some funds budgeted for implementation. Use of active PMS is almost negligible for cities with no budget, whereas 25% of the cities which have implementation funds use a network level PMS actively.

The condition survey information shows that percentage of cities performing condition surveys is greater for cities with funds to implement a PMS, than for cities which do not have funds. Among the cities with funds, about 75% perform condition surveys. The condition survey information for cities with no funds shows that at least 22% of these cities perform condition surveys. This percentage might be better since we do not have complete information of 37 (44%)

Interested Cities-Funds Division

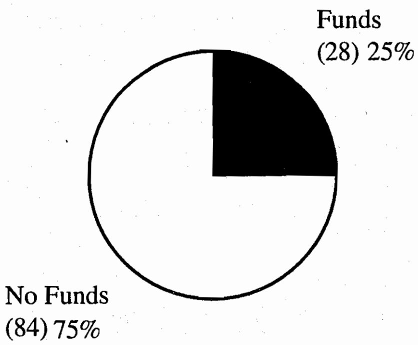


Figure 4.7 Budget division of cities interested in implementation

TABLE 4.5 RESPONSE OF INTERESTED CITIES BASED ON BUDGET DIVISION

QUESTIONS		FUNDS Y	FUNDS N
ISTEA Awareness	Y	17 (61%)	25 (30%)
	N	11 (39%)	58 (70%)
Organized Pavement Management Department	Y	8 (29%)	28 (33%)
	N	19 (68%)	56 (67%)
Network Level PMS	Y	9 (32%)	2 (2%)
	N	19 (68%)	81 (96%)
Active PMS	Y	7 (25%)	2 (1%)
	N	20 (72%)	80 (98%)
Condition Survey	Y	21 (75%)	18 (22%)
	N	5 (18%)	26 (31%)
	NS	2 (7%)	36 (44%)

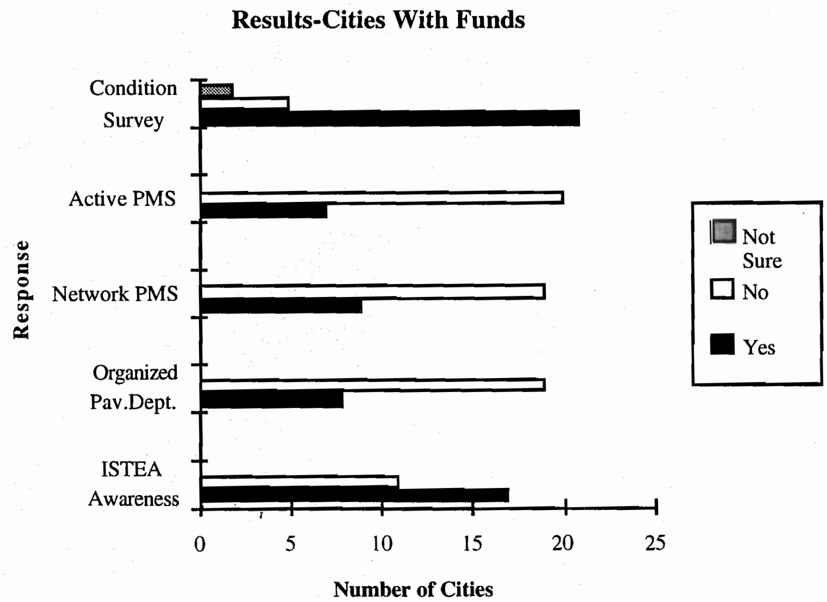


Figure 4.8 Response of cities interested with funds budgeted for implementation

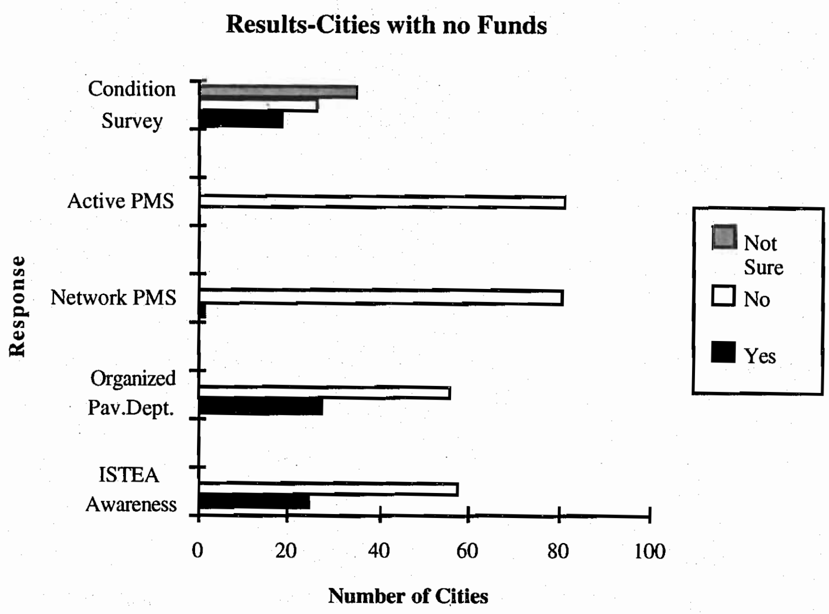


Figure 4.9 Response of cities interested with no funds budgeted for implementation

cities falling in this category. However, cities with no budget do not have a high priority as candidate cities for URMS implementation.

Results Based on PMS Use and Street Condition Data

Interest in URMS implementation, population, and funds budgeted for implementation were considered as main criteria for selection of candidate implementation cities. The other two factors, considered in this regards, were; collection of street condition data and active use of any network level PMS. The Texas Survey results, for the cities interested in URMS implementation, based on these two factors are discussed in this section.

Street Condition Data for Cities Interested. Initially, the condition survey information was not available for 64 cities. Among them 54 cities were later to be considered in the analysis to select potential cities for URMS implementation. During the analysis it was decided that the condition survey information should be gathered for 22 cities out of above mentioned 54. These cities were contacted via telephone and the required information was collected. Responses to the condition survey question hence includes a "Not Sure" category to represent cities for which we do not have condition survey information. However, these cities had the lowest priority to be selected as the candidate cities for URMS implementation.

Figure 4.10 shows the overall condition survey responses for the cities interested in URMS implementation. Table 4.6 gives the survey results for interested cities based on condition survey information. Figures 4.11 and 4.12 show these results graphically.

It is observed that for the cities which perform condition survey, about 82% do not have an active PMS and 54% have some budget to implement a PMS. Comparing the cities which perform condition survey to the ones which do not, it can be seen that a greater percentage of the former cities are aware of the ISTEA requirement, have organized pavement management department, do not have an active PMS, and have funds budgeted to implement a PMS. All the percentages are based on response to condition survey question.

Active Use of Network Level PMS by Interested Cities. Figure 4.13 shows that out of 112 cities interested in URMS implementation, only 9 (8%) were actively using network level PMS to manage their pavements. Table 4.7 gives response of interested cities based on use of any network level PMS and Figures 4.14 and 4.15 show these results graphically.

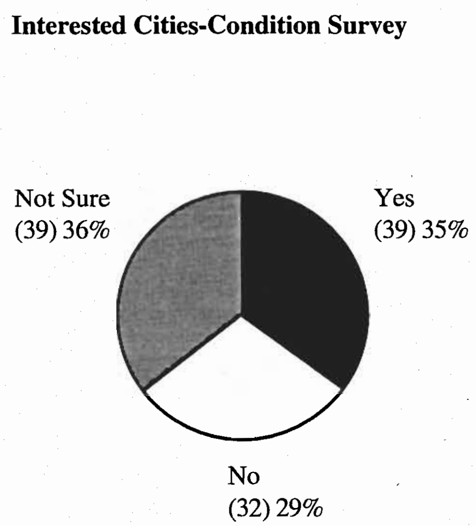


Figure 4.10 Condition survey response for the cities interested

TABLE 4.6 RESPONSE OF INTERESTED CITIES BASED ON CONDITION SURVEY INFORMATION

QUESTIONS		Condition Survey		
		Y	N	NS
ISTEA Awareness	Y	16 (41%)	11 (37%)	14
	N	23 (59%)	19 (63%)	26
Organized Pavement Management Department	Y	11 (29%)	8 (26%)	16
	N	27 (71%)	23 (74%)	24
Active PMS	Y	7 (18%)	0 (0%)	2
	N	31 (82%)	31 (100%)	37
Budget for Implementation	Y	21 (54%)	5 (16%)	2
	N	18 (46%)	26 (84%)	38

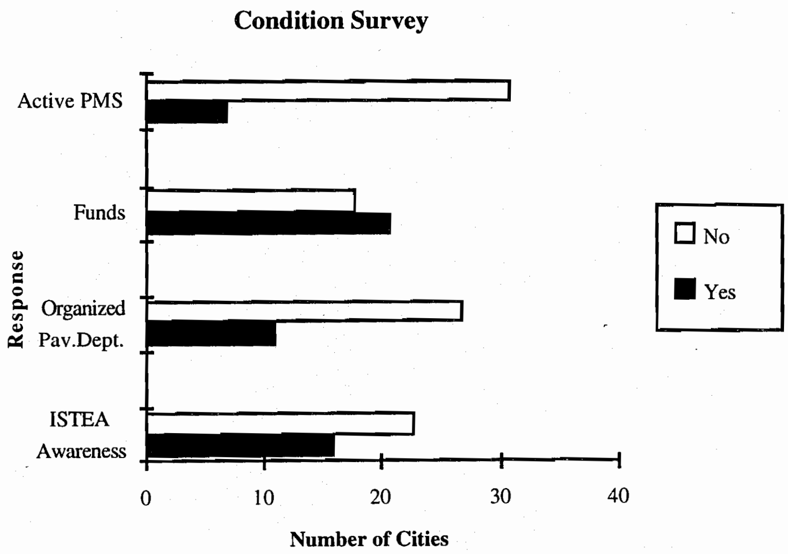


Figure 4.11 Response of interested cities performing condition survey

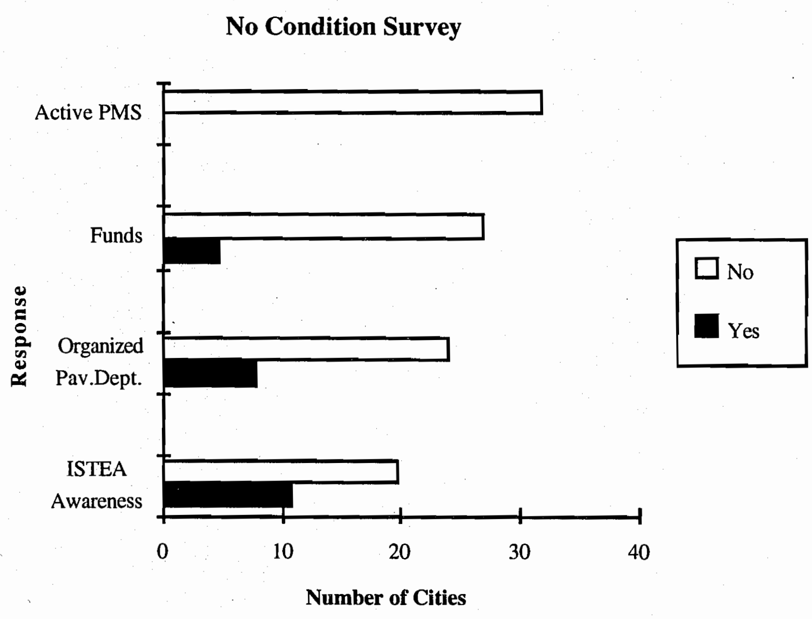


Figure 4.12 Response of interested cities not performing condition survey

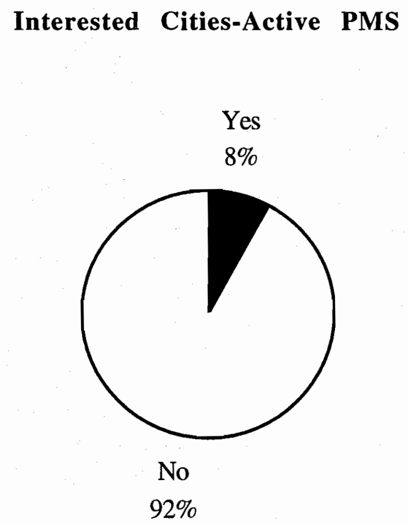


Figure 4.13 Active use of network level PMS by interested cities

TABLE 4.7 RESPONSE OF INTERESTED CITIES BASED ON THE USE OF NETWORK LEVEL PMS

QUESTIONS		Active PMS	
		Y	N
ISTEA Awareness	Y	8 (89%)	33 (33%)
	N	1 (11%)	67 (67%)
Organized Pavement Management Department	Y	4 (44%)	30 (30%)
	N	5 (56%)	70 (70%)
Budget for Implementation	Y	7 (78%)	20 (20%)
	N	2 (12%)	80 (80%)
Condition Survey	Y	7 (78%)	31 (31%)
	N	0 (0%)	32 (32%)
	NS	2 (12%)	36 (36%)

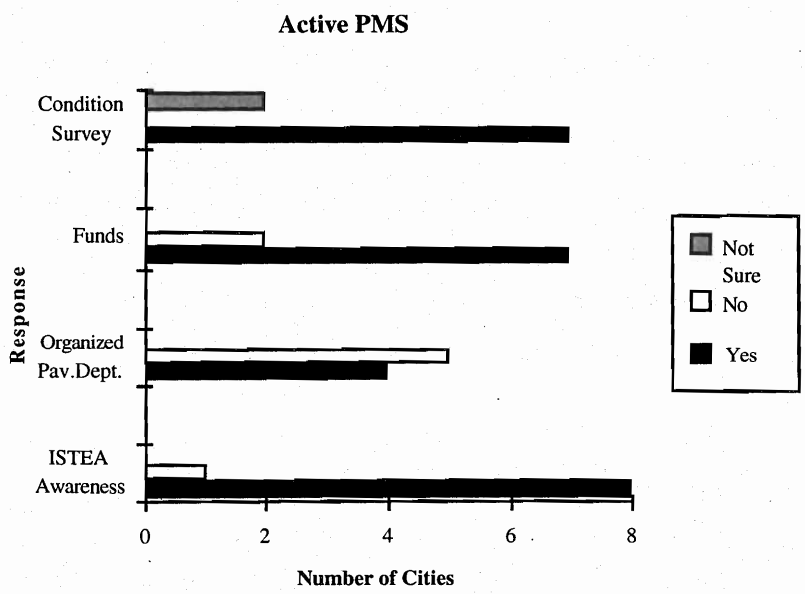


Figure 4.14 Response of interested cities actively using a PMS

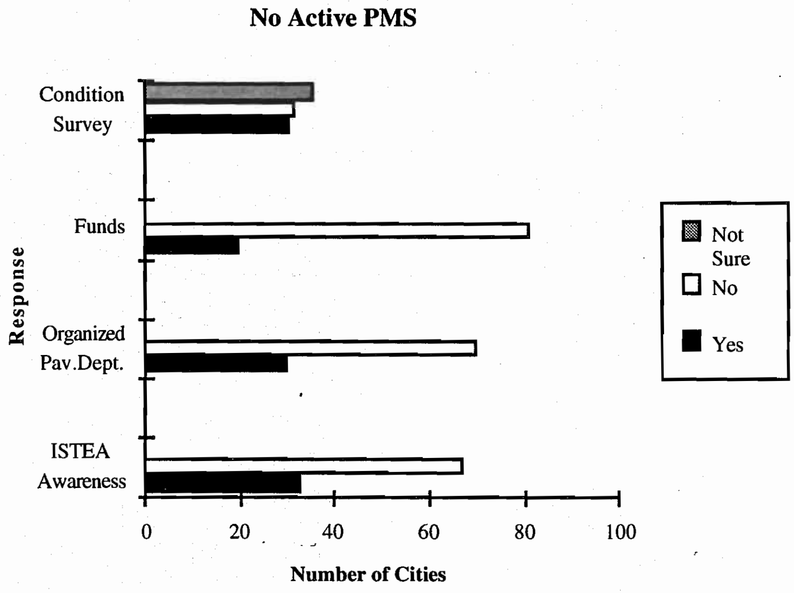


Figure 4.15 Response of interested cities not using a PMS actively

There is an obvious trend among cities which actively use a network level PMS to manage their pavements. A greater percentage is aware of the ISTEA requirement, perform condition survey, and have budget for PMS implementation. For the cities not actively using any PMS, 20% have some budget for PMS implementation, and 31% perform the condition survey on their road network. As discussed in the next chapter, cities not actively using any network level PMS and which perform condition surveys and have budget for the implementation can be good potential choices for URMS implementation. It should be noted that the percentage of cities performing condition surveys in this category can be greater because of the reasons discussed in the section of population division.

Results of Detailed Questionnaire

Analysis of results of the Texas survey (Chapter 5) led to selection of 5 top priority cities as candidate cities for URMS implementation. These 5 cities and the other 20 cities which had some budget to implement a PMS were sent a copy of URMS along with the detailed questionnaire. All 5 cities replied to the questionnaire, however, only 5 of the remaining 20 cities responded. Due to time constraints no follow-up survey was done. The replies of the 5 top priority cities were used in the final selection (Chapter 5). If the second phase of this project is funded, the 15 cities which did not reply to the detailed questionnaire will be contacted. The information obtained, for the cities which were selected for detailed study but where URMS could not be implemented in this project, can be used for any future implementation.

RESULTS OF THE US SURVEY

A postcard survey for 650 member regional councils of National Association of Regional Councils (NARC) was conducted in October, 1994. The objective was to get a broader picture of the current pavement management practices at local bodies level over the country. If the second phase of this study gets funded, the information obtained can be helpful in the implementation of URMS all over the United States.

The US survey was conducted in one stage. Post cards were mailed to all 650 member councils of NARC. Sixty five councils replied. While there was only a 10% response to the 650 questionnaires, the information from the 65 respondents provides an indication of how the 650 would have responded. Hence, this section is based on the 65 responses. At some future date it will be imperative to have a follow-up survey, but for this study the additional expense to continue the survey was not justified.

Overall Results

Table 4.8 shows the overall response to the US survey. It was observed that a large proportion of regional councils, 86%, were aware of the ISTEA 91 requirements. The questions related to current pavement management practices showed that out of the councils that replied only 17% have an organized pavement management department, 18% have a network level PMS implemented, and only 12 % are actively using any network level PMS, and 30% perform condition surveys on their road network. These figures indicate that at the time of the survey a large proportion of councils were not using a PMS in their jurisdiction despite awareness of the ISTEA requirements. Availability of funds is a crucial element for PMS implementation, and only 31% respondents have some funds budgeted to implement a PMS. Finally, 69% of the councils replied were interested in implementing URMS. Results are shown graphically in Figure 4.16.

Results Based on Interest in Implementation

Survey results by interest of regional councils in the implementation of URMS are shown in figure 4.17. Thirty one percent of the respondents showed interest in implementing URMS in their jurisdiction.

TABLE 4.8 OVERALL RESPONSE TO THE USA REGIONAL COUNCIL'S SURVEY

QUESTIONS	RESPONSE	
	Yes	No
ISTEA Awareness	56 (86%)	9 (14%)
Organized Pavement Management Department	11 (17%)	54 (83%)
Network Level PMS	12 (18%)	53 (82%)
Actively Using PMS	8 (12%)	57 (88%)
Condition Survey	19 (30%)	46 (70%)
PMS Implementation Budget	20 (31%)	45 (69%)
Interested in URMS Implementation	45 (69%)	20 (31%)

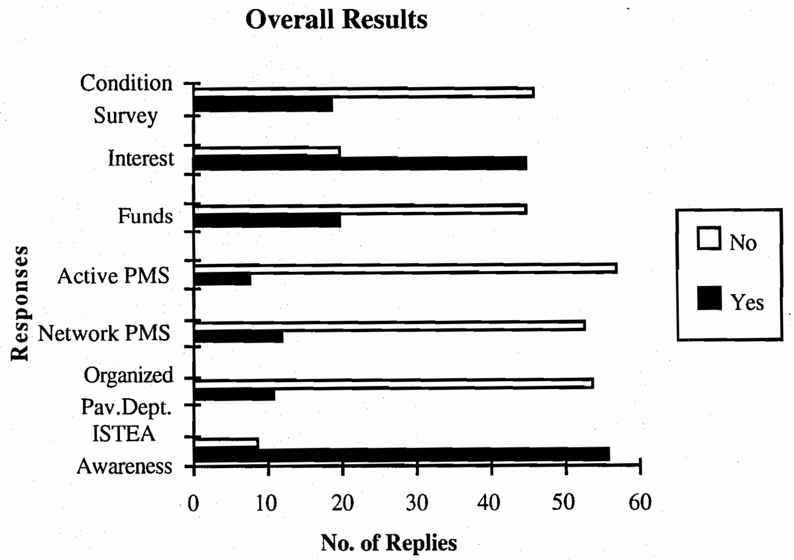


Figure 4.16 Overall response to the USA Regional Council's survey

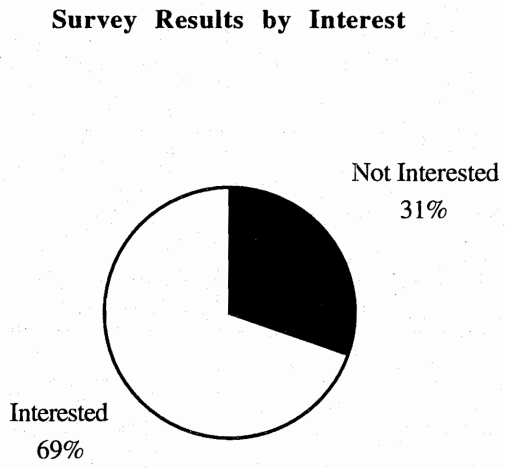


Figure 4.17 Survey results by interest of Regional Councils in implementation

Table 4.9 gives survey results for the 45 councils interested in URMS implementation and Figure 4.18 presents the similar results graphically.

Most councils interested in implementation are aware of ISTEA requirements. However, only 16% have an organized pavement management department, 13% have a network level PMS, and 9% are actively using a PMS. Twenty four percent perform condition survey on their streets, and 31% have funds budgeted for PMS implementation.

Since the scope of implementation was limited to Texas cities, no further analysis of US survey results was carried out for selection of regional councils for implementing URMS.

MICRO PAVER SURVEY RESULTS

Postcards for Micro PAVER survey were sent to 198 users, listed in the active PAVER users list provided by APWA. As shown in Table 4.10, Micro PAVER users included Department of Public Works (DPWs) of cities, consulting companies, universities, and international organizations. Forty nine users (24.75%) replied the survey. The results are given in the following two sections. Overall results are presented first, followed by responses of Departments of Public Works (DPWs). Four of the replies did not have addresses on them, and were discarded.

TABLE 4.9 RESPONSE OF REGIONAL COUNCILS INTERESTED IN IMPLEMENTATION

QUESTIONS	RESPONSE	
	Yes	No
ISTEA Awareness	39 (87%)	6 (13%)
Organized Pavement Management Department	7 (16%)	38 (84%)
Network Level PMS	6 (13%)	39 (87%)
Active PMS	4 (9%)	41 (91%)
Condition Survey	11 (24%)	34 (76%)
PMS Implementation Budget	14 (31%)	31 (69%)

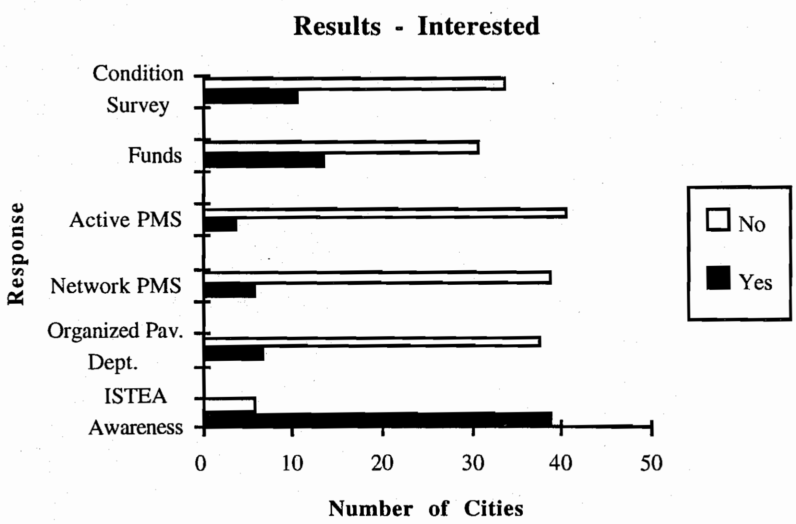


Figure 4.18 Response of Regional Councils interested in implementation

TABLE 4.10 ACTIVE MICRO PAVER USERS

Micro PAVER Users	Mail Out	Replied
DPW	154	36
Consulting Co.	31	4
Universities	5	2
International Organization	8	3

Overall Results

Among the 49 respondents to this survey, 69% had an organized pavement management department, 84% performed condition survey on road network, and 67% were active Micro PAVER users. About 90% were interested in examining the URMS. The results are shown in Table 4.11 and graphically represented in Figure 4.19.

TABLE 4.11 OVERALL RESULTS OF MICRO PAVER SURVEY

QUESTIONS	RESPONSE	
	Yes	No
Organized pavement management dept.	34 (69.4%)	15 (30.6%)
Perform condition survey	41 (83.7%)	8 (16.3%)
Active Micro PAVER user	33 (67.3%)	16 (32.7%)
Interested in examining URMS	44 (89.8%)	5 (10.2%)

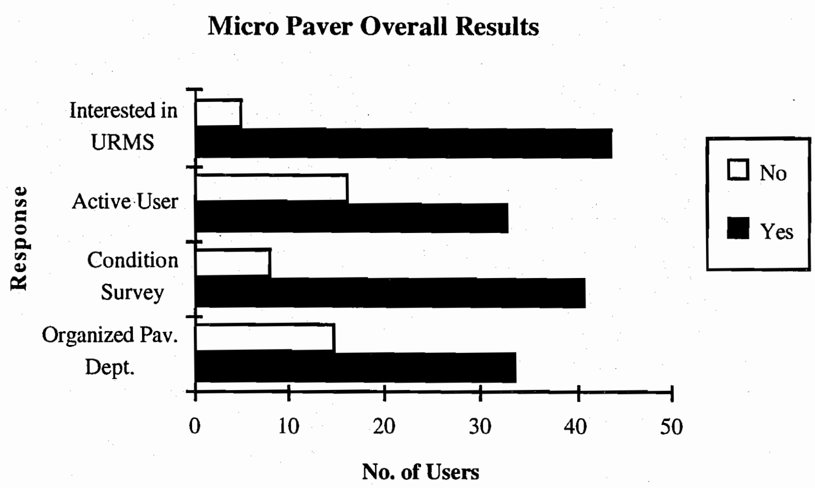


Figure 4.19 Overall results of Micro PAVER survey

Results Based on DPW's Replies

Out of 154 DPWs contacted, 36 (23.4%) replied to the survey. Among these, 69% had an organized pavement management department, 86% performed condition survey on road network, and 64% were active Micro PAVER users. About 86% were interested in examining URMS. The results are graphically represented in Table 4.12 and Figure 4.20.

TABLE 4.12 RESPONSE OF DPWS TO MICRO PAVER SURVEY

SURVEY QUESTIONS	RESPONSE	
	Yes	No
Organized pavement management dept.	25 (69.4%)	11 (30.6%)
Perform condition survey	31 (86.1%)	5 (13.9%)
Active Micro PAVER user	23 (63.9%)	13 (36.1%)
Interested in examining URMS	31 (86.1%)	5 (13.9%)

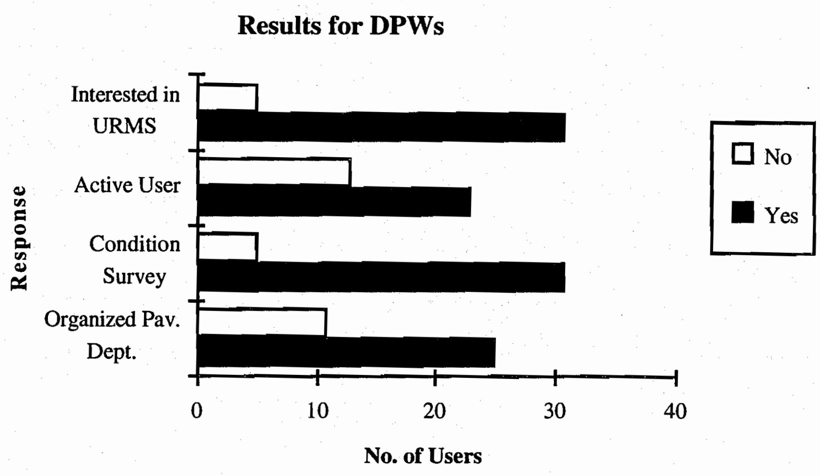


Figure 4.20 Micro PAVER survey results for DPWs

Results for DPW replies were further analyzed with respect to two descriptive questions: 1) the most useful aspect of Micro PAVER and 2) the most crucial problem while using PAVER.

Most Useful Aspect of Micro PAVER. The respondents were asked to state the most useful aspect of Micro PAVER in the survey postcards. A variety of responses were received due to the open nature of the question. The replies were sorted and grouped in to general response descriptions given in Table 4.13.

Since the question was very general, no accurate inferences can be established. However about only half (19) of the respondents did reply to this question, which apparently indicated the difficulty faced by the respondents to identify a useful aspect of the Micro. The most frequent reported aspect however was the capability of determining the PCI value for the road section.

Most Crucial Problem While Using Micro PAVER. In the survey, postcard respondents were also asked to mention the most crucial problem they encountered while using Micro PAVER. The replies were sorted and grouped in a general response descriptions as given in Table 4.14.

TABLE 4.13 MOST USEFUL ASPECT OF MICRO PAVER

DESCRIPTION	NO.OF RESPONSES
PCI, pavement condition based on objective data	9
Network level budget management	3
Road inventory data	3
Selection of maintenance & rehabilitation strategies	2
Widely practiced software	2

TABLE 4.14 MOST CRUCIAL PROBLEM WHILE USING MICRO PAVER

DESCRIPTION	NO.OF RESPONSES
Cumbersome, slow, and complex	8
Deficient reporting features	6
Difficulties in field data collection and updating	8
PCI not compatible to actual road condition	2
Difficulties in using costing and budgeting features	2

Twenty four out of 36 respondents replied to this question. Most frequently encountered problems to the PAVER users are: complexity of the system, difficulties in data collection and updating, and useful reports. The complexity of PAVER was reported in terms of extensive input data requirement and non user friendliness. The laborious field data requirements also indicates system complexity. The deficient report generating options and the non flexibility was also mentioned by the users.

Conclusions of Micro PAVER Survey

The post cards for Micro PAVER survey were sent to the "active PAVER users", as listed by APWA. However, 33% of the respondents were not actively using PAVER due to problems faced while implementing the system. For DPWs the non-user percentage is 36%.

Many active users have pointed out problems associated with the general complexity and non-user-friendliness of Micro PAVER. Deficient report generating capabilities, extensive data requirements, and practical problems in collection of data required were also criticized by the users. A large number of active users have identified the determining of Pavement Condition Index as the most useful aspect of the Micro PAVER. However some users questioned the reliability of the PCI generated by PAVER.

It was observed that URMS has most capabilities identified by the users to be lacking in Micro PAVER. It is simple, flexible and user-friendly. It generates a variety of reliable reports and charts, as needed by the DPW for planning and reporting purposes. Most cities already collect the minimum data required to implement URMS, and hence the system can be easily implemented in small to medium size cities.

CHAPTER 5. SELECTION OF CITIES FOR IMPLEMENTATION

Results of the Texas survey were used to come up with the cities for the implementation of URMS. Considering together the two stages in which the Texas Survey was administered, 131 out of 238 cities responded to the survey. This gives us an overall response rate of 55%. However, 32 postcards (24.4%) came back with no name, address, or telephone number on them, and had to be discarded from the analysis to select cities for implementation. Hence, 99 cities were considered and this amounts to 41.5% of the total 238 cities.

PARAMETERS FOR THE SELECTION OF CITIES

Replies to the Texas survey are analyzed considering the following parameters:

i) Interest in URMS Implementation (the cities are divided into two categories):

a) those which are interested in URMS implementation, and

b) those which are not interested in URMS implementation.

Out of 99 cities considered, 88 are interested in implementation. The 11 cities not interested in implementation, are not considered further in the analysis.

ii) Population of Cities (the cities are divided into three categories):

a) population 1: Large cities with population over 250, 000,

b) population 2: Medium cities with population between 50,000 and 250,000, and

c) population 3: Small cities with population under 50,000.

iii) Availability of Funds for the Implementation (the cities are divided into three categories):

a) funds > $ 5000,

b) funds < $ 5000, and

c) no funds.

iv) Condition Survey (the cities are divided into two categories):

a) those which perform condition surveys, and

b) those which do not perform condition surveys.

v) Pavement Management System (PMS) (the cities are divided into two categories):

a) those which are actively using a PMS, and

b) those which are not actively using a PMS.

Postcards designed for the first stage survey did not have any question asking cities about performing condition surveys. Hence there were 54 cities in all, and 54 cities considered for analysis, which did not have data regarding condition surveys. It was decided that data should be complete for all the cities interested in the URMS implementation and which had some budget for PMS implementation. Hence, the 17 cities which fell in this category and had no condition survey data were contacted by telephone and data regarding any condition surveys was collected.

A closer look at the cities with population between 50,000 and 250,000 revealed that Longview, a city with no budget to implement a PMS, having no active network level PMS, and which performs condition surveys, can be a potential implementation city because of its existing street data base. To save our analysis from any bias, it was necessary to gather the condition survey information for the other 5 cities which fell in the same category as Longview. These cities were contacted on the telephone and the information was collected. Hence, we have complete knowledge on condition survey for all cities with some budget for URMS implementation, and for all cities falling in population category 2, i.e., cities with population between 50,000 to 250,000. This leaves us with 32, cities for which we do not have the condition survey information. All of these cities do not have budget to implement a PMS. Two cities have population more than 250,000 (large cities), whereas, 30 cities have population less than 50,000 (small cities). It was observed that URMS cannot be implemented in large cities because of the limitation of the number of street sections which can be managed by the program. Also, cities with no budget to implement a PMS should have a low priority for implementation selection. Since we already have enough small cities with some funds budgeted, we did not collect the condition survey information for the above mentioned 30 cities which do not have budget for implementation.

FACTORIAL APPROACH FOR PRIORITIZATION

A factorial approach was utilized to come up with candidate cities for URMS implementation. Considering the above parameters, a matrix of 5x7 was generated providing 42 subgroups. Figure 5.1 shows the matrix along with the number of cities falling in each cell.

The prioritization criteria utilizes a broader perspective at the initial stage by eliminating the least priority cells from the matrix of Figure 5.1. First the 21 cells associated with the large cities (9 cities), where URMS can not be implemented due to limitation of manageable sections, are eliminated. This leaves the cells for medium and small cities. Among these, 3 cells associated with cities which have no funds budgeted to implement URMS, and perform no condition surveys (18 cities) are eliminated. The 3 cells associated with cities which do not have funds budgeted to implement URMS, and have no condition surveys information (30 cities) are eliminated next. The remaining 3 cells associated with medium and small cities which do not have any funds (14 cities) are low on the priority list. Cities in the remaining cells have some funds budgeted to implement a PMS. Among these, the cells associated with the cities which do not perform condition survey have a lower priority. Furthermore, all cities which are actively using a PMS are given a lower priority.

Based on the criteria in Figure 5.1, the following priorities were assigned

PRIORITY 1: The 2 cells associated with small and medium population cities, which have more than $5000 budgeted to implement a PMS, which perform condition surveys, and which are not actively using any PMS.

PRIORITY 2: The 2 cells associated with small and medium population cities which have less than $5000 budgeted to implement a PMS, which perform condition surveys, and which are not actively using any PMS.

PRIORITY 3: The 2 cells associated with small and medium population cities which have less than $5000 budgeted to implement a PMS, which do not perform condition surveys, and which are not actively using a PMS. The 2 cells associated with small and medium population cities, which do not have funds budgeted to implement a PMS, but which perform condition surveys and are not actively using any PMS are given the same priority.

SELECTION OF CANDIDATE CITIES FOR IMPLEMENTATION

From priority 1, 2, and 3 cells, the 5 top priority candidate cities were selected. A meeting with these cities was held at the University of Texas at Austin on January 12, 1995, to come up with the city for assisted implementation. The remaining 4 cities and all the other cities which were provided with the URMS package, and which showed enough interest in implementation, were offered assitance via telephone.

Population	Active P M S	Budget > 6000		Budget < 6000		No Budget		
		Y	N	Y	N	Y	N	N S
> 250,000	Y	1						
	N	3						2
50,000-250,000	Y	2		1				
	N					7	6	
< 50,000	Y	1		1				
	N	1		9	5	7	12	30

Division / Condition Survey / Active P M S / Population

Priority 1
Priority 2
Priority 3

Figure 5.1 Factorial approach for prioritization

The selection of 5 top priority cities was based upon:

1) the priority cell each city fell in,
2) number of candidate cities to be selected from each population subdivision,
3) the distance of the selected city from Austin, and
4) interest of city in URMS implementation.

The medium and small cities subdivisions are discussed separately, and each city mentioned is given a number in parenthesis so as to recognize it on the figures. Some of the cities were contacted via telephone to get information which was not clear in the postcard reply.

Medium Cities

It was decided to select at least one city falling in this category as a candidate implementation city Figure 5.1 shows that there was no city with medium population falling in priority 1 or 2 cells. However, there are seven such cities which fall in priority 3 cell. These are: Odessa (1), Lewisville (2), Mesquite (3), Longview (4), Plano (5), Garland (6), and Port Arthur (7). These cities are not using any network level PMS, perform condition survey, but do not have funds budgeted to implement a PMS. Figure 5.2 shows the location of these cities on the map of Texas. Considering the distance from Austin and the amount of data it collects, Port Arthur (7) and Longview (4) become potential choices. Longview (4) has an in-house system which is used primarily to develop a list of streets for preventive maintenance, such as chip seal and micro seal, and rehabilitation. The data they collect can be imported to URMS through ASCII files. Longview (4) was selected as candidate city in this category.

Small Cities

Four cities were selected to implement the URMS in this category. In all there were 22 cities with small population which fell on the priority cells. Figure 5.3 shows these cities, with different shades showing the priority cells in which they fall. Southlake (8) is the only city with priority 1, and hence is a candidate city for the implementation.

Twelve Cities fell in the priority 3 cells. As there were enough small cities which had budget to implement a PMS and also performed condition surveys, the cities in priority cell 3 which performed condition surveys but had no budget to implement a PMS were eliminated. These included Dalhart, Plainview, New Brauntels, Pans, South Houston, Fredricksburg, and

Balch Spring. The remaining 5 cities in this priority order had funds (less than $5000) to implement a PMS, but do not perform condition surveys. These include Terrel (9), Cedar-Park (10), Mercedes (11), San Juan (12), and Vidor (13). Cedar Park (10) was selected as a candidate city for implementation because firstly it is very close to Austin and secondly with the funds it had, it might be able to collect the minimum data required.

Nine cities fall in priority 2 cells. These are: Big Spring (14), Del Rio (15), Lampasas (16), Palestine (17), Azle (18), Hurst (19), Rosenburg (20), Weatherford (21), and Benbrook (22). Lampasas (16) is close to Austin, collected most of the basic street data, and was selected as a candidate city. Palestine (17) has some budget for pavement maintenance, but they were not sure about the amount they could spend on URMS implementation. Del Rio (15) and Rosenburg (20) do not collect most of the basic data required by URMS, perform only visual street maintenance inspection, and do not have any organized data base. Hence, Palestine, Del Rio, and Rosenburg are neglected. Azle (18), Hurst (19), Weatherford(21), and Benbrook (22) fall in the Fort Worth area. Southlake (8) was selected for detailed analysis in this area. Selection of one more city in this area can give a good comparison among cities in one county for the assisted implementation. Weatherford (21) and Hurst (19) have some sort of PMS, which they are using partially (not actively). Furthermore, Hurst (19) is in the same county as the selected Southlake (8), and Weather ford (21) has a very small budget as compared to others (less than $1000). Hence they are neglected. Out of Azle (18) and Benbrooks (22), Azle (18) was selected as a candidate city because of the enthusiasm they showed in URMS implementation.

Hence Longview (4), Southlake (8), Cedar Park (10), Lampasas (16), and Azle (18) were selected as the candidate cities for the implementation of URMS. Figure 5.4 shows these cities on the map of Texas.

DISTRIBUTION OF URMS PACKAGE

The URMS package was distributed to 25 cities in Texas on December 12, 1994. The package included URMS software, URMS user's manual, a detailed questionnaire, and a cover letter by Dr. W. R. Hudson. The 5 top priority cities and

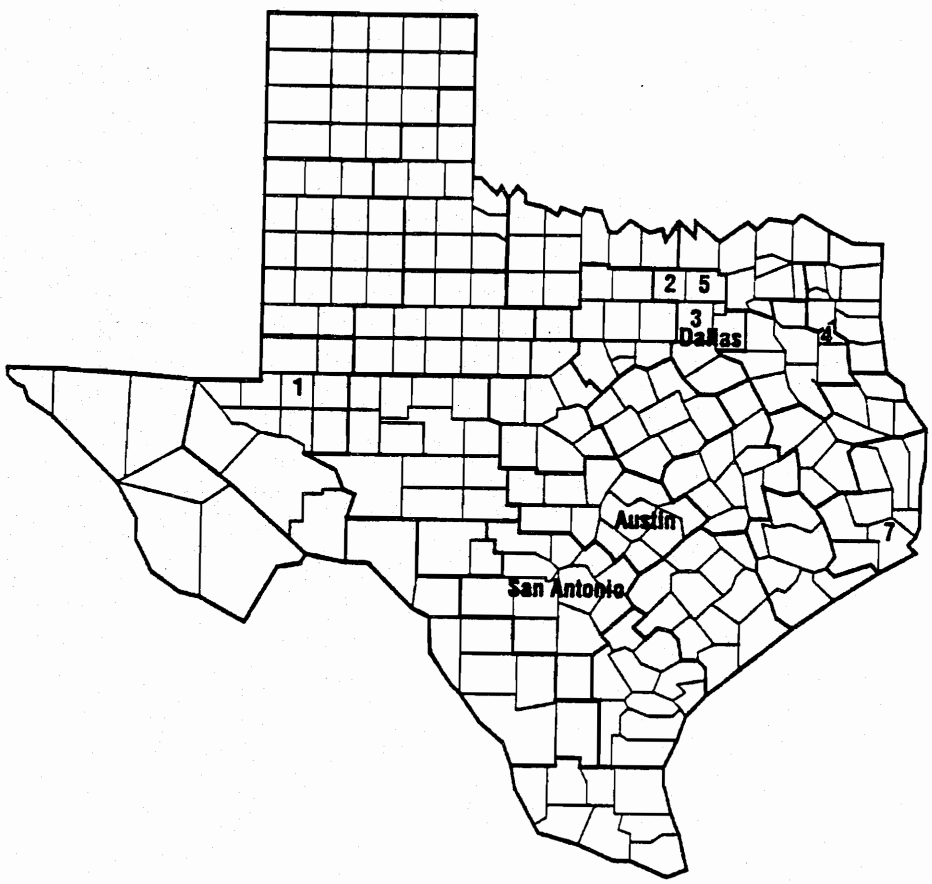


Figure 5.2 Medium sized cities falling in priority cell 3

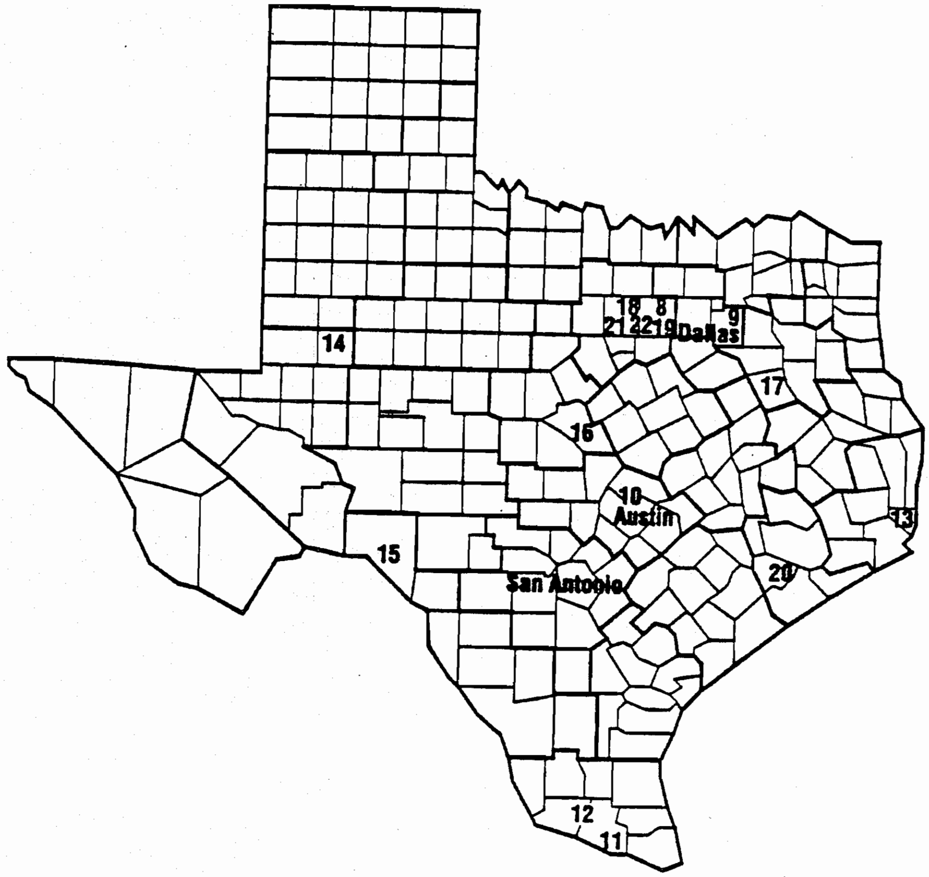


Figure 5.3 Small sized cities falling in priority cells 1, 2, and 3

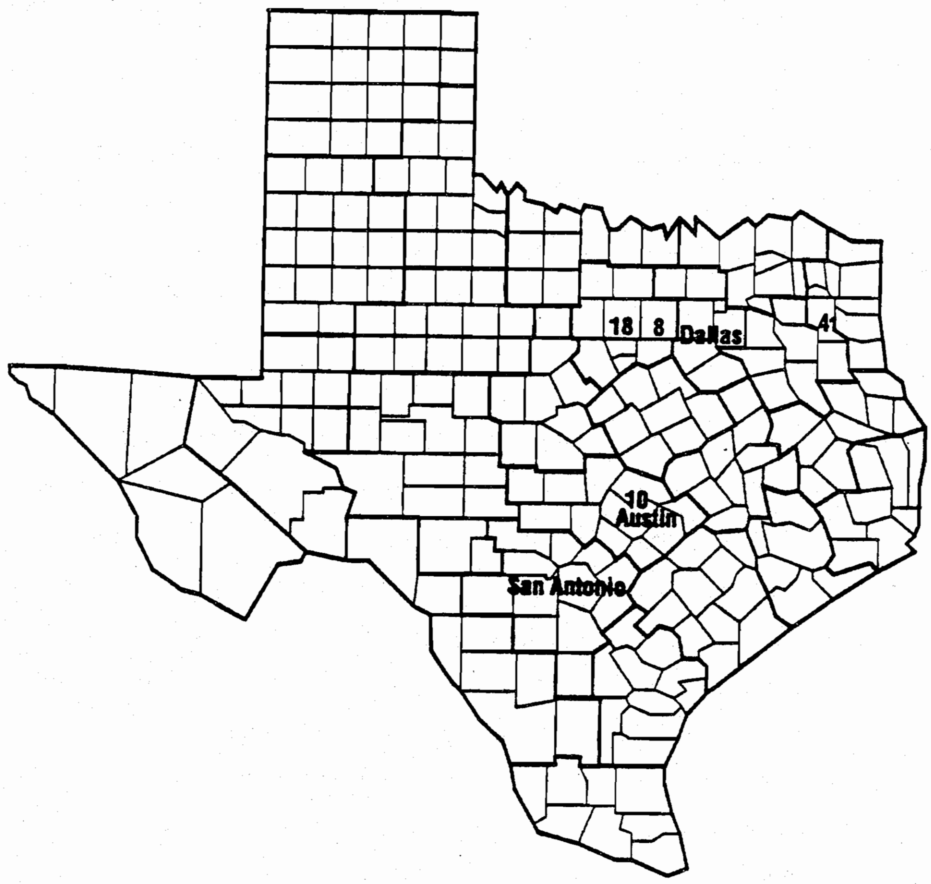


Figure 5.4 Five top priority cities

20 other cities, which were interested in implementation and had funds budgeted for the implementation process, were the 25 cities. Time and funds constraints limited the assisted implementation in only one city. However, all the other cities were offered full help via telephone. The detailed questionnaire (Appendix A) was included so as to get useful information about current pavement management practice of these cities, and to get in depth knowledge of the data collected by them for their street maintenance. This information was used to select the final city for the assisted implementation. Knowledge gained from the overall replies of detailed questionnaire can also be useful to select more cities for assisted URMS implementation in the future.

SELECTION OF TERRELL FOR IMPLEMENTATION VIA TELEPHONE

The City of Terrel was included in the 24 cities which received the URMS package, however, it was not one of the 5 top priority cities. The City showed immense interest in URMS implementation. It was decided to assist Terrel via telephone because of this interest and their resources.

SELECTION OF THE CITY FOR ASSISTED IMPLEMENTATION

A meeting with 5 top priority cities was scheduled for January, 12 1995, at The University of Texas at Austin. The purpose of the meeting was to select one city for assisted implementation and to provide all the cities with an implementation training session. The city of Terrell was also invited to attend the meeting. The agenda for the meeting is attached in Appendix C. The staff of City of Longview got tied up with urgent nature work at that time and requested not to be included in the implementation process. All other cities attended the meeting.

In the meeting Dr. W. R Hudson gave the background of pavement management systems to the representatives of cities . Dr. Xin Chen talked about the development of URMS. Farrukh Sohail presented a demonstration of URMS and discussed the implementation project. This was followed by a brief presentation from representative of each city to explain the current pavement management practice in his/her city. Finally, after a group discussion, the meeting was adjourned.

Criteria for Selection

Based on the discussion in meeting and the replies of detailed questionnaire, following criteria was established to select the city for the assisted implementation of URMS.

i) Basic Data for URMS. The basic data required for the network level pavement management in URMS include street code, street name, street location, pavement type, section length, pavement width, number of traffic lanes, construction year or subgrade, average daily traffic, percentage growth rate, truck percentage, and pavement condition index. The data can be entered manually, or can be transferred from an existing data base.

ii) Street Map Data. The street map can be created by inputting the starting and ending x-y coordinates of road sections, or it can be transferred from an existing street map data base.

iii) Distress Data. The pavement condition index value for URMS can either be entered manually as a rough estimate for each section, or it can be calculated from the distress data. The distress data include the severity; low, medium, or high, and density of different distresses specified by the user. If a city wants the URMS to calculate the pavement condition index, it is required to obtain the data for severity and density of different distresses it want to specify for its pavements.

iv) Number of Roadway Sections or Total Miles of Network. Preference was given to cities which had a manageable road network under the constraints of time and funds.

v) Distance from Austin. How far a city is from Austin, was one of the deciding factors to set the frequency of trips we can make to that city during the implementation process.

vi) Technical Support. Technical support is essential to collect all the data required for URMS, to transfer the data in to URMS data base, to implement the system in a city, and to continue using URMS after the implementation.

All the four candidate cities were weighted in the light of the selection criteria discussed above.

South Lake. South Lake collects all the basic data required for URMS, but does not have a computerized data base. Their street network is on Auto-Cadd. The city does not have organized distress data or a data base. South Lake is located in Tarrant county near Fort Worth, and has 300 miles of roadway. The city lacks technical support at this time, but has enough funds and determination to organize data and carry out the implementation.

Azle. Azle collects most of the data required for URMS. Their street network is on Auto-Cadd and they do not have a data base for the distress data of their road network. Azle is located in the Parker county near the FortWorth city, and has 240 miles of roadway included in their network. The city lacks the technical support and funds to implement URMS at this stage.

Cedar Park. Cedar Park collects most of the basic data, except for the construction year and average daily traffic (ADT). The city is in the process of developing a computerized data base for the data they collect on their roads. Their street map is on Auto-Cadd. At present, the city does not have any distress data information for their road network. Cedar Park is located in the William count very near to Austin, and has 190 miles of roadway included in their network. The city lacks the technical support and funds to implement URMS at this stage.

Lampasas. Lampasas collect all the data, but ADT, required for the URMS. The city is currently working on their road data base, which should be complete by the end of January, 1995. The street map for the city is present on Auto-Cadd and Map-Info (GIS) formats. The city performs the visual inspection on their street network and rates the roads on the scale of 1-10, 1 being poor and 10 being excellent. Lampasas is in Lampasas county, and is located near Austin. 58 miles of roadway is included in their street network. The city has got sufficient technical support and funds at this time to implement URMS.

Based on the above discussion, Lampasas was selected as the city for the assisted implementation. All the other cities were offered help via telephone for the implementation of URMS.

CHAPTER 6. IMPLEMENTATION OF URMS

We decided to carry out the implementation of URMS at two levels. At the first level, the city of Lampasas was directly assisted and the project staff worked closely with the city on the implementation. At the second level, the city of Terrell, and all the other cities which showed enough interest in the implementation of URMS, were assisted in the implementation via telephone.

STRATEGY FOR THE IMPLEMENTATION

Factors which contribute to successful implementation of a PMS include reliable data, realistic models for processing the data, and user-friendly software for organizing the inputs and presenting the outputs. Adopting simple and consistent PMS practices in the initial phase of PMS implementation is recommended for medium to small sized urban pavement networks where a complex system is not justified [9].

URMS provides a simple, user friendly, and flexible PMS with realistic models for processing the data for small to medium sized cities. In implementation process, every effort was made to obtain reliable data for the streets considered. The process involved the following stages:

1) training of the cities' personnel in implementation,
2) helping the cities to collect and organize the data required,
3) helping the cities to determine the model parameters of URMS,
4) converting the data obtained by cities to the URMS format, and
5) running the software and getting the outputs, in the form of reports, identifying and selecting the M&R projects for the cities.

Training

In the technology transfer meeting discussed in Chapter 5, the top five priority cities were given a demonstration about use of URMS at the network and project levels. The URMS User's Guide [3] was also distributed among the cities. In the "group discussion" session of the meeting, all the questions asked by cities' representatives were answered by URMS implementation staff. The meeting provided a training session for representatives of cities in the implementation of URMS.

IMPLEMENTATION IN THE CITY OF LAMPASAS

Lampasas is a small city in central Texas with an area of about 5.4 square miles. The 1990 census indicated a population of 6,382. The Department of Public Works (DPW) is responsible for maintenance of 68 miles of pavements in the city limits, out of which 85% are flexible and remaining 15% are unpaved. The principal distress experienced in Lampasas is alligator cracking. The major M&R strategy is routine maintenance, consisting of patching pot holes, level up, and drainage work. The amount of paving is very limited, approximately 2 miles per year. The poor current condition of the streets are due to poor sub base, poor drainage, lack of curb and gutters, and poor maintenance schedules.

In 1992 Lampasas acquired a PMS, Pavement Rehabilitation and Maintenance System (PARMMS), which offered a possible solution to the city's planning needs. However, the DPW found the program to be difficult to understand and operate. The city could not use the PMS to its full potential because of the difficulties encountered during the data entry and changing basic values and measurements. The city was also not satisfied with the street maintenance schedule produced by the PMS. The DPW hence decided not to use PARMS for management of its road network.

Data Preparation

The road network of Lampasas is divided into 428 sections, of which 407 sections are paved, and are included in the evaluation module of URMS. The city collects all the basic data, but ADT, required by URMS. The data collected includes section code, street name, location from, location to, pavement type, section length, pavement width, number of lanes, construction year, traffic growth rate, truck percentage, and the condition index for streets. The ADT was divided into three levels: light, medium, and heavy, and was estimated by the city staff for all streets in the network. The city performs a visual inspection on their street network and rates roads on the scale of 1 to 10, 1 being poor and 10 being excellent. All the condition ratings for streets were multiplied by a factor of 10 to be used in URMS.

For the implementation project, a data base for basic data was prepared in Excel format by the city for all 428 sections. The data base was transferred from Excel file to URMS format using the ASCII file format in the import data module of URMS. Lampasas has GIS and Auto Cadd installed for their street map. However, this map is for the whole county and when imported to URMS format, was lacking the street names. Hence, street map data for URMS were manually entered, using starting and ending xy coordinates for the streets, instead of importing from GIS or Auto Cadd file.

Figure 6.1 presents the main screen of the data base module with data from the city of Lampasas. The street map shows the 428 sections stored in the data base.

Determination of Model Parameters

Figure 6.2 presents the levels and their limiting values for different evaluation indices used by Lampasas.

The city used pavement age, instead of soil type as an evaluation index for pavements. For the condition index model, the manual input was selected over the calculation of condition index using the distress data. The PCI and AGE are divided into five levels, while the ADT is divided into three levels.

The major M&R strategies utilized in Lampasas include routine maintenance, crack and fog seal, seal coat over, seal coat, 2 course, and hot mix. The city wanted to approximate M&R programs for the next five years and has provided with their M&R budget from 1995 to 1999. It is anticipated that the DPW will get $250,000 per year to carry on the M&R program for the next five years. The description and average unit costs of the M&R treatments are listed in Table 6.1. Since all work is performed by the city staff, the cost of labor is not included in M&R budget.

TABLE 6.1 M&R STRATEGIES DEFINED FOR THE CITY OF LAMPASAS

No.	M&R Strategy	Description	Unit Cost
0	Do Nothing		$0.00/SY
1	Routine Maintenance	Patch potholes, level up work, vegetation control, reshape ditches for better flow.	$2.15/SY
2	Crack Seal	Latex emulsion is applied to seal cracks	$3.52/SY
3	Seal Coat	ReReplace base and surface with one coat of emulsion and one coat of rock.	$1.65/SY
4	Seal Coat Over	One coat of rock and emulsion over existing road surface.	$0.30/SY
5	2 Course	Replace base and surface with two coats of rock and two coats of emulsion	$2.60/SY
6	Hot Mix	Replace base and surface with hotmix asphaltic concrete.	$9.00/SY

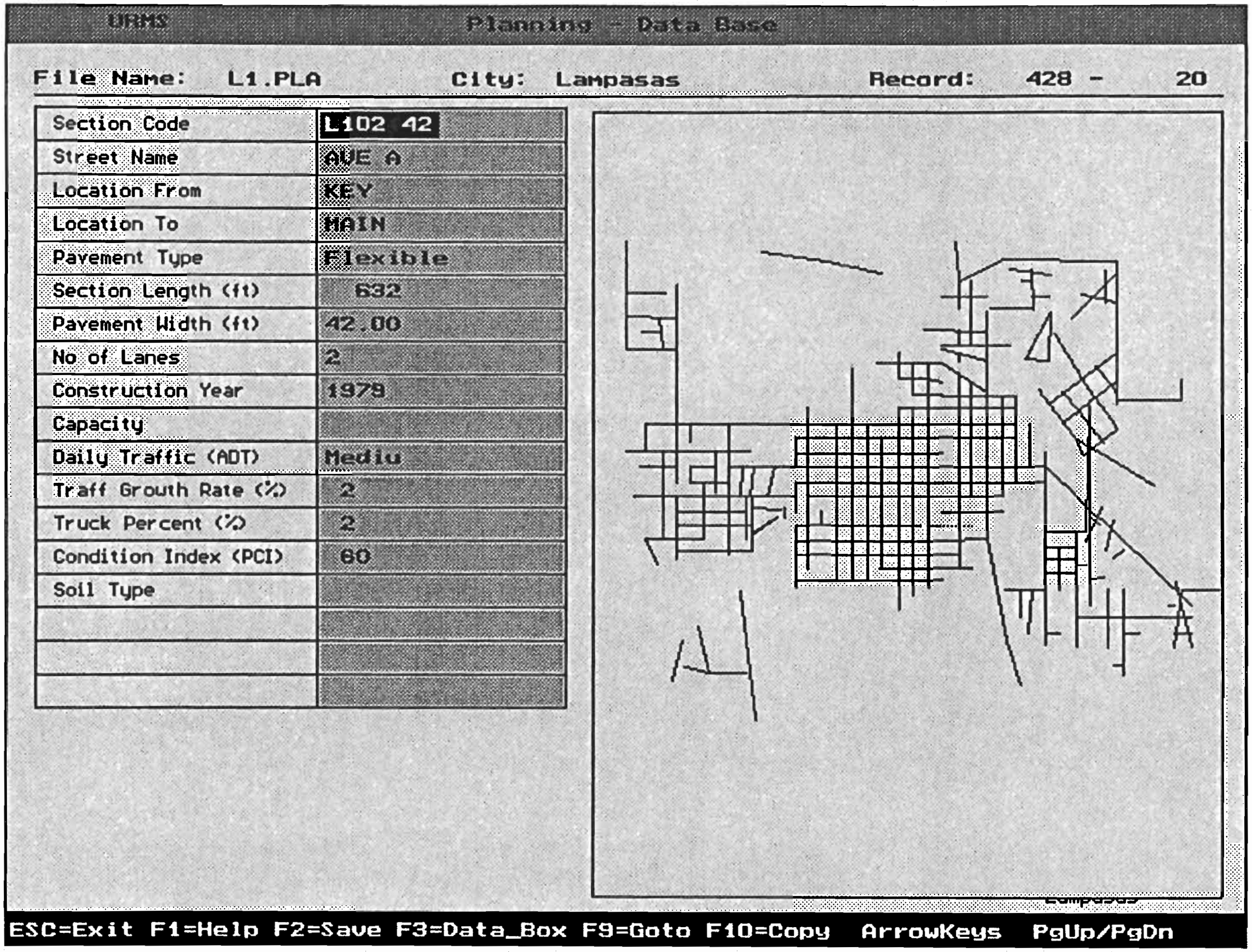


Figure 6.1 Data base main screen for the city of Lampasas

URMS Planning - Edit Model

Page 7-3 Evaluation Criteria

PROGRAM YEAR 1995

Pavement Condition Index (PCI)

	1 Bad	2 Poor	3 Fair	4 Good	5 Excell
PCI	< 25	25 - 45	45 65	65 85	>= 85

Pavement Age (AGE)

	1 V. Old	2 Old	3 Average	4 New	5 V.New
Flexible	> 20	20 - 15	15 10	10 5	<= 5
Rigid	> 40	40 - 30	30 20	20 10	<= 10

Traffic Classification

ADT(x1000)	1 V.Heavy	2 Heavy	3 Medium	4 Light	5 V.Light
1. Mixed	> 2.0	2.0 - 1.3	1.3 0.5	0.5 0.3	<= 0.3
2. Truck	> 0.4	0.4 - 0.3	0.3 0.2	0.2 0.1	<= 0.1
Volumn/Capacity	1.00	(V/C) Ratio for pavement widening			

ESC=Exit F2=Save PgUp/PgDn

Figure 6.2 Evaluation indices for the city of Lampasas

In constructing the decision tree for assigning an M&R strategy to each section, pavement condition is considered to be the main factor. Figure 6.3 shows the M&R assignment model built for the city of Lampasas. Since only three levels of ADT are defined, the code of "1" and "5" are not used in model for ADT.

Figure 6.4 shows the priority index model for Lampasas. The PCI and ADT are considered to be more important than AGE and street functional class respectively in constructing the priority index model. For example, a section with AGE code of 2 (old) and level 1 PCI (bad) has a higher priority (smaller PIX) than that with level 2 PCI (poor) and AGE code of 1 (very old).

Outputs of Implementation

Of 428 sections included in the data base, 407 are paved and were evaluated as of May, 1995. After all data was entered in the data base, the evaluation and M&R modules were run. Outputs of the pavement evaluation and M&R program for the 407 sections considered are shown in Figures 6.5 through 6.8. Figure 6.5 is one of the summary printouts which lists pavement evaluation results. Figure 6.6 presents another printout listing the M&R program summary for both M&R needs and recommended M&R projects for the next five years. Figure 6.7 is one of the screens showing evaluation results in pie charts. Figure 6.8 shows the pie chart of recommended M&R projects for next five years in terms of length.

It can be seen from Figure 6.6 that of all the 407 sections considered, 80 require routine maintenance, 126 require crack and fog seal, 30 require seal coat over, 9 require seal coat, 113 require 2 course, and 9 require hot mix. The total budget needed to fulfill these requirements is $2,167,300. For the $1,250,000 budget allocated from 1995 to 1999, 80 sections for routine maintenance, 17 sections for crack and fog seal, 4 sections for seal coat over, 2 sections for seal coat, 102 sections for 2 course, and 9 sections for hot mix are recommended by the program. Appendix D gives a listing of typical input and output data for the city of Lampasas.

IMPLEMENTATION IN THE CITY OF TERRELL

Terrell is a small city near Fort Worth in north Texas. The 1990 census indicated a population of 12,490 people. The area of the city is about 20 square miles. The city has approximately 80 center line miles of pavements with the following breakdown:

Flexible	60 miles (75%)
Rigid	8 miles (10%)
Unsurfaced	12 miles (15%)

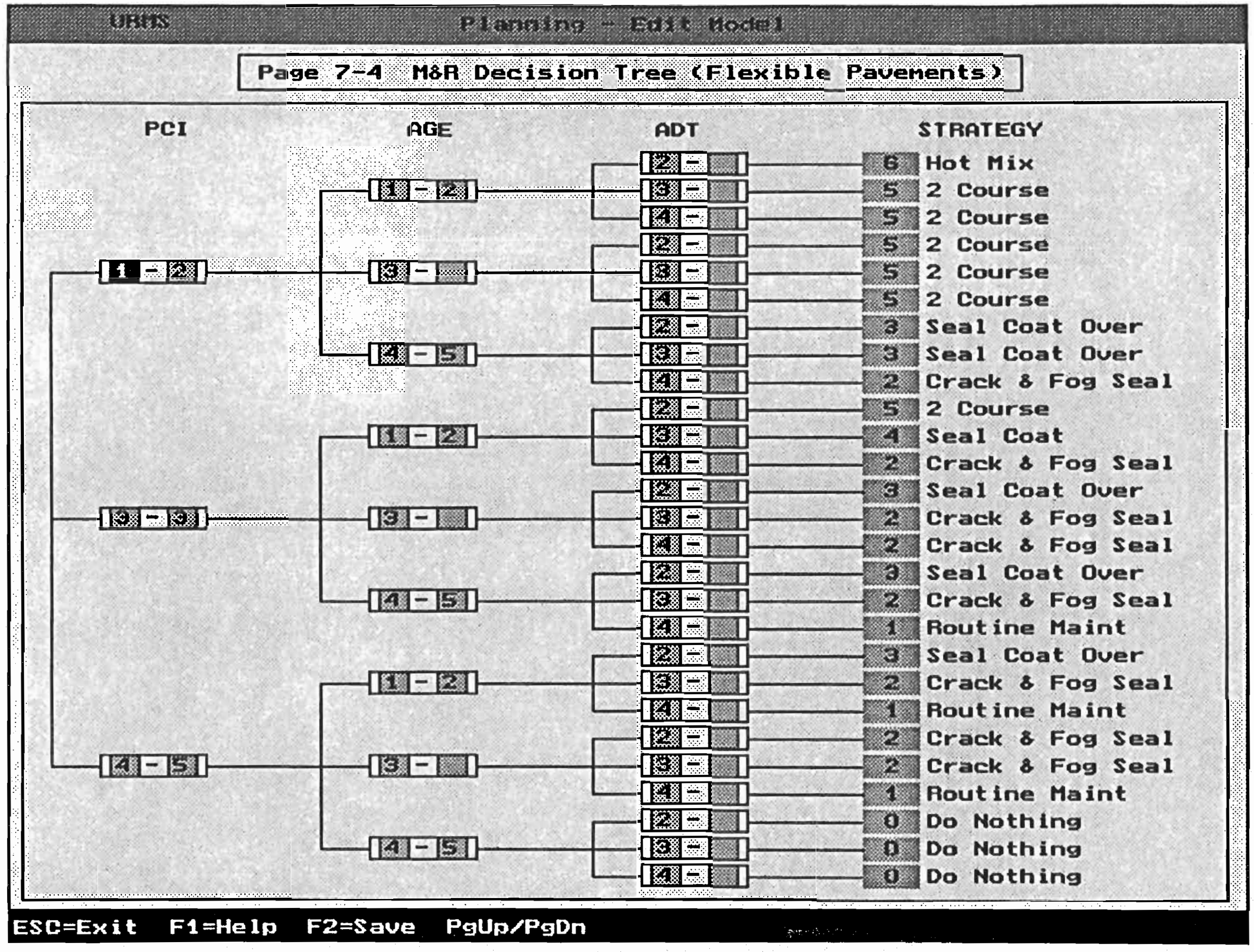


Figure 6.3 M&R assignment model for the city of Lampasas

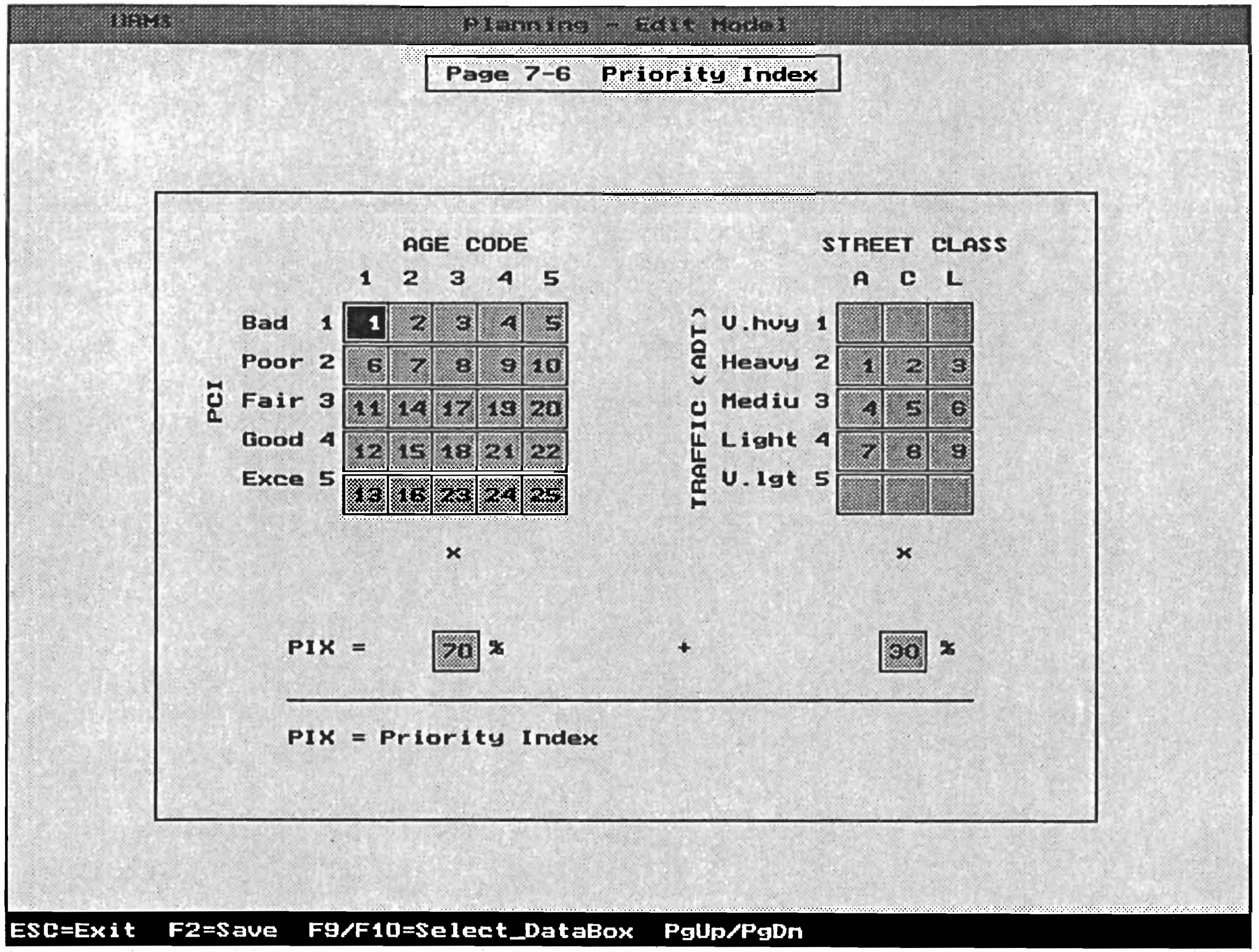


Figure 6.4 Priority index model for the city of Lampasas

SUMMARY OF PAVEMENT CONDITION AND TRAFFIC EVALUATION (1995)

Input File: L1.PLA Report Date: 3-20-1995

CONDITION CODE	DESCRIPTION	LIMITING VALUE	SECTION NUMBER	%	LENGTH MILES	%	AREA 1000 SY	%
* PCI								
1	Bad	<= 25	77	18.9	8.5	19.8	180.4	19.7
2	Poor	25 - 45	63	15.4	7.5	17.4	144.1	15.7
3	Fair	45 - 65	90	22.1	10.4	24.1	222.6	24.3
4	Good	65 - 85	137	33.6	11.8	27.5	265.3	28.9
5	Exce	> 85	41	10.0	4.8	11.2	105.1	11.5
* AGE								
1	V.Old	> 20	100	24.5	11.1	25.8	230.3	25.1
2	Old	15 - 20	169	41.4	13.8	32.1	316.4	34.5
3	Fair	10 - 15	52	12.7	6.20	14.5	136.5	14.9
4	New	5 - 10	34	8.30	4.60	10.7	82.30	9.0
5	V.New	<= 5	53	13.0	7.30	16.8	151.9	16.6
* MADT								
1	V.Hvy		0	0.0	0.0	0.0	0.0	0.0
2	Heavy	1300 - 2000	63	15.4	6.50	15.1	155.3	16.9
3	Mediu	500 - 1300	83	20.3	11.0	25.6	229.7	25.0
4	Light	300 - 500	262	64.2	25.6	59.3	532.5	58.0
5	V.Lgt		0	0.0	0.0	0.0	0.0	0.0
* TADT								
1	V.Hvy		0	0.0	0.0	0.0	0.0	0.0
2	Heavy	1300 - 2000	63	15.4	6.50	15.1	155.3	16.9
3	Mediu	500 - 1300	83	20.3	11.0	25.6	229.7	25.0
4	Light	300 - 500	262	64.2	25.6	59.3	532.5	58.0
5	V.Lgt		0	0.0	0.0	0.0	0.0	0.0
--								
	TOTAL		408	100	43.1	100	917.5	100

City: Lampasas User: Department of Public Works

Figure 6.5 Printout of the summary for pavement evaluation for Lampasas

 No: 7-6

SUMMARY OF MAINTENANCE & REHABILITATION PROGRAM
FLEXIBLE PAVEMENT

1. Maintenance & Rehabilitation Needs

Input File: GURMS.PLA Report Date: 3-20-1995

M&R STRATEGY Code	Description	UNIT COST ($/SY)	SECTION Number	%	LENGTH (mile)	%	BUDGET $ 1000	%
0	Do Nothing	0	45	11.0	6.36	14.8	0.0	0.0
1	Routine Maint.	2.15	80	19.6	6.99	16.2	317.7	14.8
2	Crack&Fog Seal	3.52	126	30.9	11.97	27.8	910.87	42.6
3	Seal Coat Over	0.3	30	7.4	3.73	8.7	23.87	1.1
4	Seal Coat	1.65	9	2.2	0.73	1.7	26.52	1.2
5	2 Course	2.60	109	26.7	12.44	28.9	674.53	31.5
6	Hot Mix	9.00	9	2.2	0.84	2.0	187.15	8.7
--								
	TOTAL		408	100	43.06	100	2140.7	100

2. Recommended M & R Projects for 1995 - 1999

M&R STRATEGY Code	Description	UNIT COST ($/SY)	SECTION Number	%	LENGTH (mile)	%	BUDGET $ 1000	%
0	Do Nothing	0	193	47.3	20.41	47.4	0.0	0.0
1	Routine Maint.	2.15	80	19.6	6.99	16.2	317.7	25.4
2	Crack&Fog Seal	3.52	20	4.9	2.08	4.8	138.02	11.1
3	Seal Coat Over	0.3	4	1.0	1.35	3.1	6.74	0.5
4	Seal Coat	1.65	5	1.2	0.45	1.0	15.19	1.2
5	2 Course	2.60	97	23.8	10.93	25.4	583.71	46.8
6	Hot Mix	9.00	9	0.84	0.84	2.0	187.15	15.0
--								
	TOTAL	408	100	43.06	100	1248.5	100	

City: Lampasas User: Department of Public Works

Figure 6.6 Printout of M&R program for Lampasas

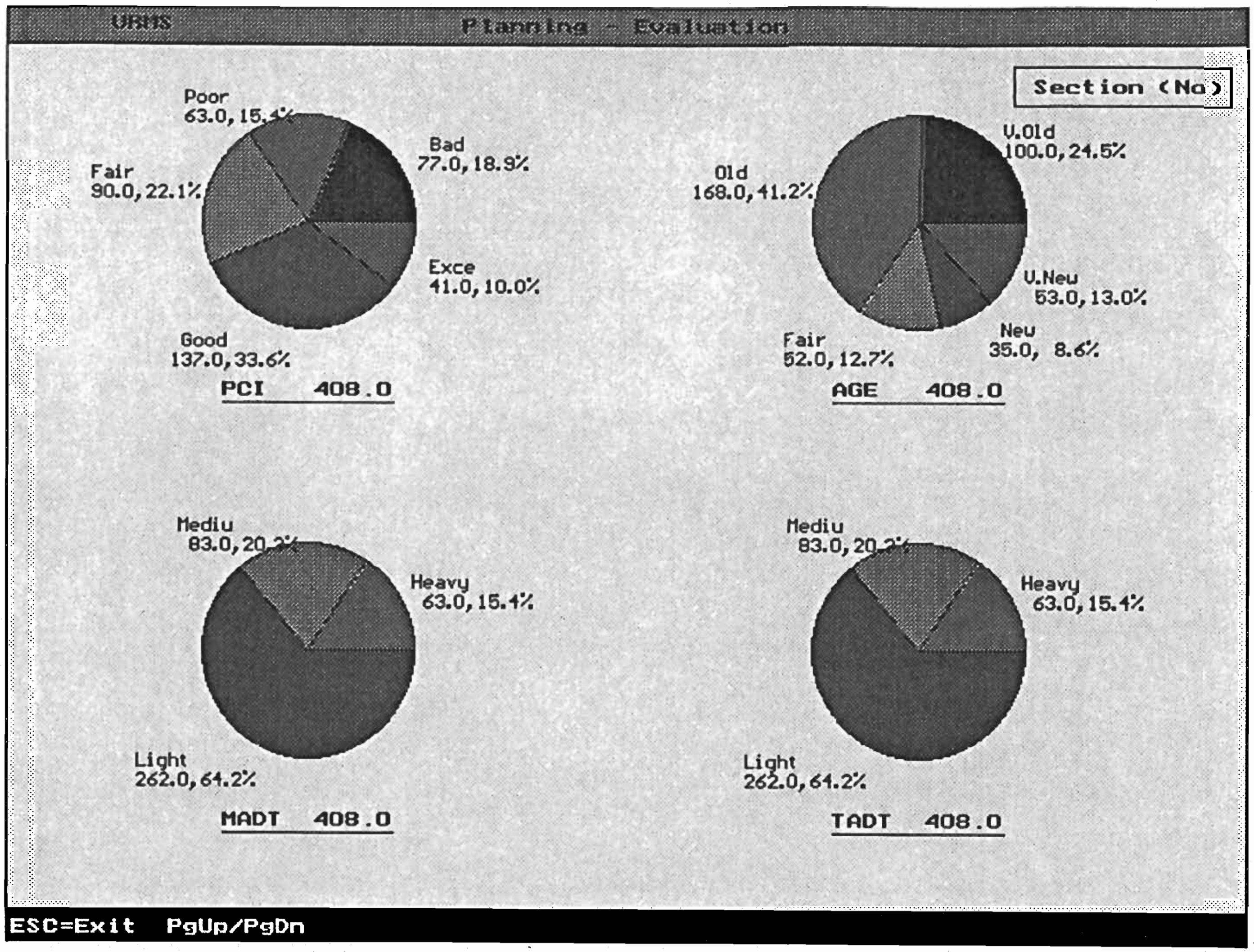


Figure 6.7 Screen of the summary for pavement evaluation for Lampasas

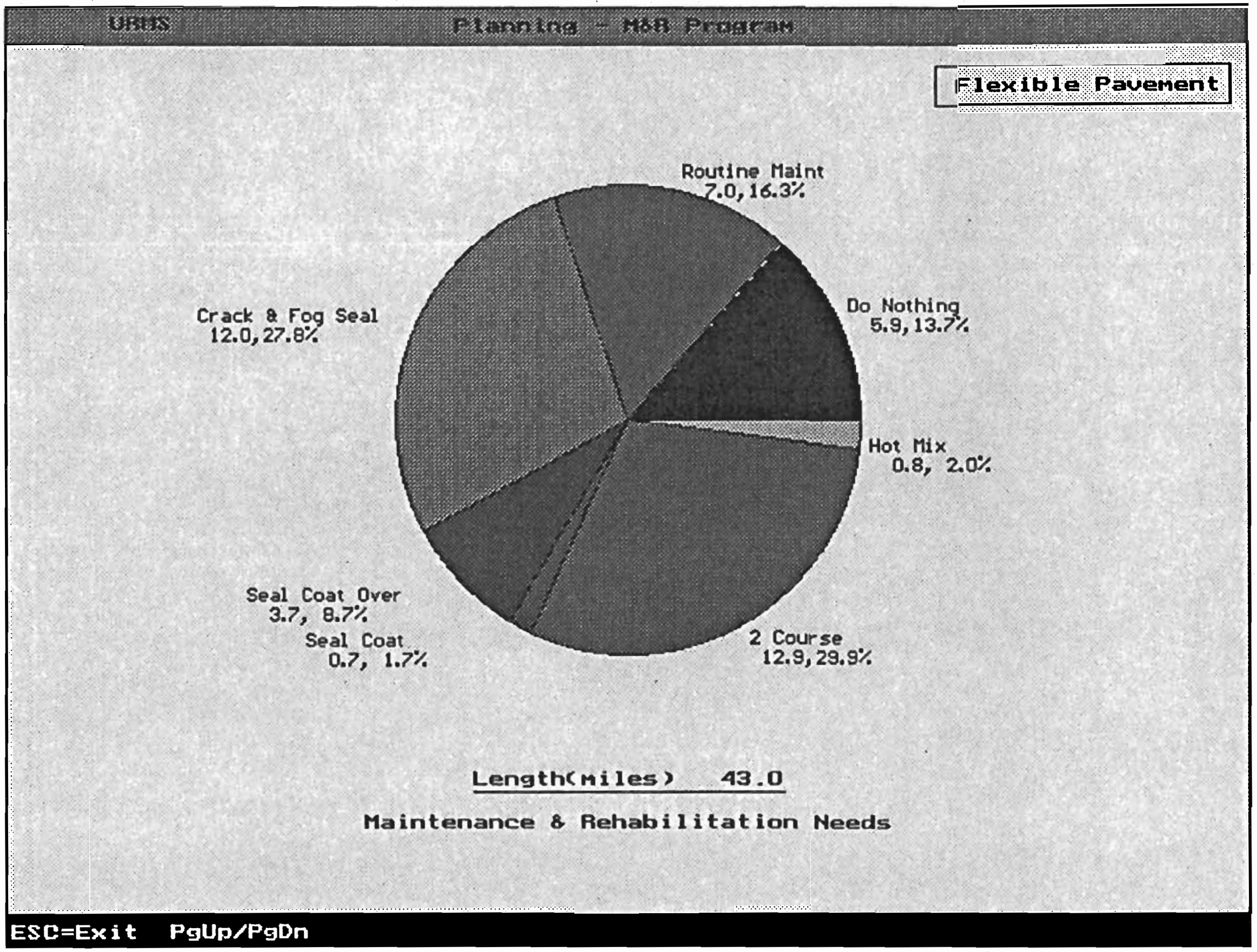


Figure 6.8 Screen for recommended M&R projects for Lampasas in terms of length

The principle distress experienced in Terrell is longitudinal and transverse cracking. The primary maintenance and repair strategy is routine maintenance consisting of pothole patching, minor level-up, and drainage improvements. Due to limited funding, the city could not implement a network level PMS before. The DPW is responsible for maintaining streets of the city.

Data Preparation

The road network of Terrell consists of 895 sections. The city collected most basic street data required by URMS, however, no information was available for condition of roads in the network. The data collected was stored in DBase format. The city decided to start implementation process with 671 flexible pavement sections. All the basic data available for these sections was transferred from the DBase format to the URMS data base by the city staff.

For implementation project, Terrell decided to collect distress data for flexible pavement sections considered, so as to calculate the PCI using the PCI model in the URMS Model Selection Module. The severity of different distress types was obtained and entered into the data base of URMS. Street map of the city has not been included in the data base as of May, 1995. Figure 6.9 presents the main screen of the data base module with data from the city of Terrell.

Determination of Module Parameters

Pavement age instead of soil type was used by the city of Terrell to evaluate their pavements. The calculation of PCI using the distress data was preferred over the manual input for the PCI Model. The weights given by the city to severity levels of different distresses are shown in Figure 6.10. It can be seen that high density alligator cracking was given a weight of 1, and all the other severity levels for different distresses were weighted with respect to that. The PCI, AGE, and ADT were divided into five levels. Figure 6.11 presents different levels and their limiting values for all the evaluation indices. Routine maintenance, patch and seal, level and seal, overlay, and reconstruction are the major M&R strategies utilized in Terrell. The city wanted to approximate M&R programs for the next five years, and has provided with their M&R budget from 1995 to 1999. It is anticipated that the DPW will get $100,000 for 1995, $150,000 per year for 1996 and 1997, and $200,000 per year for 1998 and 1999. The description and average unit costs of the M&R treatment are listed in Table 6.2. Pavement condition is considered to be the main factor in constructing the decision tree for assigning an M&R strategy to each section. Figure 6.12 shows the M&R assignment model built for the city of Terrell. The PCI and ADT are considered to be more important than AGE and street class respectively in constructing the priority index model for the city. Figure 6.13 shows the PIX model for Terrell.

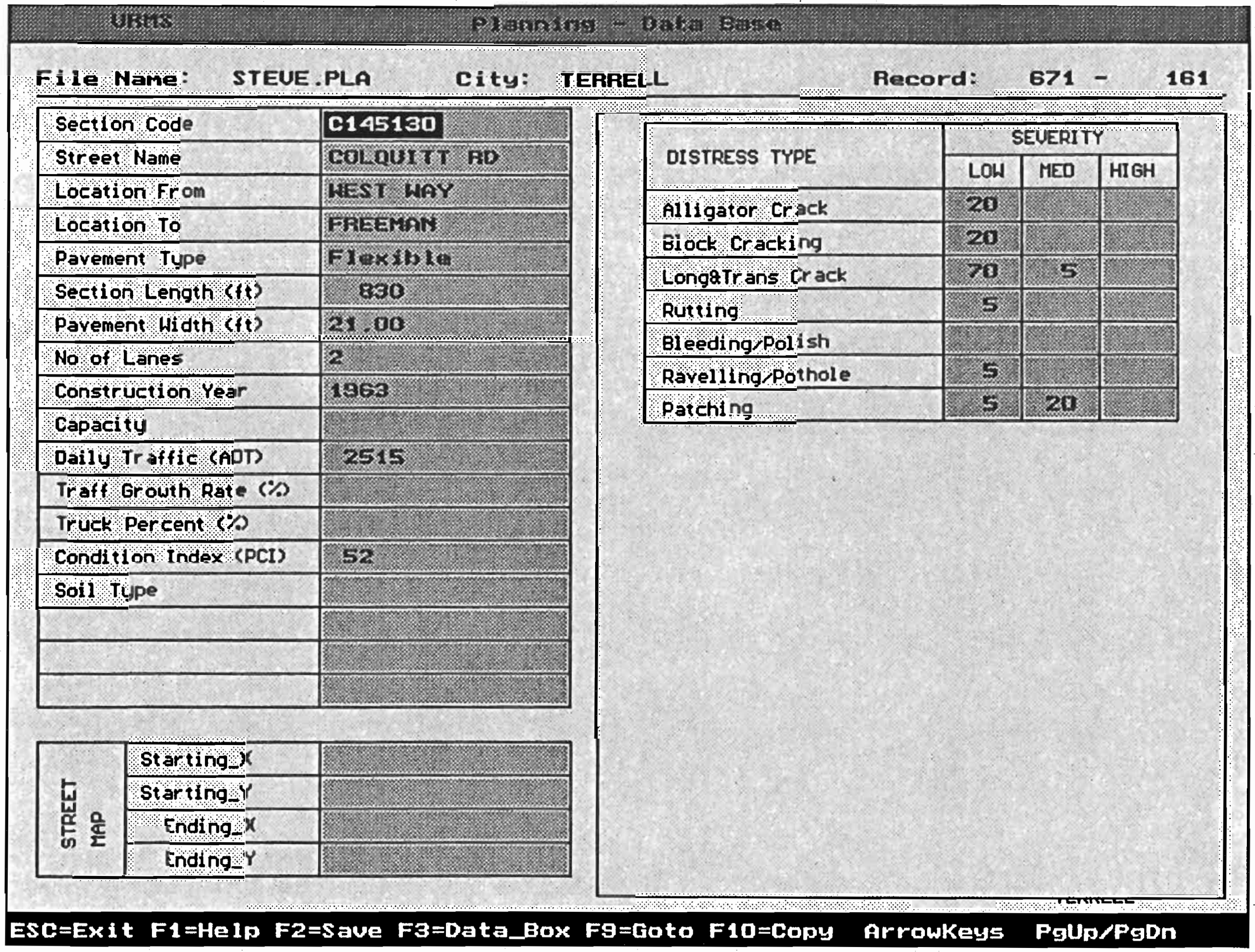
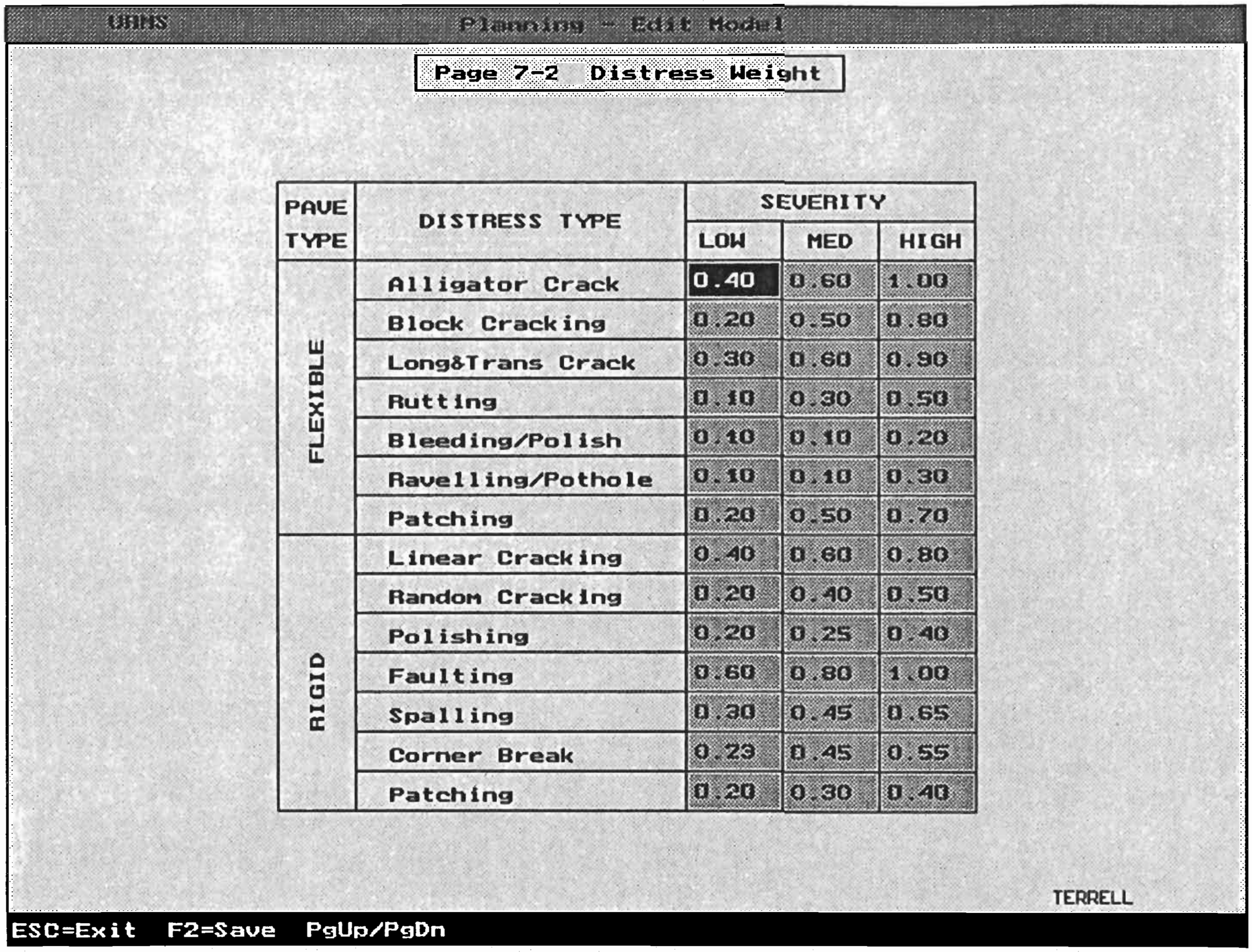


Figure 6.9 Data base main screen for the city of Terrell



PAVE TYPE	DISTRESS TYPE	SEVERITY		
		LOW	MED	HIGH
FLEXIBLE	Alligator Crack	0.40	0.60	1.00
	Block Cracking	0.20	0.50	0.80
	Long&Trans Crack	0.30	0.60	0.90
	Rutting	0.10	0.30	0.50
	Bleeding/Polish	0.10	0.10	0.20
	Ravelling/Pothole	0.10	0.10	0.30
	Patching	0.20	0.50	0.70
RIGID	Linear Cracking	0.40	0.60	0.80
	Random Cracking	0.20	0.40	0.50
	Polishing	0.20	0.25	0.40
	Faulting	0.60	0.80	1.00
	Spalling	0.30	0.45	0.65
	Corner Break	0.23	0.45	0.55
	Patching	0.20	0.30	0.40

Figure 6.10 Distress weights for the city of Terrell

UHMS Planning - Edit Model

Page 7-3 Evaluation Criteria

PROGRAM YEAR 1995

Pavement Condition Index (PCI)

	1 Bad	2 Poor	3 Fair	4 Good	5 Excell
PCI	< 30	30 - 50	50 70	70 90	>= 90

Pavement Age (AGE)

	1 V. Old	2 Old	3 Average	4 New	5 V.New
Flexible	> 40	40 - 25	25 10	10 5	<= 5
Rigid	> 40	40 - 30	30 20	20 10	<= 10

Traffic Classification

ADT(x1000)	1 V.Heavy	2 Heavy	3 Medium	4 Light	5 V.Light
1. Mixed	> 2.0	2.0 - 1.3	1.3 0.5	0.5 0.3	<= 0.3
2. Truck	> 0.4	0.4 - 0.3	0.3 0.2	0.2 0.1	<= 0.1

Volumn/Capacity 1.00 (V/C) Ratio for pavement widening

TERRELL

ESC=Exit F2=Save PgUp/PgDn

Figure 6.11 Evaluation indices for the city of Terrell

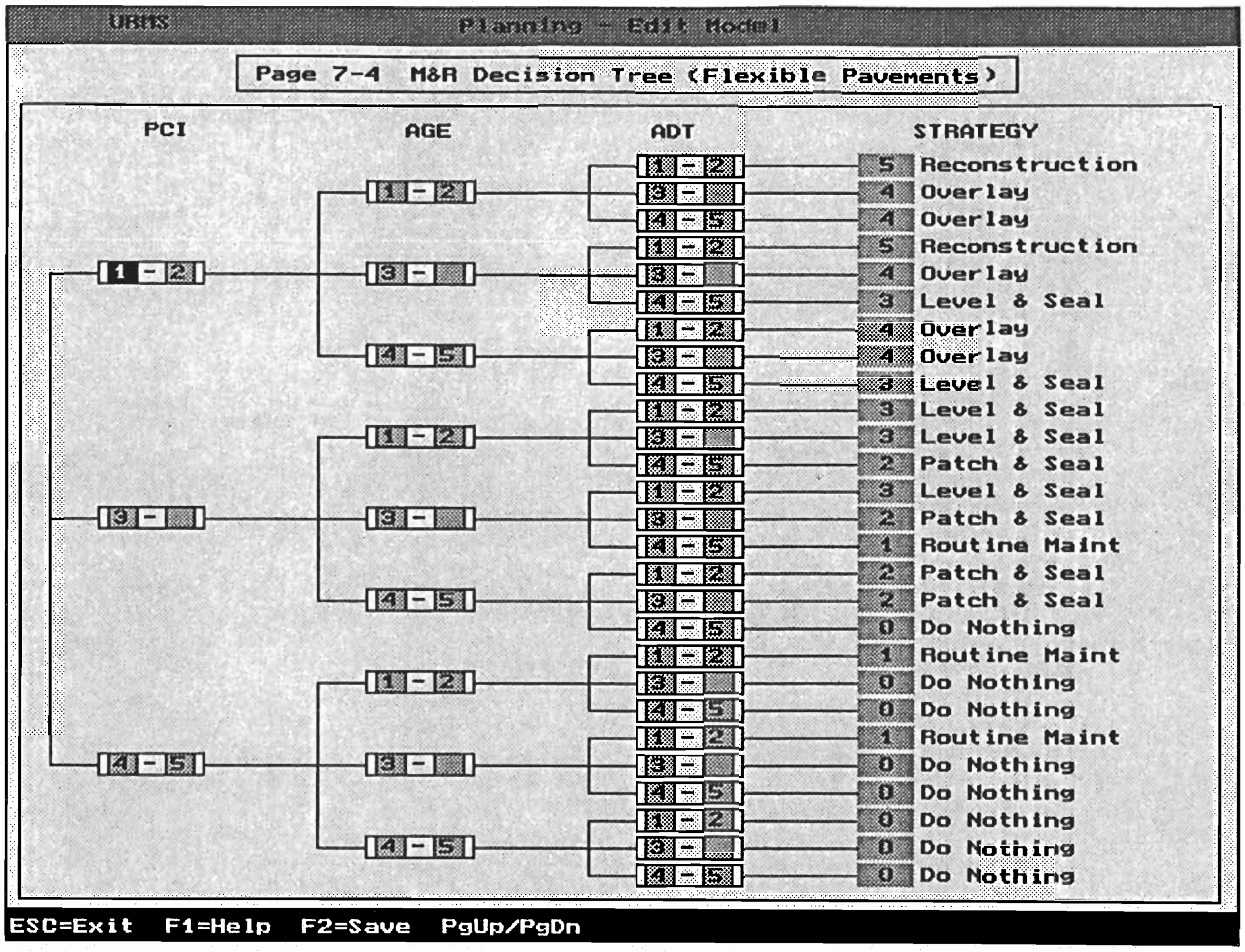


Figure 6.12 M&R assignment model for the city of Terrell

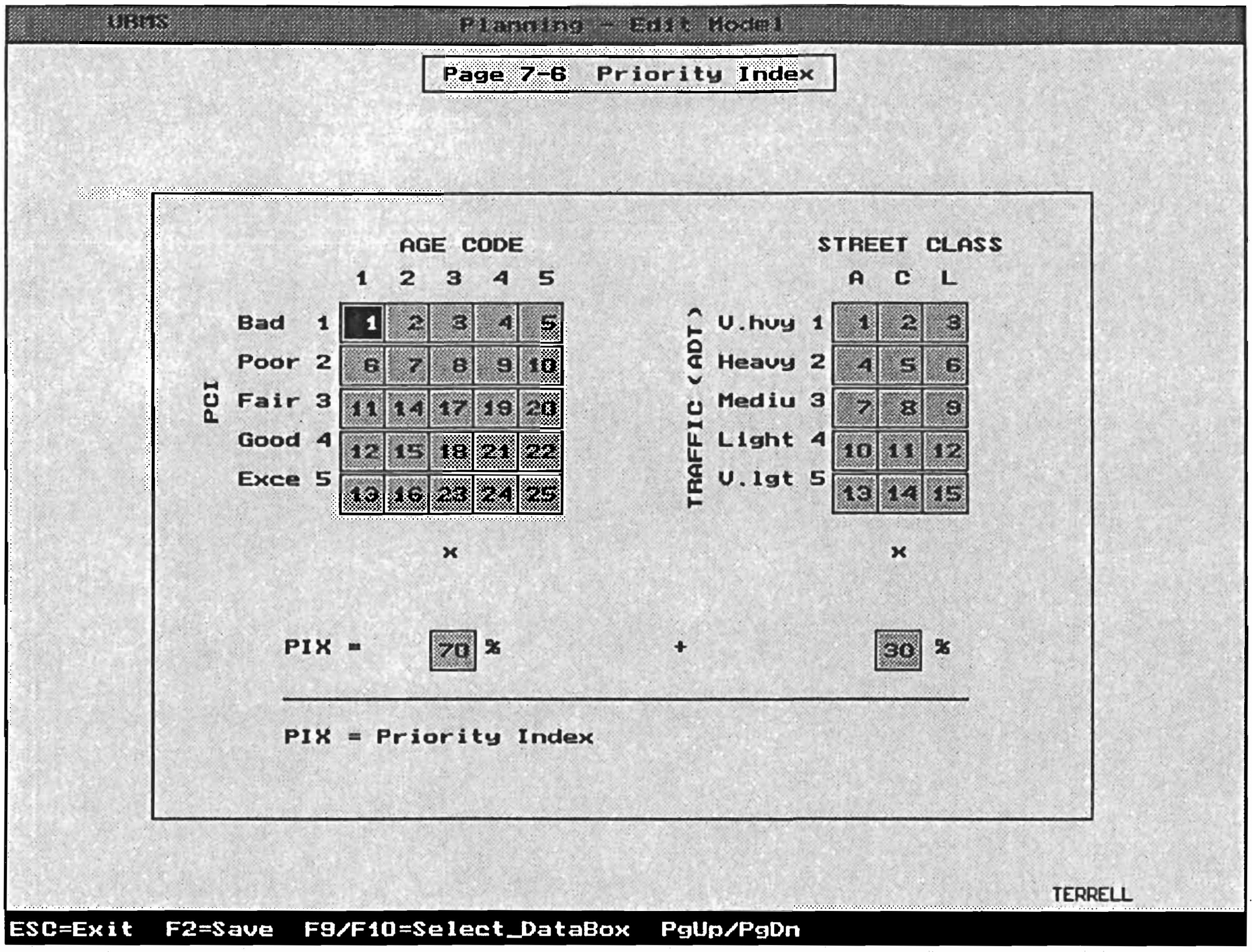


Figure 6.13 Priority index model for the city of Terrell

TABLE 6.2 M&R STRATEGIES DEFINED FOR THE CITY OF TERRELL

No.	M&R Strategy	Description	Unit Cost
0	Do Nothing		$0.00/SY
1	Routine Maintenance	Patch potholes, level up work, vegetation control, minor drainage improvements.	$2.00/SY
2	Single Course Seal Coat	Patching and some minor level-up.	$3.00/SY
3	Single Course Seal Coat	Necessary level-up and base repair.	$7.00/SY
4	Overlay	3 inch average overlay. Necessary level-up and base repair.	$10.00/SY
5	Reconstruction	New pavement and subgrade	$30.00/SY

Outputs of Implementation

Pavement evaluation and M&R program output for the 671 sections considered are shown in Figures 6.14 through 6.17. Figure 6.14 is one of the summary printouts which lists the pavement evaluation summary. Figure 6.15 presents another printout listing the summary of M&R program for both M&R needs and recommended M&R projects for the next five years. Figure 6.16 is one of the screens showing evaluation results in pie charts. Figure 6.17 shows the pie chart of recommended M&R projects for 1995 in terms of length. Figure 6.15 shows that of all the 671 sections considered, 55 require routine maintenance, 57 require patch and seal, 71 require level and seal, 57 require overlay, and 11 require reconstruction. The total budget needed to fulfill these requirements is $2,281,400. For the $800,000 budget, allocated from 1995 to 1999, program recommended 55 sections for routine maintenance, no section for patch and seal, no section for level and seal, 3 sections for overlay, and 9 sections for reconstruction. Appendix E gives a listing of typical input and output data for Terrell.

TELEPHONE IMPLEMENTATION IN OTHER INTERESTED CITIES

A number of cities showed interest in implementation of URMS. Telephone assistance was offered to these cities. but limited funds restricted complete implementation in these cities. The city of Corpus Christi showed immense interest in coming the the University of Texas to learn about URMS. A special training session was conducted for the city to help them understand and implement the system.

CONDITION CODE	DESCRIPTION	LIMITING VALUE	SECTION NUMBER	%	LENGTH MILES	%	AREA 1000 SY	%
* PCI								
1	Bad	<= 30	30	4.50	3.40	5.90	59.60	7.00
2	Poor	30 - 50	50	7.50	3.60	6.30	48.50	5.70
3	Fair	50 - 70	140	20.9	12.5	21.4	177.5	20.8
4	Good	70 - 90	281	41.9	23.7	40.8	351.6	41.2
5	Exce	> 90	170	25.3	14.9	25.6	217.0	25.4
* AGE								
1	V.Old	> 40	162	24.1	12.3	21.2	195.0	22.8
2	Old	25 - 40	314	46.8	27.6	47.5	398.7	46.7
3	Fair	10 - 25	172	25.6	16.0	27.4	231.5	27.1
4	New	5 - 10	10	1.50	1.40	2.40	19.70	2.3
5	V.New	<= 5	13	1.90	0.90	1.50	9.40	1.10
--								
* MADT								
1	V.Hvy	> 2000	48	7.2	3.0	5.1	53.3	6.2
2	Heavy	1300 - 2000	20	3.0	2.0	3.5	39.2	4.7
3	Mediu	500 - 1300	115	17.1	11.6	20.0	192.0	22.5
4	Light	300 - 500	98	14.6	8.10	13.9	116.1	13.6
5	V.Lgt	<= 300	388	57.8	33.3	57.2	451.3	52.80
--								
* TADT								
1	V.Hvy	> 2000	48	7.2	3.0	5.1	53.3	6.2
2	Heavy	1300 - 2000	20	3.0	2.0	3.5	39.2	4.7
3	Mediu	500 - 1300	115	17.1	11.6	20.0	192.0	22.5
4	Light	300 - 500	98	14.6	8.10	13.9	116.1	13.6
5	V.Lgt	<= 300	388	57.8	33.3	57.2	451.3	52.80
	TOTAL		671	100	58.1	100	854.3	100

City: Terrell User: Department of Public Works

Figure 6.14 Printout of the summary for pavement evaluation for Terrell

SUMMARY OF MAINTENANCE & REHABILITATION PROGRAM
FLEXIBLE PAVEMENT

1. Maintenance & Rehabilitation Needs

Input File: TERL.PLA

Report Date: 4-01-1995

M&R STRATEGY Code	Description	UNIT COST ($/SY)	SECTION Number	%	LENGTH (mile)	%	BUDGET $ 1000	%
0	Do Nothing	0	420	62.6	36.18	62.2	0.0	0.0
1	Routine Maint.	2.00	55	8.20	4.72	8.10	151.77	6.70
2	Patch & Seal	3.00	57	8.50	4.75	8.20	188.54	8.30
3	Level & Seal	7.00	71	10.6	6.20	10.7	666.84	29.2
4	Overlay	10.0	57	8.5	5.62	9.70	821.54	136.0
5	Reconstruction	30.0	11	1.6	0.66	1.10	452.70	19.8
	TOTAL		671	100	58.14	100	2281.4	100

2. Recommended M & R Projects for 1995 - 1999

M&R STRATEGY Code	Description	UNIT COST ($/SY)	SECTION Number	%	LENGTH (mile)	%	BUDGET $ 1000	%
0	Do Nothing	0	604	90.0	51.65	88.9	0.0	0.0
1	Routine Maint.	2.15	55	8.20	4.72	8.10	151.77	19.1
2	Crack&Fog Seal	3.52	0	0.0	0.00	0.0	0.00	0.0
3	Seal Coat Over	0.3	0	0.0	0.00	0.0	0.00	0.0
4	Seal Coat	1.65	3	0.4	1.15	2.0	214.27	27.0
5	2 Course	2.60	9	1.3	0.61	1.0	427.05	53.8
	TOTAL		671	100	58.14	100	793.10	100

City: Terrell User: Department of Public Works

Figure 6.15 Printout of M&R program for Terrell

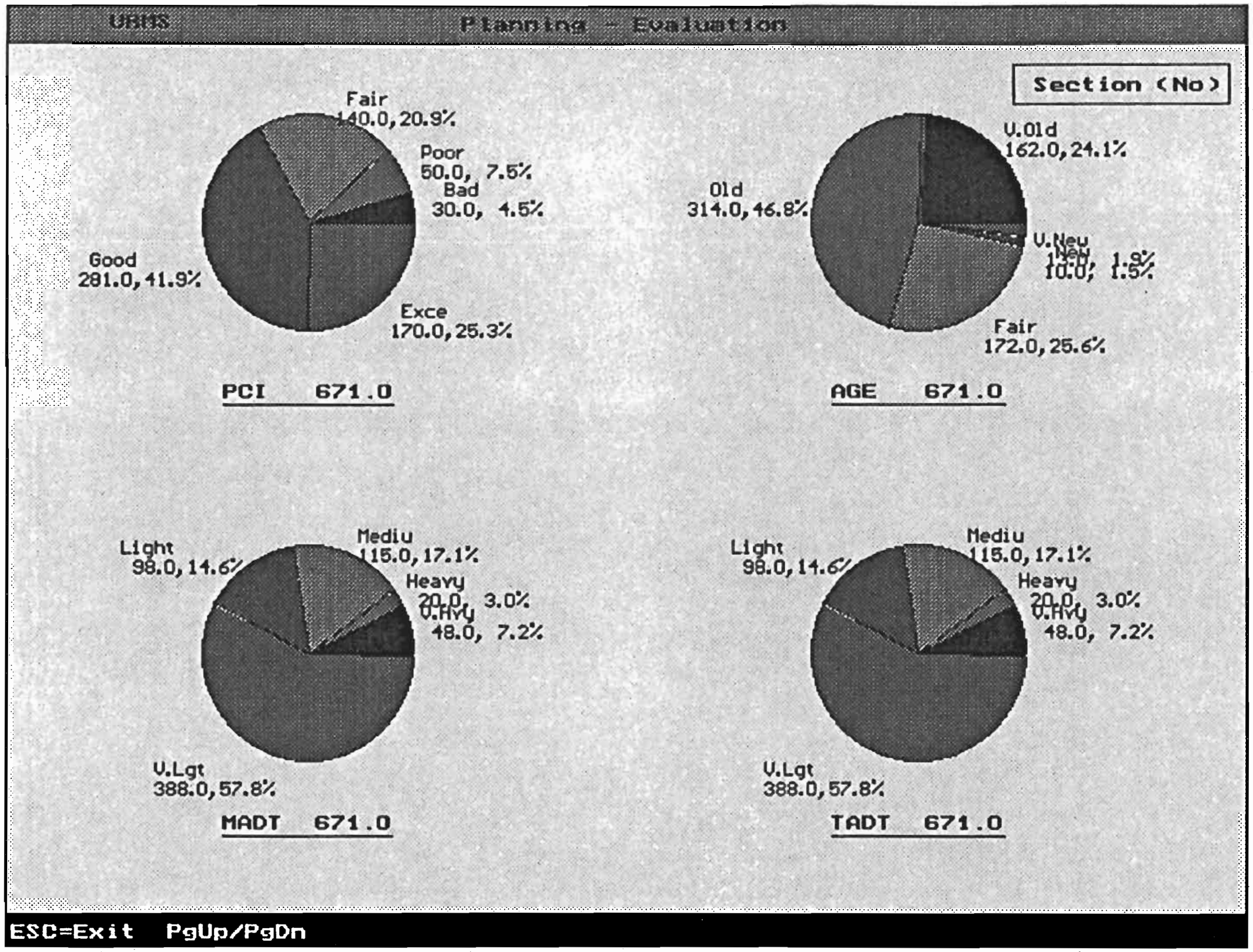


Figure 6.16 Screen of the summary for pavement evaluation for Terrell

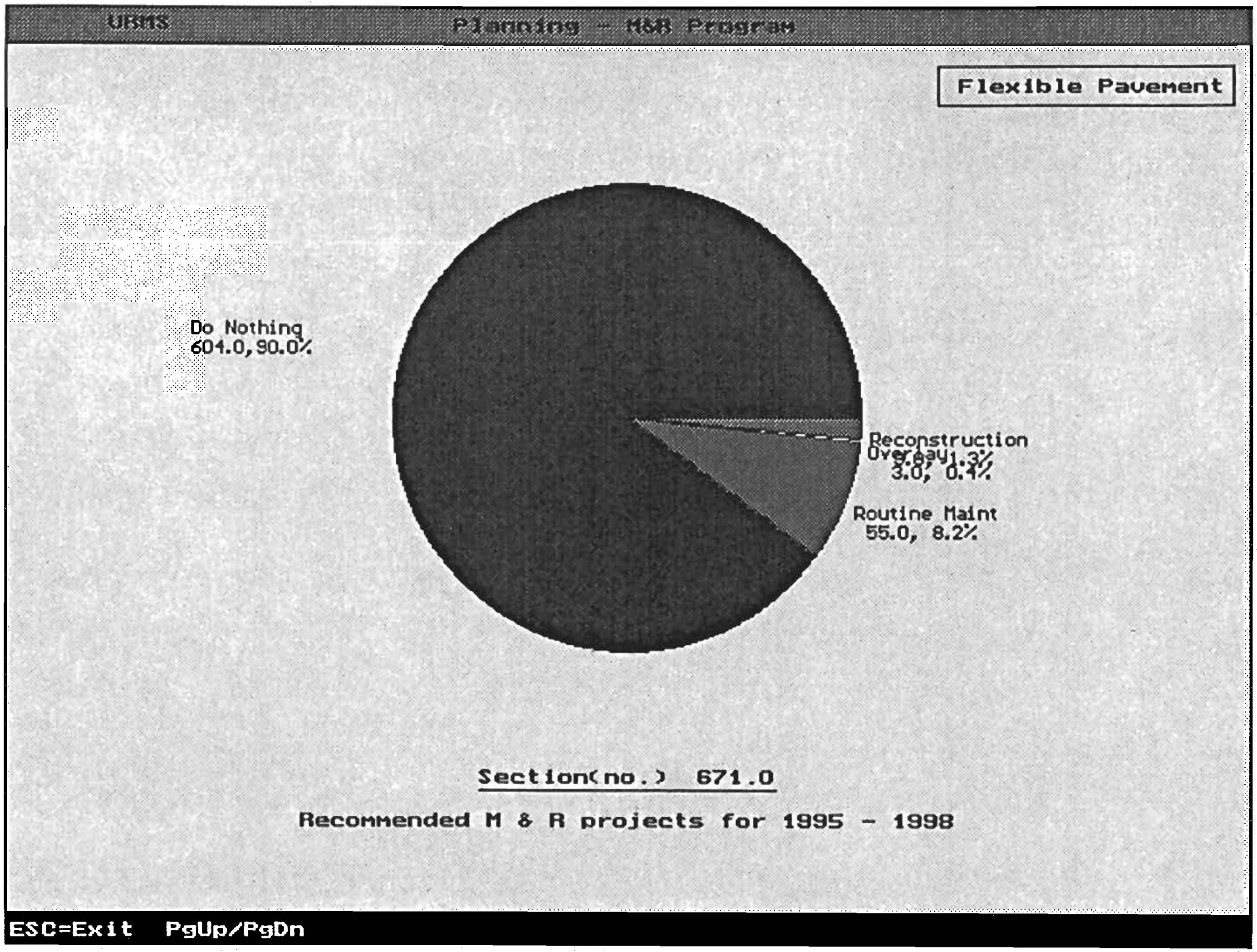


Figure 6.17 Screen for recommended M&R projects in terms of length

CHAPTER 7. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The objectives of this project were to implement URMS in small to medium sized cities and to gain knowledge of pavement management practice at the regional level all over the country. The limitations of funds and time restricted implementation to Texas cities only.

URMS is a comprehensive pavement management system for small to medium size cities, developed at the University of Texas at Austin by Dr. Xin Chen, Dr. W. Ronald Hudson and Terrence E. Dossey. Implementation of URMS was carried out at two levels. At the first level, the city of Lampasas was directly assisted and the project staff worked closely with the city on implementation. At the second level all other cities, which showed considerable interest in implementation, were offered assistance via telephone. However, due to constraints of funds, complete second level implementation was possible only in the city of Terrell.

SUMMARY AND CONCLUSIONS

To achieve the objectives of this study, three surveys were conducted. The Texas survey was performed in the summer of 1994 to gain knowledge of regional level pavement management practice in Texas. Information obtained was utilized to identify candidate cities for URMS implementation. The US survey was conducted in November, 1994, to identify pavement management practice at the regional level across the country. The Micro PAVER Survey was carried out in September, 1994, to assess the active use of PAVER by its users, as listed by APWA, and to find their interest in examining the URMS.

Results of the surveys revealed that there is a shortage of simple, flexible, and user-friendly PMS for urban streets. Micro PAVER is the most commonly used PMS at the local government level. Many active users pointed out problems associated with the general complexity and non user-friendliness of Micro PAVER. Deficient report generating capabilities, extensive data requirements, and practical problems in collection of required data were criticized by the users. URMS seems to have most of the capabilities identified to be lacking in Micro PAVER by its users. It is simple, flexible and user-friendly. It generates variety of reliable reports and charts, as needed by the DPW for planning and reporting purposes. Most of the cities already collect the minimum data required to implement URMS, and hence the system can be implemented in small to medium sized cities without any extensive data collection efforts. The survey results also revealed immense interest of a large number of cities in the implementation of URMS. However, the limitation of funds restricted complete implementation to only two cities of

Texas. If the second phase of this study is funded, the results can be used to implement URMS in many other cities.

The Texas survey results were analyzed to select cities for the two level URMS implementation. Interest of cities, their population, availability of funds, collection of street condition data, and active use of any network level PMS were considered as main selection parameters. Based on these parameters, a factorial approach was utilized to come up with the 5 top priority implementation cities. The URMS package, along with a detailed questionnaire, was distributed to the 5 top priority cities and all other cities which showed interest and had implementation funds budgeted. Analysis of replies of detailed questionnaire and immense interest in implementation led to the selection of the city of Terrell for telephone implementation of URMS. A meeting with the 5 top priority cities was held in January, 1995, to come up with the city for assisted implementation. Based on the discussion in the meeting and the replies of detailed questionnaire, the city of Lampasas was selected.

The implementation process in the cities of Lampasas and Terrell included; training city personnel, helping the cities to collect and organize required data, helping the cities to determine the Model Parameters of URMS, converting the data obtained by cities to the URMS format, and running the software and getting the reports identifying and selecting M&R projects.

URMS was implemented in the two cities without any extensive added data collection effort by city personnel. Once the data was collected, it took only a data base manager and a city engineer to completely implement the system in each city. Reports generated for M&R needs and recommended M&R projects were used by DPWs for network planning purposes. The successful implementation in Terrell shows that URMS can be implemented in a city using the URMS user's guide and with some support, which can be provided via telephone. A similar process can be adapted in future for implementation in other cities, identified as priority cell cities in chapter 5 of this report, provided the second stage of implementation is funded.

RECOMMENDATIONS

Recommendations for the Improvement of URMS

1) The URMS uses either pavement age or soil type in the Priority Index Model to come up with the priority of M&R strategies assigned. Replacing soil type with a more general index, e.g. riding quality, would improve system flexibility.

2) A deterioration model is not included in the current version of URMS, since historic data on pavement condition is not available for most small and medium sized cities. Multi year

M&R programs can be significantly improved if deterioration models are provided in the Network Planning Module.

3) Most of the small and medium sized cities have a considerable percentage of unpaved roads in their jurisdictions. At present URMS does not consider unpaved roads in its planning and design modules. Consideration of unpaved roads in URMS will help the cities to evaluate their complete network using the system.

4) Network optimization is not a part of the existing URMS. The application of simplified optimization models with graphical explanation may greatly help decision making in pavement management.

5) During the implementation process, problems were faced in converting the street map data from the GIS format to the URMS format. An interface needs to be developed between the URMS and GIS software for better communication.

6) The current version of URMS can only import and export ASCII files. A more powerful interface needs to be developed in order to import data from and export data to some popular data base management systems, such as dBASE, FoxPro, Oracle etc.

7) Microsoft Windows Operating System has become very popular in PMS. A windows version of URMS should be developed in the future.

Recommendations to the Two Cities

1) For the implementation process in Lampasas ADT was estimated as low, medium, or high. A traffic count should be done on their streets by the city and the ADT calculated should be used.

2) Lampasas selected manual input over calculating the Pavement Condition Index (PCI) by distress data. A street condition survey should be performed by the city in future, and the distress data obtained should be used in URMS to calculate the PCI.

3) Around 20 sections of streets (15%) in Lampasas are unpaved. The basic data for these sections is included in the URMS Data Base, however, these sections are not included in evaluation. The sections which are unpaved now should be included in the evaluation as they are paved.

4) For the implementation process in Terrell, flexible pavement are considered only at the present time. The city should add rigid pavements to URMS in future. The unpaved roads should also be included in the system as they are paved.

5) Terrell collected the distress data on their flexible pavements and used URMS to calculate PCI on these pavement. Distress data should also be calculated for rigid pavement and incorporated in the system in future.

6) The Department of Public Works of Terrell decided not to include the city map in URMS at the present time. A map of road network of the city should be added to the system in future.

7) Both cities need to update the inputs each year.

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16. Roger E. Smith, M.Y. Shahin, M.I. Darter, and S.H. Carpenter, "A Comprehensive Ranking System for Local Agency Pavement Management", Transportation Research Record 1123, Transportation Research Board, National Research Council, Washington, D.C., 1987.
17. Roger Smith, "Pavement Management for Local Governments", FHWA, 1994.
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19. W. Wells, M.Y. Shahin, R.E. Smith, and M.I. Darter, "Implementing Pavement Management Systems, Do's and Don'ts at the County/City Level", Proceedings, North American Pavement Management Conference, Toronto, Ontario, Canada. 1985.
20. E.J. Wentland and K.W. Smith, "Survey Responses: An Evaluation of Their Validity, Academic Press, Inc., San Diego, 1993.
21. Christopher Jon Oswald, "Evaluating the Acceptability of Highway Tolling in Texas: Exploratory Analysis," The University of Texas , Master's Thesis, August 1994.

APPENDIX A. DETAILED QUESTIONNAIRE

Please find some time to answer the following questions and return the questionnaire in the enclosed postage paid envelope ASAP. Thank you for your time and consideration.

A) CURRENT PAVEMENT MANAGEMENT

1) Are you using any network level Pavement Management System (PMS)

☐ Yes ☐ No

If not, please leave this section and answer section B.

2) Please write the trade name of the system you are using.

3) Does it produce useful network output to help you make decisions?

☐ Yes ☐ No

4) Does your PMS productively contribute to your use of funds?

☐ Yes ☐ No

5) What areas have you seen the most improvement in since implementing a PMS, if any.

6) For the PMS that you are using, please rate the following on the scale given

	Poor	Fair	Very Good	Excellent
• User friendliness	☐	☐	☐	☐
• Decision Making	☐	☐	☐	☐
• Flexibility	☐	☐	☐	☐
• Capability to draw street maps	☐	☐	☐	☐
• Report generation	☐	☐	☐	☐

6) Do you feel that a different PMS can help to process your data to give a better management of your road network?

☐ Yes ☐ No

B) DATA COLLECTION

1) How many lane miles of roadway is included in your road network? (Approximations accepted)

2) How many lane miles of roadway is covered by your PMS (if any)?

3) For your road network, please give the approximate proportion of:

Flexible Pavements = ________% (or lane miles)

Rigid Pavements = __________%(or lane miles), and

Unpaved Roads = ___________% (or lane miles)

4) For a PMS, road network is divided into homogeneous or uniform sections. Do you divide your road network into sections?

☐ Yes ☐ No

If yes, what is the total number of roadway sections you maintain?

5) Pavement condition index (PCI) is used in a PMS as an estimate of condition of pavement at a particular time. Do you use PCI for your road network?

☐ Yes ☐ No

6) If you do not use a PCI, how do you estimate the condition of the roads you have to maintain?

7) Below is the minimum data required for the network planning in URMS. Tick whatever is applicable for the data you collect on your network.

i) Street names	☐ Yes	☐ No
ii) Length of streets	☐ Yes	☐ No
iii) Width of streets	☐ Yes	☐ No
iv) Number of lanes	☐ Yes	☐ No
v) Construction year or subgrade type	☐ Yes	☐ No
vi) Average daily traffic	☐ Yes	☐ No

8) If you do not collect the data above, do you have the capability (funds, equipment and manpower) to collect this data when required?

☐ Yes ☐ No

9) Do you collect data other than mentioned in Q7, for your road net work?

☐ Yes ☐ No

If yes, please describe and/or attach a sample of whatever data you collect.

10) Your name:

Your Address:

11) Your Comments:

Thank you very much for participating in our survey. Your answers were extremely helpful.

APPENDIX B. COVER LETTERS

Cover Letter for the Texas and the US Surveys

August 1, 1994

Mr. Don Anderson
Houston Metro
P.O. Box 61429
Houston, TX 77208-1429

Dear Mr. Anderson,

The purpose of this letter is to provide information to you about pavement management expertise available from The University of Texas. As you may know, the Intermodal Surface Transportation Efficiency Act as a prerequisite for receiving federal aid requires by October 1, 1994 that each state shall develop a work plan that identifies major activities and includes a schedule that demonstrates full operation and use of the PMS on the National Highway Systems (NHS) by October 1, 1995 and on the non-NHS Federal aid highways by October 1, 1997.

We have developed a management system which includes a software package which may be of interest to you. This tool, along with associated data collection and processing can be used for prioritizing, rehabilitation, and maintenance projects for cities in small counties in terms of life cycle costs, energy costs and user costs. The software operates on IBM compatible personal computers (386 or 486), and it seems therefore to be within the means of even small cities. A primary feature of the program is that, unlike other available software, it can provide useful output with a minimum of data input, and can be easily custom tailored to the particular pavement distress problems and rehabilitation decision processes of each individual city. It has a user friendly graphic interface that is designed to be easily accessible to persons only slightly familiar with personal computers.

We have already implemented this system in the city of Georgetown and in a portion of the city of Austin. We've also had a working group made up of representatives from Dallas, Houston, Austin, and Georgetown on our advisory committee for the past three years.

We are trying to develop a methodology for transferring this software to interested users. This can be done at relatively low cost if we can obtain the proper information and determine interested parties. In order to accomplish this, we need your help in filling out the attached post card. You may also feel free to call us at the University of Texas, ask for Farrukh Sohail at 512-471-7741. If you have any questions, please feel free to write us or call us, but we hope you will, as a minimum, fill out the post card and return it to us. We certainly appreciate your assistance in this matter. We look forward to assisting you with your transportation needs.

NOTE: If you are not the right person, please forward the post card to the appropriate person.

Very truly yours,

W. R. Hudson
Dewitt C. Greer Centennial
Professor in Civil Engineering

Cover Letter for the Follow-up Survey

September 29, 1994

Edward Barmore
Superintendent Streets
2716 Main St.
Dickinson, TX 77539

Dear Mr. Barmore,

On the first of August we sent you a letter along with a post card asking some questions about the management of pavements in your area, and providing information to you about the pavement management expertise available from the University of Texas at Austin. Unfortunately, we have not received a reply from you. The purpose of this letter is to follow up on the postcard survey. We would really appreciate if you could find some time to complete the post card we are sending with this letter.

As you may know, the University of Texas at Austin has developed a system, called Urban Roadway Management System (URMS), which includes a software package for the management of pavements. This tool, along with associated data collection and processing, can be used for prioritizing, rehabilitation, and maintenance projects for cities in terms of life cycle costs, energy costs, and user costs. The simple, flexible, and user friendly software operates on IBM compatible personal computers (386 or 486), and it seems therefore to be within the means of even small cities. Unlike other available software, it can provide useful output with a minimum of data input, and can be easily custom tailored to the particular pavement distress problems and rehabilitation decision process of each individual city.

We are trying to develop a methodology for transferring this software to the interested cities around the United States. To determine the potential cities for the implementation of URMS, we have designed a questionnaire, which we are enclosing again with this letter. As we said in our previous letter, this package can be transferred to you for only a nominal duplication charge. All you need to do right now is to fill out the attached post card. If you have any questions, please feel free to write us or call us at the University of Texas, ask for Farrukh Sohail at 512-471-8270. We certainly appreciate your assistance in this matter.

NOTE: If you are not the right person, please forward the post card to the appropriate person.

Very truly yours,

W.R.Hudson
Dewitt C. Greer Centennial
Professor in Civil Engineering

Letter to the 5 Top Priority Cities

December 9, 1994

Edward Barmore
Superintendent Streets
2716 Main St.
Dickinson, TX 77539

Dear Mr. Barmore,

Thank you for replying to our recent survey about city pavement management. We sent out approximately 238 questionnaires to cities in Texas. Over 130 cities responded and from that group, we selected 5 top priority cities which we hope will be able to participate in our implementation. In addition, we sent our program to 24 other cities for their review and consideration.

Your city has been selected as 1 of the 5 cities for possible assisted implementation. Unfortunately, our budget does not permit us to work closely with more than 1 or 2 cities. We are therefore including our implementation package in this mailing to you. We hope that you will review it and give it your strong consideration. We will work with all the 5 cities either by telephone or through personal visits based on availability of funds and the individual city interests.

Our plan is to try to have a meeting in Austin, Texas for the cities interested and able to implement a pavement management system, in the week starting January 9. We would appreciate your calling Mr. Farrukh Sohail at (512) 471-8270 to discuss your availability for this meeting. Our FAX number is (512) 471-0592, if you wish to provide us with the days you prefer during that week. We would like to choose a day when as many of our 5 cities can attend the meeting, which would probably start at 10 a.m. and close by 3 p.m. Therefore, you could drive in and back to your city on the same day. In this meeting we will demonstrate the program, discuss various aspects of data collection and related issues and determine your willingness and availability to participate. This will also provide you with an opportunity to meet our staff face to face, and for us to meet you. That way , if your implementation is handled by phone, we will at least know each other for discussions. If you are unable to attend our meeting , we still hope that you will call Farrukh and let us know, and we will try to work with you via telephone to assist you in the implementation.

Thank you for your attention in this matter. We look forward to the opportunity of working with you, either in person or by mail, fax, and telephone. Best wishes for a Merry Christmas and Happy New Year. We look forward to hearing from you.

Very truly yours,

W.R.Hudson
Dewitt C. Greer Centennial
Professor in Civil Engineering

Cover Letter to the Cities Selected for Detailed Survey

December 9, 1994

Mr. Don Anderson
Houston Metro
P.O. Box 61429
Houston, TX 77208-1429

Dear Mr. Anderson,

We are in the process of final selection of cities for the implementation of a pavement management software, The Urban Roadway Management System (URMS), developed at the University of Texas at Austin. We appreciate your help in this process by replying with the post card we sent earlier.

We sent out the post card to many cities around Texas, and received 131 replies to our survey. The preliminary analysis of these responses led us to the selection of 29 cities for a more detailed survey. Due to limitations of funding and time, we will be able to assist with the implementation of URMS in only some of these cities, selected after the detailed analysis. However, if we can not directly interact with a city, we can still assist via telephone.

The good news for you is that your city has qualified as one of these 29 selected cities We are sending you a copy of URMS along with some literature about the software. A questionnaire has been developed for the detailed analysis which is also enclosed with this letter. Please find some time to fill out the questionnaire and send it back to us as soon as possible. A follow up to this questionnaire will be sent to you in the second week of January 1995, asking you to evaluate URMS. If you have any questions, please feel free to write us or call us at the University of Texas; ask for Farrukh Sohail at 512-471-8270. We certainly appreciate your assistance in this matter.

Very truly yours,

W.R.Hudson
Dewitt C. Greer Centennial
Professor in Civil Engineering

APPENDIX C. AGENDA FOR URMS TECHNOLOGY TRANSFER MEETING

TENTATIVE AGENDA FOR URMS TECHNOLOGY TRANSFER MEETING

10:00 AM	Welcome and Finalize Agenda (Dr. W. R. Hudson)
10:15 AM	Development of URMS (Dr. Xin Chen)
10:35 AM	Demonstration of URMS (Farrukh Sohail)
11:05 AM	Implementation Project (Farrukh Sohail)
11:15 AM	Current Pavement Management Practice (Representatives from cities)
12:00 Noon	Lunch
1:15 PM	Computer Requirements for PMS (Terry Dossey)
1:30 PM	Group Discussion
3:00 PM	Adjourn

APPENDIX D. TYPICAL INPUT AND OUTPUT DATA FOR LAMPASAS

URBAN ROADWAY MANAGEMENT SYSTEM (URMS V.1.0) Planning Subsystem
Copyright (c) 1993 The University of Texas at Austin Report No: 7 - 1

LISTINGS OF BASIC INPUT AND OUTPUT DATA

Input File: L1.PLA Report Date: 04-30-1995

SECTION IDENTIFICATION

NO	SECTION CODE		STREET NAME	LOCATION FORM	LOCATION TO	TYPE	LENGTH (ft)	WIDTH ft	TRAF LN	CONSTRU YEAR	CAPACIT	ADT	GROWTH %	TRUCK %	PCI	M&R	P INDEX	ACTION YEAR	M&R COST KS
00036	L319	7	RICE	AVE C	AVE B	F	283	32	2	1979	-	Light	2	1	80	1	1.0	1995	2.16
00037	L319	10	RICE	NORTH	1ST	F	299	32	2	1978	-	Light	2	1	80	1	1.0	1995	2.29
00038	L319	9	RICE	AVE A	NORTH	F	302	32	2	1978	-	Light	2	1	80	1	1.0	1995	2.31
00039	L319	4	RICE	4TH	5TH	F	292	35	2	1977	-	Light	2	1	80	1	1.0	1995	2.44
00040	L319	2	RICE	PERKINS	3RD	F	282	35	2	1980	-	Light	2	1	80	1	1.0	1995	2.36
00041	L319	6	RICE	AVE C	DEAD END	F	154	32	2	1979	-	Light	2	1	80	1	1.0	1995	1.18
00042	L319	5	RICE	5TH	6TH	F	283	35	2	1977	-	Light	2	1	80	1	1.0	1995	2.37
00043	L401	6	CHESTNUT	WATER	VINE	F	320	42	2	1976	-	Light	2	1	60	1	1.0	1995	3.21
00044	L401	5	CHESTNUT	MAIN	WATER	F	310	42	2	1976	-	Light	2	1	60	1	1.0	1995	3.11
00045	L401	8	CHESTNUT	4TH	SOUTH	F	1725	40	2	1975	-	Light	2	1	70	1	1.0	1995	16.48
00046	L401	7	CHESTNUT	RIVERVIEW	END	F	98	42	2	1976	-	Light	2	1	60	1	1.0	1995	0.98
00047	L326	1	CHEVY WAY	DEB LYNN	CHRIS JAMES	F	656	32	2	1976	-	Light	2	1	50	1	1.0	1995	5.00
00048	L324	1	SAMAC	1ST	DEAD END	F	950	42	2	1976	-	Light	2	1	50	1	1.0	1995	9.53
00049	L401	3	CHESTNUT	PEACH	HWY 190	F	284	42	2	1987	-	Light	2	1	60	1	1.0	1995	2.85
00050	L401	2	CHESTNUT	BARNES	PEACH	F	316	20	2	1987	-	Light	2	1	60	1	1.0	1995	1.51
00051	L401	1	CHESTNUT	BARNES	CITY LIMITS	F	780	20	2	1987	-	Light	2	1	60	1	1.0	1995	3.73
00052	L304	1	PARK	AVE D	AVE C	F	246	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.47
00053	L303	13	RIDGE	1ST	2ND	F	284	42	2	1980	-	Light	2	1	70	1	1.0	1995	2.85
00054	L304	3	PARK	AVE B	AVE A	F	280	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.81
00055	L304	2	PARK	AVE C	AVE B	F	298	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.99
00056	L411	1	MILLICAN	3RD	AVE A	F	725	27	2	1992	-	Light	2	1	60	1	1.0	1995	4.68
00057	L301	1	WALNUT	NORTH AVE	1ST	F	292	42	2	1979	-	Light	2	1	100	1	1.0	1995	2.93
00058	L301	8	WALNUT	1ST	2ND	F	280	40	2	1979	-	Light	2	1	80	1	1.0	1995	2.68
00059	L407	2	ELM	3RD	4TH	F	285	35	2	1968	-	Light	2	1	70	1	1.0	1995	2.38
00060	L313	1	ACORN	MATTHEWS	STEELE	F	446	42	2	1979	-	Light	2	1	90	1	1.0	1995	4.47
00061	L304	9	PARK	4TH	5TH	F	270	32	2	1982	-	Light	2	1	70	1	1.0	1995	2.06
00062	L319	1	RICE	1ST	PERKINS	F	284	35	2	1980	-	Light	2	1	80	1	1.0	1995	2.37
00063	L314	1	COCKRELL	1ST	END	F	263	24	2	1986	-	Light	2	1	100	1	1.0	1995	1.51
00064	L304	5	PARK	NORTH	1ST	F	295	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.96
00065	L304	4	PARK	AVE A	NORTH	F	298	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.99
00066	L304	8	PARK	3RD	4TH	F	212	22	2	1982	-	Light	2	1	70	1	1.0	1995	1.11
00067	L304	7	PARK	2ND	3RD	F	286	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.87
00068	L304	6	PARK	1ST	2ND	F	282	42	2	1982	-	Light	2	1	70	1	1.0	1995	2.83
00069	L104	13	AVE C	HARRELL	WILLIS	F	547	42	2	1983	-	Light	2	1	70	1	1.0	1995	5.49
00070	L100	1	NORTH AVE	RICE	FAIRVIEW	F	398	42	2	1978	-	Light	2	1	90	1	1.0	1996	3.99

Pavement Type: F = Flexible Pavement R = Rigid Pavement
Flexible Pavement M&R Strategy
0=Do Nothing 1=Routine Maint 2=Crack & Fog Seal 3=Seal Coat Over 4=Seal Coat
5=2 Course 6=Hot Mix
Rigid Pavement M&R Strategy
0=Do Nothing 1=Routine Maint 2=Thin AC Overlay 3=Medium AC Overlay 4=Thick AC Overlay

City: Lampasas User: University of Texas Analyst: F.S.

LISTINGS OF BASIC INPUT AND OUTPUT DATA

Input File: L1.PLA Report Date: 04-30-1995 Page: 3

SECTION IDENTIFICATION

NO	SECTION CODE		STREET NAME	LOCATION FORM	LOCATION TO	TYPE	LENGTH (ft)	WIDTH ft	TRAF LN	CONST YEAR	CAPACIT	ADT	GROWTH %	TRUCK %	PCI	M&R	P INDEX	ACTION YEAR	M&R COST K$
00071	L105	1	STANDEFER	GANEL	NORTHINGTON	F	270	27	2	1978	-	Light	2	1	90	1	1.0	1996	1.74
00072	L435	1	HILLCREST	HWY 190	SUN SET	F	1020	32	2	1982	-	Light	2	1	90	1	1.0	1996	7.80
00073	L100	3	NORTH AVE	WILLIS	HARRELL	F	560	42	2	1978	-	Light	2	1	90	1	1.0	1996	5.62
00074	L100	2	NORTH AVE	HARRELL	RICE	F	571	42	2	1978	-	Light	2	1	90	1	1.0	1996	5.73
00075	L104	11	AVE C	RICE	STEELE	F	708	42	2	1983	-	Light	2	1	70	1	1.0	1996	7.10
00076	L104	12	AVE C	HARRELL	RICE	F	624	42	2	1983	-	Light	2	1	70	1	1.0	1996	6.26
00077	L436	1	HOLLYWOOD	HILLCREST	SUN SET	F	1185	32	2	1982	-	Light	2	1	90	1	1.0	1996	9.06
00078	L102	50	AVE A	HILLICAN	HACKBERRY	F	917	27	2	1991	-	Light	2	1	60	1	1.0	1996	5.91
00079	L432	1	CASBEER	AVE E	FM 580	F	1650	27	2	1987	-	Light	2	1	50	1	1.0	1996	10.64
00080	C103	50	AVE B	GANEL	HACKBERRY	F	678	27	2	1992	-	Light	2	1	60	1	1.0	1996	4.37
00081	C103	43	AVE B	KEY	LIVEOAK	F	985	42	2	1968	-	Heavy	2	30	10	6	1.3	1996	41.37
00082	L218	4	10TH	RIDGE	END	F	305	42	2	1972	-	Heavy	2	30	20	6	1.6	1996	12.81
00083	L218	1	10TH	KEY	WALNUT	F	282	42	2	1972	-	Heavy	2	30	20	6	1.6	1996	11.84
00084	L218	2	10TH	WALNUT	BROAD	F	121	42	2	1972	-	Heavy	2	30	20	6	1.6	1996	5.08
00085	L218	3	10TH	BROAD	RIDGE	F	295	42	2	1972	-	Heavy	2	30	20	6	1.6	1996	12.39
00086	A403	3	WESTERN	NORTH	AVE B	F	300	42	2	1979	-	Heavy	2	5	20	6	1.7	1996	12.60
00087	L323	1	CASTLEBERRY	AVE B	1ST	F	984	40	2	1972	-	Mediu	2	1	10	5	2.5	1996	11.37
00088	L404	1	CAMPBELL	AVE B	FM 580	F	2369	27	2	1968	-	Mediu	2	1	20	5	2.5	1996	18.48
00089	L430	2	GEORGETOWN	FOURTH	HWY 190	F	1504	42	2	1969	-	Mediu	2	1	10	5	2.5	1996	18.25
00090	C212	3	6TH	BROAD	RIDGE	F	290	42	2	1982	-	Heavy	2	30	10	5	2.7	1996	3.52
00091	C212	5	6TH	RIDGE	RACE	F	643	42	2	1982	-	Heavy	2	30	10	5	2.7	1996	7.80
00092	C212	1	6TH	KEY	WALNUT	F	290	42	2	1982	-	Heavy	2	20	10	5	2.7	1996	3.52
00093	C212	2	6TH	WALNUT	BROAD	F	290	42	2	1982	-	Heavy	2	20	10	5	2.7	1996	3.52
00094	C322	1	WILLIS	AVE C	DEAD END	F	148	32	2	1974	-	Light	2	1	20	5	3.1	1996	1.37
00095	L204	1	2ND	KEY	WALNUT	F	282	38	2	1978	-	Mediu	2	1	8	5	3.2	1996	3.10
00096	L306	4	SPRING	4TH	5TH	F	289	46	2	1971	-	Light	2	1	10	5	3.4	1996	3.84
00097	L306	4	SPRING	AVE A	AVE B	F	274	42	2	1971	-	Light	2	1	10	5	3.4	1996	3.32
00098	L214	1	CLOUD	COLLEGE	OLD GEORGETOWN	F	2030	42	2	1971	-	Light	2	1	20	5	3.4	1997	24.63
00099	L108	52	AVE F	HACKBERRY	CAMPBELL	F	3100	27	2	1967	-	Light	2	1	20	5	3.4	1997	24.18
00100	L434	1	CREEK	FOURTH	END	F	1012	22	2	1968	-	Light	2	1	20	5	3.4	1997	6.43
00101	L406	1	PECAN	AVE F	DEAD END	F	576	27	2	1969	-	Light	2	1	20	5	3.4	1997	4.49
00102	L306	3	SPRING	AVE B	AVE C	F	279	42	2	1971	-	Light	2	1	10	5	3.4	1997	3.39
00103	L102	3	AVE A	BROAD	RIDGE	F	286	42	2	1970	-	Light	2	1	20	5	3.4	1997	3.47
00104	L207	1	HILL	CREEK	OLD GEORGETOWN	F	1325	22	2	1966	-	Light	2	1	20	5	3.4	1997	8.42
00105	L102	1	AVE A	KEY	WALNUT	F	188	42	2	1970	-	Light	2	1	20	5	3.4	1997	2.28

Pavement Type: F = Flexible Pavement R = Rigid Pavement
Flexible Pavement M&R Strategy
0=Do Nothing 1=Routine Maint 2=Crack & Fog Seal 3=Seal Coat Over 4=Seal Coat
5=2 Course 6=Hot Mix
Rigid Pavement M&R Strategy
0=Do Nothing 1=Routine Maint 2=Thin AC Overlay 3=Medium AC Overlay 4=Thick AC Overlay

City: Lampasas User: University of Texas Analyst: F.S.

APPENDIX E. TYPICAL INPUT AND OUTPUT DATA FOR TERRELL

LISTINGS OF BASIC INPUT AND OUTPUT DATA

Input File: STEVE.PLA Report Date: 04-30-1995 Page: 1

SECTION IDENTIFICATION

NO	SECTION CODE	STREET NAME	LOCATION FORM	LOCATION TO	TYPE	LENGTH (ft)	WIDTH ft	TRAF LN	CONSTRU YEAR	CAPACIT	ADT	GROWTH %	TRUCK %	PCI	M&R	P INDEX	ACTION YEAR	M&R COST K$
00001	L201070	HATTIE ST S	NEWTON	HOOD	F	901	16	2	1973	-	99	-	-	64	1	1.0	1995	3.20
00002	L368060	SOUTH ALLEY	VIRGINIA S	DELPHINE	F	334	18	2	1975	-	499	-	-	50	1	1.0	1995	1.34
00003	L159040	DIXON ST	ATHENS	CHAPPEL	F	612	16	2	1973	-	99	-	-	66	1	1.0	1995	2.18
00004	L159030	DIXON ST	TYLER	ATHENS	F	336	16	2	1973	-	99	-	-	66	1	1.0	1995	1.19
00005	L313085	ST LUKE ST	GILBERT	TERMINUS/TISD	F	238	20	2	1972	-	499	-	-	61	1	1.0	1995	1.06
00006	C365020	UNIVERSITY AVE	FRANCES	MEDORA	F	323	20	2	1968	-	4999	-	-	99	1	1.0	1995	1.44
00007	C208010	HIGH ST W	CATHERINE	FRANCES	F	329	38	2	1962	-	3936	-	-	97	1	1.0	1995	2.78
00008	C208040	HIGH ST W	ROCKWALL	HATTIE	F	332	38	2	1962	-	2712	-	-	97	1	1.0	1995	2.80
00009	L368070	SOUTH ALLEY	DELPHINE	MOORE	F	420	24	2	1975	-	499	-	-	50	1	1.0	1995	2.24
00010	A267083	NINTH ST	OAK	STATE	F	391	38	2	1957	-	2665	-	-	96	1	1.0	1995	3.30
00011	C208020	HIGH ST W	FRANCES	NASH COURT	F	328	38	2	1962	-	4999	-	-	97	1	1.0	1995	2.77
00012	L274020	OLD TALTY RD	MELLON	WILLIAMS	F	354	21	2	1981	-	333	-	-	69	1	1.0	1995	1.65
00013	L274010	OLD TALTY RD	WEST END	MELLON	F	167	21	2	1981	-	333	-	-	69	1	1.0	1995	0.78
00014	L297070	ROOSEVELT AVE	LINCOLN	TERMINUS	F	133	31	2	1972	-	99	-	-	63	1	1.0	1995	0.92
00015	L304070	SAN JACINTO ST	ALAMO	GREENWOOD	F	594	16	2	1973	-	99	-	-	58	1	1.0	1995	2.11
00016	L110020	BENNETT ST	STALLINGS	RUNNELS	F	344	20	2	1972	-	99	-	-	67	1	1.0	1995	1.53
00017	L110030	BENNETT ST	RUNNELS	HENDERSON	F	349	20	2	1972	-	99	-	-	67	1	1.0	1995	1.55
00018	L297040	ROOSEVELT AVE	ROCKWALL	LINCOLN	F	1645	31	2	1972	-	499	-	-	61	1	1.0	1995	11.33
00019	C120060	BRIN ST E	BLANCHE	LAMAR	F	379	28	2	1955	-	4999	-	-	78	1	1.0	1995	2.36
00020	C120070	BRIN ST E	LAMAR	PECOS	F	336	28	2	1955	-	4999	-	-	78	1	1.0	1995	2.09
00021	C120040	BRIN ST E	SAN JACINTO	CALLIE	F	203	28	2	1955	-	4999	-	-	78	1	1.0	1995	1.26
00022	C120050	BRIN ST E	CALLIE	BLANCHE	F	331	28	2	1955	-	2827	-	-	78	1	1.0	1995	2.06
00023	C120110	BRIN ST E	DELLIS	STATE S	F	114	28	2	1955	-	4999	-	-	78	1	1.0	1995	0.71
00024	C120112	BRIN ST E	STATE S	TERRELL STATE H	F	37	28	2	1955	-	4999	-	-	78	1	1.0	1995	0.23
00025	C120080	BRIN ST E	PECOS	GREEN	F	186	28	2	1955	-	4999	-	-	78	1	1.0	1995	1.16
00026	C120090	BRIN ST E	GREEN	ARTESIA	F	323	28	2	1955	-	4999	-	-	78	1	1.0	1995	2.01
00027	C120100	BRIN ST E	ARTESIA	DELLIS	F	315	28	2	1955	-	4999	-	-	78	1	1.0	1995	1.96
00028	L239010	LINCOLN LANE	ROSEHILL	ROOSEVELT	F	959	31	2	1972	-	99	-	-	67	1	1.0	1995	6.61
00029	C207020	HIGH ST E	ADELAIDE	VIRGINIA	F	340	38	2	1962	-	4044	-	-	94	1	1.0	1995	2.87
00030	C365010	UNIVERSITY AVE	CATHERINE	FRANCES	F	332	20	2	1968	-	4999	-	-	99	1	1.0	1995	1.48
00031	C207010	HIGH ST E	CATHERINE	ADELAIDE	F	325	38	2	1962	-	4999	-	-	94	1	1.0	1995	2.74
00032	L362020	NEWTON ST W	FRANCES	MEDORA	F	286	20	2	1973	-	499	-	-	63	1	1.0	1995	1.27
00033	C120030	BRIN ST E	VIRGINIA	DELPHINE	F	335	28	2	1955	-	4999	-	-	78	1	1.0	1995	2.08
00034	C120038	BRIN ST E	DELPHINE	SAN JACINTO	F	125	28	2	1955	-	4999	-	-	78	1	1.0	1995	0.78
00035	A267010	NINTH ST	MOORE	LIONS CLUB	F	852	42	2	1957	-	3500	-	-	82	1	1.0	1995	7.95

Pavement Type: F = Flexible Pavement R = Rigid Pavement

Flexible Pavement M&R Strategy

0=Do Nothing 1=Routine Maint 2=Patch & Seal 3=Level & Seal 4=Overlay
5=Reconstruction

Rigid Pavement M&R Strategy

0=Do Nothing 1=Routine Maint 2=Thin AC Overlay 3=Medium AC Overlay 4=Thick AC Overlay

City: TERRELL User: DPW Analyst: F.S.

LISTINGS OF BASIC INPUT AND OUTPUT DATA

Input File: STEVE.PLA Report Date: 04-30-1995 Page: 2

SECTION IDENTIFICATION

NO	SECTION CODE	STREET NAME	LOCATION FORM	LOCATION TO	TYPE	LENGTH (ft)	WIDTH ft	TRAF LN	CONSTR YEAR	CAPACIT	ADT	GROWTH %	TRUCK %	PCI	M&R	P INDEX	ACTION YEAR	M&R COST K$
00036	L135120	CATHERINE ST S	UNIVERSITY	TERMINUS	F	540	31	2	1972	-	99	-	-	67	1	1.0	1995	3.72
00037	C121010	BRIN ST W	CATHERINE	FRANCES	F	325	31	2	1955	-	2841	-	-	81	1	1.0	1995	2.24
00038	C193020	GROVE ST W	FRANCES	MEDORA	F	271	35	2	1972	-	4999	-	-	91	1	1.0	1995	2.11
00039	A191070	GRIFFITH AVE	NINTH	WALNUT	F	967	32	2	1940	-	3882	-	-	79	1	1.0	1995	6.88
00040	A191062	GRIFFITH AVE	GRACE	NINTH	F	625	32	2	1940	-	3882	-	-	79	1	1.0	1996	4.44
00041	C102120	AIRPORT RD	DELPHINE	INDUSTRIAL BLVD	F	1572	22	2	1971	-	4679	-	-	88	1	1.0	1996	7.69
00042	C208030	HIGH ST W	NASH COURT	ROCKWALL	F	384	38	2	1962	-	3159	-	-	97	1	1.0	1996	3.24
00043	C193040	GROVE ST W	MEDORA	ROCKWALL	F	443	35	2	1972	-	3700	-	-	91	1	1.0	1996	3.45
00044	C102110	AIRPORT RD	VIRGINIA	DELPHINE	F	442	22	2	1945	-	4514	-	-	88	1	1.0	1996	2.16
00045	L222010	JONES ST	PACIFIC	ROCKWALL	F	420	18	2	1985	-	99	-	-	69	1	1.0	1996	1.68
00046	L274030	OLD TALTY RD	WILLIAMS	FM 148	F	1615	21	2	1981	-	333	-	-	69	1	1.0	1996	6.60
00047	A191010	GRIFFITH AVE	ROCKWALL	PACIFIC	F	166	32	2	1940	-	4999	-	-	79	1	1.0	1996	1.18
00048	L190040	GREENWOOD ST	SAN JACINTO	CROCKETT	F	328	27	2	1972	-	99	-	-	56	1	1.0	1996	1.97
00049	A191040	GRIFFITH AVE	ROBERTS	THIRD	F	285	32	2	1940	-	3011	-	-	79	1	1.0	1996	2.03
00050	A191045	GRIFFITH AVE	THIRD	GRACE	F	854	32	2	1940	-	3856	-	-	79	1	1.0	1996	6.07
00051	A191020	GRIFFITH AVE	PACIFIC	FIRST	F	618	32	2	1940	-	4999	-	-	79	1	1.0	1996	4.39
00052	A191030	GRIFFITH AVE	FIRST	ROBERTS	F	267	32	2	1940	-	4999	-	-	79	1	1.0	1996	1.90
00053	C262020	NASH ST E	ADELAIDE	VIRGINIA	F	340	41	2	1950	-	3368	-	-	77	1	1.0	1996	3.10
00054	L103030	ALAMO ST E	VIRGINIA	SAN JACINTO	F	474	19	2	1973	-	499	-	-	62	1	1.0	1996	2.00
00055	L103040	ALAMO ST E	SAN JACINTO	CROCKETT/STATE	F	284	18	2	1973	-	99	-	-	62	1	1.0	1996	1.14
00056	A295020	ROCKWALL AVE S	SOUTH ALLEY	GROVE	F	434	45	2	1960	-	4800	-	-	23	5	1.7	1996	65.10
00057	A295095	ROCKWALL AVE S	HOOD	MYERS	F	411	45	2	1957	-	4999	-	-	28	5	1.7	1997	61.65
00058	A295105	ROCKWALL AVE S	HELEN	RILEY	F	418	45	2	1957	-	4999	-	-	28	5	1.7	1997	62.70
00059	A295090	ROCKWALL AVE S	NEWTON EAST	HOOD	F	873	45	2	1957	-	3758	-	-	28	5	2.6	1998	130.95
00060	A295100	ROCKWALL AVE S	MYERS	HELEN	F	162	45	2	1957	-	2735	-	-	28	5	2.6	1998	24.30
00061	A295010	ROCKWALL AVE S	MOORE	SOUTH ALLEY	F	250	45	4	1950	-	4999	-	-	23	4	2.8	1998	12.50
00062	C295130	ROCKWALL AVE S	UNIVERSITY	BAKER	F	1573	45	2	1963	-	1270	-	-	28	4	3.8	1998	78.65
00063	A295060	ROCKWALL AVE S	ROCHESTER	BENGIE	F	292	27	2	1950	-	4999	-	-	45	5	4.5	1999	26.28
00064	A295070	ROCKWALL AVE S	BENGIE	NEWTON WEST	F	168	27	2	1950	-	4999	-	-	45	5	4.5	1999	15.12
00065	A295050	ROCKWALL AVE S	COTTAGE WEST	ROCHESTER	F	319	27	2	1950	-	4498	-	-	45	5	4.5	1999	28.71
00066	C378000	INDUSTRIAL BLVD	S.H. 34	AIRPORT ROAD	F	4262	26	2	1973	-	1860	-	-	6	4	4.5	1999	123.12
00067	A295040	ROCKWALL AVE S	COTTAGE EAST	COTTAGE WEST	F	136	27	2	1950	-	4700	-	-	45	5	4.5	1999	12.24
00068	A295030	ROCKWALL AVE S	GROVE	COTTAGE EAST	F	231	27	2	1950	-	4700	-	-	45	5	4.5	-	20.79
00069	L176060	FRANCES ST S	NEWTON	TEMPLE	F	589	22	2	1970	-	999	-	-	25	4	5.0	-	14.40
00070	L176050	FRANCES ST S	ROCHESTER	NEWTON	F	321	22	2	1970	-	999	-	-	25	4	5.0	-	7.85

Pavement Type: F = Flexible Pavement R = Rigid Pavement

Flexible Pavement M&R Strategy

0=Do Nothing 1=Routine Maint 2=Patch & Seal 3=Level & Seal 4=Overlay
5=Reconstruction

Rigid Pavement M&R Strategy

0=Do Nothing 1=Routine Maint 2=Thin AC Overlay 3=Medium AC Overlay 4=Thick AC Overlay

City: TERRELL User: DPW Analyst: F.S.